

Abstracts of Presentations
from the
Annual Conference
of the
American Society for Horticultural Science
July 22–25, 2013
Palm Desert, California

Supplement to *HortScience*
Volume 48(9) September 2013

Contains abstracts of symposia, colloquia, workshops, plus oral and poster presentations from the 2013 ASHS Annual Conference.

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For citation purposes, abstracts should be cited as follows:

(Example)

Karlsson, M., C. Willingham. 2013. Field Performance of Transplants Grown using Light-emitting Diodes. *HortScience* 48(9):S290. (Abstr.)

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Colloquia

Presented at the Annual Conference of the American Society for Horticultural Science

July 22–25, 2013, Palm Desert, California

Monday, July 22, 2013

Springs Salon F

2:00–6:00 PM

Advances and Critical Issues in Breeding Cultivars for Organic Cropping Systems and Developing Methods of Organic Seed Production

Sponsors: ASHS Organic Horticulture, Vegetable Breeding, Seed and Stand Establishment, and Local Food Systems Working Groups

Coordinators: Xin Zhao, zxin@ufl.edu; Erin Silva, emsilva@wisc.edu

Organic crop production requires inputs and practices that emphasize holistic approaches for soil and fertility management as well as disease, insect, and weed control. Organic growers are increasingly looking for crop cultivars that are well adapted to organic growing conditions that exhibit desirable yield potential and market qualities demanded by the organic consumers, including superior nutrition and exceptional flavor. Plant breeders have increased the yield potential of horticultural crops in conventional production systems, but many organic growers either rely on 19th or 20th century heirloom varieties that often lack the productivity, disease resistance, and other quality traits incorporated into contemporary varieties, or they choose to grow unadapted contemporary varieties bred specifically under and for conventional production conditions. Among the critical issues facing organic growers today is the need for improved cultivars developed for and optimized specifically for organic production systems. Recent research findings have shown that cultivar performance may differ markedly between organic and conventional systems. Over the last 3–5 years, several funding sources have increasingly focused on this issue as a priority area for organic agriculture research and development. Several research projects in this field have completed their initial phases, thus providing a solid foundation of data and insights on which to base this timely and pertinent colloquium. This forum will allow attendees to obtain a broad perspective on the state of cultivar development for organic production and its approaches and methodology, as well as future prospects. It will focus primarily on vegetable crop breeding, and other crops to a lesser extent. The major topics include: genetic gain through selection in organic environments; models for farmer-breeder partnerships; unique traits for enhanced organic variety performance and marketability; variety trial experimental design and participatory methods; developing cultivars resistant to GMO contamination; and open-source models for germplasm development. In addition, attendees of this colloquium will also have the opportunity to network with other researchers with similar interests in this important field, thus better positioning their research to be competitive in forthcoming grant funding opportunities.

2:00 PM

The Role of Plant Breeding for Organic Producers

James R. Myers*

Oregon State University

Breeding crops for organic production systems is a relative new concept. It is predicated on the fact that unless a cultivar is specifically adapted, its performance in a particular environment may be suboptimal. With its emphasis on soil building and injunction against chemical fertilizers, herbicides, and pesticides, organic production represents a profoundly different environment from a conventional production environment. Nearly all contemporary crop cultivars developed to date having been bred in conventional systems, and as a result, may be less than optimally adapted to organic environments.

Research comparing conventional and organic production for several field and horticultural crops is now becoming available to test this idea. While some studies have found significant genotype by production system interactions, others have found less evidence for difference in performance between the two systems. A major question confronting plant breeders is whether organic plant breeding must be conducted entirely under organic production or whether blended approaches might be feasible. One surprising finding in several studies is that while organic environments are inherently more variable than similar conventional environments, heritabilities in organic are comparable to conventional environments. Apparently, genotypes in organic show a wider range of expression compared to conventional environments. This would suggest that greater gain from selection might be achieved in organic compared to conventional systems. A potential blended breeding system

An asterisk (*) following a name indicates the presenting author.

would be to conduct early generation selection solely in organic environments, but test advanced lines in both environments to identify those that are adapted to one or both. New research on what traits might provide specific adaptation to organic production includes those associated with roots and soil, and weed competitiveness. Organic plant breeding efforts around the United States are expanding in both field and horticultural crops. The expansion has been greatest in the public sector with the private sector generally lagging behind. Funds to support breeding efforts in the public sector have come from OFRF, SARE, and USDA–NIFA–OREI, but these have become less available with uncertainties in the USDA budget for federal grants programs. With overall consumer demand for organic produce continuing to increase, there will be strong incentive for plant breeders to develop cultivars that are productive under organic growing conditions.

2:30 PM

Breeding for Traits Unique to Organic Production Systems

Philipp W. Simon*

USDA, Madison, WI

John P. Navazio

Organic Seed Alliance

Organic agricultural production systems differ significantly from conventional systems in their management of soil nutrients, weeds, pests, and diseases. Concomitant with these differences in management systems, cultivars developed for organic systems can include traits that differ from cultivars bred for conventional systems. For example, genetic differences in root architecture and capacity for symbiotic relationships have been found to differ in crop breeding stocks developed for organic production systems, relative to breeding stocks targeted for conventional nutrient management. Accelerated seedling vigor, rapid plant growth, and greater leaf area are traits that promote early stand establishment and canopy closure, and consequently improved weed control for organic systems. The same pests and diseases diminish crop productivity in organic and conventional systems, but without pesticides, the urgency for the incorporation of effective genetic resistance is heightened for crops grown in organic production systems. Intra-varietal genetic diversity is being explored for variation in these traits that contribute to yield stability under the greater diversity of cropping systems that are found on organic farms. Marketers and consumers of organically grown vegetables and fruits often place a greater premium on flavor, nutritional value, and novelty, and this broad range of market demands has stimulated the incorporation of numerous traits into cultivars for organic production that are otherwise unfamiliar to most consumers. To meet these diverse production challenges and consumer expectations, plant breeders developing cultivars for organic systems have begun to draw upon the breadth of genetic diversity of the crops they breed. Continued success in breeding will rely upon screening

diverse germplasm and incorporating novel traits that will then be selected under low input, organic management practices.

Funding Source: USDA–NIFA Award no. 2011-51300-30903 of the OREI (Organic Agric. Res. & Ext. Initiative)

3:00 PM

An Evolutionary-participatory Approach for Breeding Self-pollinating Cereals in Organic Systems

Kevin Murphy*

Washington State University

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Washington State University

Stephen Jones

Washington State University

Direct selection within organic systems has been shown to increase grain yield in organic wheat from 5% to 30% when compared to indirect selection within conventional systems. However, the cost of maintaining a separate, viable breeding program for organic cereals can be logistically and economically challenging. The multiplicity of inputs and practices of organic cereal farms in a target bioregion tends to lead to greater landscape diversity than is often found among conventional farms in the same region. Genetic uniformity within most homogeneous cereal-based monocultures has been shown to limit the crops' capacity to evolve in response to adverse and challenging environmental conditions. Therefore a practical, low-cost approach to organic cereal breeding may be beneficial to fully exploit the range of genotype x organic farming system x environment interactions within the target region. One such approach is through a fusion of participatory and evolutionary breeding models. This model relies on robust on-farm, farmer-breeder co-selection of preferred genotypes within segregating, heterogeneous bulk populations. In an evolutionary breeding study, several F8–F9 winter wheat populations were shown to out-yield parental cultivars within and across selection environments, while maintaining protein contents similar to the mid-parent value. The use of single nucleotide polymorphism (SNP) sequencing and visualization has identified specific markers (and alleles) within known quantitative trait loci (QTL) that are favored through natural selection are potentially associated with increased traits related reproductive fitness, including grain yield, plant height and heading date. One farmer-bred, evolutionary-participatory population of winter wheat, WA8094, was included in the WSU Statewide Variety Testing program in 2009–10 and 2011–12 with 59 of the most promising breeding lines and established varieties from 11 regional breeding programs. In 2009–10, WA 8094 yielded the same as the most widely grown variety statewide in dry areas, 'Eltan', and significantly higher than 'ORCF-102', 'WB0528', and 'Madsen' (ranked 2,4, and 5, respectively, in Washington acreage) when averaged across six low rainfall

An asterisk (*) following a name indicates the presenting author.

locations. In 2010–11, WA8094 was statistically equal in grain yield to Eltan, WB-523 and AP 700 CL (which had replaced Madsen), though lower to Xerpha and ORCF-102. The fact that a bulk population, bred using recurrent selection, both natural and farmer-imposed, could rank high across elite variety trials demonstrates the potential for this low-cost method to be used in farmer-breeder collaborations across a broad range of organic systems.

3:30 PM

The Value of Farmer-based Participatory Plant Breeding for Organic Systems

Micaela Colley*

Organic Seed Alliance

John P. Navazio

Organic Seed Alliance

Jared Zystro

Organic Seed Alliance

As organic farming becomes more prevalent, organic farmers are seeking varieties specifically adapted to organic agriculture. While there are numerous models that may be successful for organic breeding, there are several reasons why farmer based participatory plant breeding (PPB) holds promise as a model for organic breeding. The Organic Seed Alliance (OSA) is developing effective, farmer-participatory breeding methodologies that can serve as model for other programs. PPB is defined as breeding based on methods that involve close farmer-researcher collaboration to bring about crop genetic improvement. PPB is a collaborative effort between a farmer-breeder and a formal-breeder. It is a decentralized approach and commonly conducted on working farms. Farmer-researcher collaboration leverages the strengths of both parties to create useful varieties in an efficient manner. The best farmer partners are experts in their crops and cropping systems, and are often better than researchers at identifying the requirements for a new variety. Successful PPB projects value an active farmer involvement in the breeding process. The breeding objectives, selection criteria, and ideal time to evaluate traits are based largely on input from the farmer. Also, in organic farming, many of the advances in production are due to farmer's rapid adoption of new techniques, so farmer partners are often the best equipped to identify the most up-to-date production systems to test in. The appropriate breeding methodology is supplied from the formal breeder. The breeder is instrumental in determining appropriate field plot design, calculating heritability of traits and performing statistical analysis. The strengths of the PPB model rest on these two elements: farmer-researcher collaboration, and decentralization of the breeding process onto farms. By fostering this collaboration, PPB offers an economical way to encourage the adoption of varieties adapted to low-input organic agriculture. OSA's breeding program forms strong collaborations with organic farmers for on-farm breeding of open-pollinated varieties for organic agriculture. Examples of successful PPB

projects include; 1) a cold soil tolerant sugary-enhanced (SE) sweet corn; 2) a drought and wind tolerant zucchini; 3) a cold hardy, powdery mildew resistant red kale; and 4) a cold hardy, uniform winter sprouting broccoli. Farmers decided the breeding priorities and participated in field breeding with OSA's formal breeder. These projects demonstrate the feasibility of developing a commercially viable, open-pollinated variety through on-farm, participatory breeding methods.

4:00 PM

Break

4:15 PM

Seed and Plant Breeding for Wisconsin's Organic Vegetable Sector: Understanding Farmers' Needs and Practices

Erin Silva*

University of Wisconsin, Madison

4:45 PM

The Open Source Seed Initiative and its Potential Role in Supporting Organic Seed Systems

Irwin L. Goldman*

University Wisconsin, Madison

The Open Source Seed Initiative (OSSI) has been developed over the past two years by a working group of plant breeders, farmers, non-profit agencies, seed advocates, and policy makers. A complete list of participants can be found on a poster presented at this conference. The OSSI is dedicated to maintaining fair and open access to plant genetic resources worldwide. The OSSI supports innovative plant breeding that produces resilient and productive cultivars. Enabling the open exchange of germplasm, with no restrictions on further breeding, is crucial to this new agriculture. The OSSI will work toward achievement of: 1) a germplasm licensing framework with no breeding restrictions on the germplasm released through its auspices other than that derivatives must also be released with the same license; 2) a robust, vibrant, and well-supported public plant breeding sector producing germplasm and cultivars that can be equitably grown, sold, changed, and distributed; 3) a plurality of sources for farmers, gardeners, and breeders to obtain seed; 4) integration of the skills and capacities of farmers with those of plant scientists for enhancing and enlarging participatory plant breeding; and 5) respect for the rights and sovereignty of indigenous communities, and of farmers and farm communities, to play a role in solutions to obtaining seed for food production. Three OSSI licenses have been drafted to enact the core principles described above, with a planned release date of these licenses in 2014. The objective of this presentation is to describe the framework that led to OSSI's development and to highlight potential opportunities where OSSI may support organic seed systems.

An asterisk (*) following a name indicates the presenting author.

5:15 PM

Participatory Variety Trials: Value and Methods

Jared Zystro*

Organic Seed Alliance

Organic agricultural systems represent a set of environments that are distinct from conventional systems, and frequently distinct from each other. Done correctly, participatory variety trials can benefit breeders developing varieties for organic systems. Distributed participatory trials help breeders identify varieties with wide adaptation and stability, and varieties with adaptation to specific environments. When breeders decide what material to release as finished cultivars, they are limited to choosing based on known performance in the locations tested. However, many varieties are never tested in organic production systems, or only in a very limited set of organic systems. For organic farms, it is a lucky coincidence when available cultivars are superior to other breeding material for their farms. By testing material on many farms, breeders can identify specific varieties that are adapted to unique environments. When breeders partner with farmers to conduct participatory trials, the producer-cooperator provides the breeder with the sort of high-quality feedback that is difficult to obtain via other avenues. In comparison to feedback at field days, producer-cooperator feedback reflects a deeper understanding of how

the crop actually functions in their system. In comparison to feedback from producers who have tried released varieties, producer-cooperator feedback gives breeders information that they can use to improve their material prior to release. Finally, on farm trials can occasionally reveal to breeders novel ways that organic producers use a crop. The way that the farmer uses the crop may lead the breeder to focus on new traits in their breeding program. Participatory variety trials can take many forms, representing trade-offs between cost, scope, and precision. These trade offs must be considered when evaluating vegetable entries in organic systems. Within-field heterogeneity can often be a challenge when conducting participatory variety trials. Complete block designs can allow experimenters to collect data that are relatively precise. However, their cost may limit the number of locations where trials can be conducted. Organic systems also display large differences between locations. For this reason, more cost efficient designs, such as augmented or alpha-lattice designs, may allow researchers to evaluate varieties in more organic systems and produce results that are relevant to a wider audience. As with experimental design, data collection protocols must be developed to balance the accuracy of the results with the time and cost involved.

5:45 PM

Wrap-up and Discussion

An asterisk (*) following a name indicates the presenting author.

Tuesday, July 23, 2013

Desert Salon 4-6

8:00 AM–12:00 PM

Integrated Pest Management for Vegetable Crops in the Tropics

Sponsor: Tropical Horticulture Crops Working Group

Moderator: Rangaswamy Muniappan, rmuni@vt.edu

Coordinators: Ricky Bates; rmb30@psu.edu; Rangaswamy Muniappan; rmuni@vt.edu

The Integrated Pest Management Innovation Lab (IPM IL, formerly the IPM CRSP), funded by USAID, addresses horticultural crop issues faced by farmers in sixteen developing countries in six different regions of the tropical world. The program collaborates with scientists, researchers, students, extension officers, and development practitioners at universities, NGOs, and government entities in the United States and around the world. In this colloquium, an international group of scientists will discuss program developments and strategies. Country-specific presentations will focus on Bangladesh, Ecuador, Ghana, Honduras, India, and Kenya, while additional presentations will focus on techniques developed for specific crops and diseases: antagonistic fungi, grafting, a host-free period, and roguing.

8:00–8:30 AM

An Overview of IPM CRSP

Rangaswamy Muniappan*

Virginia Polytechnic Institute and State University

8:30–8:50 AM

Use of *Trichoderma* spp., *Pseudomonas fluorescens*, and *Bacillus* spp. in Seed and Soil Treatment

Barry Jacobsen*

Montana State University

8:50–9:10 AM

Grafting Vegetable Seedlings for Soil Borne Disease Resistance

Sally Miller*

Ohio State University

9:10–9:30 AM

Roguing for Control of Peanut Bud Necrosis Virus Disease in Tomato

G. Karthikeyan*

Tamil Nadu Agricultural University, India

9:30–9:50 AM

Host Free Period for Tomato Yellow Leaf Curl Virus Control

Robert Gilbertson*

University of California, Davis

9:50–10:10 AM

IPM Packages for Vegetable Crops in Central and South America

Jeff Alwang*

Virginia Polytechnic Institute and State University

10:10–10:30 AM

Coffee Break

10:30–10:50 AM

IPM Packages for Vegetable Crops in India

G. Karthikeyan*

Tamil Nadu Agricultural University, India

10:50–11:10 AM

IPM Packages for Vegetable Crops in Bangladesh

Syed Nurul Alam*

Bangladesh Agricultural Research Institute

11:10–11:30 AM

IPM Packages for Vegetable Crops in East Africa

Monicah Waiganjo

Kenya Agricultural Research Institute, Kenya

11:30–11:50 AM

IPM Packages for Vegetable Crops in West Africa

Michael Osei*

Crops Research Institute, Ghana

11:50 AM–12:00 PM

General Discussion

An asterisk (*) following a name indicates the presenting author.

Wednesday, July 24, 2013

Springs Salon F

8:00 AM–12:00 PM

Strategy for Developing Mechanical Harvesting of Horticultural Crops: Simultaneous Short-, Medium-, and Long-term Strategies

Sponsor: Mechanical Harvest Working Group

Moderators and Coordinators: Rachel B. Elkins, rbelkins@ucdavis.edu; Stephanie Walker, swalker@nmsu.edu; Louise Ferguson, lferguson@ucdavis.edu

The objective of this colloquium is to delineate through successful examples the simultaneous steps of a mechanical harvesting development program from the harvesting technology through the extension program for adoption, including composition of the research team. The steps of developing a mechanical harvesting program will be presented as the short-, medium- and long-term goals and highlight the critical limiting factors of each. The short-term goal is identifying a fruit/vegetable/flower removal principal and demonstrating that it can meet the first limiting factor of producing a marketable product. The second limiting factor is demonstrating that this does not harm the plant (if perennial) physically or exacerbate disease, insect pests, or physiological problems. The third limiting factor is developing the mobile platform with a competent catch frame, a process that requires cooperation with the commercial harvester industry. The medium-term goal is orchard management to increase the final efficiency of the harvesting machines developed; this includes orchard establishment, tree training and pruning, developing chemical compounds that induce abscission, and pre- and postharvest treatments. The first limiting factor is decreased yield or quality resulting from the new orchard or planting systems and abscission chemicals. The second limiting factor is developing the harvester operating parameters, tons per hour, cost per ton, and the economic analysis that demonstrates mechanical harvesting is logistically and economically feasible. The long-term goal is breeding cultivars more suitable to mechanical harvesting with both traditional and molecular methods. The limiting factor is defining the goal precisely; for example, a compressed maturity period to increase harvester efficiency through having all the fruits/flowers/vegetable ripen simultaneously. Finally, development of a successful mechanical harvesting system is more than producing the technology and adapting the orchards. An extension education program, ideally conducted in parallel with the mechanical harvesting development project, for both the horticultural crop producers, and their current labor pool, is a prerequisite for successful adoption of mechanical harvesting

8:00–8:30 AM

How Agricultural Engineers Develop Mechanical Harvesters: The University Perspective

Sergio Castro-Garcia*

University of Cordoba, Spain; SCastro@uco.es

Developing mechanical harvesting is the most effective, and most difficult, factor, in improving horticultural crop profitability. It requires simultaneous incremental change by multiple entities; University engineers, horticulturists, food scientists, economists and local extension personnel, the commercial harvester industry, growers and displaced laborers and their management. It has a narrow annual testing window. The initial research by engineers and horticulturists focuses on developing effective removal technologies and can be applied or basic. With local funding research is generally applied adaptations of existing technology. With national funding the research is basic or novel technologies. Both are conducted on model systems or individual plants. Properly executed both types can be published but publication is difficult if engineering parameters are changed during trials. Evaluation of developed removal technologies requires cross disciplinary teams to evaluate the effects on

final marketable product quality long term tree health. Teams include horticulturists, pathologists, food scientists, economists and extension personnel and local funding. Publications can be produced on testing technology or effects on marketable product quality or plant health. An industry education program with field days, industry publications and websites and annual presentations should frequently report progress. Finally, economic feasibility on a mobile platform with catching technology, a prototype, should be demonstrated. The research team now expands to include the harvester industry and grower cooperators. Planting adaptations to increase harvester efficiency are incorporated. All research is applied and the funding local. If results demonstrate economic feasibility the technology should segue to the commercial harvester to industry as University laboratories lack the capacity to generate truly commercial harvesters. Patents are possible but preclude publication.

8:30–8:45 AM

How Companies Select and Develop Harvesters: The Commercial Perspective

Rachel B. Elkins*

Lake County UCCE, Clear Lake CA; RBelkins@ucdavis.edu

An asterisk (*) following a name indicates the presenting author.

Agricultural equipment fabricators are often reluctant to develop and produce mechanical harvesters for horticultural crops. This presentation will summarize interviews with multiple companies querying this question.

8:45–9:10 AM

Preparing Fresh Apple, Peach, and Pear Orchards for Mechanical Harvesting

Terence Lee Robinson*

New York State Agricultural Experiment Station, Geneva;
tlr1@cornell.edu

In the early 1970s concern over the availability of harvest labor led to significant research on mechanical harvest on apples and peaches. This early research resulted in mass removal trunk shaking machines that detached apples by applying a centrifugal force to the trunk, which then fell onto catching frames and were collected and transported to a bin with conveyor belts. This technology resulted in significant adoption of mechanical shake and catch harvesters in the largely processing growing regions of Western New York, Pennsylvania, Michigan, and California. However, fruit bruising was substantial. In an effort to design the tree for the machine, several tree designs were studied including the Geneva Y-trellis and the Lincoln apple canopy. The Geneva Y-trellis growing system allowed most of the fruit to borne in a single plane so that there were few fruit-to-branch impacts as the fruit fell. When the Y-trellis was combined with an impact trunk shaker, much less energy was imparted to the fruits than the centrifugal shakers. The best results with this system showed only 10% fruit bruising. However, this technology was never adopted by the apple industry since by the late 1980s the interest in mechanical harvest of apples in the United States had waned, as it appeared there would be an endless supply of migrant workers who could harvest the crop relatively cheaply. In Europe a different approach was pursued to reduce harvest labor by developing harvest assist machines. As early as 1980, researchers in the Netherlands had built machines that used humans to detach the fruit from the tree and then place it on conveyers to transport the fruit to a central mechanical bin filler. These machines were best suited to simple trees narrow trees. Since the 1980s, numerous designs have been developed. In general, research showed that these harvest assist machines could improve labor efficiency by only 15% to 20%. Their efficiency was greater with simple thin canopies and high tree planting densities. This relatively small improvement in labor efficiency did not result in rapid adoption of harvest assist machines. However, slowly over the years more and more European growers have purchased these harvest but they have never been adopted in the United States. In the early 2000s, new concerns in the United States over labor cost revived an interest in mechanical harvest and a new round of research began based on two concepts: harvest assist machines and robotics.

9:10–9:35 AM

Transformation of an Ancient Crop: Preparing Oil and Table Olives for Mechanical Harvesting

Louise Ferguson*

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As one of the oldest continuously produced tree crops, it is ironic that table olive production has benefitted from few technological innovations. However, research since 2006 has successfully completed the first two steps of developing mechanical harvesting, identifying two effective harvesting technologies, and eliminating the limiting factors of fruit and tree damage. By simultaneously focusing on increasing harvester efficiency through engineering modification and orchard adaptation in 2012 we achieved the final step, economically feasible mechanical harvesting for both harvesting technologies. Both trunk shaking and improved canopy contact harvesting technologies now deliver mechanically harvested olives that receive total adjusted prices per ton and canning percentages, and sensory and consumer evaluations of the processed fruit, equal to those of hand harvested fruit. Canopy damage produced by the canopy contact harvester is less than 2% and less severe than that produced by hand harvesting. Trunk damage from trunk shakers has been mitigated but the interaction with tree water status needs to be better characterized. Topping and hedging in a 13 x 26 foot orchard, 139 trees per acre, increased average annual yields/acre by an insignificant 0.03 tons/acre from 2008 through 2012, and may decrease alternate bearing. Hedgerow tree training at 12 x 18 feet, 202 trees per acre in a newly developed hedgerow orchard did not decrease tree yield or fruit quality relative to traditional tree training at the same spacing. Mechanical hedging and topping significantly increased canopy contact harvester efficiency by 7% in a traditional orchard adapted to a hedgerow with mechanical topping and hedging. Both the trunk shaking and canopy contact harvesters averaged 77% final efficiency in prepared orchards.

9:35–10:00 AM

Chili Peppers: Challenges and Advances in Transitioning Harvesting of New Mexico's Signature Crop

Stephanie Walker*

New Mexico State University, Las Cruces; swalker@nmsu.edu

New Mexico-type chile (*Capsicum annuum* L.), often referred to as 'Anaheim', is the signature crop of New Mexico. Both the red and green (fully sized, but physiologically immature) crops are celebrated in local cuisine, culture, and art, and the production and processing of chile is an integral contributor to the state's economy. Although the red chile crop has mainly transitioned to mechanical harvest, the green chile crop continues to be hand-harvested. Lack of a predictable labor

An asterisk (*) following a name indicates the presenting author.

supply and higher input costs have prompted industry interest, as well as affiliated research projects, in green chile mechanical harvest. The history and ongoing challenges in mechanizing this crop mirror those faced by many horticultural crops produced in industrialized societies. Mechanizing the green chile harvest has been difficult because of a low tolerance for damaged fruit, and stem removal is a critical quality and safety concern. In addition, although New Mexico-type green chile is an important crop to New Mexico, the total acreage in the United States is too low to attract research and development investment by large agricultural equipment companies. With support from the New Mexico Chile Association, a consortium of growers and industry representatives, research efforts have been conducted by agricultural engineers and horticultural scientists from New Mexico State University and the USDA–ARS Cotton Ginning Laboratory (Las Cruces, NM). Efforts have focused on identifying cultivars with superior mechanical harvest efficiency, breeding to develop cultivars improved for mechanization, and crop management strategies to maximize the process. Agricultural engineers' efforts in identifying the optimal picking head and development of an efficient mechanical destemmer have bolstered these efforts. This presentation will discuss the history, ongoing research efforts, and continuing challenges in the mechanization of green chile harvest and destemming in New Mexico.

10:00–10:25 AM

Grapevine Varieties, Trellis Systems, and Mechanization of the California Raisin Industry

Matthew W. Fidelibus*

Kearney Agricultural Research and Extension Center,
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Growers in California's San Joaquin Valley produced more than 25% of the world's raisins in 2012, with a farm-gate value of more than \$590 million, making the United States the leading global producer of raisins. California's traditional raisin-making method in is a laborious process in which clusters of grapes (*Vitis vinifera*) are harvested by hand onto paper trays that are left in the vineyard to dry. The drying fruit may need to be turned or rolled, tasks requiring manual labor, and the trays of dried raisins are also picked up by hand. Most California raisins continue to be made in this way but in recent years the declining availability and increasing cost of labor has prompted many growers to implement one of two mechanized production systems, "continuous tray" (CT), or "dry-on-vine" (DOV). In CT systems, machines are used to pick the berries, lay them onto a tray, and pick up the dried raisins. The CT system could be considered a short-term strategy: it is compatible with existing conventional 'Thompson Seedless' raisin vineyards, and has been widely adopted. The DOV system could be considered a medium-term strategy: it is best suited for vineyards specifically designed for DOV, with early-ripening grapevine varieties on expansive trellis systems, which ensure timely

drying, and capitalize on the fact that sunlit row middles are not needed for fruit drying. Grapevine breeding programs are currently working toward the development of raisin grape varieties with fruitful basal nodes, and whose fruit dry naturally upon ripening. This is a long-term strategy to further reduce labor needs by enabling mechanical pruning in winter, and eliminating the need for cane severance in the summer.

10:25–10:50 AM

Progress in Breeding Highbush Blueberry Cultivars Adapted to Machine Harvest for the Fresh Market

James W. Olmstead*

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Highbush blueberry production, including northern highbush (*Vaccinium corymbosum*), southern highbush (*V. corymbosum* hybrids), and rabbiteye (*V. virgatum*), that is destined for the processed market is largely machine-harvested. Over the last five years, processed highbush blueberry production has accounted for less than 40% of the total world production. The remaining fruit harvested for fresh consumption has remained largely hand-harvested. As worldwide production of highbush blueberries surpassed 1 billion pounds in 2012, increasing concerns about labor availability and higher production costs have led to increasing utilization of machine harvest for fresh (MFF) market production. Until recently, only rabbiteye blueberries have had a high percentage of fresh production picked as MFF. A sequential harvest strategy where high-value early season fruit are hand harvested and later maturing fruit are machine harvested, has most often been adopted for northern and southern highbush producers using existing cultivars and harvest equipment. However, to truly facilitate MFF, new blueberry cultivars need to be developed. Bush architecture, easy detachment of mature berries compared to immature berries, loose fruit clusters, small, dry stem scar, firm fruit, and a concentrated ripening period are breeding goals to develop blueberry cultivars amenable to machine harvest.

10:50–11:15 AM

Breeding Oil and Table Olives for Mechanical Harvesting

Luis Rallo*

Universidad de Cordoba, Cordoba; lrallo@uco.es

The olive and table olive industries in the world are almost entirely supported by local cultivars empirically selected by farmers through centuries. New early and high bearing plantation systems adapted to mechanical harvesting have being designed and developed during the last fifty years. Intensive rainfed (150–200 trees/ha) and irrigated (250–400 trees/ha), high density irrigated large hedgerows (400–800 trees/ha) and very high density hedgerows (superintensive) rainfed (800–1000 trees/ha) and irrigated (>1,500 trees/ha) orchards

An asterisk (*) following a name indicates the presenting author.

are being progressively planted to be harvested by different mechanical systems. However, these orchards depend on traditional cultivars in most cases. In Spain a long term effort on exploration, conservation and sustainable use of olive genetic resources starting in 1970 has been followed by breeding programs developed since early 1990's by the Universities of Córdoba and Seville and the IFAPA to obtain new cultivars adapted to mechanical harvesting by cross breeding. Methodological (shortening the Juvenile Period (JP) and developing early tests of selection), agronomical (earliness of bearing, high cropping, tolerance to abiotic stresses and resistance to main diseases, particularly to Verticillium wilt, and low chilling requirements) and industrial suitability (high oil content and diversity olive oil composition for oil cultivars and fruit size and shape for table olives) objectives are being pursued. Specific criteria for adaptation of oil olive and table olive cultivars to mechanical harvesting such as low vigor trees with compact habit of growth, fruit removal force, natural fruit abscission, resistance to bruising and enlarging ripening time among cultivars of compressed maturity period are evaluated in progenies. Up to date many progenies have been already evaluated and more than 400 preselections are on intermediate field trials. More than 30 advanced selections are being established in a network of field trials open to private and international cooperation. A new protected cultivar 'Sikitita' ('Chiquitita' in the United States), selected for very high density narrow hedgerows, was released in 2008 and it is currently authorized for propagation in 12 countries. Recently a first project on olive genomics heralds the use of MAS in the midterm. Cultivars adapted to the new mechanical harvest systems will be progressively released in the future.

11:15–11:40 AM

Mechanization of Tasks in Horticultural Crops: The Labor Perspective

Guadalupe Sandoval*

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California's labor-intensive crop production has relied on over 400,000 seasonal farm workers. Traditionally, the work of planting, pruning, thinning, irrigating, harvesting, and packing the wide array of fruits, vegetables, and other agricultural commodities depends on an abundant and skilled workforce. The vast majority of these workers are low-paid immigrants from Mexico and other Latin American countries. Several factors contribute to a decline in available workers. This includes tighter border enforcement; declining birthrates; and improving economies south of our borders. Pending immigration reform may stabilize, but would likely not increase the available supply of labor. Shortages of available farm workers are likely to continue. Farm labor contractors (FLCs) play a major role in providing the labor needed in California agriculture. Their employees may perform simple tasks such as weeding and thinning crops, or more the complex work of operating harvest and other equipment. For many FLCs, increased mechanization of agricultural tasks may pose a threat to their livelihood, and presents a variety of challenges. Increased mechanization helps reduce the impact of labor shortages, but, it would also reduce payrolls to FLCs, increase certain hazards to workers, require more specialized workers, and require greater investments in FLC operations. As mechanization takes a greater role in agricultural production, the effects on labor and the farm labor contractors must be considered. The increasing role of mechanization in agriculture must be facilitated by increased outreach to the farm labor contractor community.

An asterisk (*) following a name indicates the presenting author.

Workshops

Presented at the Annual Conference of the American Society for Horticultural Science
July 22–25, 2013, Palm Desert, California

Monday, July 22, 2013 **Desert Salon 9-10**

1:00–4:00 PM

SCRI Project Directors

Sponsor: USDA–NIFA

Moderator: Thomas A. Bewick, tbewick@csrees.usda.gov

Coordinator: Caroline Sherony, csherony@nifa.usda.gov

This meeting is the annual Project Director’s workshop for the Specialty Crop Research Initiative (SCRI), a USDA funded program that was established to solve critical industry issues for specialty crops through long term, systems-focused research and extension activities. SCRI projects are often multi-state, multi-institutional, and trans-disciplinary and each include a mechanism to communicate results to producers and the public. Each project addresses at least one of the five program focus areas: 1) research in plant breeding, genetics, and genomics to improve crop characteristics; 2) efforts to identify and address threats from pests and diseases, including threats to specialty crop pollinators; 3) efforts to improve production efficiency, productivity, and profitability over the long term; 4) new innovations and technology, including improved mechanization and technologies that delay or inhibit ripening; and 5) methods to prevent, detect, monitor, control, and respond to potential food safety hazards in the production and processing of specialty crops. This workshop will highlight several SCRI projects.

Monday, July 22, 2013 **Desert Salon 1-2**

1:45–3:45 PM

Ten Great Ideas for Your Master Gardener/Consumer Horticulture Program

Sponsor: Consumer Horticulture and Master Gardeners Working Group

Moderator: Pamela J. Bennett, bennett.27@cfaes.osu.edu

Coordinator: Ellen Bauske, ebauske@uga.edu

Participants will learn from their colleagues successful ideas that have been utilized in Master Gardener volunteer and consumer horticulture programs. The goal for this fast-paced workshop is for participants to take home at least 10 ideas that they can use in their programs. Presenters will share their innovative programs, social media and project management strategies, and other tips

that have led to successful programs and impact in their community. Come prepared to take notes, discuss, and learn how to improve your program. There will also be an opportunity to participants to share and discuss projects and challenges.

Monday, July 22, 2013 **Springs Salon D/E**

1:45–3:45 PM

Contributions of Luther Burbank: Plant Breeding Artist and Legend

Sponsor: History of Horticultural Science Working Group

Coordinators: Jules Janick; janick@purdue.edu;

David A. Karp, dkarp@sprintmail.com

The objectives of this workshop are to: 1) honor Luther Burbank, legendary plant breeder and horticulturist; 2) examine the contributions and present fate of Luther Burbank’s creations; and 3) emphasize the role of artistry and horticulture in plant breeding.

1:45–2:05 PM

Luther Burbank: Plant Breeding Artist, Horticulturist, and Legend

Jules Janick*

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Luther Burbank (1849–1926), the best-known horticulturist in the United States, was honored in 1940 on a U.S. postage stamp—as a scientist! Burbank became a legend in his time as the plant inventor and wizard releasing a prodigious 800 new cultivars, a number of which are still being grown, the most famous being the ‘Burbank’ potato, the ‘Santa Rosa’ plum, and the ‘Shasta’ daisy. During his lifetime he was considered a coequal with Henry Ford (inventor of the assembly line factory) and Thomas Edison (inventor of the light bulb and phonograph). Hugo DeVries and Nicolai Vavilov visited him and lauded his operation. Burbank promoted the concept that plant breeding could be the basis of a business and his headquarters in Santa Rosa, CA, became world famous. He established a publication company to spread his work, and was instrumental in the eventual passage of the Plant Patent Act of 1930. However, Burbank was not a scientist. While a strong supporter of Darwin and the theory of natural selection, he did not understand the contributions of Mendel to genetics and breeding. He performed no experiments in the classical sense and his notes were fragmentary. In 1904, he received a large grant from the Carnegie Institute (\$10,000

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annually) to promote the scientific study of plant breeding which was discontinued after five years when the reviewer, George Shull, determined that Burbank's procedure was more art than science. However, Burbank is justly famous as a successful plant breeder. He intuitively followed the modern rationale of plant breeding by obtaining abundant diversity, employing repeated and successive hybridization, and carrying out rigorous selection. Above all he had an eye and feel for plants. His success is an affirmation that plant breeding is an art as well as a science. As an innovative plant breeding artist Luther Burbank remains an inspiration to plant breeders and horticulturists.

2:05–2:15 PM

Russet Burbank: No Ordinary Potato

Charles R. Brown*

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The most important potato cultivar of the 20th Century in North America came out of the examination of a few sexually produced seedlings derived from a seed ball of 'Early Rose' growing in Lunenburg, MA, in the early 1870s by young Luther Burbank. In 1875, the rights to propagate the seedling were sold to the seedsman James J.H. Gregory for \$150 who listed it in his catalogue as 'Burbank Seedling'. The money was used to finance Luther's relocation to California. 'Burbank' was a fortuitous selection from materials that formed the backbone of potato genealogy in the late nineteenth century. No other potato bred by Luther was even close. A russet skinned sport was selected by Lou Sweet and became the basis for the large potato processing industry which developed in the United States. Luther Burbank regarded potato breeding as a mission necessary to feed a hungry humanity. His writings indicated great passion associated with this endeavor. Today 'Russet Burbank' is the potato with the greatest crop area in North America used for the dual purposes of fresh market and "French Fry" consumption. It simply is the best fryer out of long term storage.

2:20–2:35 PM

A Vast Array of Beauty: The Accomplishments of the Father of American Ornamental Plant Breeding, Luther Burbank

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Luther Burbank (1873–1926) was a prolific ornamental plant breeder, who worked with 91 genera of ornamentals, from Abutilon to Zinnia, and released nearly 1,000 cultivars to the industry. His work included both herbaceous and woody plant materials and Luther pioneered efforts to breed ornamental, edible vegetables such as corn, tomatoes, and spineless cacti. His most popular ornamental release, the Shasta Daisy hybrid (first released in 1901), is still on the global market. Genera with the

highest number of cultivars bred and released by Burbank include Amaryllis, Hippeastrum, and Crinum, followed by Lilium, Hemerocallis, Watsonia, Papaver, Gladiolus, Dahlia, and Rosa. With Lilium, he pioneered breeding the N. American native lily species, particularly those from the Pacific coastal region, and the authority Burbankii is still applied to interspecific hybrids from the cross *L. Parryi* × *L. pardalinum*. By 1894, his critics even lauded his successes, stating that he had 3 acres of flowering seedlings with the fragrance carrying five miles away. The vast seedling beds (from sowing 1–3 pounds of lily seed/year) were highly selected by virus and other criteria with selection differentials as high as 75%. He also often sold an entire lot of selected seedlings to the highest bidder, once offering the Burbank Hybrid Lilies lot for \$250K or some of the "very handsome, hardy ones" for \$250 to \$10,000 each. Other flower cultivars also commanded high prices, such as seedling Giant Amaryllis that sold for \$1.55/bulb in 1909. Cacti were another area of emphasis (he released >63 cultivars), from the spineless fruiting and forage types (*Opuntia ficus-indica*, *O. tuna*, *O. vulgaris*) to flowering ornamentals such as *O. basilaris*, *Cereus chilensis*, and *Echinopsis Mulleri*. Interest in cacti during 1909–1915 rivaled the Dutch Tulip mania with exorbitant fees for a single "slab" of a cultivar, speculative investments, controversy with noted cacti specialists (particularly David Griffiths), and lawsuits by The Burbank Company. While most cultivars have been lost, Burbank's reputation as the Father of American Ornamental Breeding remains admirable from critics and devotees alike.

2:35–2:50 PM

Luther Burbank's Plums

David A. Karp*

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The 113 named varieties of plums introduced by Luther Burbank (1849–1926) were by far the most numerous and arguably the most significant of his horticultural accomplishments. He began by importing 12 seedlings from Japan in 1885, including 'Abundance' and 'Satsuma' (*Prunus salicina*). The cultivars he released in the late 19th and early 20th century played a crucial role in developing commercial cultivation of Asian-type plums in California, the United States, and much of the world; they also served as founding clones for later breeders. His crowning achievement was 'Santa Rosa' (introduced 1906), which appears to have derived its reddish flesh from 'Satsuma'; firmness and acidity from the apricot or Simon plum (*P. simonii*); and disease resistance and a rich wild aroma from a native American plum (*P. americana*). In 1961 'Santa Rosa' accounted for 35% of the California plum harvest. Many of Burbank's other cultivars of primarily *P. salicina* ancestry were extensively cultivated in California in the early and middle 1900s, including 'Beauty' (1911), 'Burbank' (1888), 'Duarte' (1900), 'Eldorado' (1904), 'Formosa' (1907), and 'Wickson' (1892). His most important introductions of European plum (*P. domestica*) were 'Sugar' prune (1899) and 'Standard' prune (1911). Burbank made use of at least 11 plum species, and including hybrids and selected seedlings

An asterisk (*) following a name indicates the presenting author.

of such native species as *P. maritima* ('Improved Beach', 1897; 'Maritima', 1899; 'Peach', 1901), *P. subcordata* ('Nixie', 1911), and *P. munsoniana* ('Juicy', 1893; 'America', 1898; 'Victory', 1911). Some of Burbank's more obscure introductions never received general distribution and have disappeared; others such as 'Santa Rosa', 'Shiro' (1899), and 'Elephant Heart' (released posthumously in 1929) still are commonly cultivated today in home gardens and for sale at local markets. 'Inca' (1919), his best tasting plum, is much appreciated by fruit connoisseurs, although it has some obvious flaws for commercial use.

2:50–3:05 PM

21st Century Approach to Improving Burbank's 'Stoneless' Plum

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Luther Burbank considered the stoneless plum, 'Conquest' (1911–12 catalog), one of his best accomplishments. The plum had only a grain of stone and a complete seed, but was not commercially successful. In view of the current desire for seedless fruit such as citrus, grape, and watermelon, we have utilized a nearly stoneless plum, most likely a remnant from Burbank's breeding program, and are applying 21st century technology to achieve a pitless plum. These technologies include molecular markers, accelerated breeding cycles ('FasTrack'), genetic engineering and next generation sequencing. One aspect of this project is to define the genes that are responsible for the trait in order to create markers for breeding and targets for genetic engineering. Initial experiments have characterized the stoneless trait as a decrease in the number of endocarp cells that form the stone. Cool temperatures during pollination of 'Stoneless' result in very little stone formed while warm temperatures result in a more normal stone. During the period flanking pollination, gene expression of a number of transcription factors involved with determining endocarp cells was compared in 'Stoneless' and two cultivars that produce normal stones. Next generation sequencing of the RNA was done to evaluate all genes expressed during that time. A number of genes have been identified that are altered in their expression in 'Stoneless' including one associated with embryo development.

3:05–3:20 PM

Luther Burbank's Contributions to Walnuts

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Luther Burbank began making controlled crosses between walnut species in 1875 after hearing about a "supposed natural European hybrid walnut." He made his first crosses using two American species, *Juglans hindsii* (Northern California Black Walnut) × *J. nigra* (Eastern Black Walnut), producing 'Royal' walnut progeny that were fast growing, prolific nut producers that have been used as walnut rootstocks in the past. The next year, he began making his first *J. hindsii* × *J. regia* crosses producing progeny that he named 'Paradox' because of the extremely fast growth and "in recognition of sundry other anomalies." Even today, seedling and clonally micropropagated 'Paradox' walnuts are widely used as rootstocks by the California walnut industry. Wood from the Paradox 'Burbank,' reputed to be an original, was collected by Eugene Serr and Harold Forde in 1952 from the Burbank Garden at his home in Santa Rosa. It grows on the University of California campus and has been micropropagated and included in a current rootstock trial. Luther Burbank also collected seeds from a *J. regia* growing in San Francisco because it produced regularly and very high quality nuts with relatively thin, but poorly sealed shells. Shortly after he collected the nuts, the mother tree was destroyed by construction of a new street. He selected one of its seedlings and introduced it as 'Santa Rosa Soft-Shell.' He described the cultivar as bearing large crops of nuts that are nearly white with thin shells and delicious white meat. Burbank's contributions to the walnut industry endure to this day.

3:00–3:15 PM

Luther Burbank's Berries

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Luther Burbank, the quintessential nurseryman of the early 20th century, remarked that small fruit was the "Cinderella of the pomological family." He stated that while tree fruits had been improved to the point of an almost uncountable number of varieties, it was the time and responsibility of his generation and those to follow to develop the small fruit for human consumption. Burbank had a penchant for detecting potential qualities of unusual plants, and his broad association with plant explorers at the U.S. Department of Agriculture and elsewhere allowed him to examine diverse wild berry species. He obtained seeds of many small fruit species from throughout the world. He made wide crosses within and between these genera and species. Burbank selected and named many varieties to be introduced through his nursery and elsewhere. He named

and released about 40 blackberries, raspberries and strawberries, 4 grapes, and a hybrid *Solanum* called ‘Sunberry’. He sometimes exaggerated their descriptions for promotion or public recognition. For example, *Rubus loganobaccus* ‘Phenomenal’ was, he stated, “far superior in size, quality, color, and productivity... to ‘Loganberry’. Unfortunately, this cultivar was not a commercial success. Burbank made a few crosses and sold what he considered as improved species, e.g., ‘Himalayan Giant’ blackberry (*R. armeniacus*). He created new common names for foreign species, e.g., balloon berry (*R. illecebrosus*) and Mayberry (*R. palmatus*), to better market them. However, his amazingly keen observations of thornlessness, pigment diversity, and recognition of repeat flowering and fruiting in blackberries, raspberries, and strawberries, was insightful of future industry. Burbank was a disciple of Darwin and his theory of natural selection. Burbank’s breeding approach to make wide crosses, produce large numbers of hybrid seedlings, choose significant seedlings with his traits of choice, and backcrossing to the desired parent for several generations was successful, even without knowledge of ploidy or gene recombination. Three of his *Rubus* cultivars (‘Burbank Thornless’, ‘Snowbank’, and ‘Phenomenal’) are preserved in the U.S. Department of Agriculture, National Clonal Germplasm Repository, in Corvallis, OR.

Monday, July 22, 2013 **Springs Salon A/B**

1:45–3:45 PM

How to Get in (and Succeed in) Graduate School

Undergraduate and Graduate Student Sponsored Activity
Coordinator: Kristin Abney, kabney22@gmail.com

You’ve put in all of the hard work and now you’re about to graduate. What’s next? Have you thought about going to or staying in graduate school for an advanced degree? And once you get in, what are you supposed to do? The purpose of this workshop is to explain the graduate school interview and application process to prospective master’s and doctoral students. An additional objective is to discuss how to pick a major professor and how to foster a good relationship between you and your major professor.

Monday, July 22, 2013 **Springs Salon A/B**

4:00–6:00 PM

eXtension/Ecampus/On Campus: Synergies in Curriculum Development

Sponsor: eXtension Working Group

Coordinator: Alexandra Stone, stonea@hort.oregonstate.edu

Most eXtension agriculture-based Communities of Practice (CoPs) initially publish educational resources such as articles, videos, learning lessons, and webinars to eXtension.org to support and train farmers and the agricultural professionals who work with them. However, CoPs soon discover that educators and undergraduate and graduate students are or could be significant users of these same resources. At the same time, online credit- and certificate-based learning has exploded. This workshop will explore how eXtension CoPs are developing online curricula and educational resources that can be used in on-campus, Ecampus, hybrid, and eXtension learning venues to train undergraduate and graduate students, agricultural professionals, and farmers.

4:00–4:15 PM

Eviticulture as a Tool for Educating Future Grape Industry Professionals through Traditional and Nontraditional Teaching

Patricia A. Skinkis*

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The eXtension website (www.extension.org) is where non-biased content is posted to educate and inform different communities of interest. Within eXtension, the Grape Community of Practice (GCoP) provides a national and international web presence through eViticulture (eViticulture.org) which was created by experts in viticulture and associated disciplines within the land grant university system. Since content is science-based and peer-reviewed in an accessible online format, the website provides a rich learning environment that is available to all. While the initial intent of eViticulture was to provide educational information and tools that meet the needs of the current U.S. grape industry, it has been effectively used to educate future industry professionals through university and community college courses and professional development programs. In these programs, eViticulture has replaced traditional textbooks which are quickly outdated, costly, and inconvenient to reference online. One of the main benefits cited by educators is the clear and concise format of articles providing a well-packaged yet efficient way to obtain information that can be used in preparation for class discussions or studying. The online format allows articles to be readily linked into learning platforms in online courses, further expanding the use of the website. Students indicated that the website has been helpful in obtaining viticulture information outside of classes, particularly when there are time limitations within courses. The use of the eXtension platform makes teaching efficient for numerous audiences, spanning from current to future industry members. Often traditional Extension programs in commercial

An asterisk (*) following a name indicates the presenting author.

agriculture focus on current professionals without regard to the needs of those who are the future of the industries they serve. An integration of these resources in teaching is necessary to reinforce a life-long learning paradigm and foster a strong relationship between land-grant universities and students, both in their formal education and professional development through Extension post-graduation.

4:15–4:30 PM

Developing Topic Groups into Curriculum for Crop Improvement: Evolution of the Plant Breeding and Genomics Community of Practice

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The plant breeding and genomics community of practice (PBG CoP; <http://pbgworks.org>) develops constructive, inquiry-based tutorials to help plant breeders translate basic research into applied outcomes. Because changes in DNA sequencing, genotyping technology, and computational methods impact how plant breeders organize and conduct crop improvement programs, there is a need for continuing education and outreach to facilitate translation into applied outcomes. Resources available through www.extension.org/plant_breeding_genomics incorporate video, data sets, and scripts for software in order to facilitate self-paced learning. Our goal is to help professionals learn to implement new selection strategies using data from next generation sequencing, large data sets of single nucleotide polymorphisms (SNPs), and open-source statistical software. Although our content targets professional plant breeders, their staff, and associated professionals, a large proportion of our audience (~32%) consists of graduate students. The appeal of our content to a student audience has influenced a reorganization of existing tutorials and case-studies into curriculum groups. This reorganization has facilitated use of the material in workshop and classroom settings. The existence of over 120 videos, organized into 19 playlists, and linked to example data and software demonstrations provides opportunities for flipping traditional classroom teaching. Students or workshop participants can watch tutorials as homework, and class time devoted to hands-on implementation. Instructor time can then be spent facilitating

individual and team-based efforts in comparative analysis and problem solving related to analysis and data flow. Assessment and use statistics from PBG CoP's first two years suggests that educational materials are meeting a growing demand for plant breeding and genomics education. Inquiry-based extension has proven a successful way to provide computational training to plant breeders, postdoctoral researchers, and students. The information was collaboratively developed by the Solanaceae Coordinated Agricultural Project (SolCAP), the Conifer Translational Genomics Network (CTGN), the Barley Coordinated Agricultural Project (BarleyCAP), and RosBREED and supported by the USDA National Institute of Food and Agriculture through AFRI and SCRI grant programs.

4:30–4:45 PM

Development of Technical Training and Support for Agricultural Service Providers and Farmers in Certified Organic Dairy Production Systems through eOrganic

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Over the past ten years, organic dairy production has been the fastest growing sector of the organic market, yet there has been a lag in the development of science-based information for producers. Still greater is a lack of agricultural service providers knowledgeable of allowed practices on certified organic dairies. To increase organic dairy production systems knowledge among agricultural service providers, eOrganic's dairy team has been developing and delivering organic dairy content as part of a USDA–NIFA Organic Agriculture Research and Extension Initiative (OREI) project. eOrganic.info, the organic agriculture Community of Practice for eXtension.org, publishes science-, experience- and regulation-based organic agriculture information online. To date, 107 organic dairy peer-reviewed articles and videos have been published to the site. Over 1330 farmers and stakeholders have participated in 17 organic dairy webinars offered over the past 3 years. As a result 81% of participants said they better understood the topics addressed in the webinars, and 68% said they would make a change on the farm or in their work. An additional 12,330 people have viewed the webinar recordings on our YouTube channel. In 2012, "An Introduction to Organic

An asterisk (*) following a name indicates the presenting author.

Dairy Production” online course was developed for training of students and service providers. The course is composed of 10 modules addressing a range of topics related to organic dairy production, including certification, soil health, pasture and forages, herd health and nutrition, milk quality, and calf management. Each module has required readings, a narrated powerpoint presentation, and recommended additional resources. During the 2012 fall semester, the course was piloted with a group of 57 undergraduate students at California State University, Chico. Students took the course either entirely online, or online with supplemental in-person instruction. An end-of-course survey revealed that all students gained knowledge on all topics covered through the course. All but one student indicated they would use the information learned in the future, mostly as they prepare for their careers in agriculture. Further, student grades and course evaluation data revealed that students performed well in online and in-person instruction sections of the course. The course has been recently published to eXtension’s Moodle campus and is available for farmers, educators, and service providers. As a result of our efforts, a network of providers knowledgeable about organic dairy production will better provide assistance to current and/or aspiring organic dairy farmers, helping them gain information to guide farming decisions and ensure success of the organic dairy community.

4:45–5:00 PM

Problem- and Planning-based Learning in Organic and Ecological Agroecosystems: An Eorganic and OSU Ecampus Partnership

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eOrganic, the eXtension Community of Practice for organic agriculture, is partnering with the College of Agricultural Sciences (CAS), the Department of Horticulture, and the Graduate School at Oregon State University (OSU) in the development of an online curriculum in systems management of organic and ecological farms. The curriculum will be grounded in situation-based learning in which students learn from organic and ecological farming systems analyses, solve problems, and develop and evaluate management plans for organic and ecological farms. Each farm system analysis will focus on one experienced farming operation, and will include: 1) a description of how the farmer employs systems thinking and planning; 2) a detailed examination of farm records; 3) descriptions and evaluations of effective systems (e.g. soil, insect/weed/disease pest, biodiversity, food safety) management strategies and programs; and 4) explorations of farm trends using existing farm-generated data,

on-farm research data, and expert review. The curriculum will include training and problem-solving in systems management, pest (insect, disease, weed) management, soil management, biodiversity and wildlife management, food safety, economic viability, and interrelationships amongst these factors. Course materials will include whole farm case studies, articles, videos, narrated powerpoints/webinars, homework assignments, and quizzes/exams. All course materials will undergo eOrganic’s peer-refereed and NOP compliance review processes before publication at eXtension.org/organic_production or http://Youtube.com/eOrganic. Each student will develop a detailed farming system management plan as his/her capstone project. Oregon State University’s Department of Horticulture will initially deliver the curriculum through an online non-thesis Master of Applied Science degree program (MAS) in Ecological and Organic Agriculture. The MAS is a new degree type at Oregon State University geared to better prepare students for careers in agricultural business, public/non-profit agricultural and natural resource professions, consulting, and farming. In the future, the MAS program will expand to include other departments and farming systems (e.g. agronomic crops and livestock). The curriculum will also be delivered as certificate courses for farmers and agricultural professionals through eOrganic and the eXtension Moodle campus.

Monday, July 22, 2013

Desert Salon 1-2

4:00–6:00 PM

How Public Policy Engagement Helps Horticultural Scientists

Sponsor: National Issues Task Force

Coordinator: Thomas Björkman, tnb1@cornell.edu

The sources of financial support for U.S. horticultural scientists are changing rapidly. The Federal government continues to be an important source, but the amount and purpose of that funding can change markedly with legislative and administration action. ASHS communicates actively with stakeholders and decision-makers to keep the importance of horticultural science visible and prioritized. ASHS also provides a platform to help members have influence on their future both in Washington D.C., and in their home community. This workshop will have an update on ASHS’ participation in the wild action regarding the new Farm Bill and budget stalemates, and what are the next steps. One of the most popular programs in Congress is the Specialty Crop Block Grants to the states; so popular that funding is slated for increase to \$70 million per year despite the overall budget reduction. Is this funding stream providing as much horticultural research and extension in your state as it should? Find out how to help increase that amount, if needed. Finally we will have interactive practice with engaging decisionmakers who influence overall funding for our members’ work, so that more are empowered to do their part.

An asterisk (*) following a name indicates the presenting author.

4:00–4:30 PM

How Public Policy Will Help Horticultural Scientists

4:30–5:00 PM

ASHS' Impact on Washington Decision Makers

Jonathan Moore*

ASHS, Alexandria, VA; jomo4@earthlink.net

Thomas Björkman

Cornell University, Geneva, NY; tnb1@cornell.edu

Federal funding for horticultural research has hung in the balance between the sequester and work on the next Farm Bill. ASHS has been working diligently to see that these important programs for our members, the horticultural industry, and the health of the county, are not forgotten. Many members have played a part, and our consultant, Mr. Moore, has been keeping the communication channels with legislators and the USDA active and effective. This presentation is a roundup of where we are at, and what to expect in the coming year. A particular focus will be on Specialty Crop Block Grants are awarded to the states who then award them to research, education, and market development. These are very popular with industry and seen by Congress as some of the most effective agriculture-related programs. ASHS members in some states are benefitting considerably, but there is great variation depending on how they engage their state departments of agriculture.

5:00–5:30 PM

Engaging Congressional Staff

Rebekah Rodriguez-Lynn*

Office of Congressman Raul Ruiz, Palm Springs, CA;

Rebekah.Rodriguez-Lynn@mail.house.gov

Thomas Björkman

Cornell University, Geneva, NY; tnb1@cornell.edu

An opportunity to learn how to engage decisionmakers who influence overall funding for our members' work. Ms. Rodriguez-Lynn covers natural resources and agriculture in the local congressional district, which covers much of the country's winter fruit and vegetable production area. She is interested in learning how to help the horticulture industry in the district, and we will have the opportunity to let her know about some of the Federal programs that make it possible for us to do so through research and extension.

Monday, July 22, 2013 **Desert Salon 13-14**

4:00–6:00 PM

Sustainable Production of Essential Oils

Sponsor: Herbs Spices and Medicinal Plants Working Group

Moderator: Valtcho Jeliaskov, valtcho.pubs@gmail.com

Coordinator: Lyle E. Craker, craker@pssci.umass.edu

While peppermint and spearmint essential oil production in the United States has a long history and well established international market, other essential oil crops are produced at much smaller acreage. The United States is a major consumer (an importer) of essential oils from various species. Field and laboratory studies in the last 80 years and recent research demonstrated that domestic production of a number of essential oil species is feasible. Domestically grown essential oil crops can provide cash crop for American growers and could reduce dependency on foreign imports. This workshop will bring together industry and research representatives to share knowledge on sustainable production of a traditional and promising essential oil crops in the United States. The workshop will stimulate discussions on future directions for research and development on essential oil crops and essential oil production.

5:30–6:00 PM

Discussion

Monday, July 22, 2013

Springs Salon D/E

4:00–6:00 PM

What Happens When Your Growth Chamber Lighting or Controls Become Obsolete? Retrofitting Growth Chambers to Improve Performance

Sponsor: Growth Chambers and Controlled Environments Working Group

Moderator: Marc van Iersel, mvanier@uga.edu

Coordinator: Gioia D. Massa, gioia.massa@nasa.gov

Recent federal legislation (The Energy Policy Act) has phased out the T12 VHO fluorescent light that has long been the standard in many growth chambers. It is increasingly difficult and expensive to purchase replacement lamps or ballasts for these lights. This workshop will discuss cost effective options for restoring these chambers. New lighting options are available to increase PPF, uniformity, and electrical efficiency. At many institutions, it may be possible to get funding for this retrofit through energy efficiency programs. Updated control systems can also be installed, and refrigeration systems can be improved. These modifications are usually significantly less than the cost of purchasing new growth chambers.

4:00–4:15 PM

Lighting Options for Growth Chambers

Jacob A. Nelson*

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An asterisk (*) following a name indicates the presenting author.

4:15–4:30 PM

General Growth Chamber Lighting Obsolescence

Reg Quiring*

Conviron, Winnipeg, MB; rquiring@conviron.com

4:30–4:45 PM

Upgrading a Plant Growth Chamber Controller

Marc Theroux*

BioChambers, Winnipeg, MB; marc.theroux@
biochambers.com

4:45–5:00 PM

Retrofitting Growth Chambers for Improved Intensity, Efficiency, Uniformity, and Spectral Characteristics

Richard Tuck*

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Jennifer Dennis

Purdue University, West Lafayette, IN; jhdennis@purdue.edu

Some consumers are becoming more interested in and purchasing products that are locally grown and/or ecologically friendly. Market segmentation and product targeting are efficient methods to allocate a firm's scarce marketing resources in order to supply heterogeneous markets. This study's objective was to identify consumer segments, focusing on their gardening purchases, in order to determine whether there were differences in consumer preferences for provenance and environmental attributes for transplant purchases. Utilizing a consumer survey of United States and Canadian consumers, we found that participants who purchased different plant types had distinct preferences for varying environmental attributes and provenances. We profiled nine consumer segments, identifying their plant purchases and preferences for local and sustainably grown products and plant containers. Results provide plant producers and retailers with market segments which can be identified and targeted, and provide a basis for customizable marketing communications to enhance profits.

Tuesday, July 23, 2013 **Desert Salon 13-14**

10:15 AM–12:15 PM

Consumer Research on Sustainability

Sponsor: Marketing and Economics Working Group

Coordinator: Bridget K. Behe, behe@msu.edu

Sustainability is a multidimensional yet ambiguous term with application to the horticulture industry and beyond. A research team of North-American scientists collaborated to conduct a series of investigations about consumer perceptions, attitudes, and behaviors with regard to sustainability and horticulture. The studies demonstrate how consumers in the U.S. and Canada define terms, perceive benefits, and offer willingness to pay information that is of value to producers, intermediates, and retailers of horticultural products, services, and experiences. The goal of the workshop is to integrate the findings from these studies and present a holistic set of implications for academia and industry.

10:15–10:30 AM

Consumer Perceptions of Sustainability

Bridget K. Behe*

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Ben Campbell

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Charles R. Hall

Texas A&M University, College Station; c-hall@tamu.edu

Hayk Khachatryan

University of Florida, Apopka; hayk@ufl.edu

10:30–10:45 AM

Plant Container Preferences for North American Consumers

Ben Campbell

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Concepts of eco-friendly and sustainable products have become increasingly popular topics of investigation in many disciplines. Consumer products are increasingly being advertised by promoting their green or environmentally friendly attributes and characteristics, with the expectation of appealing to a larger consumer base. Consequently, the need to investigate the impact of environmentally friendly attributes on choice behavior has escalated over the last decade. According to the Google Scholar website, the term eco-friendly appears 2,420 times in article titles from 1990 to 2000 (November 2012) and the number of articles that include the term eco-friendly in their titles has increased almost tenfold (23,700 articles) from 2001 to 2012. In order to better understand U.S. and Canadian consumer perceptions of eco-friendly and sustainable labeling, data was collected from the Global Marketing Institute database to ascertain consumer preferences and behavior on purchasing behaviors, environmen-

An asterisk (*) following a name indicates the presenting author.

tal attitudes, demographics and perceptions. We received 2,511 responses with 68% from the U.S. and 32% from Canada. Our hypotheses were that there would be differing perceptions from those having heard the terms before as well as between U.S. and Canadian consumers. Further, we anticipated that these terms are beginning to become associated with local and organic. Finally we hypothesized that a definable subset of consumers would associate these terms with negative characteristics of expensive and a sales gimmick. Through the use of a U.S. and Canadian online survey, we failed to reject the hypotheses above. We found that consumers having heard of eco-friendly and sustainable have differing perceptions from those saying they had never heard of them before. Approximately 5% and 8% of U.S. and Canadian consumers have not heard of the term eco-friendly, while 26% and 23% of U.S. and Canadian consumers have not heard of the term sustainable, respectively.

10:45–11:00 AM

Consumer Perspectives on Local, Organic, and Sustainable Terms

Ben Campbell*

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Prior research has shown consumers are willing to pay price premiums for products labeled local, organic, and sustainable. However, there tends to be a disconnect between what these labels represent and what consumers perceive them to be. This study sought to better understand these differences and examine differences between U.S. and Canadian consumers. Given the amount of horticultural trade between the United States and Canada, it is essential to understand how these messages impact the consumer mindset. As with previous work, our results indicate widespread confusion between the terms local and organic. Our results indicate that this confusion is not limited to Canadian or U.S. consumers. Further, there are differences between U.S. and Canadian consumers, notably for local. For organic, Canadians were more likely to perceive organic as being higher priced. However, for local, Canadian consumers were more likely to perceive environmentally friendly attributes as local compared to their U.S. counterparts. For instance, Canadians were more likely to perceive fewer miles, better for the environment and lower carbon footprint as local while U.S. consumers were more likely to perceive local as produced organically. These results give producers and retailers that either compete domestically or export product valuable information that can be used to better their messaging to different consumer groups.

11:00–11:15 AM

Environmental Incentives and Willingness to Pay Price Premiums for Environmentally-friendly Plant Attributes

Hayk Khachatryan*

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The U.S. green industry, which includes businesses such as nursery and greenhouse growers, input suppliers, wholesalers, mass-merchandisers, independent retail operations, and landscape design and maintenance firms, has experienced considerable growth and modernization over the last several decades. With recent economic downturns, however, significant declines in consumer demand for highly discretionary goods affected the industry's financial performance. As the green industry struggles to cope with declining demand, increased attention on consumer preferences and factors that influence individual choice behavior is needed to operate profitably in the increasingly competitive landscape. Recently, marketing of products with environmentally-friendly characteristics has become a promising strategy to attract a specific segment comprised of environmentally-conscious consumers. In this study the effects of individuals' environmental concerns (ECs) on willingness to pay (WTP) for sustainable plant attributes were investigated using data from a representative panel of U.S. and Canadian consumers. The study linked consumers' ECs and three relevant EC orientations (egoistic, altruistic, and biospheric) to WTP premiums for plant attributes such as grown locally, using environmentally-friendly production practices, and non-conventional container types. Results showed that while some individuals were willing to pay a premium for selected plant attributes that address eco-concerns, not all eco-motivations produce similar WTP.

11:15–11:30 AM

The Use of Smartphone Technologies to Access Gardening Information

Charles R. Hall*

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Our interests for this project were driven by an interest in the impact of smartphone ownership and Internet search behavior on product purchasing related to gardening products and items and how search and purchase were similar to (or different from) non-gardening information and products. Given the sharp rise in use of smartphones and mobile media use, we explored differences among online shoppers, specifically those who had searched online for gardening information with those that were online for other purposes. We found differences between those who had searched online for nongardening information compared to those who had searched online for gardening information. Women were more likely to search online for both gardening and nongardening information, but men were more likely to make online gardening purchases. Education level, ethnicity, and geographic location of residence had varying impacts on the likelihood of online search and purchase.

Tuesday, July 23, 2013

Desert Salon 9-10

10:15 AM–12:15 PM

Perspectives on Building Strong University–Industry Research Relationships

Sponsor: Industry Division

Moderator and Coordinator: Jeffrey Norrie, jnorrie@acadian.ca

This workshop will provide an understanding of how several prominent researchers and industry representatives interact to establish, conduct, and report on collaborative research. The speakers may touch on issues ranging from identification of qualified research partners to funding, execution, and technology transfer.

Tuesday, July 23, 2013

Desert Salon 4-6

1:45–3:45 PM

Plasticulture Technologies for Expanding the Season and Improving the Sustainability of Eastern U.S. Strawberry Production

Sponsor: Plasticulture Working Group

Moderator: Peter Nitzsche, nitzsche@aesop.rutgers.edu

In this workshop leading university and industry experts in commercial strawberry plasticulture production in the Eastern U.S. will provide the most up-to-date, expert information on plasticulture technologies for expanding the season and improving strawberry production sustainability.

1:45–2:00 PM

Non-irrigation Alternatives for Freeze Protection of Strawberries in Florida

Bielinski M. Santos*

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Ixchel M. Hernandez-Ochoa

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Craig Stanley

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Two studies were conducted to compare the performance of freeze protection methods for strawberry (*Fragaria xananassa*) growth and yields. Treatments consisted of: a) 4.5 gal/min sprinkler heads (control); b) 3.5 gal/min sprinkler heads; c) heavy row covers on the crop canopy (0.9 oz/yd²); d) heavy row covers on 1.5-ft high minitunnel hoops; e) light row covers on the crop canopy (0.6 oz/yd²); and f) light row covers on 1.5-ft high minitunnel hoops. Row covers were placed on the crop between 12 and 3 pm on the afternoon of the forecast freezing night, while sprinklers were turned on when air temperature at 4-ft above the surface reached 34 °F and they were turned off when ice on strawberry leaves melted. There were 18 freezing and near freezing nights (≤ 34 °F) at the experimental site during the two seasons. The minimum air temperatures in non-irrigated areas during the two seasons were 21 and 27 °F, respectively. In covered plots, the minimum temperature directly above the crop canopy was 34 °F, regardless of the cover weight and the use of hoops to raise the covers above the canopy. Approximately 39 acre-inch/acre were needed in the control plots. Using nonirrigation alternatives for freeze protection resulted in the highest early and total marketable fruit weights, where total yields in plots treated with these alternatives ranged between 15.1 and 15.4 ton/acre while there was approximately a 20% fruit weight decline when sprinkler irrigation was utilized, regardless of the output volume.

2:00–2:15 PM

Biological Feasibility of High Tunnel Production of Strawberries in Florida

Bielinski M. Santos*

University of Florida, GCREC, Wimauma; bmsantos@ufl.edu

Teresa Salame-Donoso

University of Florida, Wimauma; tsalame@ufl.edu

Protected culture of strawberry (*Fragaria xananassa*) has increased steadily in Florida in the last few years. The crops harvested during the winter months when preferential prices are available to growers. High tunnels are the preferred protected cul-

An asterisk (*) following a name indicates the presenting author.

ture structure due to their relatively lower price than greenhouses and their effectiveness on freeze protection. A five-year study revealed that marketable fruit weight increased by an average of 51% in 15 validations when strawberry were produced inside high tunnels in comparison with yields in the open fields. There was a strong correlation ($r = 0.81$) between the number of nights with cold weather (≤ 2 °C) requiring freeze protection versus the increase on marketable fruit weight in all cases.

2:15–2:30 PM

Ohio Strawberry Plasticulture Row Cover Management

Brad R. Bergefurd*

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Strawberry plasticulture production has been researched under southern Ohio conditions since 2001. It has been identified that strawberry plasticulture is a viable season extension technique for Ohio farmers, however growing plasticulture strawberry under harsh Ohio winters requires the use and proper management of frost and freeze protection techniques to prevent or replace radiant heat loss in the crop canopy and to minimize winter injury and maximize crop production. Row covers provide winter protection but when applied reduce light transmission into the plant canopy, thus reducing photosynthetic activity and reducing plant yield. To optimize production of plasticulture strawberry Ohio field research has been conducted to determine row cover management techniques which optimize winter protection and enhance yield and fruit quality. Trials have evaluated the effect of row cover management treatments, such as applying lighter weight covers with great light transparency in the late fall and early winter then applying a second layer when winter temperatures and conditions traditionally are colder, which is typically in early January for our southern Ohio growing region. Results from replicated trials conducted at the Ohio State University Piketon Research and Extension Center in Piketon Ohio indicate that a lighter weight row cover, 0.55 ounces per square yard applied in the fall when temperatures average 50 °F for one week then a second 0.90 ounce per square yard row cover applied the first week of January when temperatures historically are the coldest of the year. This paper will share the results and experiences of the past 4 years of replicated strawberry plasticulture row cover management research and the lessons we have learned.

2:30–2:45 PM

Practical Opportunities to Reduce Sprinkler Irrigation Usage with Row Cover Technology for Pre-bloom and Bloom Cold Protection and Preliminary Observations on using Drip Irrigation under Row Covers for Frost Control

E. Barclay Poling*

North Carolina State University, Raleigh; strawberrydoc@gmail.com

In the short term, strawberry plasticulture growers across the Mid-South (NC, VA, SC, GA, TN), mid-America (AR, MI, KY, OK), and Mid-Atlantic regions, are critically dependent on sprinkler irrigation for plant establishment and for managing extremes of heat and cold, especially during the critical pre-bloom and bloom period. This paper will identify practical opportunities to reduce sprinkler irrigation during plant establishment, as well explore opportunities to use row covers alone, as well as in conjunction with sprinkling, to prevent catastrophic crop losses during windborne freezes and black frosts in the Mid-South. In addition, a new strategy for strawberry frost protection of running drip irrigation underneath row covers will be discussed.

2:45–3:00 PM

Modeling Yield of ‘Chandler’ and ‘Camarosa’ as a Function of Accumulated Fall Growing Degree Days and Practical Row Cover Intervention Strategies

Jeremy Pattison*

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Floating row covers have been used by strawberry growers across the Eastern United States to moderate microclimate conditions to buffer environmental extremes. Frost and freeze protection have been common uses to provide modest protection of flowers during bloom and protect crown tissue from winter injury in colder climates. Recently, interest in using row covers to enhance fall, plant growth and development have increased to allow producers in the mid-south to grow cultivars that are less adapted to regional climate although possess superior fruit quality (appearance and firmness). Planting date is one of the primary factors that influence yield and productivity of plasticulture strawberries; however, growers often experience yield fluctuations with ‘Camarosa’ despite planting on optimum dates. Conversely, ‘Chandler’ tends to reliably produce adequate yields across diverse years and locations. An analysis of the past 10 years of North Carolina’s yield statistics in conjunction with meteorological data, demonstrated that a significant amount of variation (63%) in yields could be explained by the average fall growing conditions across the state. This modeling approach corroborated previous research conducted in the late 1990s in the Tidewater region of North Carolina which reported significant economic benefits associated with an early November row cover application during the first 2 weeks of November. However, recommendations for fall row cover strategies based on the crop’s temperature requirements to accomplish yield optimization and stabilization were lacking. For the last 3 strawberry seasons we

An asterisk (*) following a name indicates the presenting author.

have explored the potential of utilizing floating row covers to enhance floral initiation and differentiation in the late fall in three diverse locations in North Carolina (Mountains, Piedmont, and Coastal Plain). Strawberry cultivars, Chandler and Camarosa, were treated with various planting dates and row cover application treatments based on daily high temperatures (18 °C, 15 °C, 12 °C and untreated controls) within each location. Our results show that fall applications before temperatures dropped below an average daily high of 18 °F can result in a 14% increase in yield compared to the uncovered treatments. The row cover by planting date interaction showed that all 3 planting dates responded positively to early applications and produced an average increase in yield of 16% or 3,360 kg/ha. We have developed a model that describes the yield of ‘Chandler’ and ‘Camarosa’ as a function of accumulated heat units during the fall growing period. This model can be used to help guide when and if row cover deployment is necessary to achieve maximum yield potential.

Tuesday, July 23, 2013

Springs Salon D/E

1:45–3:45 PM

Potential Impact of Precision Agriculture Methods on Roots and Root Function

Sponsor: Root Growth & Rhizosphere Dynamics Working Group

Moderator and Coordinator: R. Paul Schreiner, paul.schreiner@ars.usda.gov

Precision agricultural methods are being adopted in a growing number of agricultural crops, including some horticultural crops. However, little information is known about how variable rate nutrient and/or water use may impact root growth and soil properties (chemical and biological) that interact with roots and govern root function. The purpose of this workshop is to explore how precision agriculture may influence root and soil properties and provide a conceptual framework to better understand how farming practices can improve the efficiency of resource use in horticulture.

1:45–2:15 PM

Introduction to Precision Agriculture in Florida Citrus, with Emphasis on Fertilization and Irrigation

Arnold W. Schumann*

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Qamar Zaman

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Variable rate (VR) fertilization is most effective in orchards with high spatial variability because the technology is designed to exploit variability. Perfectly uniform orchards with no gaps between

canopies would not benefit from VR technology. If the location and size of tree canopies in the orchard can be determined, then the next logical step is to apply nutrients (inorganic or organic sources) only where they will be used and only in appropriate doses to match requirements. Roots, which are the primary targets for fertilizer applications, approximately follow the footprint of tree canopies. The highest concentrations of roots are found at the canopy edge and around the trunk, due to enhanced rainwater deposition from canopy drip and trunk flow, respectively. Large regions of an orchard receiving banded fertilizer would waste nutrients without VR fertilization. Widely-spaced orchards are more susceptible to off-target fertilizer wastage, and hence benefit the most from VR technology. Precision fertigation using computerized open hydroponics is another precision agriculture technology used in modern citrus orchards to maximize yields, and minimize water and fertilizer consumption. Daily drip fertigation can drastically alter the feeder root mass distribution under a citrus tree canopy, whereby most of the active fibrous roots are concentrated around the drip emitters. These and other selected examples will be discussed in the context of potential impacts of precision agriculture on roots and root functions.

2:15–2:45 PM

Spatial Variability in C&N Dynamics: Vineyard to AVA

Kerri Steenwerth*

USDA–ARS, Davis, CA; Kerri.Steenwerth@ars.usda.gov

2:45–3:15 PM

Site-specific Management of Soil pH and Nutrients in Blueberry

David R. Bryla*

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Site-specific management of soil pH and fertilizers is one of the most promising strategies in precision agriculture and is potentially applicable to many horticultural crops, including blueberry. Unlike most fruit crops, blueberry is adapted to low soil pH conditions in the range of 4–5.5 and has much lower requirements for essential nutrients. Blueberry also prefers the ammonium form of nitrogen over nitrate-N. Recently, we examined the effects of pH and N source on plant development and nutrient uptake in blueberry and found that the roots were sensitive to not only N form but also timing and concentration of the fertilizers applied. In this workshop, I will identify the thresholds and parameters for optimizing blueberry root growth and function in the field and present options for manipulating soil pH and fertilizers for maximum nutrient uptake efficiency. Specifically, I will discuss the use of conventional elemental sulfur applications in conjunction with nontraditional approaches for reducing soil pH such as acid injection, sulfur fertigation, and use of acidified composts. I will also present information on ideal forms of fertilizer to apply to blueberry under various soil pH conditions. With proper consideration of all the information

An asterisk (*) following a name indicates the presenting author.

available, pH and nutrient management can be fine-tuned to local conditions in order to maximum profitability and quality of production.

3:15–3:45 PM

New Methods to Quantify Root Responses to Variable Water or Nutrient Supply

Taryn Bauerle*

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Strategies and protocols for studying root dynamics and architecture are confined by the methodological challenges of studying tissues embedded in an opaque soil matrix. Techniques such as rhizotrons (glass windows), minirhizotrons (acrylic tubing), root-exclusion tubes, and ground penetrating radar have dramatically improved our understanding of root growth. However, improvement in root sampling methodology must bypass the limitation of highly disruptive root excavation, viewing roots on planar surfaces, and resolution restrictions of bulk-imaging techniques. Recent nondestructive in situ methodologies for studying roots and root systems embedded within a medium currently include MRI, laser, and ultrasound options. High-resolution X-ray computed tomography (CT) scanning offers a nondestructive option to viewing root systems in both space and time. Primary complexities include root organ visualization, due to similarities between the attenuation coefficient of root tissue and organic matter, with most studies to date using large particle substrate types comprised largely of sand and the inverse relationship between root resolution and sampling volume. I will highlight recent advances in non-destructive measurements of the root environment and these technologies can be utilized in questions surrounding precision resource management.

Tuesday, July 23, 2013

Desert Salon 1-2

1:45–3:45 PM

Teaching Online—What’s Working, What’s Not Working

Sponsor: Teaching Methods Working Group

Moderator and Coordinator: David E. Kopsell, dkopsell@ilstu.edu

This workshop will feature speakers who will share their online teaching experiences covering a multitude of horticultural courses and topics. Speakers will present on teaching methodologies, subject delivery formats, and online learning platforms that have been successful in fulfilling student learning outcomes in their courses. Time will also be devoted to those techniques that both presenters and workshop participants have found to be unsuccessful ways to deliver on-line content. Online courses discussed will range from introductory horticulture to plant identification and will include information on the online delivery

of laboratory exercises and topics. The workshop format will include PowerPoint presentations, demonstration of on-line delivery systems, and an open forum for discussion amongst the workshop presenters and attendees.

Tuesday, July 23, 2013

Desert Salon 9-10

4:00–6:00 PM

Challenges in Seedling Production and Establishment in Organic and Sustainable Production Systems

Sponsor: Seed & Stand Establishment Working Group

Coordinator: Dharmalingam Pitchay, dpitchay@tnstate.edu

Transplant technology has been gaining popularity among growers. However, organic producers are faced with numerous challenges in producing consistent quality organic seedlings from one season to the next. Probable causes may be due to the variability in organic substrates, constraints in the availability and supply of essential macro- and micronutrients in a single organic fertilizer in the industry, resulting in poor quality seedlings for establishment and field production. This is an additional burden to organic growers. Most of the organic fertilizer nutrient release curve does not synchronize with the seedling growth curve, which results in nutrient deficiency, toxicity, salinity, etc. Applying organic fertilizers also alters the physical properties of substrates, creating additional challenges in managing optimal water and air holding capacity. The lack of standardization of organic substrates and fertilizers, and other issues related to seedling and stand establishment will be highlighted during the presentation.

Tuesday, July 23, 2013

Springs Salon J-K

4:00–6:00 PM

Create an Impact!

Sponsor: Vice President for Research Initiative

Coordinator: John D. Lea-Cox, jlc@umd.edu

Workshop participants will be familiarized with key concepts and approaches to documenting impact, and work one-on-one with facilitators, to create a statement for inclusion in the ASHS Center for Horticultural Impact Statements (CHRIS <http://www.ashsmedia.org>). During the workshop, participants will be familiarized with writing for their audience, a basic step-by-step progression to streamline the writing process, the online center tools, and how impact statements can be enhanced with images and links to their congressional districts, for quick distribution to deans, department chairs, publicists, and industry stakeholders. Participation is free, but will be limited to

An asterisk (*) following a name indicates the presenting author.

25 participants. All participants will be enrolled in CHRIS in advance, and will be offered continuing editorial support and advice as they polish their draft statements during Fall 2013. Interested? Email John Lea-Cox at jlc@umd.edu to sign up, or for further information.

Speakers

4:00–4:15 PM

Thomas A. Bewick*

USDA–NIFA, Washington, DC; tbewick@csrees.usda.gov

Thomas Bewick is a national program leader at the U.S. Department of Agriculture. He serves as liaison to university scientists (as well as to the horticultural industry) on issues that affect horticulture, provides programmatic leadership and oversight for horticultural programs across the country, and directs the Specialty Crop Research Initiative.

4:15–4:30 PM

Linda Brewer*

Oregon State University, Corvallis; linda.brewer@oregonstate.edu

Linda Brewer is a project manager and technical writer with the Department of Horticulture and the Extension Agriculture Program at Oregon State University. She successfully facilitated the adoption of an online reporting process for the Extension Ag faculty. Along with her grant reporting responsibilities, this activity shaped her thinking about the components of effective impact statements. She has led impact writing workshops for the faculty at Oregon State, and works one-on-one with faculty to develop useful, meaningful impact statements. <http://agsci.oregonstate.edu/research/writingimpacts>

4:30–4:45 PM

Thomas Björkman*

Cornell University, Geneva, NY; tnb1@cornell.edu

Thomas Björkman is the chair of the ASHS National Issues Task Force. He enjoys using compelling impact statements to persuade legislators, horticulture industry leaders, and other decisionmakers that horticultural scientists are doing important and exciting work that deserves much greater support. He finds writing his own impact statements just as difficult as everyone else does. He does research in crop physiology, with projects on improving vegetable production systems through the use cover crops and developing broccoli genotypes that will produce quality inflorescences in the eastern United States.

4:45–5:00 PM

Marc van Iersel*

University of Georgia, Athens; mvanier@uga.edu

Marc van Iersel of professor of plant nutrition and physiology in the Department of Horticulture at the University of Georgia. He serves as consulting editor for the Journal of the American Society for Horticultural Science, is a member of the national

issues task force, and a past vice-president of ASHS.

5:00–5:15 PM

John D. Lea-Cox*

University of Maryland, College Park; jlc@umd.edu

John Lea-Cox is a professor in the Department of Plant Science and Landscape Architecture at the University of Maryland, specializing in water and nutrient management issues. He currently serves as research vice-president for ASHS and with the support of Linda Brewer, Tim Rhodus, and Mike Neff, established CHRIS (<http://www.ashsmedia.org>) as an online repository to communicate the direct impacts of research and extension on horticultural industries, in the United States and beyond.

Tuesday, July 23, 2013

Desert Salon 4-6

4:00–6:00 PM

The Role and Importance of Polyploidy in Ornamental Plant Breeding

Sponsor: Ornamental Plant Breeding (OPB) Working Group

Moderator: Wenhao Dai, wenhao.dai@ndsu.edu

Coordinator: Ryan Contreras, ryan.contreras@hort.oregonstate.edu

Polyploidy plays an important role in ornamental plant breeding. In the past 30 years, polyploids have been successfully identified and induced in many ornamental species. Polyploidization can not only alter plant morphology, but also change physiological and biochemical metabolisms in plants, generating new cultivars and breeding materials. The speakers will present their research findings in induction and utilization of polyploidy and discuss the role and importance of polyploidy in ornamental plant breeding.

4:00–4:15 PM

Taking Advantage of Natural Variation in Ploidy Levels

Ryan Contreras*

Oregon State University, Corvallis; ryan.contreras@hort.oregonstate.edu

Plant breeders have successfully used ploidy manipulation as part of their ornamental plant breeding programs. Induced polyploidization has been used to develop plants with larger flowers and fruit, sterile plants, and facilitate crosses otherwise not possible. Natural variation in ploidy levels offers similar opportunities without having to induce polyploidy, which can sometimes be difficult. Plant breeders can take advantage of natural ploidy variation to achieve many of the same results

An asterisk (*) following a name indicates the presenting author.

as induced polyploidy such as sterility, while often simultaneously making other improvements. Examples of utilizing natural ploidy variation will be studied including examples from Cotoneaster, *Prunus*, and others.

4:15–4:30 PM

Ploidy Modifications Enhance Flower Breeding for Winter Hardiness and Rhizome Production in *Gaura*

Neil O. Anderson*

University of Minnesota, St. Paul; ander044@umn.edu

4:30–4:45 PM

Induction and Utilization of Polyploids to Sterilize *Nandina* and *Lantana*

Zhanao Deng*

University of Florida, Wimauma; zdeng@ufl.edu

Exotic woody ornamental plants are widely sold by the nursery industry and are considered to be a major source of invasive plants in the U.S. We have been utilizing induced or existing polyploids to create sterile types of nandina (*Nandina domestica*) and lantana (*Lantana camara*) for invasiveness reduction or elimination. All existing nandina cultivars were found to be diploids. Two chemicals were used to treat three types of nandina plant materials. When applied to growing shoots or germinating seeds, colchicine induced tetraploids. More than a dozen of solid tetraploid nandina plants have been obtained. Tetraploid nandina plants exhibited slight reduction in pollen stainability but much reduction in fruit production and seed germination. Some of the nandina tetraploids showed potential to be released as sterile cultivars. Polyploids (triploids to hexaploids) were found to be common in existing lantana cultivars. Many lantana polyploids, including some triploids and tetraploids, were rather fertile and prolific in fruit and seed production. Extensive ploidy and molecular marker analysis of polyploids' offspring revealed that the fertility of these polyploids resulted from the production of unreduced female gametes and/or apomictic seeds. With these two traits in lantana, even triploids and tetraploids can be highly fertile and produce large numbers of seeds. In order to obtain highly sterile triploid lantana, it was imperative to use tetraploids and diploids without the ability to produce unreduced female gametes and apomictic seeds. Hundreds of new lantana triploids have been generated and evaluated, and two new sterile, triploid lantana cultivars have been released. The male and female sterility of these triploid cultivars was high and stable when tested at multiple sites in Florida and grown side by side with fertile native lantana (*Lantana depressa*). More triploid lantana cultivars are expected to be released in the coming years. Our results indicate that polyploid induction or production followed by vigorous screening and evaluation is an effective approach to sterilizing some of the exotic invasive woody ornamental plants and developing sterile, non-invasive cultivars.

4:45–5:00 PM

Applications of Ploidy Manipulation and Analysis in an Applied Nursery Crop Breeding Program

Thomas G. Ranney*

North Carolina State University, Dept. of Horticultural Science, Fletcher; tom_ranney@ncsu.edu

Wednesday, July 24, 2013 Desert Salon 13-14

8:00–10:00 AM

I've Earned My Degree . . . What's Next?

Sponsor: Graduate Student (GRAD) Working Group

Coordinators: Kristin Abney, kabney22@gmail.com; Amanda Bayer, bayer10@uga.edu

You've put the time, energy, blood, sweat, and tears into finishing your degree. Now that you've got that little piece of paper, what's next? Explore the possibilities of a career in academia or with the USDA. Professors, USDA scientists, post-docs, and technicians will share their experiences and will provide an idea of what their career path could be like for you. Join us to have the opportunity to speak with professors from both land grant and non-land grant universities, post-docs from the USDA and academia, and USDA scientists involved with universities or research stations.

Wednesday, July 24, 2013 Springs Salon D/E

8:00–10:00 AM

Sustainable Weed Management

Sponsors: Weed Control and Pest Management (WCPM) and Organic Organic Horticulture (ORGH) Working Groups

Moderator and Coordinator: Teri Gadd, teri.gadd@colostate.edu

This workshop will offer interactive weed control research presentations that lessen or eliminate the need of herbicides and compare certified organic weed control to uncertified. Topics include: 1) certified organic and uncertified weed management comparison; 2) weed seedbanks, mulches, cover crops, and soil fertility; and 3) physical and cultural weed control. Each topic will be followed by a short discussion period.

8:00–8:02 AM

Overview of Workshop Topics, Timing, and Speaker Introductions

An asterisk (*) following a name indicates the presenting author.

8:02–8:15 AM

Do Certified and Uncertified Fresh-market Organic Tomato Farmers in the Midwest Manage Weeds Differently?

Kevin D. Gibson*

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Jose M. Gomez Vargas

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Ariana P. Torres Bravo

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Many growers who manage their lands organically choose not to seek certification. In 2012, we surveyed fresh market tomato growers in the midwestern United States who use MarketMaker™, an online platform that connects food producers and consumers, regarding their farm management practices, including weed management. Respondents were placed into three groups based on their responses: certified organic, uncertified organic, and conventional. The certified organic group grew more crops, worked fewer off-farm hours, and had higher incomes than the uncertified organic group. Incomes were similar between the certified organic and conventional growers. All three groups relied to some extent on manual and mechanical cultivation to control weeds in tomatoes. However, the certified organic group reported fewer mechanical tillage passes than the uncertified organic group. Differences in perceived weed pests were also detected among the three groups. Cumulatively, this study suggests that key differences in weed and farm management exist between certified and uncertified organic tomato growers in the Midwest.

8:15–8:20 AM

Discussion of Topic 1: Certified Organic and Uncertified Weed

8:20–8:32 AM

Can Living Mulches Reduce Weed Seed Banks in Fresh Market Tomatoes?

Kevin D. Gibson*

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Weeds that emerge late in the growing season can escape control and contribute to large increases in the soil weed seed bank. This is particularly problematic in widely spaced row crops like tomatoes where weeds that emerge between rows face no competition from the crop. In a series of experiments, we planted buckwheat and red or crimson clover between rows six to eight weeks after transplanting tomatoes. The living mulches were mowed to limit competition with the crop and, in the case of buckwheat, to prevent seed production by the mulch. Both living mulches reduced weed seed production and either reduced weed

seed banks or weed emergence in the following year. Tomato yields were not affected by buckwheat but were reduced by the use of clover as a living mulch. Potential explanations for these results and suggestions for using living mulches will be discussed.

8:32–8:51 AM

Cover Crops Influence Weed Management in Dry Edible Beans

Erin C. Taylor

Michigan State University, East Lansing

Karen A. Renner*

Michigan State University, East Lansing; renner@msu.edu

Christy L. Sprague

Michigan State University, East Lansing

Cover crops release or scavenge nitrogen, and nitrogen availability may influence weed seed decay, weed seed germination, and weed growth. Dry edible beans are poor nitrogen fixers and incorporating a leguminous cover crop may improve nitrogen availability in dry beans. Field experiments were conducted in Michigan at two university research farms and numerous on-farm sites to determine the effect of cover crops on weed populations and yield of organic dry beans. There were four cover crop treatments at the university research farms: medium red clover, oilseed radish, rye, and no cover. The on-farm sites each had one cover crop treatment (clover, oilseed radish, or rye) and one no cover treatment. Weeds were managed uniformly by farmers at each site using various cultivation tools. Weed seeds were placed in mesh bags and buried immediately following incorporation of red clover and rye to determine the influence of cover crop amendments on weed seed decay. Weed density and biomass within the bean rows were sampled using three 0.12 m² quadrats (15 cm wide by 76 cm long) at both the V2 and R1 stages of bean development for all sites. Few differences in weed populations occurred at the on-farm sites. At the university research farm sites, beans planted following medium red clover had higher weed densities and weed biomass than the other cover crop treatments in some site-years. Available soil nitrogen was greater following a frost-seeded red clover treatment; however, red clover did not increase dry bean yields.

8:51–9:00 AM

Discussion of Topic 2: Weed Seedbanks, Mulches, Cover Crops, and Soil

9:00–9:11 AM

Timing of Early Weed Control Practices by Growing Degree Days

Erin C. Taylor

Michigan State University, East Lansing

Karen A. Renner*

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An asterisk (*) following a name indicates the presenting author.

Christy L. Sprague

Michigan State University, East Lansing

Farmers producing crops organically or with few herbicide options must control very small weeds early in the growing season. We compared weed control using propane flaming to weed control with rotary hoeing, and we evaluated the use of growing degree days (GDD) to optimize rotary hoe timing. Propane flaming was not effective on grassy weed species in our research. Common lambsquarters, redroot pigweed, and velvetleaf were easier to control by flaming than common ragweed and common purslane. Flaming was more effective in the morning through mid-afternoon; evening flaming was not effective. In dry beans the most effective weed control treatments were rotary hoeing three times or a treatment of flaming once prior to dry bean emergence, followed by rotary hoeing twice. Timing rotary hoe passes every 300 GDD (base 3.3 C) from the time of dry bean planting resulted in fewer passes compared with rotary hoeing every 7 day or every 150 GDD, and weed control and bean yields were similar to the weed-free treatment in one of two years.

9:11–9:31 AM

Physical Pest Control: Soil Disinfestation with Steam in Strawberry and Machine-vision Intra-row Cultivation in Vegetables

Steven A. Fennimore*

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Regulatory constraints on the use of soil fumigants for soil disinfestation, and continued lack of new herbicide tools for vegetables suggests that physical pest control tools may be the best options available for specialty crops. Strawberry is susceptible to soilborne pathogens such as *Verticillium dahliae*, and thus most strawberries are grown on previously fumigated soils. Steam has been used since the 1880s to disinfest greenhouse soils. However, steam application methods used in greenhouses are not appropriate for field use. Soils are disinfested with steam by maintaining the soil temperatures above 70 °C for 20 minutes. We have evaluated an automatic steam applicator prototype that rapidly blends steam with soil, thus raising soil temperatures from ambient to 70 °C in about 90 seconds. Field results from 2011 to 2013 indicate that steam controls weeds and soilborne diseases and produces strawberry fruit yields comparable to chloropicrin. The main deficiency with this approach is lack of commercial-scale machinery to apply steam. However, if we commit to developing a cost-effective commercial steam applicator this obstacle can be overcome. A commercial intra-row cultivator was tested for weed removal effectiveness in transplanted celery, lettuce, and radicchio and as a crop thinner and cultivator in direct-seeded lettuce. The intra-row cultivator utilized machine-vision guidance to align a rotating cultivator disk with the crop plant to be protected and to remove weeds elsewhere in the plant line. The intra-row cultivator was compared to a standard inter-row cultivator

that could not remove weeds from within the plant line. Weed densities, hand weeding times, crop stand, and yields were monitored. Economic analysis was performed on the data. The intra-row cultivator generally removed more weeds and had shorter weeding times than the standard inter-row cultivator. However, the rotating cultivator reduced lettuce stands more than standard hand thinning practices and as a result, lettuce yields were lower with the rotating cultivator than with the standard cultivator. In transplanted celery, lettuce and radicchio, the rotating cultivator removed more weeds than the standard cultivator, but without reducing transplanted crop stand or yields as was the case in seeded lettuce. The economic analysis does not indicate any advantage to the use of the rotating cultivator tested here and significant increases in speed and accuracy will be needed to improve upon the current standard practices in California vegetables.

9:31–9:51 AM

Impact of Vineyard Floor Management Practices on Weed Communities and Soil Quality

Richard F. Smith*

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Vineyards in the low rainfall areas of central California have vegetation in the row middles and no vegetation in a swath 0.46–0.61 m wide in the vine rows. The vine rows are kept free of vegetation by the use of pre- and/or post-emergent herbicides, mechanical cultivation, and hand hoeing. In a study conducted from 2001–05 we observed that the choice of weed control strategy resulted in distinct weed communities over time. In this same study, vine rows were kept weed free and row middles were cover cropped or kept bare; soil organic matter, microbial biomass and nutrient levels were evaluated in all treatments. The cover crops, cereal rye (*Secale cereale* L.) or triticale (X *Triticosecale* Wittm. Ex A. Camus.), were planted in strips 0.93 m wide. We observed significant increases in soil organic matter, microbial activity and some nutrients in the row middles that were cover cropped. However, no improvements in soil health parameters were observed in vegetation free vine rows adjacent to cover cropped row middles. Given the benefits that cover crops provide to the soil system, we conducted a follow-up trial from 2006–09 to evaluate ways to include a barley (*Hordeum vulgare* L.) cover crop in the vine row. Treatments include killing the cover crop when it was 0, 15.2, 30.1, 45.7, and 61.0 cm tall to manage the competition of the cover crop on the vine growth and soil moisture used by the cover crop. In a low rainfall area, any

An asterisk (*) following a name indicates the presenting author.

water used by the cover crop would have to be replaced by irrigation, which would increase the cost of production. We observed that killing the cover crop when they were 30.1 inches tall safeguarded the yield of the vines and increased the levels of soil organic matter by the third year of the trial. Cover crops grown in the vine row reduced nitrogen levels in the vines, indicating that care must be taken to offset this negative impact of this practice; however, vine row cover crops increased potassium and phosphorus levels in vines. Evidence indicated that vine row cover crops improved irrigation water infiltration from drip emitters because higher levels of soil moisture were observed in the vine row cover crop treatments vs. uncover cropped treatments during the summer irrigation season. This research indicated that vine row cover crops can be successfully managed to improve soil quality while not adversely affecting crop growth.

9:51–10:00 AM

Discussion of Topic 3: Physical and Cultural Weed Control

Wednesday, July 24, 2013 Springs Salon C

10:00 AM–12:00 PM

Waste Utilization in Horticulture Walking Tour of Related Posters

Sponsor: Waste Utilization in Horticulture Working Group

Moderator: William B. Evans, wbe1@ra.msstate.edu

Coordinators: William B. Evans, wbe1@ra.msstate.edu, Joseph P. Albano joseph.albano@ars.usda.gov

This workshop will be a walking tour of posters related to all aspects of Waste Utilization in Horticulture (WUH). This session is not planned to be part of the regular poster sessions or poster competitions, but instead will be an opportunity to tour a subset of the posters with colleagues interested in the field of WUH. The session will begin with a brief introduction, followed by an informal walk around the poster area to view work being done related to waste processing; waste recovery; composts and composting; substrates, containers, and fertilizers made from waste products; and other aspects of the role that horticulture plays in finding uses for byproducts and wastes. Members and nonmembers of WUH Working Group (WG) are encouraged to attend. As the tour starts, a list of posters planned for the tour will be distributed, based on the published list of submitted poster presentations. At each stop, we will be able to review the poster and discuss its relationship to WUH science, outreach, and teaching. The intent will not be to critique the works presented, but to discuss the science of WUH in the context of the works selected for viewing. The intent of this tour is to expose the attendees to the breadth of work being done in WUH, to promote interaction among the WUH

WG membership, and to foster future collaborations. The tour will finish with a brief round table and invitation to follow on discussion.

Wednesday, July 24, 2013 Desert Salon 13-14

10:15 AM–12:15 PM

Challenges and Opportunities of Operating a University Garden

Sponsor: Public Horticulture Working Group

Coordinator: Susan Wilson Hamilton, sueham@utk.edu

One of the fastest-growing segments in public horticulture is that of the college or university affiliated gardens. However, university gardens can be quite different from non-university botanical gardens. From the setting of the garden as part of the university campus to their organizational structure, mission, funding, and staff, university gardens are unique. Having access to teaching and research facilities as well as faculty expertise can provide unique opportunities. This workshop will be a roundtable discussion about the unique challenges and opportunities of those involved with the management and operations of university gardens. The intent of this workshop is to provide an opportunity for researchers to exchange and discuss practices and experiences in working in the university garden environment. Members of the Public Horticulture Working Group are encouraged to come prepared to participate in this roundtable discussion.

Wednesday, July 24, 2013 Springs Salon D/E

10:15 AM–12:15 PM

Organic Agriculture in Southern California—Producing Organic Products in the Low Desert

Sponsor: Organic Horticulture Working Group

Coordinators: Milton E. McGiffen, milt@ucr.edu; Erin Silva, emsilva@wisc.edu

The Sonoran or Low Desert holds records for both high temperatures and high yields. It presents many unique challenges—extreme climate, low organic matter soils, and rapid breakdown of organic amendments. But it also presents many unique opportunities, including low water costs and a chance to supply uniquely profitable market niches. This workshop focuses on meeting both universal organic agricultural challenges in a challenging environment, and taking advantage of the unique situation the desert presents. Local growers, researchers, and

An asterisk (*) following a name indicates the presenting author.

extension personnel talk about working in the unique environment surrounding the site of this year's conference.

10:15–10:30 AM

Certified Organic Compost and Compost Tea Production and Use

Abira Selvaraj*

University of California, Riverside; abira.selvaraj@gmail.com

10:30–10:45 AM

Cost of Production Study for Organic Avocado

Eta Takele*

University of California, Riverside.; ettakele@ucanr.edu

10:45–11:00 AM

Organic Date Production

Vince Samons*

University of California, Riverside; vince.samons@ucr.edu

11:00 –11:15 AM

Organic Farming in the Imperial Valley

Scott Howington*

Oasis Farms, El Centro, CA; milt.mcGiffen@ucr.edu

11:15–11:30 AM

Organic Vegetable Production in the Coachella Valley

Jose Luis Aguiar*

University of California, Indio; jlaguiar@ucanr.edu

11:30–11:45 AM

Short- and Long-term Effects of Adding Organic Carbon to Low Organic Carbon Desert Soils

Milton E. McGiffen*

University of California, Riverside; milt@ucr.edu

Wednesday, July 24, 2013 Desert Salon 1-2

12:30–1:30 PM

International Consultation, Outreach, and Capacity Building

Sponsors: International Consultants, International Horticulture and Issues, and Postharvest Working Groups; and the Working Group of Asian Horticulture

Coordinators: Mary E. Henry, mbhenry@ufl.edu; David Obenland, david.obenland@ars.usda.gov

In the past decade, increasing trends in transcontinental travels and commerce, easier access to digital information, and

a greater level of cooperation in agriculture among public and private institutions have led to increased opportunities in international horticulture. These opportunities also come with challenges—ranging from difficulties in scientific research to perhaps monetary challenges, ethical questions, or legal complexities. This workshop will inform participants on strategies to craft a career with the potential to translate to international work in the future. Updates on current USAID projects, as well as those funded by other sources, including volunteer assignments will be offered. Participants will benefit from honest discussion of in country experience and learn how they can get involved in international employment and consultation opportunities.

12:30–12:45 PM

Farmer-to-Farmer Volunteer Opportunities: University Lectures and Labs in Tajikistan with CNFA

John L. Griffis, Jr.*

Florida Gulf Coast University, Ft. Myers; jgriffis@fgcu.edu

Most USAID Farmer-to-Farmer volunteer projects involve a U.S.-based expert who gives advice and shares expertise with groups of growers, producers, sellers, or members of a cooperative in a foreign country who have requested help with particular issues. The NGO staff (in this case, CNFA) in the foreign country (Tajikistan) evaluates the issues presented by the local growers and develops a project proposal; then the NGO staff in the United States screens the proposal and recruits volunteers. Occasionally a project will be proposed that doesn't follow this exact pattern: this was the case here. There is very little expertise available in Tajikistan concerning commercial hydroponic crop production, although some growers do use drip "fertigation" when growing vegetables in soil in sunken, Chinese-style greenhouses. The Engineering–Technologic Faculty of Khujand Polytechnic Institute of Tajik Technical University (ETF KhPITTU) founded in 2010, offers 20 different disciplines to students pursuing a 4-year course of study, but none of the faculty have any training in hydroponics. The faculty wants to prepare the students for jobs when they graduate and they know that many of the students will work locally. They are aware that local vegetable producers often complain about decreasing production levels because of disease and nutritional problems related to the soil and they believe that some farmers might switch to hydroponic growing if they were provided with the appropriate information. Students trained in hydroponics might find good jobs working for companies or growers that are interested in implementing this technology, and so, faculty members approached CNFA for assistance. The proposal was approved and a volunteer was recruited to provide university-style lectures and practical laboratories in hydroponics to be taught at the University as a short course. Translation of the presentations into Russian was provided although some students spoke good English. Some laboratory materials were brought from

An asterisk (*) following a name indicates the presenting author.

the United States and others were purchased locally. Some hydroponic books were given to the university faculty, as were electronic files for a syllabus, lectures, and labs. Students, faculty members, and some growers attended the short course. U.S.-based horticulture teaching faculty should watch for this type of opportunity to appear again. Some may find this classroom situation more appealing than one where they may be asked to work under less familiar or uncomfortable conditions.

12:45–1:00 PM

Career Opportunities at USAID

John E. Bowman*

Bureau for Food Security (BFS), Office of Agricultural Research & Policy (ARP), USAID Bureau for Food Security (BFS), Bartow, FL

1:00:1:15 PM

Study Abroad/International Field Trips to Increase Students' and Agriculture Professionals' Competitiveness in the International Arena

Mengmeng Gu*

Texas AgriLife Center, College Station

James A. Robbins

University of Arkansas Coop. Extn., Little Rock

Xin Zhao

University of Florida, Gainesville

Study abroad is one form of the high-impact educational practices and beneficial for college students from diverse backgrounds. Students with study abroad experiences exhibit a greater improvement in intercultural communication skills than students who never participate in study abroad programs. Field trip, an interpersonal method and experiential learning tool, was the second preferred method (following on-farm demonstration) of receiving information on new or innovative farming practices. Over 30 students and agriculture professionals participated in a combined study abroad and international field trip program partially funded by a USDA International Science and Education grant to learn season extension horticulture production and marketing in China since 2010. Participants benefited from direct exposures to the production technologies and marketing strategies commonly used in China, which could be easily transferred to the United States through direct field experience and extension outreach programs, helping U.S. producers successfully compete in the global arena. Participants shared their experience on a blog <http://aggiehortgoestochina.blogspot.com/>, which is continuously available online for those who could not participate in the trips. The blogs received close to 10,000 views from audience from the United States, Russia, France, India, United Kingdom, Philippines, China, Canada, Germany, and Thailand.

1:15 AM–1:30 PM

Hort CRSP Update

Elizabeth J. Mitcham*

University of California, Davis; ejmitcham@ucdavis.edu

Wednesday, July 24, 2013 Springs Salon A/B

1:00–3:00 PM

Fantastic Fruits Grown in California

Sponsor: American Pomological Society

Moderator and Coordinator: Michele R. Warmund, warmundm@missouri.edu

This workshop will feature three of California's fascinating fruit crops, including figs, persimmon, and pitahaya. Figs were purportedly introduced into California in 1759 by Franciscan missionaries. Production of this crop increased steadily over the years and peaked in 1943. While fig acreage has declined, California currently ranks third in world production. Japanese and Chinese persimmons were introduced into the United States in the mid-1800s and are primarily grown in the San Joaquin valley and in southern California today. In the 1990s, adventurous producers started growing pitahaya or dragon fruit, which can be found in local markets. Each of these exotic fruits has production opportunities and challenges in a changing environment.

1:00–1:55 PM

Figs: An Old California Industry in Transition

Louise Ferguson*

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Ed Stover

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Carlos H. Crisosto

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The cultivated fig, *Ficus carica* L., is a tropical to subtropical deciduous tree well adapted to high heat and drought. Its composite fruit, a syconium, is a shell of receptacle tissue enclosing hundreds of drupelets with achenes. Figs have a unique pollination biology that co-evolved with their pollinating wasp, *Blastophaga psenes* L. Their high sugar content and stability make them easily transportable when dried but also highly desirable as a fresh fruit. However, due to their short postharvest life, most of the world's figs are produced and consumed locally. The commercial industries have focused on dried figs. Because most cultivars developed locally, it is not

An asterisk (*) following a name indicates the presenting author.

surprising there are over 600–1900 species in the genus *Ficus*. As better postharvest technologies and molecular breeding tools develop, this diversity of figs is being exploited to produce a worldwide commercial fresh fig industry. The current extensive fig collections vary markedly both bearing habit, fruit characteristics, and postharvest qualities suggesting that breeding efforts to enhance and pyramid desirable traits could provide longer production seasons, improved varieties, and better postharvest quality. For example, currently new cultivars that produce larger and better Breba figs—the early large first figs of the season produced on last year’s wood—are now marketed fresh. The combined basic research ethylene biosynthesis and controlled atmosphere research with fresh figs suggests significant manipulation of postharvest quality is increasingly possible. As a result, the traditional dried fig industry is now being eclipsed by a more varied, high quality fresh fig industry.

1:55–2:25 PM

Pitahaya Cultivars and Their Production Potential in Southern California

Ramiro Lobo*

University of California, San Marcos; relobo@ucdavis.edu

2:25–2:55 PM

Persimmon Diversity and Cultivar Status

Dan Parfitt*

University of California, Davis; deparfitt@ucdavis.edu

Wednesday, July 24, 2013 Springs Salon D/E

1:45–3:45 PM

A Speed Dating Approach to Career Options

Sponsor: Industry Division

Moderators: Kristin Abney, kabney22@gmail.com;
Jeffrey Norrie, jnorrie@acadian.ca

Students are increasingly looking at options other than university or government positions when exploring career paths. Industry is one of the most important potential avenues for these alternative choices. This workshop is designed to expose students to the requirements and responsibilities of several Industry scientists in a fun and quick-paced way. Scientists from several horticultural companies will a brief description of their education, past experience, current responsibilities and advice for students looking at career options, with emphasis on how their education has supported their career path. Students will have time afterward to mingle and discuss career ideas with the speakers, and carry on the discussion poolside in the evening.

Wednesday, July 24, 2013 Desert Salon 9-10

1:45–3:45 PM

Current Techniques for Non-destructive Quality Evaluation of Postharvest Horticultural Commodities

Sponsor: Postharvest Working Group

Coordinator: David Obenland, david.obenland@ars.usda.gov

The current state of evaluating horticultural quality parameters by nondestructive sensing techniques for use in laboratory and commercial settings following harvest will be discussed.

1:45–2:00 PM

Rapid Agricultural Product Quality Measurements using Magnetic Resonance Based Sensors

Michael McCarthy*

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Nuclear magnetic resonance and magnetic resonance imaging provide complementary measurements of sample properties when compared with other experimental techniques. NMR/MRI based analyses have been historically limited to laboratory settings and only recently have begun to be utilized in remote geographical and industrial settings. The advances permitting NMR/MRI to be utilized in these new settings are driven by hardware and software innovations. These advances in hardware/software will be described by examples of the implementation of MRI/NMR for fruit quality measurements.

2:00–2:15 PM

The Use of X-ray Imaging Technology for Nondestructive Inspection of Horticultural Crops for Defects and Contaminants

Ronald Haff*

USDA–ARS, Albany, CA; ron.haff@ars.usda.gov

The ability of X-rays to traverse through matter and reveal hidden contaminants or defects has led to their extensive use in manufacturing industries for quality control inspection. The difficulties inherent in the detection of defects and contaminants in food products have kept the use of X-ray in that industry limited mainly to the packaged foods sector. Nevertheless, the need for nondestructive inspection of horticultural crops for defects and contaminants has motivated a considerable research effort spanning many decades. Improvements in technology, especially more compact and affordable high

An asterisk (*) following a name indicates the presenting author.

voltage power sources, high speed computing, and high resolution detector arrays, have made many x-ray detection tasks possible today that were previously unfeasible. These improvements can be expected to continue into the future.

2:15–2:30 PM

Use of Electronic Nose for Evaluation of Fruit Harvest Maturity, Variety, and Quality

Elizabeth Baldwin*

USDA–ARS, Horticultural Research Laboratory, Ft. Pierce, FL; Liz.Baldwin@ars.usda.gov

Electronic nose (enose) crudely mimics the human smell (gas sensors) and their communication with the human brain. The human olfactory system is by far the most complex and contains thousands of receptors that bind odor molecules and can detect some odors at parts per trillion levels and include between 10 and 100 million receptors. Apparently some of the receptors in the olfactory mucus can bind more than one odor molecule and, in some cases, one odor molecule can bind more than one receptor. This results in a mind-boggling amount of combinations that send unique signal patterns to the human brain. The brain then interprets these signals and makes a judgment and/or classification to identify the substance consumed, based in part, on previous experiences or neural network pattern recognition. The electronic nose often consists of non-selective sensors that interact with volatile molecules that result in a physical or chemical change that sends a signal to a computer which makes a classification based on a calibration and training process leading to pattern recognition. The non-selectivity of the sensors results in many possibilities for unique signal combinations, patterns or fingerprints determined with multivariate statistical programs. For enose sensors, the metal oxide semiconductors (MOS), conducting polymer, surface acoustic wave (piezoelectric sensors) are most common, but the newer Z-nose contain short columns such as are found in gas chromatographs. It is only upon establishing a relationship to sensory perception that the enose can then be substituted for sensory panels in giving objective classifications for quality control, process monitoring, authenticity, shelf-life stability and differences between samples or products. As a nondestructive instrument for testing of fruits and vegetables, it has been used to differentiate harvest maturity and storage conditions for tomato, mango, strawberry, blueberry, and other fresh produce. It has also been used to differentiate between healthy and diseased citrus leaves infected with citrus canker.

2:30–2:45 PM

Real Time Inspection of Agricultural Products with NIR

Thomas Pearson*

USDA–ARS, Manhattan, KS; thomas.pearson@ars.usda.gov

2:45–3:00 PM

Using Chlorophyll Fluorescence for the Rapid, Nondestructive Assessment of Fruit Quality

Jun Song*

Agriculture and Agri-Food Canada, Kentville, NS; jun.song@agr.gc.ca

The high level of competition in domestic and international markets for stored apple fruit requires high quality packed fruit. Segregating high- and low-quality fruit based on internal quality is key to consumer satisfaction and is an important component of quality control of the final pack-out. Nondestructive technology based on one or more of the attributes of quality for sorting the whole population is desirable to reduce losses and improve the quality of fruit delivered to the consumer. Considerable research has been conducted in developing technologies to non-destructively assess, grade, and sort fruit for internal quality of apple fruit. However, technologies for sorting apple fruit for internal quality are still not available. Chlorophyll fluorescence (CF) has been used as a measure of chloroplast function and, indirectly, the physiological status of whole plants and plant organs. Changes in chlorophyll fluorescence of many fruit during ripening, senescence, and stress have been reported. In this talk, investigations on the changes in apple fruit chlorophyll fluorescence and its relationship not only limited to firmness and ground color, but also to other internal quality parameter such as SS, TA, and aroma production during ripening as well as response to stress will be introduced and discussed. Our studies indicate that the ripening process is complex and dynamic, but that CF may provide a meaningful nondestructive tool to monitor these changes. It is possible to use different CF parameters to predict fruit quality indices such as Fv, Fm, Fv/Fm, or Fv/Fo. The relationships that have been found so far may be improved by further analysis of data and mathematical modeling. The further defining of the relationship between CF and firmness, TA, and SS/TA is promising and may lead to the development of a nondestructive fruit quality detector to sort fruit based on eating quality prior to fruit being shipped to the consumers.

3:00–3:15 PM

An Industry Perspective on Nondestructive Testing of Horticultural Commodities

Ken Moynihan*

Compac Sorting Equipment, Auckland, New Zealand; ken.moynihan@compacsort.com

Wednesday, July 24, 2013 Desert Salon 13-14

1:45–3:45 PM

Horticultural Substrates: Current Research, Development, and Characterization for Improved Crop Production

Sponsor: Nursery Crops Working Group

Moderator: Cheryl R. Boyer, crboyer@k-state.edu

Coordinators: John Majsztrik, jcmajsz@umd.edu;

Brian Jackson, brian_jackson@ncsu.edu;

Sarah A. White, white4@clemson.edu

Alternative substrate (potting material) studies have been an important area of research for many years. Introduction of alternative substrates to growers has contributed to the continued growth and profitability of container-grown plant production. Over the past 10 years, wood-based substrates have been evaluated as alternatives to peat and pine bark substrates. Researchers across the United States have investigated locally available, sustainable resources as components of or alternatives to peat- and pine bark-based growing media. These materials range from amendments to peat moss (up to 40% by volume) and pine bark supplements/extenders (more than 50% by volume). A variety of woody species have been evaluated for substrate use including pine (*Pinus taeda*) trees, eastern redcedar (*Juniperus virginiana*), and other low-cost tree species. Additional research has also focused on the potential problems associated with recycling of media, including physical changes over time and the potential to reintroduce pathogens from recycled media. This workshop will focus on current research methods in traditional and alternative substrates including root growth, fertility, and water management, how mechanical processing changes the properties of wood and pine bark, the status of commercialization of these products, as well as potential problems associated with recycling substrates.

1:45–2:05 PM

Introduction and Overview of Current Issues and Advances in Traditional and Alternative Substrate Manufacturing and Utilization

Brian Jackson*

North Carolina State University, Raleigh; brian_jackson@ncsu.edu

This presentation will explore the current issues facing the growing media (substrates) industry for both nursery and greenhouse producers. An overview of peat, pine bark, and pine tree substrate usage, supplies, industry trends, processing advances, and issues will be discussed. A summary of

recent advances and current commercialization efforts of new substrate components will also be addressed.

2:05–2:30 PM

Proper Statistical Methods for Analyzing Substrate Mixtures

James Altland*

USDA–ARS, MWA ATRU, Wooster, OH; James.Altland@ars.usda.gov

Substrates are most often described as mixtures of various components in proportions that sum to 1 (for example .0.7 bark : 0.15 peat : 0.15 sand). When conducting a statistical comparison of substrates with varying component proportions, parameter estimates in a traditional regression analysis cannot be uniquely determined. This seminar will discuss a simple and practical approach to proper statistical analysis of substrate mixtures. We will also discuss how mixture analysis differs from factorial analysis in substrate experiments. Examples will be provided along with sample SAS code.

2:30–2:55 PM

Irrigating Substrates to Improve Nutrient Retention and Plant Growth

Rodney Thomas Fernandez*

Michigan State University, East Lansing; fernan15@msu.edu

Technological advances have made implementing improved irrigation practices easier through better monitoring capabilities of substrate moisture, electrical conductivity, and pH. Basing irrigation on plant use and substrate properties is now more easily accomplished and can result in improved water relations and growth with decreased nutrient leaching and runoff volume. This presentation will focus on benefits of improved irrigation management with respect to plant performance, water conservation, and runoff quality.

2:55–3:20 PM

Root Growth of Container Crops: Techniques for Enhancing and Measurement

Brian Jackson*

North Carolina State University, Raleigh; brian_jackson@ncsu.edu

This presentation will provide an overview of research techniques and methodologies used for studying, observing, and quantifying root growth in container grown plants (woody and herbaceous crops). New measurement devices/tools that are designed as nondestructive techniques for quantifying and observing root growth will be discussed. Studies on root growth of nursery and greenhouse crops grown in substrates amended with pine wood (pine tree substrates) will also be presented.

An asterisk (*) following a name indicates the presenting author.

3:20–3:45 PM

Methods for Analysis of Soilless Substrate Physical and Hydraulic Properties

James S. Owen*

Virginia Tech, Virginia Beach; jim.owen@vt.edu

This presentation will discuss the varying methodologies used to measure soilless substrate hydrology and physical properties focusing on static versus dynamic measures that provide insight to water availability and solute transport.

Wednesday, July 24, 2013 **Desert Salon 4-6**

1:45–3:45 PM

Intellectual Property Fundamentals and Current Issues

Sponsor: Intellectual Property Rights Working Group

Moderators: Amelie Aust, ameliea@fallcreeknursery.com; John R. Clark, jrclark@uark.edu

Coordinators: Larry D. Knerr, lknerr@shamrockseed.com; Todd P. West, todd.p.west@ndsu.edu; Timothy F. Bourne, timbourne@sunviewvineyards.com

The IPR workshop will act as a resource for ASHS members on the domestic intellectual property landscape, including both prepared speeches and a panel for questions. The presentations will present an overview of the various types of Intellectual Property rights and their application in horticulture and agriculture, and how they can be used. In addition, we will address current events relevant to horticulture, specifically addressing new laws and legal precedents that you should be aware of. A panel of speakers will include a variety of perspectives, including Researchers, Intellectual Property Attorneys, and Industry Experts. In the first hour, panel speakers will provide an overview of the types of intellectual property protection beyond Plant Patents and Plant Breeder's Rights Certificates. These rights include Trademarks, Trade Secrets, Utility Patents, and Copyrights, all of which can be utilized to maximize your intellectual property benefits. This information will serve as the foundation material for the panel speakers to build upon during the second hour.

Topics

IP Basics—Domestic Focus

Chelle Bos, Plant Patent Attorney)

Current Events—Changes in the Patent Law, Legal Precedent, and What It Means to the Horticulture Community

Robert Jondle, Plant Patent Attorney

Breeding—The Future Role of Public versus Private IP in Horticulture

Speaker tba

The moderated panel presentation for the second hour will address relevant current events in intellectual property law, and the resulting implications to the agricultural and horticultural industries. The goal of the workshop is for participants to gain an understanding of the interface between intellectual property rights, and how to maximize the benefits from protecting those rights. There will be time allotted during the second hour for questions and discussion.

Wednesday, July 24, 2013 **Desert Salon 1-2**

1:45–3:45 PM

The Challenges of Using Alternative and Recycled Water Sources for Horticultural Use

Sponsor: Water Utilization and Management Working Group

Coordinator: John D. Lea-Cox, jlc@umd.edu

The objective of this workshop is to illustrate some the issues surrounding the use of alternative and recycled water sources in the production and management of horticultural commodities.

1:45–2:15 PM

The Challenges of Graywater as an Alternative Water Source for Landscape Irrigation

Raul I. Cabrera*

Texas A&M AgriLife Research, Uvalde; r-cabrera@tamu.edu

Continuing drought, water competition and severe restrictions on urban water use are hastily pushing for the implementation of water conserving practices and utilization of alternative water sources in landscaping activities. Graywater, identified as untreated water that comes from clothes washers, showers, and bathtubs constitutes $\geq 50\%$ of the total household wastewater, and has the potential for becoming a significant source for landscape irrigation. Chemical, physical, and biological considerations and challenges associated with the use of graywater in home lawns and landscapes will be discussed in this presentation.

2:15–2:45 PM

Pharmaceuticals and Persistent Organic Micropollutants in Reclaimed Irrigation Water

Sarah A. White*

Clemson University, Clemson, SC; swwhite4@clemson.edu

Reclaimed water is one alternative source of water for irrigation of specialty crops. Reclaimed water, though treated effluent,

An asterisk (*) following a name indicates the presenting author.

often contains organic micropollutants including pharmaceuticals, hormones and other endocrine disrupting compounds, personal care products, and persistent organic pollutants that are not removed via wastewater treatment processes. When reclaimed water is used for irrigation, there is the potential for micropollutant accumulation within plant tissues or for offsite loss via irrigation runoff. The physiochemical properties of individual micropollutants drives their environmental fate, whether that is accumulation within plant tissues or soils, runoff into surface waters, or leaching into groundwater. This presentation will detail some of the most prevalent micropollutants, their physiochemical properties, the risk of accumulation within plant tissues, soils, surface waters, and ground waters, and the potential for remediation of micropollutants via irrigation applications.

2:45–3:15 PM

Pesticides in Recycled Water: What Are the Issues?

Rodney Thomas Fernandez*

Michigan State University, East Lansing; fernan15@msu.edu

Societal pressures for improved water management are driving many producers to use recycled production water for nursery irrigation. The same need is also resulting in improved irrigation practices. Irrigation effluent is known to carry pesticides and other contaminants. These contaminants will be captured in recycling reservoirs if effluent is not treated before entering. Improved irrigation management can result in increased concentration of contaminants in effluent although total load may be reduced. Depending on the pesticide and reservoir management, pesticides can be reintroduced onto crops and/or accumulate in reservoir sediments. Impacts of reservoir overflow must be taken into consideration as well. The implications of pesticides in sediments, recycled water, and overflow will be discussed in this presentation.

3:15–3:45 PM

Daily and Seasonal Changes in the Water Quality of Irrigation Containment Ponds

John D. Lea-Cox*

University of Maryland, College Park; jlc@umd.edu

We have been continuously monitoring water quality parameters in containment ponds at five commercial nursery and greenhouse operations in Maryland and Virginia, since 2011. Diurnal changes in pH, EC, water temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), chlorophyll AB, and blue-green algae counts were measured every 15 minutes. Environmental conditions (rainfall, air temperature and relative humidity, photosynthetically-active radiation [PAR] and wind speed) were continuously measured every 5 minutes at all locations. Results from all locations showed

surprisingly similar seasonal patterns, where water temperature and EC tended to increase from early spring, peak in early Fall and then decrease to a minimum in late winter (averaging 0.20 to 0.5 dS·m⁻¹). Water temperatures, EC, and turbidity were typically stratified with depth and were affected by rainfall events. Longer-term pH dynamics were damped by influxes of water from runoff events, and appeared to be limited primarily by minimum water temperatures and PAR on a seasonal basis. When temperature and PAR limitations were removed, diurnal changes in pH were rapid and extreme, ranging from pH 6.8 to 10.5, often within a few hours. Rapid changes in pH appear to be tightly coupled with DO concentrations, peaking at 4:00–5:00 PM and returning to minimum values between 6:00–7:00 AM. Changes in pH therefore appear to be driven by the daily photosynthetic activity of microorganisms in the water column, especially in ponds with good water quality, where changes in pH are poorly buffered. Despite relatively low EC levels, it appears that none of these ponds are nitrogen or phosphorus limited, which appears to be the primary catalyst for algal productivity.

Thursday, July 25, 2013 **Springs Salon A/B**

8:00–10:00 AM

Citrus Breeding

Sponsor: Fruit Breeding (FRBR) Working Group

Moderator: Vance M. Whitaker, vwhitaker@ufl.edu

Coordinators: Vance M. Whitaker, vwhitaker@ufl.edu; Glenn C. Wright, gwright@ag.arizona.edu

Workshop objectives are: 1) Provide an updated perspective on new cultivars and future directions for U.S. citrus breeding programs; 2) Illustrate the tools used in citrus breeding including transgenics, triploidy, somaclonal variation and somatic hybridization; and 3) examine current challenges and opportunities in topic areas such as cold hardiness, resistance to HLB and other diseases, germplasm utilization, rapid-cycle breeding, rootstock development and seedlessness.

8:00–8:20 AM

Underutilized Citrus Germplasm and How to Obtain Priority Germplasm in the United States

Richard Lee*

University of California, Riverside

8:20–8:40 AM

Breeding Citrus for North Florida

José Chaparro*

University of Florida, Gainesville; jaguey58@ufl.edu

An asterisk (*) following a name indicates the presenting author.

8:40–9:00 AM

Citrus Breeding at UCR—Progress and Challenges

Mikeal L. Roose*

University of California, Riverside

9:00–9:20 AM

Biotechnology Facilitated Breeding of Improved Citrus

Jude W. Grosser*

University of Florida, CREC, Lake Alfred

Fred Gmitter

University of Florida, CREC, Lake Alfred

9:20–9:40 AM

Transgenic Approaches to Improved Disease Resistance in Citrus

Manjul Dutt*

University of Florida, CREC, Lake Alfred

Jude W. Grosser

University of Florida, CREC, Lake Alfred

9:40–10:00 AM

Critical Needs of U.S. Citrus Growers in Scion and Rootstock Breeding

Ted Batkin*

California Citrus Research Board

Thursday, July 25, 2013 Springs Salon D/E

8:00–10:00 AM

New Innovations in Commercial Horticultural Applications

Sponsor: Technical Program Committee

Moderator: tba

This workshop will introduce conference participants to new and innovative technologies available for research, teaching, and extension.

8:00–8:20 AM

Amperometric Ethylene Sensor with Interfering Gas Trap

Michael Larman*

Camas, WY, and Afghanistan; mlarman@cid-inc.com

CIDBio-Science, Inc., reports on experimental studies on a commercial ethylene sensor to improve its operational performance. The largest improvement achieved was in sensor selectivity in the working environment that interferes with the sensing of ethylene. Selectivity of the sensor was increased by passing the

analyte air stream through a trap for interfering gases. By applying the basic chemistry principle of “like dissolves like” polar molecules such as ethanol are removed by the trap. Ethylene, a nonpolar hydrocarbon, passes through the trap with relative ease. The gas trap was regenerated by reversing the concentration gradient between the trap and the analyte air stream. The poster and instrument will be on hand for your review.

8:20–8:40 AM

Drip Irrigation/Plastic Mulch Kits for Home Gardeners

Keith Williamson*

Guardian Ag Plastics, Hartsville, SC; keith.williamson@guardianag.com

Because most small-scale farmers, urban growers, and home gardeners have difficulties utilizing a combination of drip irrigation and plastic mulch, a method to facilitate the usage of this commercially proven method of production is of much interest among this group of growers. This report will evaluate plots from multi-state tests conducted at university research centers, community gardens, and home gardens employing a newly designed drip/mulch kit. The report will cover the pros and cons of such a system and will include analyses of installation, water and weed management, soil conditioning, crop responses, disposal and recycling options, and overall cost.

8:40–9:00 AM

ARM Tablet Data Collector

Steven R. Gylling*

Gylling Data Management, Brookings, SD; steve@gdmdata.com

The use of capable in-field data collection software to directly enter assessments and capture photographs of research plots can improve data quality through in-field data review and analysis. This session will demonstrate use of ARM Tablet Data Collector, a Windows 8 touch tablet computer plus ARM trial management software, to enter and review assessment information. An assessment can constitute values, notes, digital photographs, and GPS coordinates. Once entered, immediate data quality checks, graphs, and full statistical analysis can be applied to assessments. Additionally, all trial site details plus summary and conclusions can be entered on-site.

9:00–9:20 AM

Optimizing Drip Irrigation System Uniformity with Proper Design and Management

Inge Bisconer*

The Toro Company, El Cajon, CA; inge.bisconer@toro.com

Agricultural irrigation system uniformity directly affects resource use efficiency as well as yield and quality potential. This is because highly uniform systems will require less run time for the driest portion of the field to receive adequate water, and thus

An asterisk (*) following a name indicates the presenting author.

will consume fewer resources including water, fertilizer, energy, labor, chemicals, etc. For example, if a farmer wishes to apply 1” of water with a drip irrigation system that has a 90% EU, fewer operating hours will be required to achieve this than an irrigation system with lower EU. As a result, drip irrigation systems with a high EU consume fewer inputs than less uniform systems since they are operated fewer hours to achieve desired results. In addition, highly uniform drip irrigation systems have been reported to provide higher yields and improved crop quality since crops may be spoon fed inputs evenly and when needed. In order to optimize drip irrigation system uniformity, Toro Micro-Irrigation has recently released two free tools that assist with the proper design, installation, operation and maintenance of a state of the art drip irrigation systems. First, Toro has released AquaFlow 3.2 Design Software which enables the end user to evaluate drip irrigation design options more quickly and accurately, leading to better, more effective drip irrigation design decisions and systems. As a result, drip irrigation systems are better able to improve farm profitability and increase resource use efficiency. Second, the Toro Micro-Irrigation Owner’s Manual is a heavily referenced, 129-page, four-color, fully illustrated, spiral-wound document that provides a comprehensive guide to the operation and maintenance of both new and existing micro-irrigation systems for row, field and permanent crops. The resource comes in both English and Spanish versions, with measurements in English and Metric Units. Chapter titles include Drip Irrigation System Overview, Starting Up Your System, Basic System Operation, Fertigation and Chemigation, Salinity Management and System Maintenance. Both the Software and the Manual are available for free download from toro.com or driptips.toro.com. This presentation will provide an overview of these new tools and will highlight their practical usage by both field practitioners and academic interests alike.

Thursday, July 25, 2013 **Springs Salon A/B**

10:15–11:15 AM

Commercial Use of PGRs to Increase Color Development of Fruit

Sponsor: Growth Regulators in Fruit and Nut Production (PGR) Working Group

Moderator and Coordinator: Derek D. Woolard, derek.woolard@valent.com

In this workshop industry representatives will present information about two exciting new PGR products available to commercial fruit growers for increasing the coloration of fruit. The marketplace demands table grapes and apples with sufficient red color. Development of this desired level of color is often a significant challenge for the grower. Due to the variability in color development, growers use multiple harvests, over an

extended harvest period, in order to harvest an entire crop. Low color results in lower fruit quality, lower marketable yields, and potentially significant economic losses for the grower. If fruit has insufficient color, the value is substantially decreased or the fruit is potentially unmarketable. Fruit color development can be influenced by a number of factors including the cultivar, rootstock, plant vigor, climate, canopy management, light exposure, crop load, irrigation, fertilization, and plant growth regulators. Presenters will discuss the commercial development of Blush™, a new plant growth regulator developed by Fine Americas, Inc., to promote fruit color in red and bi-color apples which contains prohydrojasmon (PDJ), and formulations of S-Absciscic acid (S-ABA) for use on table grapes commercialized by Valent BioSciences Corporation (VBC) under the trade name of ProTone®.

10:15 AM - 10:30 AM

The Use of S-Absciscic Acid for the Enhancement of Grape Coloration

Rob Fritts*

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Johan Pienaar

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Worldwide, premium table grape production tends to be from warmer growing regions that are generally considered difficult coloring areas for quality red varieties. Fruit color development can be influenced by a number of factors including the cultivar, rootstock, plant vigor, climate, canopy management, light exposure, crop load, irrigation, fertilization, and plant growth regulators. Consequently, achieving optimal fruit color requires a programmatic approach rather than the use of a single tool or practice. The plant growth regulator ethephon is one tool that can be used to help improve color development; however, ethephon can be inconsistent and can cause berry softening. Research has demonstrated that application of the plant hormone absciscic acid

An asterisk (*) following a name indicates the presenting author.

(S-ABA) to grape clusters increases fruit color in table grape varieties. Since 2008, nine international registrations have been granted to Valent BioSciences Corporation (VBC) for the commercial use of S-ABA for the acceleration of color development of red table grapes. Formulations of S-ABA for use on table grapes have been commercialized under the trade name of ProTone®. Commercial table grape vineyards were selected for field trials in multiple regions. Application timing was keyed to veraison, which is defined as the point at which 50% of the harvestable fruit has softened. Split rate and sequential timing treatments were also incorporated into field evaluations. Plot sizes varied from one to several acres (or hectares). An equivalent size area treated with the grower standard coloring program was evaluated from adjacent rows. At commercial harvest all fruit in the blocks of each treatment were evaluated. The data was then transformed into boxes per unit area based on vine spacing within each site. Financial analysis showing the increased returns following ProTone® treatment will be shown. Large scale grower trials conducted in numerous table grape growing regions around the world, using conventional vineyard application equipment, have been conducted since 2009. These trials were successful in demonstrating the commercial feasibility of using S-ABA (ProTone®) as a color enhancing product for red table grapes. The field data confirmed a wide application window in which S-ABA can be used from veraison to late in the harvest season to increase harvestable yields.

10:30–10:45 AM

BLUSH™, a New Fruit Color Enhancer for Apples

Kevin Forney*

Fine Americas, Inc., Bakersfield, CA; kevinf@fine-americas.com

Blush™ is a new plant growth regulator developed by Fine Americas, Inc., to promote fruit color in red and bi-color apples, thereby improving the commercial value of the crop. Blush™ contains 5.25% prohydrojasmon (PDJ), a synthetically produced jasmonate. PDJ is known to act as a functional analogue of jasmonic acid (JA) in plants. Jasmonates are considered a new class of plant hormones with several beneficial physiological and biological properties, including improved color development by enhanced anthocyanin and carotene accumulation within the fruit. It has been reported that PDJ is up to 10 times more biologically active than the naturally occurring hormone, methyl jasmonate (MJ); probably due to its higher chemical stability. PDJ is currently registered for use in several countries, including Japan, Taiwan, and Korea. In 2007, Fine Americas, Inc., initiated field efficacy trials evaluating the effects of Blush™ on fruit color and quality enhancements in apples. In 2010, an Experimental Use Permit (EUP) for commercial testing of Blush™ on apples was approved by the USEPA, allowing for non-crop destruct trials. Preharvest applications of Blush™ have shown positive responses in trials conducted on multiple varieties across the United States in the key apple growing states. Full Section 3 Fed-

eral registration of Blush™ is expected for the 2013 use season. Upon registration, Blush™ will be classified as a biopesticide.

Thursday, July 25, 2013 Desert Salon 13-14

10:15 AM–12:15 PM

Teaching with Tablets and Apps

Computer Applications in Horticulture

Moderator: Tim Rhodus, rhodus.1@osu.edu

Three significant changes affecting society are challenging our traditional approaches to classroom and outreach education programs throughout all subject matter areas of ASHS. First, increasing numbers of students show up on campus each year with their own mobile technologies. These “digital natives” are practiced in using smart phones and tablets for checking *email*, texting friends, or browsing web sites. Second, the wave of technology change continues to challenge our teaching and outreach programs with an almost unlimited list of new opportunities, especially with regard to accessing information and communicating globally. Third, mobile devices, including smart phones and tablets are capable of running apps that replicate and even surpass desktop software, thus providing students and clients anytime, anywhere access to online and app-based programming. Each of these forces alone provide sufficient justification for examining how we design and deliver education programs. Taken together, the new digital reality created by ever improving smart/mobile devices in the hands of skilled users demands that we alter our thinking on how and what we offer in horticulture education. As a result, this workshop is very important for what it addresses and how the presenters will utilize mobile devices and a mobile wireless system for presenting their stories. The goal of this workshop is to learn how other educators have incorporated tablets and apps into their teaching and how that decision affects the type of assignments and activities that are presented to students. Topics being discussed include: setting up your classroom and tablet for presenting to an audience; selecting basic apps for creating useful assignments; extending the scope and variety of your apps; spontaneous information needs demand mobile solutions; designing lecture capture systems for use in online education; and using apps to monitor irrigation systems. If you would like to learn more about these new technologies, using a tablet and one or more apps to assist students in your classroom, you must attend the first wireless, tablet-based workshop to be organized for Annual Conference.

10:15–10:30 AM

Workshop Overview

Tim Rhodus*

The Ohio State University, Columbus; rhodus.1@osu.edu

As stated in the goals of this workshop, we are here to learn how other educators have incorporated tablets and apps into

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their teaching and how that decision affects the type of assignments and activities that are presented to students. Hopefully, you will be able to take away a lot of useful information from today's presentations, including (but not limited to) the type of teaching environment facing each presenter, their tablet and app selections, and what advice they would offer anyone looking to replace their activities. A description of today's wireless network configuration, how we are connecting to the projector and how we are recording today's presentations will be covered.

10:30–10:45 AM

Teaching with Tablets and Apps over Wireless

Tim Rhodus*

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Walk into a classroom, turn on the projector and the podium computer (or your laptop) and start teaching with your iPad or iPhone using wireless. Walking around the class you can monitor student progress on an assignment and ask students (up to four different devices at a time) to show their progress on the screen, side-by-side if you like. Playing a video on the iPad with audio? No problem—the sound is directed from the computer to the room's audio system. Need to block outsiders from hijacking your projector? No problem—add a password. Having students work on an assignment or presentation at home and accessing it in the classroom? No problem—just add Dropbox. Creating iPad screen captures or plant ID photos during the class and need to save it for a presentation to share with others? No problem—just add Picasa. Want to make student audio recordings for use with a website or digital portfolio? No problem—just add Recorder and Evernote. These scenarios and countless more can be easily facilitated over wireless with various iOS devices and a few select apps. The most common of these include: screen capture, camera, iBooks, Dropbox, iFiles, Recorder, Prezi, Pages, and Keynote. Even for PC users who prefer to work on a Windows operating system, their content/documents can be transferred to an iPad for use in the classroom via Dropbox. The wireless connection between the iPad or iPhone and the laptop (computer) and projector is most easily handled, at this time via Apple's Airplay feature on iOS devices and AirServer software installed on the computer. In addition to AirServer, each device in the room needs to be on the same wireless network. While connecting your own access point to the building's network may not be approved by your College or University CIO, it is the most direct route. An easy alternative for hosting just a few iPads would be to use a Mac laptop and share its Internet access to all devices connecting via wireless. That way, each iPad can connect to AirServer. A mobile hotspot can be used to offer wireless service to a small number of mobile devices and one computer running AirServer. Just as with websites that are constantly being created, updated, and/or replaced, recommendations regarding specific devices, apps or software requirements needs to be confirmed in order to guarantee the desired results.

10:45–11:00 AM

Students Keep Your Cell Phones On, Please

Margaret J. McMahon*

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One of the more frustrating factors in teaching today is the ubiquitous presence of smartphones and other mobile devices in the classroom. You just know the students are paying more attention to Facebook, text messages, and who knows what else (and you probably don't want to know) than you. Instead of fighting that battle, why not consider joining it? Some of the ways I have found to capitalize on student mobile devices is to ask them to use them to contribute to class activities and discussions. For example, we'll use a weather app to see how conditions vary around the country that day, the calculator function to compute various formulas applicable to the class discussion, and Google Earth to view real pictures of various greenhouse companies located around the world. I also ask students to conduct web searches during class and share their results. I really like this when a question has come up that I can't answer. It is particularly handy to use my email archives to look up and link to a website showing an industry magazine article or a journal article that was originally sent out via email. In each of these examples, there is a need to be able to project the iPhone or iPad results on the screen and share your app/website with the class—running AirServer will help. The podium computer is not appropriate because it does not provide access to iPhone/iPad apps and in our classrooms and it is cleared of all new downloads at the end of each day. One last thing, I am not particularly techno savvy, so if I can do it, anyone can.

11:00–11:15 AM

Enhancing Tropical Plant and Soil Sciences (TPSS) Instruction with Mobile Devices

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Apple mobile devices (iPhone, iPad, and iPad mini) have been used in several TPSS courses. Clientele include undergraduate and graduate students, agricultural professionals, growers, master gardeners, and youth. Examples will be presented from two programs. The Photobiology Program utilizes several applications. Zapd, an iPhone/iPad app to create websites, was used to create the Micro-hydroponics website to help students learn about a noncirculating hydroponics system. News aggregator apps (FeedReader, Pulse, and Zite) help find articles and videos about cutting edge technological developments in horticulture which are discussed in class. Mind mapping apps (SimpleMind, ThinkingMap) create mind maps of course syllabi and lecture topics such as environmental monitoring, photoperiod, and hydroponics. QR (quick response) code generator apps (QRS+) produce a QR code of instructor

An asterisk (*) following a name indicates the presenting author.

contact information which is placed in course syllabi and on the instructor office door. Students use mobile devices and laptops in class to do web searching for relevant information to supplement class discussions. Keynote is an iPhone/iPad app to create and deliver a presentation. With the Keynote Remote app, the iPhone becomes a remote control to control a Keynote presentation running on the iPad. The Sustainable and Organic Farming Systems Laboratory utilizes an iPad and iPhone for instruction in the classroom and field. Heaviest use is for grading papers (iAnnotate) and for creating, modifying, and delivering presentations (Keynote and Keynote Remote). Field trips are supported by GIS applications (GISroam) which allow for soil series identification and other relevant activities. Data and images are recorded, processed, and presented using multiple applications, including Numbers, Camera, Photosynth, Zapd, and Web Albums. Communication with clientele is also conducted to an increasing degree via Social Media (MyPad+, Facebook, and Twitter). Transferring material between devices is done via Dropbox and *email*, and compatibility issues between the Windows and iOS operating systems have been minimal. Use of mobile devices for instruction is expected to continue to expand rapidly in the foreseeable future.

11:15–11:30 AM

Live Lecture Capture with Whiteboard Annotation and iTunesU Delivery for Asynchronous Learning

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Yes, you can turn your classroom into a recording studio and supercharge your digital presentations. Once I began putting my greenhouse management and floriculture classes online using a learning management system more than 10 years ago, I was constantly searching for a way to represent the “lecture” approach for students accessing the course asynchronously. Converting PowerPoint slides to jpeg images in sequence did not seem too effective to me and an online course needs to be more than just a set of word slides. Live screen capture software has made recording your classroom simple. There are many versions of screen capture software available and many are free. My personal choice is Camtasia that is sold by TechSmith. This and other products all record the screen well, but audio does provide some challenges. My next step was to invest in a quality professional grade microphone. Screen capture software does not capture your laser pointer on the screen. There are many new forms of display boards that will capture what you project, but not all classrooms have that technology. And if you are an extension educator, you cannot carry that technology to your workshops in the field. There are many forms of digital tablet applications that one can use that will mirror your laptop on a tablet wirelessly. I use an application called Doceri, which allows me to generate a pointer, draw lines or highlight sections of a slide and/or switch back and forth to a whiteboard. All the

while, your computer is capturing the entire activity. That way your asynchronous audience can understand what part of the slide you are addressing without actually seeing you physically point to that part of the screen. Next, I upload the lecture video to Apple iTunesU and students can then subscribe to the feed and view the lecture on their own time. They can also download the video for use at a location without internet access. The students appreciate the opportunity to view lectures that they may have missed if they are attending class face-to-face and do take advantage of the ability to stop the video, rewind, and repeat a topic. Students where English is not their first language finds this option even more valuable.

11:30–11:45 AM

Accessing Real-time Data from Sensor Networks

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As part of the SCRI—Managing Irrigation and Nutrition via Distributed Sensing (MINDS) project (<http://smart-farms.net>), we have developed advanced software which provides layers of information for growers to both monitor crop data and control irrigation events in nursery and greenhouse production environments. This software is accessed through a dedicated website that is setup for each farm, thereby enabling the information to be accessed over the internet from a smart-phone or tablet. The homepage provides instantaneous information from each sensor node in the farm network, by simply color coding the status of each node. Tapping or hovering on a node shows the latest data from the sensors and grower tools attached to that node. Color-coding is linked to sensor ranges, which are setup by the grower, e.g. average soil moisture from 27% to 30% volumetric water content. When the average readings from those sensors deviates from those ranges, the node will change color on the homepage (green–amber–red); the software can also be set up to send a text or email alert. The software is designed to provide much deeper levels of customized capability for automatic irrigation control. Throughout the development of this system, continuous grower feedback and interaction ensured that the functionality and use of the system focused on the needs of the end-user. One of the primary requirements was the ability to check the status, or make an informed decision (action) within a 5-minute window, by quickly reviewing data through the homepage or charts. The charting tools were designed to be dynamic and allow the user to work with charts from a smart-phone or tablet. This software was used extensively by a number of growers in 2012, and by researchers to access and control irrigation decisions from locations across the

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United States. We have also integrating this functionality into local greenhouse and greenroof networks for student directed research and demonstration projects.

Thursday, July 25, 2013 Springs Salon A/B

11:30 AM–1:30 PM

**RosBREED Fruit Quality QTLs:
from Publications to Applications**

Sponsor: Genetics and Germplasm (GG) Working Group

Moderator: Cholani Kumari Weebadde, weebadde@msu.edu

Coordinator: Amy F. Iezzoni, iezzoni@msu.edu

“RosBREED” is a multi-disciplinary, multi-institutional project dedicated to enabling marker-assisted breeding of Rosaceae crops. Funded by the Specialty Crop Research Program of the United States Department of Agriculture’s National Institute of Food and Agriculture (USDA–NIFA), the project aims to genetically improve five rosaceous crops (apple, sweet and sour cherry, peach, and strawberry) through the targeted application of genomics and socio-economics knowledge and tools to increase the efficiency of breeding programs, engage stakeholders, and train the next generation of plant breeders. RosBREED works closely with the U.S. Rosaceae genomics, genetics, and breeding community to move QTL discoveries beyond the publication phase and into the application phase so that conventional breeding programs can benefit from modern genomics tools through marker-assisted breeding (MAB). Through a process referred to as the “MAB Pipeline”, the project converts existing or newly discovered QTLs into routine genetic tests for marker-assisted selection. While the project focuses on fruit quality, the approach can be adopted by any breeding program of perennial and clonally propagated crops.

11:30–11:45 AM

Discovering a QTL: A Major Milestone or a Stepping-stone into Practical Marker-assisted Breeding?

Cholani Kumari Weebadde*

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11:45 AM–12:00 PM

You’ve Just Identified a QTL for a Major Trait of Interest—What Now? QTL and QTL Allele Validation in Cherry

Amy F. Iezzoni*

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12:00–12:15 PM

QTL and QTL Allele Validation in Apple

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12:15–12:30 PM

QTL and QTL Allele Validation in Peach

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12:30–12:45 PM

Marker-assisted Breeding for Apple at the University of Minnesota and Washington State University

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Oral Abstracts

Presented at the Annual Conference of the American Society for Horticultural Science
July 22–25, 2013, Palm Desert, California

Monday, July 22, 2013 Desert Salon 1-2

Undergraduate Student Oral Competition

Moderator: Yessica Garcia, garcia.yessica11@gmail.com

Coordinator: David E. Kopsell, dkopsell@ilstu.edu

12:00–12:15 PM

A Semiyearly Study on the Effect of Light Quality on Flavor of Greenhouse Grown Tomatoes: LED versus HPS

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Seasonal variation in solar daily light integral (DLI) makes it logistically and financially burdensome to produce greenhouse-grown tomatoes during the winter in a northern climate. Two separate studies investigating interactions among light quantity and spectrum, fruit yield, flavor development, and composition of tomato fruit comparing supplemental lighting from energy-efficient LED intracanopy lighting vs. traditional overhead high-pressure sodium lighting vs. unsupplemented controls were performed during 2012. Two tomato cultivars, ‘Success’ and ‘Komeet’, were grown in soilless slab culture within a greenhouse using high-wire trellising. Tomato production experiments were conducted from July to December 2012 and from January to June 2013. In each experiment, supplemental DLI was determined on a monthly basis by subtracting solar DLI from 25 mol/m²/d. Fruits were harvested at the vine-ripe stage, counted, and weighed. Quality metrics were selected that are standard in the Horticultural and Food Science Industries. Objective measures of fruit quality included Brix, titratable acidity, pH, electroconductivity, and chromatic index. These attributes were linked to consumer acceptance via subjective organoleptic taste panels. Both hedonic (indicating preference) as well as absolute scales of evaluation (without indicating preference) were used to evaluate tomato fruit for flavor characteristics including sweetness, acidity, texture, aroma, bitterness, after-taste, color, and overall approval. Both subjective and objective metrics of fruit quality were correlated with type of supplemental lighting used, total DLI, cultivar, and time of year when harvested.

Results from the first and second fruit-production experiment conducted in 2012 and 2013 will be presented. Additionally, the efficacy of testing heirloom fruits in the future will be presented.

Specified Source(s) of Funding: NIFA SCRI grant 2010-51181-21369

12:15–12:30 PM

Physiology of Solanaceous Scion and Rootstock Seedlings for Grafting in Low Temperature Storage Conditions under Low Light Intensity

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A potential application of low temperature storage is to establish techniques and conditions that increase the production of grafted vegetable seedlings for the planting season. If stored seedlings are provided with optimal light intensity and temperature, growth and development can be suppressed while not deteriorating seedling quality due to chilling injury. This will allow propagators to store seedlings, adjust the propagation schedule, and/or increase volume over time without increasing labor input. Finding storage light and temperature parameters on ungrafted seedlings would provide the foundational knowledge for further studies on the effect of low temperature storage on grafted seedlings. In this experiment performance of solanaceous scion and rootstock seedlings were evaluated during and after storage. Cultivars included in the experiment were tomato (*Solanum lycopersicum* ‘Aloha’, ‘Conchita’, and ‘Durinta’, and *S. lycopersicum* × *S. habrochaites* ‘Maxifort’), pepper (*Capsicum annuum* ‘Double up’, ‘Red Bull’, and ‘Ti-135’), eggplant (*S. melongena* ‘Black Bell’, and ‘Black Shine’, *S. melongena* × *S. sp.* ‘Red Scorpion’), and *Solanum torvum* (‘TI-216’). Seedlings were stored for a period of 4 weeks at 10 °C under 5 μmol·m⁻²·s⁻¹ photosynthetic photon flux (PPF). All cultivars maintained a visual quality score of 5 for day 0, 1, and 7. By day 14 all cultivars maintained a visual quality score of 5 ± 0, except for ‘Maxifort’ tomato which had a significantly different visual quality score of 4.7 ± 0.12. By day 21 all cultivars maintained a score of 5 ± 0, except for ‘Maxifort’ tomato, and ‘Black Shine’, and ‘Black Bell’ eggplant, demonstrating scores of 4.6 ± 0.13, 3.8 ± 0.08, and 3.4 ± 0.1, respectively. By day 28, the storage caused chilling damage on all genotypes, except for ‘Aloha’ and ‘Durinta’ tomato, which maintained a visual quality score of 5 ± 0. Chilling damage was most prominent on

An asterisk (*) following a name indicates the presenting author.

'Black Bell' and 'Black Shine' eggplant leading to the lowest significantly different score of 3.0 ± 0 . At the end of storage, the seedlings were moved to a greenhouse for further observation. Poststorage observations taken at day 14 showed complete recovery, with all cultivars having a score of 5 ± 0 . With most cultivars not exhibiting any damage until day 21 it can be recommended that solanaceous seedlings can be stored without loss of quality for 14 days. These preliminary results will be repeated to confirm the findings and used to test storability of grafted vegetable seedlings.

12:30–12:45 PM

Comparisons of Auxin Application Methods and Rates on Rooting of Perennial Cuttings

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While the quick-dip of individual cuttings is the most common method of applying rooting hormone (auxin), foliar spray and immersion of cuttings has been reported as potential time- and labor-saving alternatives. Starting with unrooted cuttings of four perennial species (*Coreopsis* x 'Full Moon', *Eupatorium maculatum* 'Phantom', *Euphorbia* x *martinii* 'Ascot Rainbow', and *Phlox divaricata* 'Blue Moon'), indole-3-butyric acid (IBA) in the form of Hortus IBA Water Soluble Salts (20%) was applied as a basal dip, foliar spray, and an immersion solution at three rates (500, 1000, 1500 mg·L⁻¹) plus controls. Rooting response [rooting percentage, root dry weight (DW), and a visual root rating on a scale of 1 (no roots) to 5 (ready for transplant)] was measured at two intervals. For *Coreopsis*, neither application method nor rate affected rooting percentage (100%), DW, or rating by three weeks after treatment (WAT). One hundred percent of Phlox cuttings also rooted by 3 WAT regardless of application method; root DW at 4 WAT was greatest across all application methods with 1500 mg·L⁻¹ IBA. *Eupatorium* proved more difficult to root; by 4 WAT, rooting percentage varied from 50% to 92%, with the immersion method yielding the greatest root DW and rating; immersion and 1500 mg·L⁻¹ IBA achieved the greatest rooting percentage. There was little difference between the dip and spray results. Spray and immersion application methods resulted in greater rooting percentages for *Euphorbia* at 21 DAT; by 28 DAT, there was 100% rooting with all application methods and rate combinations excluding control and dip at 500 mg·L⁻¹ IBA. Root rating and mass were greatest with the spray application; spray combined with the higher rates resulted in greater root DW for *Euphorbia*.

12:45–1:00 PM

Drought Stress Tolerance Induced in Ornamental Plants through Foliar Application of Synthetic Abscisic Acid (s-ABA)

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Drought stress is a major contributing factor to inventory loss in shipping and retailing phases of bedding plant production. Plug transplants (seedlings grown at high densities in small, individual cells) are particularly susceptible to drought stress during post-production due to their small root to shoot ratios and low media volume from which to absorb water. An exogenous application of the synthetically derived form of abscisic acid (s-ABA) should reduce transpirational water loss, allowing plants to remain marketable longer when periods of drought stress are experienced. To test the effectiveness of s-ABA in extending marketability of bedding plants in 288 cell plug trays (one plant per 2 cm²), foliar applications of 0, 300, 600, or 900 mg·L⁻¹ s-ABA were applied to half trays of *Impatiens walleriana* (impatiens) or *Petunia xhybrida* (petunia), and treatments of 0, 250, 500, or 750 mg·L⁻¹ s-ABA were applied to half trays of *Tagetes patula* (marigold). For each species, a randomized complete-block design with 4–5 blocks was utilized and each experiment was conducted twice. Plug trays were shipped overnight from the producer and maintained in a greenhouse (38.0 °C day/18.0 °C night). Water was withheld until plants were no longer marketable (more than 50% of evaluated plants per experimental unit visibly wilting). Tray mass was measured and wilting and chlorosis of 100 plants in the center of each tray were evaluated daily. For impatiens and petunias, evapotranspiration (as measured by tray weight) was significantly lower for s-ABA treated plants as compared to controls on the first two days following s-ABA application and treated marigolds had significantly lower evapotranspiration than controls for the first day following s-ABA application. Additionally, s-ABA treatments resulted in significant extensions in marketability (1 to 4 days) as compared to controls. For impatiens and petunias, 600 mg·L⁻¹ and 900 mg·L⁻¹ s-ABA treatments provided significantly greater extensions in marketability than 300 mg·L⁻¹. For marigolds, days of marketability were not significantly different between the s-ABA treatments. Chlorosis was not observed in impatiens, but was noted in the cotyledons of petunias and marigolds; however, chlorosis was not severe enough to cause unmarketability of plant material. Taken together, these results demonstrate that s-ABA applications can significantly extend the marketability of impatiens, petunia, and marigold plug trays, suggesting that s-ABA can be utilized to extend plug tray shelf life during incidents of drought stress common in shipping and retail environments.

Specified Source(s) of Funding: Agricultural Research Initiative.

An asterisk (*) following a name indicates the presenting author.

Monday, July 22, 2013

1:00–1:15 PM

Elicitation of Physiological Stress and Kaempferol Accumulation in Soybean by Sugar Treatment

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Soy flavonoids, such as kaempferols, are well-known anticancer phytochemicals biosynthesized especially under environmental stress. Natural easy-to-use elicitors that can impose the right level of stress to adequately induce flavonoid accumulation in soy plants are not readily available. Thus, a greenhouse experiment was conducted to test the hypothesis that rare sugars will impose physiological stress and increase leaf flavonoid kaempferol yields. Two rare sugars, D- psicose and allose, and two common sugars, D- glucose and fructose were applied at 10 mM semi-hydroponically at V5 stage for seven days. Net photosynthesis was reduced by all sugars up to a maximum of 48% by D-psicose. Reduced stomatal conductance, rubisco carboxylation and photosystem II efficiency appear to contribute to lower photosynthesis. Rare sugar-treated plants quenched excitation energy nonphotochemically more than control or common sugar-treated plants. Growth of expanded and expanding leaves was reduced up to 11% and 24%, respectively, by the sugars.

Concentrations of leaf kaempferols increased under all sugar treatments up to a maximum of 40% in D- allose-treated plants. Both natural and rare hexose sugars are promising natural elicitors of physiological stress that can induce anticancer flavonoid kaempferol synthesis in soy plants.

Specified Source(s) of Funding: NSF - REU Program and Xavier University of Louisiana

1:15–1:30 PM

Studying the Market Potential for Specialty Cultivars of Sunflower, *Helianthus annuus*, Cut Flowers

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In the United States, there is a developing market for field grown specialty locally grown cut flowers. However, certain varieties and cultivars of cut flowers are not readily available in the market. The purpose of research is to time a crop of novelty cultivar sunflowers and research the marketability of the cultivar to wholesalers, retailers, and consumers. *Helianthus annuus* ‘Firecracker’ cut flowers were grown in greenhouses on the campus of Texas State University. Stems were harvested and shown while interviewing floral wholesalers, floral retailers, and Farmers’ Market patrons on their perceptions of the cut flower as a product. The surveys to determine the potential market included interviewing floral wholesalers and retailers and collecting qualitative data through open-ended questions. This was followed up with collecting quantitative survey data at Farmers’ Markets. Results indicated whether specialty cultivar sunflowers cut flowers would be well-received in the cut flower industry.

Monday, July 22, 2013

Desert Salon 4-6

Genetics and Germplasm

Moderator: Tomas Ayala-Silva; ayala-silva@ars.usda.gov

1:00–1:15 PM

Mapping *Alternaria cucumerina* Resistance in *Cucumis melo*

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Alternaria Leaf Blight (*Alternaria cucumerina*) is a serious fungal pathogen affecting worldwide production of melon (*Cucumis melo*). Introgression of resistance genes and selection for resistance requires identification of resistant varieties and would be greatly facilitated by the availability of molecular markers. We are attempting to identify markers linked to *Alternaria* resistance in a recombinant inbred line (RIL) from an initial cross of MR-1 (resistant) and Ananas Yokneam (susceptible). The resistance gene Ac has been reported in USDA breeding line MR-1, but molecular markers have yet to be identified. Utilizing bulked segregant analysis, we have been conducting marker discovery using 176 RAPD and 295 High Frequency Oligonucleotides-Targeting Active Genes (HFO-TAG) primers. Ninety-nine RAPD and 38 HFO-TAG primers were screened using agarose gel electrophoresis, yielding 212 polymorphisms. Additionally, HFO-TAG primers were modified for screening on a fragment analysis system resulting in an additional 544 polymorphisms. Three hundred of the most prominent polymorphisms identified during BSA have been used to construct a linkage map of a population of 94 RILs. This map will have immediate utility in marker identification of gene loci associated with *Alternaria* resistance, as well as other resistance genes found in MR-1.

1:15–1:30 PM

Open Field and High Tunnel Screening for Powdery Mildew Resistance in Strawberry Species and Cultivars in Florida

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Florida is the major fresh strawberry supplier to the eastern states and Canada from December through March, and usually there are several nights with frost each season when overhead irrigation is used to protect against freeze damage. The use of water for freeze protection may become challenging due to increasing water restrictions. Protected environments such as high tunnels and row covers may provide an alternative means of freeze mitigation. However, due to the lack of free water in these systems, conditions are favorable for development of powdery mildew disease. Many breeders have turned to wild relatives as sources of beneficial traits. In strawberry, the wild octoploid species *Fragaria virginiana* and *F. chiloensis* are fully interfertile with the cultivated species, *F. xananassa*. Therefore, the objective of this study was to screen an elite group of wild strawberry accessions for resistance to powdery mildew. In 2010–11 and 2012–13, 27 wild accessions from

the National Clonal Germplasm Repository in Corvallis, OR, and three cultivar checks were planted in a randomized complete block in both open field and high tunnel environments at the Gulf Coast Research and Education Center in Balm, FL. Plots were visually rated for percent coverage of mycelia on the abaxial surface of fully expanded trifoliate leaves using a modified Horsfall-Barratt scale of 0 to 6. Mean scores for the wild species and cultivars ranged from 0.00 to 5.44 and 0.63 to 1.18, respectively. There was a significant difference between genotypes, and the most resistant subspecies showed consistently high levels of resistance. With mean scores of 0.00, the most resistant subspecies were *F. virginiana* subsp. *grayana*, which included accessions NC 95-21-1 (PI 612569) and JP 95-9-6 (PI 612320) and *F. virginiana* subsp. *virginiana*, which included accessions Eagle 14 (PI 612492), Fredrick 9 (PI 612493), Montreal River 10 (PI 612497), NC 96-48-1 (PI 612324) and NC 96-35-2 (PI 612323). Within *F. chiloensis*, BC Canada (PI 612488) and Darrow 72 (PI 236579) had mean scores below one. Ten accessions contributed to a significant year x location x genotype interaction, but there was a high correlation between environments for genotype mean scores with years combined ($r = 0.89$, $P = < 0.001$). This information may be useful for breeders, as sources of resistance to powdery mildew are available within the wild accessions. Many accessions are more susceptible than current cultivars, and this must be considered when using these accessions in breeding to access other important traits.

1:30–1:45 PM

Two New Promising Cultivars of Mango for Florida Conditions

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Mango cultivars are mostly the result of random selections from open pollinated chance seedlings of indigenous or introduced germplasm. The National Germplasm Repository (genebank) at the Subtropical Horticulture Research Station (SHRS) in Miami, FL, is an important mango germplasm repository and has contributed in many ways to the development of numerous tropical and subtropical fruit cultivars. This study was carried out to compare the physico-chemical and morphological characteristics of these two promising mango cultivars. In an effort to develop novel mango cultivars at the SHRS, mature fruit was randomly harvested from open pollinated trees. From these fruit and subsequent seedlings two selections have been developed and named, 'Seedling of S-10' and 'Seedling of Keitt'. Data on various physico-chemical and morphological characteristics

An asterisk (*) following a name indicates the presenting author.

were collected on ripe fruit. Traits assessed included fresh and dry fruit weight, weight, length and width of seed, and stone, total soluble solids, fruit color, fiber content, internal breakdown “jelly seed,” and anthracnose resistance. At room temperature, fruit of both selections took approximately 4–5 days to ripen. However, ‘Seedling of Keitt’ demonstrated larger fruit size with increased fruit firmness and lower anthracnose incidence indicating its potential for extended shelf life. Highest levels of total soluble solids were observed for ‘Seedling of S-10’ with 19.75 °Brix with ‘Seedling of Keitt’ having an average of 14.71 °Brix. The lower soluble solids levels observed in ‘Seedling of Keitt’ could be an advantage as extended storage/shelf life has been reported in fruits with lower sugar content. At least two taste panels also demonstrated clear preference for ‘Seedling of S-10’ selection. ‘Seedling of S-10’, is a high yielding mid-season cultivar with attractive reddish to yellow skin, excellent taste and very low fiber. Characteristics of these two new selections are described using over twenty descriptors (IPGRI, 2006) for mango. Results of the research will help introduce the two new selections, show their qualities and promote their use in local and international markets.

1:45–2:00 PM

Agronomic Performance of Several Cavendish Cultivars (*Musa spp.* AAA) under Plastic Greenhouse

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Banana has been grown both in open-field and protected cultivation in Turkey. Protected cultivation is very popular due to the high yield and quality. The objective of the study was to evaluate agronomic performance of five new banana cultivars under plastic greenhouse. ‘MA 13’, ‘Williams’, ‘Jobo’, ‘CV 902’, and ‘Dwarf Cavendish’ (control) cultivars were used as experimental material. Stem circumference, stem height, plant height, total number of leaves, active number of leaves / bunch, stalk circumference, and days from shooting to harvest and bunch weight were determined according to cultivar. The lowest stem circumference, stem height and bunch stalk circumference were found in ‘Dwarf Cavendish’ and the highest in ‘Williams’. Total number of leaves varied between 26 and 33. Number of days from shooting to harvest was the shortest (141 days) in ‘Williams’ and the longest (163 days) in ‘MA 13’. ‘MA 13’ had the highest bunch weight (59 kg) and the lowest (43 kg) in ‘Dwarf Cavendish’. In conclusion, we found that all tested cultivars were superior to ‘Dwarf Cavendish’ under unheated plastic greenhouse.

2:00–2:15 PM

Reconstructing the Domestication Pathway of Macadamia from Australia via Hawaii and California

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Macadamia F. Muell is an iconic Australian plant as is the only international food crop developed from the Australian flora. The genus is a member of the ancient Gondwantic family, Proteaceae, and is endemic to the lowland rainforests of the sub-tropical rainforest of eastern Australia. This paper reviews historical records and current international collaborative research efforts to better define the pathway and wild origin of the domesticated germplasm. The first recorded ex-situ planting of *Macadamia* F. Muell. was in 1858 in the Brisbane Botanical Gardens and over the subsequent decades macadamia became a popular backyard tree in subtropical Australia. In the late 19th century, macadamia seed were introduced into California and Hawaii. There are two recorded introductions into Hawaii of *M. integrifolia*, the preferred commercial species; by William Purvis to the big island in 1881 and by Robert Jordan to Oahu in 1892. There is strong evidence linking the Jordan introduction to a remnant tree on the Gold Coast hinterland of SE Queensland, Australia, but the wild origin of the Purvis introduction is unknown. By 1920, commercial interest in macadamia had developed in Hawaii and several large and other small orchards were established using seed reportedly collected from the Purvis and Jordan introductions. Following the successful development in Hawaii of grafting in the mid-1930s, a selection program was initiated by surveying the seedling orchards for elite performing individuals from which the initial cultivars of the Hawaiian breeding program were selected. It is estimated that 70% of the current world’s commercial macadamia orchards are planted with cultivars originating in Hawaii. Macadamias were also introduced into California in the late 19th century, but much less is known

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of the origin of this germplasm. A subsequent selection program in California produced cultivars that were commercially planted in California and South Africa. With the expanding opportunities offered through molecular technology it is now possible to better define the wild origins of the commercial cultivars. The results from this study will be used to highlight the heritage importance of this unique plant and assist focus current breeding programs.

2:15–2:30 PM

Geographical Distribution of Genetic and Phenotypic Diversity of *Dirca palustris*

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We sought to document genetic and phenotypic diversity within eastern leatherwood (*Dirca palustris*), a North American shrub that is rare in horticulture despite its yellow flowers and autumnal leaves, arborescent form, disease resistance, and shade tolerance. Strength of the genetic structure among 92 populations of *D. palustris* throughout its distribution was assessed to identify populations of special interest to horticulturists and conservationists. The *psbD-trnT^(GGU)*, *trnL-trnF*, and *rpl32-trnL^(UAG)* noncoding chloroplast regions of three plants from each population were sequenced, and haplotype diversity was determined from a concatenated sequence of 3236 bases. High genetic diversity was found; there were 24 haplotypes, including private haplotypes in 14 populations. Areas of diversity, which had either many haplotypes or unique haplotypes, included the Cumberland Plateau (Kentucky/Tennessee), the Ozark Mountains (Arkansas/Missouri), the southern Atlantic Seaboard (Carolinas), and the Gulf Coast (Mississippi/Florida). Plants in northern latitudes appear derived from northern refugia (e.g., Cumberland Plateau or Ozarks), and two haplotypes farther south have not dispersed northward since the last glacial maximum ~18,000 years ago. The Atlantic Seaboard and Northeast have a distinct collection of haplotypes, suggestive of dispersal limitation across the Appalachian Mountains. Individuals in several populations in the Southeast were phenotypically distinct, with wider calyxes and bud scale pubescence that was white instead of the brown described for the species. Plants in these populations were united by a chloroplast mutation, indicating they are derived from a common maternal ancestor. The taxonomic status of these southeastern populations awaits clarification expected from the study of nuclear genotypes and morphology. Our results should facilitate making horticultural selections of *D. palustris* and will inform decisions about the preservation of rare genotypes.

2:30–2:45 PM

Genetic Diversity of Ruth's Golden Aster (*Pityopsis ruthii*), An Endangered Species

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Ruth's golden aster (*Pityopsis ruthii*) is federally endangered species endemic to the Hiwassee and Ocoee Rivers in Tennessee. Plants grow in crevices on exposed rocks that are in and between the river channel and the adjacent forested slopes. Populations occur downstream of hydroelectric dams. The available long-term data, though limited in scope, suggests that substantial declines in *P. ruthii* have occurred since monitoring began in 1986, especially along the Hiwassee River. The reach of the Ocoee River where the plants occur regularly receives water flows, which maintains open habitat for the species. Run-off from precipitation and input from small tributaries comprise the normal flow in the river and represents a small portion of the total flow formerly present in the Hiwassee River. Without normal flow in the river and the associated disturbance, multiple woody and herbaceous plants are colonizing the habitat and displacing *P. ruthii*. Knowledge of genetic population structure is essential for understanding the magnitude of seed dispersal, genetic drift and selection pressures. The attributes of the genetic structure of *P. ruthii*, in particular genetic erosion in isolated and fragmented populations, may exacerbate the effects of habitat degradation. To assess genetic diversity, 134 samples from 4 discrete locations were genotyped with 12 microsatellite loci. The number of alleles per locus, observed (H_o) and expected (H_e) heterozygosity, and the proportion of genetic variance (F_{ST}) were calculated using ARLEQUIN and FSTAT, and genetic structure of the population was evaluated using STRUCTURE. The number of alleles per locus ranged from 4 to 13, H_o was 0.41 and H_e was 0.58, and F_{ST} was 0.32. STRUCTURE analysis assigned the individuals into three distinct clusters that corresponded well to the a priori grouping of plants from the sampled populations. The AMOVA analysis found that most of the genetic variation was attributed from variance among all individuals (49.10%) rather than among three groups indicated by STRUCTURE (23.47%), among populations within groups (9.24%), and among individuals within populations (18.19%). These results imply that gene flow is limited between the rivers and that nonrandom mating is occurring within populations and warrants further examination of population structure, mating systems, and pollen and seed dispersal.

Monday, July 22, 2013 Desert Salon 13-14

Viticulture and Small Fruits

Moderator: Mercy A. Olmstead, mercy1@ufl.edu

1:45–2:00 PM

Applications of Acadian LSC™, a Commercial Extract of *Ascophyllum nodosum* Increase Yield and Improve Uniformity in ‘Pinot Noir’ Wine Grapes

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Acadian Seaweed extracts (ASE) have been used in wine grape production to improve plant establishment, rachis length, increase set, and to enhance yields. In addition to these responses, visual improvements in color uniformity have been observed following applications of ASE, potentially indicating increased uniformity of maturity. The objective of this study was to evaluate the effects of ASE on yield, and Brix uniformity of ‘Pinot Noir’ grapes grown on the central coast of California. A commercial ‘Pinot Noir’ vineyard in Soledad, CA, was selected for this trial. Large blocks were paired by rootstock and clone, and assigned to either a grower standard practice or ASE (Acadian LSC, Acadian Seaplants Limited) treatment. ASE treatment consisted of a full season application program at recommended rates and timings. Samples taken approximately one month before commercial harvest showed a significant increase in cluster weight in ASE treated clusters. Untreated clusters had more berries with shrivel than treated clusters. Brix measurements from composite berry samples indicated lower Brix on ASE treated clusters. This higher bunch weight and lower Brix in ASE treated fruit may be a result of the increased early shrivel in control fruit. No differences in juice pH were detected, and the amount of juice per gram of berry was similar in both treatments. When individual berries in a bunch were measured for Brix, ASE treated bunches showed less variation in Brix. Across all of the samples, ASE treated fruit had a smaller range in Brix than did the control fruit. This reduction in variation in Brix comes primarily from fewer berries with very low Brix measurements in the ASE treated fruit. Yield at commercial harvest was 7.4% higher in ASE treated blocks, and Brix was 0.55 degrees higher. These results indicate the potential to extend applications of ASE beyond improving rachis length, berry set, and yield to increasing the uniformity of berries both within bunches and across vines.

2:00–2:15 PM

Mechanical Canopy Management Reduces Labor Costs and Maintains Fruit Composition in ‘Cabernet Sauvignon’ Grape Production

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Three canopy management methods, hand pruning (HP), mechanical prepruning with hand shoot thinning (MP+HT), and mechanical box-pruning with mechanical shoot thinning (MP+MT), were applied with the objective of achieving similar and commercially marketable ‘Cabernet Sauvignon’ grape (*Vitis vinifera*) yields while maintaining vine balance and comparing labor operations costs. Canopy management system labor operation cost estimates indicated a 62% and 80% labor savings with the MP+HT and MP+MT treatments, respectively when compared with HP. The total shoot density of the vines was unaffected by the treatments applied. However, the contribution of count shoots increased with the concomitant addition of mechanization to canopy management. All treatments achieved similar canopy architecture and microclimate. The treatments did not affect photosynthetically active radiation (PAR) intercepted in the fruiting zone of canopy at veraison. All treatments had similar yield, total soluble solids (TSS), juice pH, and titratable acidity (TA) at harvest. Berry skin total phenolics, anthocyanins, and tannins when measured at harvest were also similar among the treatments applied. All treatments tested were within acceptable Ravaz index limits of 5 to 10 lb/lb. However, only MP+MT treatment reached a near optimum leaf area to fruit ratio of 1.2 m²·kg⁻¹ and pruning weight of 1.0 kg·m⁻¹ for warm climate viticulture. The results of this study provide commercially acceptable mechanical canopy management options that may provide labor cost savings for winegrape growers in California’s San Joaquin Valley.

2:15–2:30 PM

Training Systems for Hybrid Winegrapes in Subtropical Climates

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Vine productivity is a function of adequate shoot growth, disease management, and light penetration into the canopy. High vigor, prevalent in a humid climate, can lead to decreased vine productivity and fruit yield by increasing shading in the canopy. Reduced light penetration into the fruit zone reduces fruit bud initiation, resulting in declining yield over subsequent years. The objective of this project was to address declining yields in

An asterisk (*) following a name indicates the presenting author.

Florida hybrid bunch grapes by improving vine balance with the application of different training and renewal systems. In 2011 and 2012, six-year-old 'Stover' grapevines were trained to two different pruning systems, a bilateral cordon (control) or four-arm kniffen (4AK). In addition, the existing bilateral cordon system was altered in two separate treatments to renew cordons [1/2 of vine each year; cordon renewal (CR)] or extend cordon length, in which every other vine was removed [alternate vine removal (AVR)]. All treatments were pruned to approximately 100 buds/vine during the dormant season. Total yield per vine, berries per cluster, berry weight, fruit quality assessments [Brix, pH, and titratable acidity (TA)], dormant pruning weights, and calculated Ravaz index was collected each year. In 2011, the average yield per vine was greatest in control, followed by AVR, while in 2012, vines in the AVR had the greatest average yield per vine. In both years, extending the cordon length in the AVR treatment resulted in the highest number of buds per vine, contributing to the higher average yield per vine. Berry weight was not affected in either year; however berries per cluster were reduced in the control when compared other training or renewal systems in 2011. The Brix, pH, and TA were not affected by training system in either year. Retraining or renewing vines reduced pruning weight in the 4AK treatment when compared to CR or AVR treatments in 2011 only. The Ravaz index, a measure of vine balance, indicated that all treatments were undercropped in both 2011, with ratios of yield (kg):pruning weight (kg) approaching the ideal (i.e., 5–10) in only the 4AK and AVR treatments. It appears that fruit quality is not compromised with shifts in either the training or renewal process in 'Stover' bunch grapes; however the Ravaz index indicates that either extending the cordon length or spreading the canopy vertically with a 4AK system improves vine balance in Florida. Further monitoring of these training and renewal systems is required to determine long-term effects.

2:30–2:45 PM

The Effect of Root Restriction on Nitrogen Levels and Gene Expression Regulating Nitrate Reduction and Ammonium Assimilation in Grapevines (*Vitis vinifera* L. x *Vitis labrusca* L.)

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To unravel the inhibition of root restriction on shoot growth, the changes of nitrogen levels and glutamine synthetase (GS) activity were investigated in four-year-old root-restricted 'Kyoho' grapevines (*Vitis vinifera* x *Vitis labrusca*) in greenhouse from veraison up until 62 days after harvest. Results showed that root restriction significantly decreased nitrogen levels (the total amount of N, (NO₃⁻ + NO₂⁻)-N and NH₄⁺-N content) in leaves and roots of grapevines. Root restriction reduced not only N remobilization and recycling from leaves to roots after harvest, but also the total GS activity in both leaves and roots, suggesting that root restriction has a negative influence on glutamine synthesis in grapevines. Therefore, less N reserve in root-restricted vines might be responsible for shoot growth inhibition under root restriction. To further evaluate the effect of root restriction on expression of key nitrogen metabolism-involved genes (NR, NiR, pGS1;1, pGS1;2, GS2, Fd-GOGAT and NADH-GOGAT), two-year-old 'Jumeigui' grapevines (*Vitis vinifera* L. x *Vitis labrusca* L.) were selected for the experiment. Root restriction resulted in down-regulation of genes involved in nitrate reduction and ammonium assimilation in leaves, especially at midday, regardless of the slightly higher transcript levels of all these genes in white and brown roots under root restriction. In addition, the mRNA levels of genes related to GS1/NADH-GOGAT pathway was lower in root-restricted petioles, while coinciding with the up-regulation of genes involved in GS2/Fd-GOGAT route, suggesting a compensatory strategy helpful to alleviating the reduced ammonium assimilation efficiency under root restriction. The inhibition of vegetative growth in grapevines under root restriction is closely associated with the down-regulation of gene expression in nitrogen metabolism at the whole-plant level.

Specified Source(s) of Funding: National Natural Science Foundation of China (No.30871695)

2:45–3:00 PM

Vine-row Groundcover Management Affects Pruning and Cluster Weights, Petiole C and N Content, and N Leachate in a New York Vineyard

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New York vineyards are often situated on fertile soils where excessive vine growth causes problems with high vigor and undesirable “green” flavors in red wine-grapes. We are comparing the effects of four vine-row groundcover management systems (GMS) on vine nutrient status, vine growth and yields, soil conditions, and nutrient leaching in a Finger Lakes ‘Cabernet Franc’ vineyard. Four GMS treatments were maintained in 1-m-wide strips beneath the vine rows: 1) native vegetation; 2) glyphosate herbicide; 3) white clover (*Trifolium repens*) seeded in May each year; and 4) mechanical cultivation. After two years of treatments, fruit yields, dormant pruning weights, cluster counts, and cluster weights were greater in glyphosate plots than in other treatments. Petiole C and N content were greatest in white clover plots, and soil N and K availability were greater in the glyphosate and white clover plots. Subsoil N leaching was greater beneath white clover plots, while dissolved organic carbon leaching was greater in cultivated and glyphosate treated plots. Volumetric soil water content usually ranked glyphosate > cultivated > native vegetation > white clover during the growing season, but vine water potential was not closely correlated with soil water content even during a prolonged drought during 2012.

Specified Source(s) of Funding: USDA–SCRI

3:00–3:15 PM

Pruning Systems and Canopy Management Practice Interact on ‘Syrah’ Yield and Fruit Composition

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A production trial in California’s San Joaquin Valley (SJV) was conducted where the canopy microclimate of ‘Syrah05/SO4’ grapevines was altered through three pruning systems, and two leaf removal treatments arranged factorially to rejuvenate vineyards with declining productivity. Vines were either pruned by hand to 44 nodes each, mechanically box-pruned to a 10 cm hedge, or cane-pruned by hand to six, 8-node canes arranged in opposing directions of the row with horizontal canopy separation. Outer surface layer of leaves were removed mechanically 20 days postbloom on the east side of the canopy in a 45 cm zone above the cordon in the fruit zone, or not. Yields from spur and mechanically box-pruned vines were considered too low for the study area, and leaf removal had no effect on yield components. Spur pruned vines reached 24 °Brix earlier than mechanically box pruned and cane pruned vines, in each year. Leaf removal had no effect on fruit composition of ‘Syrah’ at harvest. Berry skin phenolics were not consistently affected by treatments applied. Cane pruning resulted in 3.8 leaf layers, with 32 shoots per 30 cm of row, 7.77 kg/kg Ravaz Index, and

consistently ripened 22 tons/ha to 24 °Brix and should therefore be used in the SJV to improve yields in vineyards with declining productivity. The study identified a pruning system for vineyards in warm climates that can sustain yields and provides management information for growers on how to rejuvenate vines that have declined in productivity.

Specified Source(s) of Funding: American Vineyard Foundation

3:15–3:30 PM

Mechanical Canopy and Crop Load Management of Pinot Gris in a Warm Climate

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A field study was conducted to determine interactive effects of mechanical canopy management on the optimum cropping level and Ravaz Index of Pinot gris in a warm growing region. The study examined two pruning methods, three shoot thinning and two leaf removal treatments arranged factorially in a randomized complete-block design with four replications. The pruning methods were applied by either hand pruning to 23 nodes/m or mechanically hedging and retaining a 100 mm spur height. The shoot thinning treatments were applied mechanically at modified E-L stage 17 to retain 23 (low), 33 (medium) or 45 (high, not thinned) shoots/m of row. The leaf removal treatments removed leaves on the east side of the canopy in a 450 mm zone in the fruiting zone, 20 days post bloom with a mechanical de-leafer or no leaf removal was done. The interaction of mechanical hedging and medium shoot thinning treatments reduced the contribution of non-count shoots to total shoots. The percentage of canopy gaps, and photosynthetically active radiation increased, while canopy leaf layers decreased with the application of leaf removal regardless of pruning or shoot thinning regime in both years. Yield increased and berry and cluster weight decreased in both years with the application of mechanical hedging and medium shoot thinning compared to hand pruned vines without any detrimental effects on fruit composition. To achieve the economic crop level threshold of 8.15 kg/m, a Ravaz Index of 10.2 to 12.0/kg kg was needed. This Ravaz Index corresponded to a pruning weight of 0.82 to 0.92 kg/m. The study identified a mechanical hedging and shoot thinning method where a 100 mm spur height was retained during the dormant season, and 35 shoots/m of row is retained at E-L stage 17 to optimize crop load without adversely affecting pruning weight or fruit composition in a warm climate. The identified method provided 79% labor operations cost savings compared to hand pruning alone.

Specified Source(s) of Funding: American Vineyard Foundation

An asterisk (*) following a name indicates the presenting author.

Monday, July 22, 2013**Desert Salon 4-6****Postharvest**

Moderator: Bruce D. Whitaker; bruce.whitaker@ars.usda.gov

3:00–3:15 PM

Strawberry Flavor: Diverse Chemical Compositions, a Seasonal Influence, and Their Effect on Sensory Perception

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Fresh ripe strawberries are valued globally for their characteristic red color, juicy texture, distinct aroma, and sweet fruity flavor. To ensure continued consumption, flavor must be consistently high in quality, but defining this complex trait has proven to be difficult. Human perception of flavor is the integration of multiple sensory inputs, the most influential being the chemical senses of taste and olfaction. Olfaction is divided into orthonasal (smell) and retronasal (flavor). Previous efforts detailing strawberry flavor have supplied an index of volatile constituents, in which the significance of an aroma volatile to flavor is determined indirectly by the orthonasal odor threshold. This is an inappropriate methodology, as orthonasal olfaction does not integrate with taste perception like retronasal olfaction. In this study, genetic and environmentally induced variation among strawberry fruit is exploited by simultaneously assaying fruit for: biochemical inventories of volatile compounds, sugars, and organic acids; physical measures of titratable acidity, soluble solids content, and firmness; and consumer hedonic and sensory responses. Data are analyzed to determine seasonal effects, gross variation across genotypes, and fruit attributes influencing hedonics and sensory perception of strawberry fruit using a psychophysical approach. This approach, previously only applied to tomato, garners insights into flavor chemistry, the interaction between taste and olfaction, and a paradigm for enhancing liking of natural products. Seasonal progression exerts a negative influence on soluble solids content in subtropical Florida and sucrose is identified as the waning primary metabolite, leading to decreased

volatile content. These alterations are perceivable as sweetness intensity, flavor intensity, and texture liking have significant influence on overall liking of strawberry fruit through variations in sugar concentration, specific volatile compounds, and fruit firmness. Interestingly, some of the most abundant volatiles do not contribute to consumer liking, whereas other less abundant volatiles contribute significantly. Thus reducing the importance of previously determined volatiles and recognizing novel components with a positive influence on flavor. In strawberry, a subset of specific aroma volatiles make contributions to perceived sweetness independent of sugar concentration in the fruit. More volatiles have been identified as having a positive effect on perceived sweetness in strawberry than previously observed in tomato. This observation suggests that strawberry is a more appropriate system for studying the effects of aroma volatiles on perceived sweetness. Volatiles that increase perception of sweetness without adding sugar will have far-reaching effects in food chemistry, and also provide metabolic targets for future breeding efforts of consumer defined traits.

3:15–3:30 PM

Development of Tomato Aroma Profiles during Low Temperature Storage in Air or CA and Recovery during Shelf Life

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Commercial tomatoes are usually harvested before full red ripe color has developed to ensure that they attain the desired color after being exposed to low temperature during distribution. Since the lowest recommended as safe temperature for tomatoes (12.5 °C) was identified based on external appearance (i.e., lack of chilling injury symptoms) we hypothesize that this doesn't necessarily mean that the volatile composition of the fruit is not significantly altered at 12.5 °C, degrading the flavor profile of the fruit. 'Tasti Lee' tomatoes were held for 5 or 10 days in air or CA (12% O₂ + 4% CO₂ or 8% O₂ + 6% CO₂ at 12.5 °C; 8% O₂ + 6% CO₂ and 3% O₂ + 8% CO₂ at 15 and 18 °C). Using GC-MS, we obtained the full flavor profile of fruit both after low temperature storage as well as after shelf life of 2 days in

An asterisk (*) following a name indicates the presenting author.

air at 20 °C. In most cases, total volatiles after the shelf life increased significantly both after 5 and 10 days of storage. Lower temperature reduced total volatile production and the CA treatments reduced the effect of storage temperature on the total volatiles. Volatile inhibition at lower temperatures was only temporary since the total volatile amounts recovered during the shelf life period. The CA inhibited volatile formation during storage compared to air and the recovery during shelf life was less than in the air-stored fruit. However, it was observed that the total amount of volatiles after 5 and 10 days of storage for the more extreme CA treatment at each temperature remained close to initial amounts. The CA storage resulted in limited amounts of 6-methyl-5-heptene-2-one(MHO), a basic tomato flavor compound with a fruity, floral aroma. Air storage resulted in higher amounts of MHO than CA storage with more extreme atmosphere compositions resulting in significantly lower amounts of MHO, which remained close to the initial levels even after 10 days of storage. Also, the temperature effect on MHO production under CA was limited since MHO remained at similar levels after 5 and 10 days of storage. Trans-2-hexanal and cis-3-hexanal, two lipid derived molecules with green, grassy attributes that are significant for tomato flavor, were higher in air storage while temperature had less effect than storage atmosphere. The results suggest that it is important to compare volatile profiles of tomatoes at equivalent ripeness stages when comparing storage treatments, which will be addressed in our future experiments.

3:30–3:45 PM

Metabolomics Combined with Standard Quality Measures of ‘Honeycrisp’ Apple Fruit Reveals Aspects of Metabolism Related to Flavor, Crispness, Maturity, and Storability

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‘Honeycrisp’ is popular dessert apple. As acreage of planted ‘Honeycrisp’ increases, reliably assessing optimum storage duration is becoming increasingly important. Apple fruit quality is typically assessed by measuring titratable acidity, internal ethylene concentration, firmness, soluble solids, and starch index. These evaluations are commonly used both in commercial and research settings to analyze storage potential to decide whether fruit is ready to harvest and how long it will be expected to store. In research, metabolomic techniques can be used to attribute metabolic events to the progression of quality data measurements. The current study evaluates changes in levels of peel metabolites including volatiles, amino acids, organic acids, carbohydrates, cell wall, and membrane components and relates them to standard quality measures associated with ripening, flavor development, and storage potential. Volatile compounds characteristic of ripeness to overripeness tend to increase with storage, concomitant with increases in internal ethylene and starch clearing. Certain amino acids and organic acids exhibited variable patterns of response that may suggest metabolic shifts such as the response to initial chilling and the transition from ripeness to senescence. While metabolic indication of senescence corresponds to changes quality parameters such as the loss of firmness, the fruit response to chilling is not consistently captured by quality measurements. Results suggest that the divergence from a healthy metabolome following storage disorder onset, which includes changes cell membrane and cell wall components, is not consistently captured or predicted using standard apple maturity and quality measurements. Monitoring metabolites may provide a more reliable indication of not only fruit quality, but also susceptibility to disorders.

3:45–4:00 PM

Transcriptome Analysis of European Pears (*Pyrus communis* cv. Bartlett) Reveals Significant Gene Families and Co-expressed Genes Associated with Development of Ripening Capacity by Temperature Conditioning

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Freshly harvested early-season European (*Pyrus communis*) pears often fail to achieve acceptable quality and need conditioning treatments including ethylene and/or cold temperature to develop

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ripening capacity. Our objective is to understand the influence of temperature on ripening capacity development, focusing on temperature conditioning and to identify genes closely associated with the onset of ripening capacity. Tissue samples collected from 'Bartlett' pears exposed to treatments that induce subsequent ripening within six days at room temperature (0 °C - 14 days and 10 °C - 5 days), together with the control (fruit at harvest) were submitted for RNA sequencing. Through Trinity assembler and RNA-Seq by Expectation-Maximization, 101,229 contigs (mean length = 911.7) and 68,067 unigenes were generated. Of these unigenes, more than 30.2 % were annotated to public databases. By utilizing EBSeq, 8536 and 7938 unigenes were identified as differentially (DE) expressed sequences between the 0 °C treated and control fruit, and between the 10 °C treated and control fruit, respectively. The fold changes of these DE unigenes from the two comparisons were highly correlated in the regression analysis. Mercator–Mapman annotation classification showed that the 0 °C treatment induced more stress-related unigenes than the 10 °C treatment, the largest number of DE unigenes in the hormone group were auxin- and ethylene- related (30% and 33%, respectively), and the most abundant transcription factor families were bHLH, AP2/EREBP, and MYB. According to the protein interaction network analysis in Cytoscape using the IntAct database, some temperature-regulated genes appeared to be involved in the signaling network for ripening capacity development. Additionally, weighted gene co-expression network analysis determined five clusters of co-expressed genes correlated with fruit characteristics during ripening, such as firmness and ethylene production. The unigenes that were highly correlated to the firmness at day six are likely candidates for future research to determine biomarkers for detecting pear ripening capacity.

Specified Source(s) of Funding: California Pear Advisory Board
Vietnam Education Foundation Jastro Research Fellowships

4:00–4:15 PM

Lipoxygenase and Apple Aroma: Gene Expression of Lipoxygenase Family Members in Apple Peel

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Many aroma volatiles in fresh apple are produced via cellular disruption due to cutting or mastication. Six-carbon (C6) volatiles, including the aldehydes trans-2-hexenal, hexanal and cis-3-hexenal, as well as their corresponding alcohols, are produced from action of the lipoxygenase (LOX) pathway on substrates released by tissue disruption. LOX genes are sometimes classified based on function and are grouped into 13-LOX and the 9-LOX groups, which generate C6 and C9 aldehydes, respectively. Another classification system is based on structure with those having a putative chloroplast transit peptide called type-2 LOXs, and those that do not are called type-1 LOXs. All

13 LOXs are thought to be type-2LOXs. It has been proposed that a 13-LOX gene with a chloroplast transit peptide may be involved in apple aroma. In our work, twenty-two lipoxygenase gene sequences were retrieved from the apple genome to identify possible LOX gene candidates that might participate in the aroma production in apple. We isolated RNA from apple skin for 8 time points throughout ripening (immature to senescent stage), made cDNA and performed semi-quantitative RT-PCR for all 22 LOXs. Amplified fragments from the coding sequence of each LOX were sequenced and compared to the published genomic sequence. The expression of most of genes exhibited no discernable pattern during ripening; however, at least 6 LOXs were highly expressed and ripening-dependent. qRT-PCR was performed on these 6 LOX candidates. Of these, 4 LOX genes were down-regulated during ripening, and 2 LOX genes were up-regulated as ripening progressed. Changes in the lipid profile and C6 aldehyde and alcohol production correlated (positively and negatively) with changes in gene expression data for the 6 LOX genes, suggesting they are good candidates for further investigation into their involvement in the biosynthesis of disruption-dependent aroma volatiles. Confocal microscopy analysis and biochemical characterization of apple LOX proteins is needed to interpret gene expression data and to more fully understand the role of LOX in aroma formation.

4:15–4:30 PM

Effect of Postharvest Treatments on Volatiles in 'Rio Red' Grapefruit Juice

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The effect of two commercially practiced postharvest treatments, degreening and low-temperature conditioning, on the juice volatiles of 'Rio Red' grapefruit (*Citrus paradisi* Macf.) were studied. Early season (November) grapefruits were degreened using 3.5 ppm ethylene in a commercial packing-house to accelerate the peel color change. Non-degreened (control) and degreened grapefruits were stored under simulated market conditions for 21 days at 10 °C, then 14 days at 21 °C. The volatile constituents were separated on a DB-5MS capillary column by GC and identified by comparing Kovats indices and mass spectral data. Nootkatone gives a characteristic odor to grapefruit, and was higher in non-degreened fruits after 35 days of storage as compared to levels at 0 days. By contrast, nootkatone was not detected in degreened fruits after 21, 28, and 35 days of storage. D-limonene, the major component of volatile oils, decreased in both non-degreened and degreened fruits with longer storage, with highest levels observed at 0

An asterisk (*) following a name indicates the presenting author.

days. After 35 days of storage, no difference was observed in the levels of linalool oxide between both treatments, while β -caryophyllene was higher in non-degreened fruits. Low-temperature conditioning (7 days at 16 °C) is used prior to cold storage to reduce chilling injury in grapefruits. To examine effect of low-temperature conditioning and storage at 11 °C and 5 °C on volatile oils in Rio Red grapefruit, fruits were stored for 12 weeks and juice samples were collected at 3-week intervals. D-limonene levels sharply increased in all three treatments at 3 weeks after storage; however, after 12 weeks, D-limonene levels were similar to levels at 0 days. Nootkatone was higher in the grapefruits stored at 11 °C than those stored at 5 °C and CD fruits, but, the grapefruits stored at 5 °C had higher levels of β -caryophyllene and linalool oxide compared to 11 °C and CD fruits. This project is based upon work supported by the USDA–NIFA # 2010-34402-20875 “Designing Foods for Health” through the VFIC and Research Grant Award No. TB-8056-08 from the Texas Department of Agriculture, Texas Israel Exchange and the United States–Israel Binational Agricultural Research and Development Fund.

4:30–4:45 PM

Phospholipase D α Activity in Mesocarp Tissues from Fruit of *Cucumis melo* L. *Reticulatus* and *Inodorus* Cultivars

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In muskmelon (*Cucumis melo* L.) fruit, phospholipase D α [PLD α (EC 3.1.4.4)] activity is associated with mesocarp tissue softening and plasma membrane degradation during senescence. PLD α activity is regulated by a number of factors, most notably [Ca²⁺], as well as pH, substrate lipid composition, and reaction time and temperature; however, no enzyme assay has been established specifically for *C. melo* mesocarp tissues. This study determined optimal conditions to assay total PLD α activity in homogenates of lyophilized muskmelon mesocarp tissues, which were as follows: incubation in medium buffered at pH 5.7 including 20 mM Ca₂⁺ for 30 min at 37 °C. The assay was utilized to measure PLD α activity in hypodermal and middle mesocarp tissues from fruit of four cultivars representing netted (‘Cruiser’ and ‘Nitro’) and hybrid honey dew (‘Honey Yellow’ and ‘Morning Ice’) types of muskmelon. Tissue samples were excised from fruit and frozen in liquid N₂ on day 0 after overnight transport, after 5 d storage at 4 °C, and after 5 d at 4 °C plus 3 d at 21 °C. At the end of this 8-d regime, all fruit were still in excellent condition. Generally, PLD α specific activity (units/min/mg protein) was high on day 0 in both mesocarp tis-

ues from all four cultivars, and there was a substantial increase in activity after 5 d at 4 °C, except for hypodermal mesocarp from ‘Morning Ice’ and ‘Nitro’, which showed no change. Transfer of fruit to 21 °C for 3 d after 5 d at 4 °C resulted in a marked decline in PLD α activity in both mesocarp tissues from ‘Cruiser’ melons, whereas the decrease was more modest in mesocarp from ‘Honey Yellow’ and ‘Nitro’, and activity increased in middle and hypodermal mesocarp from ‘Morning Ice’. Optimization of the PLD α enzyme assay for muskmelon mesocarp tissues, in addition to the observed differences among fruit of the four cultivars, establishes a framework for further investigation of the role of PLD α activity in postharvest fruit softening, senescence, and loss of quality.

Monday, July 22, 2013

Desert Salon 9-10

Organic Horticulture

Moderator: Carl E. Motsenbocker, cmotsenbocker@agcenter.lsu.edu

4:15–4:30 PM

Summer Cover-cropping Treatments for Enhanced Winter Vegetable Crop Nutrition, Growth, and Yield

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Summer cover crops of cowpea (*Vigna unguiculata*) or marigold (*Tagetes patula*) were tested against a summer fallow control for effects on soil and crop nutrition, growth and yield of a subsequent broccoli crop. Results showed that summer cover cropping enhanced soil organic matter content, soil and crop nutrients, crop growth, and marketable yield compared to the fallow system. Soil nutrient contents were low at the initial samplings stages, increased following cover crop incorporations, and were low at vegetable crop harvest. Higher soil NO₃ after cover crop incorporations was a likely indication of nutrient mineralization. Soil and crop nutrients, growth, and marketable yields increased with increasing years of cover cropping rotations, indicating their build-up effects. Growth and yield of the subsequent crop was more pronounced with cowpea cover cropping than marigold.

4:30–4:45 PM

Compost, Cover Crops, and Mulch Effects in Organic Vegetable Systems

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This multi-disciplinary project addresses critical stakeholder needs for improving organic vegetable farming practices to optimize pest management, crop quality, and profitability, while enhancing soil quality to help mitigate global climate change. Six cropping system treatments with different management practices were examined in Iowa: four treatments using cover crops (CC) and two without CC. Of the four CC treatments, two were treated as organic no-till (cover crop rolled) and two were tilled prior to vegetable crop planting/transplanting. Compost and mulch were applied to a subset of these treatments to test the effect of soil amendments. In 2012, peppers and sweet corn were grown, with plant growth, yields, and pests assessed throughout the season. Using lysimeter measurements, leached nitrate-N concentrations were determined throughout the growing season. Organic no-tillage crops performed better in 2012 than in 2011, with no-tillage peppers averaging 5532 lb/acre compared to 8012 lb/acre in tilled yields. Mulch provided an advantage to pepper yields, with mulched pepper plots averaging 9385 lb/acre, while non-mulched averaged 6640 lb/acre. No-tillage sweet corn failed to compete with mulched and tilled yields, averaging 2472 lb/acre. Tilled and mulched yields were excellent, with tilled sweet corn plots producing 4545 lb/acre, and mulched yielding 4423 lb/acre. While the tilled crops were more productive, the mulched and no-till peppers had higher quality fruit, due to the straw or mulch barrier affording greater protection from soil particles. Several factors impacted no-tillage sweet corn production: a severe drought that required irrigation for survival; extreme heat, which decreased pollination; and poor emergence. The greatest benefits from cover crops in these vegetable systems appear to be related to improvements in soil and water quality. After the first season in Fall 2011, soil nitrate was lower in lysimeters in tomato plots under cover crop treatments than in plots without a cover crop. Without a cover crop, the non-mulched tomato treatment had more nitrate than the mulched plots. In the onion plots, the non-mulched plots had more nitrate for both cover crop and no cover crop treatments. In both the tomato and onion plots, there was more phosphorus in tilled vs. no-till treatments, probably due to tillage stimulating the mineralization of organic phosphorus from added compost. Both phosphorus and electrical conductivity were lower in the no compost treatments. The importance of biologically active organic matter was demonstrated by the particulate organic matter carbon representing 15.4% of total soil organic carbon averaged across treatments.

4:45–5:00 PM

Soil Nitrogen Dynamics and Organic Bell Pepper Yield Are Affected by Rye–Vetch Cover Crop Residue Quality and Plastic Mulch

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Cover crops can be an important source of nitrogen (N) for organic vegetable production, but N availability depends heavily on both the characteristics of the cover crop residues and crop management practices following cover crop termination. A study was conducted over two seasons (2010 and 2011) in Michigan to investigate 1) how the proportions of cereal rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth) sown in a winter cover crop mixture influence cover crop residue quantity and quality in the spring, and 2) how rye-vetch residue characteristics and the use of black plastic mulch (PM) interact to affect soil N dynamics and bell pepper (*Capsicum annuum*) yield the following summer. Cover crop main plot treatments consisted of a gradient of 7 sown proportions of rye:vetch, from 100% rye (94 kg/ha) to 100% vetch (42 kg/ha), in addition to a no cover crop control. Subplots consisted of bell pepper grown either with or without PM. In both years, rye and vetch biomass in spring cover crop stands correlated well with fall seeding rates. Stands with higher proportions of vetch generally contained more total N and had lower total residue C:N. Both marketable bell pepper yields and soil inorganic N levels during the summers were positively correlated with expected N availability from the cover crop mixtures (based on total residue N concentration). Yields and soil N levels were generally higher when PM was used, but the differences between PM and bare ground treatments were much less pronounced in 2011 than in 2010. We suspect that differences in the magnitude and timing of summer precipitation events contributed to the discrepancy between the two years, with potentially greater N leached from bare ground treatments in 2010 than in 2011. Our results suggest that PM can serve as an important “insurance policy” for N fertility derived from high quality cover crop residues incorporated early in the season, particularly on sandy soils. Furthermore, N availability is likely a dominant factor in the effects of both rye-vetch cover crop mixtures and PM use on bell pepper yield. However, while higher proportions of vetch in the cover crop mixtures and the use of PM generally resulted in higher pepper yields, system performance must ultimately be based on a balanced consideration of all the services provided, their costs, and their relationship to primary production goals.

Specified Source(s) of Funding: Agriculture and Food Research Initiative (AFRI) Competitive Grant No. 2012-67011-19716 from the USDA National Institute of Food and Agriculture (NIFA), USDA North Central Region SARE Project No. GNC09-108, MAES Project GREEN Project No. GR09-068

5:00–5:15 PM

Assessment of Degradable Alternatives for Plastic Mulch for Organic Tomato (*Solanum lycopersicum*) Production in the Southeast

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Since the 1950s, plastic has been used as soil mulch in agriculture to increase yield, quality, and earliness of harvest, while reducing weed growth, irrigation requirements, soilborne plant diseases, and nutrient leaching. However, once removed from the field, plastic disposal and recycling can be expensive. Degradable mulches were introduced into agricultural production nearly 30 years ago as an alternative to plastic or polyethylene mulch, with the intention to reduce agricultural plastics in the waste stream. Degradable mulches have the potential to reduce removal costs and lessen environmental impacts, while providing similar benefits as plastic during the growing season. Four degradable mulch products, BioAgri Ag-Film, BioTelo Agri, WeedGuardPlus, and an experimental spunbond nonwoven fabric (SB-PLA-10/11/12), were evaluated during 2010, 2011, and 2012 in Knoxville, TN. These four products were compared with black plastic mulch and a bare ground (no mulch) control with respect to tomato (*Solanum lycopersicum*) yield, weed control, and degradability in high tunnel (HT) and open field (OF) production systems. Marketable yields in degradable mulch plots were comparable to those from the black plastic plots across all three years. Weed growth was minimal in both production systems in all three years except under SB-PLA-10 in 2010. The SB-PLA was reformulated in subsequent years and effectively suppressed weed growth, though showed very little visual degradation during the production season. While SB-PLA did not breakdown in the field, it may be useful for other agricultural purposes, such as mulching applications for multiple cropping seasons, row cover, or ground cover between rows. The commercially available products, BioAgri, BioTelo Agri, and WeedGuardPlus, achieved > 50% degradation in the OF system by the end of the season in two out of three years of the study. WeedGuardPlus breakdown in the HT system was < 10% in all three years, likely due to protection from wind, rain and solar radiation; however, WeedGuardPlus can be tilled into the soil at the end of the season and will fully degrade. Both BioAgri and BioTelo were more variable in breakdown (10% to 40%) in the HT system, but must be removed from the field in certified organic systems, due to their formulation, which includes non-organically approved additive(s). However, by the end of season, the consistency of BioAgri and BioTelo was so brittle that physical removal was time consuming and difficult, reducing their practical application in the field.

5:15–5:30 PM

Organic Habanero Pepper (*Capsicum chinense*): Effect of Intercropping Marigold (*Tagetes erecta*) and Mulching with Sawdust on Controlling the White Fly (*Bemisia tabaci*) and Root-knot Nematodes (*Meloidogyne* spp.)

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After the tomato, the habanero pepper (*Capsicum chinense* Jacq.) is the second most harvested horticultural crop of the Yucatan Peninsula, showing a continuous rise of production. Recently, organic pepper production has also benefited from this boom, but the mostly small-scaled outdoor producers are facing high prices and restricted access to commercial organic products. Furthermore, they are confronted with two harmful parasites, the white fly (*Bemisia tabaci* Gennadius) and root-knot nematodes (*Meloidogyne* spp.). A nematicide effect of the marigold is proven for *Capsicum* spp. However, there were no explicit recommendations concerning the habanero pepper. There is a single study that indicates mulching with sawdust (among other agroecological benefits) aids in controlling white fly. Therefore, in this trial, two organic pest management strategies that are preventive and based on local resources were evaluated for their effectiveness in controlling white fly and *Meloidogyne* spp. In 2009, a trial in José María Morelos (central Yucatan Peninsula) evaluated the effect of four agroecosystem-arrangements during a cropping season of habanero pepper: sawdust mulching and intercropping of marigold; only mulching; only intercropping marigold; and a control variant. Pest and weed management were based on organic farming principles. Fertilization was based on cow manure. Selective weed management was carried manually. Drip irrigation was used. The evaluation consisted in daily monitoring of selected plants and yellow traps within the rows (white fly) and evaluation of nematode-infestation on pepper roots after the cropping period. Results showed that intercropping marigolds contributes significantly to controlling root-knot nematodes. Mulching with sawdust increases the effectiveness of this treatment. Neither treatment (or their combination) showed any impact on *Bemisia tabaci* population. As for organic pepper production on the Yucatan Peninsula, soil covering with an organic layer and intercropping of marigold are successful strategies, not only for maintaining soil humidity, facilitating weed control, and increasing agrobiodiversity; but also for controlling harmful root-knot nematodes.

Specified Source(s) of Funding: CONACYT

5:30–5:45 PM

Fall Broccoli Production following Summer Cover Crops in Louisiana

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Multiyear studies were initiated to assess summer cover crops for use in fall vegetable crops in the Deep South. The research in Louisiana involved the production and incorporation of summer cover crops on the same site followed by fall-planted broccoli in 2012. The summer cover crop treatments consisted of Sunn hemp, *Crotalaria juncea*; sesame, *Sesamum indicum*; a mix of the Sunn hemp and sesame; sorghum-sudan grass, *Sorghum bicolor* x *S. bicolor* var. *sudanese*); and a weed-free check. The cover crop plots received a single irrigation after planting, but received no fertilizer or pesticides prior to or during growth. A 0.5 m² area of crop and weed shoot mass was harvested at 60 days. Data collected from the second year of the study included cover crop fresh weight and biomass, total nutrient content, and soil organic matter and nutrient content. *Crotalaria* had the highest biomass and was statistically greater than the biomass produced by the sesame or sorghum-sudan grass cover crop treatments at harvest. The effect of different rates of organic fertilizer (composted chicken litter), in combination with summer cover crops, was studied for the production of broccoli. Cover crop treatment did not affect broccoli yield nor was there an interaction with organic fertilizer treatment. The control unfertilized treatment resulted in no marketable broccoli heads while the 2x, and 3x rate plots had the highest marketable yield and marketable broccoli head weights.

5:45–6:00 PM

The Effect of *Beauveria bassiana* on Parasite Fauna of Organic Habanero Pepper in Quintana Roo, Mexico

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In Quintana Roo, Mexico, partial losses of vegetable crops due to insects are seriously limiting satisfactory output. Using native strains of entomopathogenic fungi can contribute to controlling some of the most harmful insects. In a trial carried out in 2011 and 2012 in central Quintana Roo, we evaluated the effect of a native strain of *B. bassiana* (1.1 X10¹⁰ spores/mL) on the insect fauna associated with green habanero pepper under organic management. With the goal of evaluating the effect of the applied fungus on the present parasitic fauna in 2011, 1.3 g·L⁻¹ of fungus (mixed with rice) of water were applied to 12 blocks in a 0.2-ha habanero pepper field under organic management. Randomized blocks of 5 m² and 10 pepper plants each were monitored. Systematic collections of all observed insects were performed every three days. Application started 30 days after transplanting and was carried out every 20 days.

All collected insects were placed in a moist chamber for 15 days. They were observed every 48 hours to record the number of insects killed by the fungus. Twenty-five percent (25%) of collected insects developed *B. bassiana*; the most abundant orders were Hemiptera (11% of infected insects), Coleoptera (6%), and Orthoptera (5%). All were phytophagous species. In 2012, the effect of varying doses of *B. bassiana* on the most harmful parasites was compared. Doses of 5, 10.5, and 14 g·L⁻¹ of water were applied to four blocks each. Selective collection involved *Bemisia tabaci*, *Erythrogonia* spp., and *Anthonomus eugenii*. Block design and crop management were the same as in 2011. Thirty percent (30%) of all collected parasites were killed by *B. bassiana*. The significantly most efficient treatment was observed using a dose of 10.5 g·L⁻¹ fungus but control was only satisfactory for *Erythrogonia* spp. Applying native strains of *B. bassiana* is a highly efficient measure to control *Erythrogonia* spp, a harmful parasite of the habanero pepper. Satisfactory control requires a dose of 10.5 g·L⁻¹ fungus; the commonly used dose of 1.3 g·L⁻¹ is not recommendable. As for controlling *B. tabaci* and *A. eugenii* with the entomopathogenic fungus, further research is necessary.

Specified Source(s) of Funding: PROMEP

Monday, July 22, 2013

Desert Salon 4-6

Vegetable Breeding

Moderator: Charles L. Rohwer, roh0009@umn.edu

5:00–5:15 PM

Initiating a Hop Breeding Program at the University of Minnesota

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Until recently, commercial production of hops (*Humulus lupulus* L.) in the United States has been exclusively centered in dry valleys in the Pacific Northwest. Hop breeding has historically been carried out in the major hop producing regions around the world, including in the Pacific Northwest, Germany, England, and New Zealand. Some relatively smaller growers have recently started producing hops in other regions of the United States, including states such as Wisconsin, Colorado, Michigan, New York, and North Carolina. Hop cultivars selected by major breeding programs have understandably not considered climate, soil, photoperiod, or production practices in these new produc-

An asterisk (*) following a name indicates the presenting author.

tion regions in the United States, and many newer cultivars are patent-protected and unavailable to most small growers. To meet the demand from local craft breweries for novel cultivars available to local growers, and demand from growers for cultivars selected for production in the upper Midwestern United States, we began by developing a poster displaying known pedigrees of over 40 hop cultivars. Pedigree analysis is important for selecting appropriate parents in a small breeding program such as ours. Five crosses were made in 2012 using novel USDA germplasm (PI 617471), commercial cultivars (Spalter Select, Newport, Nugget, and Chinook), and a male collected at the University of Minnesota Horticulture Research Center in Chaska, MN. Seedlings from these crosses will form the basis for selecting one or more novel cultivars or parents adapted to Minnesota and surrounding states.

5:15–5:30 PM

Regional Hybrid Broccoli Trials Provide a Means to Further Breeding Efforts of This Increasingly Important Vegetable Crop

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A Coordinated Agricultural Project (CAP) entitled “Establishing an Eastern Broccoli Industry” is funded under the Specialty Crop Research Initiative (SCRI), and a primary component of the project is a system of regional hybrid broccoli trials conducted along the eastern seaboard. Hybrids currently input into the trialing system originate from three private seed company and three public institution breeding programs and include intra- and inter-program crosses. The entrance point into the system is designated Phase One and involves testing in two replicated trials at each of four regional sites in South Carolina, North Carolina, New York, and Maine. One Phase One trial is planted at each site during an optimal season and a second during less optimal conditions (e.g., hot) that are likely to stress plants. In all trials, hybrids are compared to standard

check hybrids and given ratings for eleven quality traits to determine which entries will be promoted to additional phases. Approximately 25% of the Phase One entries are advanced to Phase Two wherein they are planted in replicated trials at each primary site at five different times of the year from early spring through late fall. The top two or three broccoli hybrids in Phase Two trials at a given site are advanced to Phase Three, which involves large strip trials conducted on farms of cooperating growers at various locations near each regional site. Floret samples from heads harvested out of Phase Two trials are used to assay levels of important nutritional constituents like glucosinolates and carotenoids. This trial system is expected to identify broccoli hybrids well adapted to East Coast growing conditions and to aid breeding programs in determining which particular hybrids to release. An added benefit of these trials is that a large body of data is generated about specific genotypes for a wide variety of economically important traits. These data are being used to estimate heritability of and genotype by environment effects for quality traits like bead size, bead uniformity, head color, and head shape. Other types of analyses (e.g., stability analysis) are also being explored as an avenue to better assess the adaptation of broccoli to eastern environments.

5:30–5:45 PM

Estimating Heritability of Skinning Resistance in Sweetpotato

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Sweetpotato (*Ipomoea batatas*) is experiencing burgeoning demand; however, high production costs continue to limit farmer income. More mechanized approaches to harvest are needed to save on labor expenses. Many of the popular varieties of sweetpotatoes are highly susceptible to skinning damage and the problems that are associated with such damage such as rotting and weight loss. A more durable skin would greatly facilitate transition to more mechanization; however, it is unknown if we can breed for a more durable skin. The objective of the present study is to develop a suitable assessment tool for skinning resistance and determine heritability. A modified torque wrench device used in potato was found superior to other techniques in measuring skinning resistance. Heritability is being estimated over two growing seasons and initial findings will be presented. Estimates of heritability r_s . The torque wrench will be used in a 2-year study of multiple varieties of undamaged sweetpotato roots in order to analyze

An asterisk (*) following a name indicates the presenting author.

the amount of skinning resistance. Heritability tests will compare the data collected in subsequent generations in order to determine if skinning resistance is a heritable trait that can be easily bred for.

Specified Source(s) of Funding: LSU AgCenter

5:45–6:00 PM

Host Plant Resistance to Cucurbit Yellow Stunting Disorder Virus and *Bemisia tabaci* in Melon: Status and Prospects

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The combination of Cucurbit yellow stunting disorder virus (CYSDV), a newly introduced virus and heavy feeding pressure by its insect vector, sweetpotato whitefly (*Bemisia tabaci*) biotype B (SPWF-B) severely impact melon production in California and Arizona. The appearance of the aggressive SPWF-B in 1990 significantly reduced the Fall melon crop directly through feeding damage; numbers of SPWF-B immatures (eggs + nymphs) was 1500-fold greater than in melon producing areas of Texas and Florida. CYSDV, which is spread by SPWF-B and other biotypes, appeared in California in Fall 2006, and the combination of CYSDV with high SPWF-B populations quickly eliminated fall melon production. Moreover, CYSDV is a potential threat to spring melon production when SPWF-B survives the winter in sufficient numbers to spread the virus. No commercial melon cultivars are available with resistance to either SPWF or CYSDV anywhere in the world. Three non-sweet, vegetable type melons from Africa and India are resistant to CYSDV. Two of them, TGR-1551 (Zimbabwe) and PI 313970 (India), have low-level resistance to SPWF that is inadequate for reducing the adverse biological and economic impacts of whitefly feeding and virus transmission in the low desert of California and Arizona. Single plant selections from six of 100 Indian melon accessions exhibited putative resistance to CYSDV in during Fall 2011 tests under severe virus pressure: PI 116482, PI 123496, PI 123689, PI 124107, PI 124431, PI 145594. Two of these (PI 123689, PI 123496) also performed well during Fall 2012 under similar conditions. All produced large plants that were in good condition at the end of the 2012 test though they were variable for expression of CYSDV symptoms and virus titer. Numbers of SPWF-B (nymphs through 4th instar; seven weeks postplanting) on two selections, PI 124107, PI 123689 were significantly lower than on TGR-1551 and PI 313970, which suggested they might be exhibiting resistance to feed-

ing by SPWF-B. Fruit of the six accessions have several fruit characteristics of sweet, dessert type melons and may be better donor parents for use in breeding CYSDV-resistant muskmelon, honeydew and mixed melons adapted to California. Combined resistances to CYSDV and SPWF-B would be important components of an integrated pest management program to reduce, if not eliminate, applications of insecticides to control this insect, and reduce the adverse impact of the virus on plant growth, and consequently on fruit yield and quality.

6:00–6:15 PM

Cucurbit Powdery Mildew Race Variation on Melon in California's Sacramento Valley

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More than 40 physiological races of cucurbit powdery mildew (CPM) incited by *Podosphaera xanthii* (syn. *Sphaerotheca fuliginea*) have been reported on melon (*Cucumis melo* L.) worldwide. Races 1 and 2, which were first described in the 1930s, are common throughout the United States, with the exception of California and Arizona. Race S was first observed in 2003 in the lower desert areas of Imperial Valley, CA, and Yuma, AZ, when it caused widespread disease in commercial fields and was observed to infect all of the common CPM race differentials of melon in use at that time. Race variability has been detected annually in those areas since that time. Race S was observed in 2007 at Five Points in the San Joaquin Valley of California, which is ca. 460 km from the lower desert and is a major area for summer melon production. Field studies were done in the Davis–Woodland area of the Sacramento Valley in order to further characterize the variation of races of *P. xanthii* in California. The tests were established using transplants in randomized complete-block designs on 26 May 2011 and 28 June 2012, and evaluated on 26 August and 7 September, respectively. The tests included 11 of the 13 commonly used *P. xanthii* race differentials, plus 22 other melon cultivars and accessions and two watermelon (*Citrullus lanatus* L.) cultivars to further characterize the CPM populations present in these tests. The 2011 test, which was near Davis, indicated presence of race SW, a variant of race S that infects watermelon. A test in 2012 at that same location indicated a unique race to which PI 414723 and PI 124111 were completely resistant; the other common differentials and 'Crimson Sweet' and 'New Hampshire Midget' watermelons were susceptible. A different race profile was observed in a field near Woodland in 2012: PI 414723, MR-1, PI 124112, PI 313970 were resistant, PI 124111 and 'Crimson Sweet' watermelon varied in their reactions, and all other common differentials were susceptible. These data indicate seasonal and spatial variation in the population of *P. xanthii* races in the Davis–Woodland area. There have been recent anecdotal reports of races 3.5 and 5, in the Sacramento Valley of California, but neither race was present in these tests.

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6:15–6:30 PM

Screening for Bacterial Fruit Blotch Resistance in the USDA Watermelon Germplasm Collection

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Cucurbit bacterial fruit blotch caused by *Acidovorax avenae* subsp. *citrulli* is a significant threat to watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] production worldwide. The disease can cause complete loss of marketable crop under ideal conditions. Since seed is the primary inoculum for bacterial fruit blotch in cucurbit crops, bacteria-free seed production has helped limiting outbreaks. Currently, the most effective strategy for managing bacterial fruit blotch has been excluding the pathogen from seeds, fruits, and transplants. However, efficacy of the external treatments varies because bacteria can be under the seed coat. Therefore, genetic resistance would be of great scientific and economic value. The overall objective of this study was to identify resistance to bacterial fruit blotch using the available Plant Introductions accessions in the USDA germplasm collection. Field evaluations based on foliar disease symptoms at the adult stage were conducted at Clinton, NC, in Summer 2011 to 2013. The experiment was a randomized complete block with 1689 cultigens, 3 years, and 2 replications of single-plant plots. Selected PIs were tested at the two-true leaf stage in a controlled environment in 2013 to confirm the resistance source. Studies are under way to improve the disease rating system by accounting for different growth stage and leaf type. Both field and greenhouse screening adopted a rating scale with 0–9 (0 = no symptoms, 1–2 = trace, 3–4 = slight, 5–6 = moderate, 7–8 = severe, and 9 = dead). Statistical analysis on weekly ratings showed that significant differences exist in disease severity among accessions ($P = 0.05$). The 10 most resistant and 2 most susceptible accessions were identified and then confirmed in retest experiments. Resistant germplasm will be made available for those interested in developing molecular markers and improved cultivars.

Tuesday, July 23, 2013

Springs Salon A/B

Growth Chambers and Controlled Environments

Moderator: Jiwan P. Palta, jppalta@wisc.edu

8:00–8:15 AM

Shoot Tissue Pigment Concentrations in Broccoli Microgreens Are Higher under Narrow-Band Wavelengths from LEDs than under Fluorescent/Incandescent Light

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Light-emitting diodes (LEDs) provide the ability to measure physiological responses to narrow-band wavelengths in plants. Previous research in our group demonstrated short-duration exposure to narrow-band blue (455–470 nm) wavelengths can improve the nutritional quality of broccoli (*Brassica oleracea*) microgreens. The objectives of this study were to measure the impact of different percentages of blue light on the concentrations of nutritionally important pigments in broccoli microgreens, and to compare LEDs with incandescent/fluorescent light. Sprouting broccoli seeds were cultured on growing pads submerged in deionized water and grown under the light treatments of: 1) fluorescent/incandescent light; 2) 5% blue (455–470 nm)/95% red (627–630 nm); 3) 5% blue/85% red/10% green (525 nm); 4) 20% blue/80% red; and 5) 20% blue/70% red/10% green in controlled environments. The light intensity was set at 250 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for all light treatments with a 16-h photoperiod and air temperature of 24 °C. Upon emergence of the first true leaf, a complete nutrient solution (20% Hoagland's #2 solution) was used to submerge the growing pads. Microgreens were harvested after 20 days under the light treatments. Shoot tissues were freeze dried and measured for chlorophyll and carotenoid pigments. Pairwise contrasts revealed that LED light treatments increased shoot tissue beta-carotene, lutein, total carotenoids, chlorophyll a, chlorophyll b, and total chlorophyll when compared to the incandescent/fluorescent light treatment. Broccoli microgreens grown under the incandescent/fluorescent light treatment had higher concentrations of violaxanthin and neoxanthin. Higher blue light percentages also increased shoot tissue chlorophyll, but did not impact carotenoid pigments. Narrow-band wavelengths from LEDs increased many of the nutritionally important pigments in broccoli microgreen tissues, which would be beneficial when consumed in the diet.

8:15–8:30 AM

Glucosinolate Concentrations of Broccoli Microgreens Are Greater under Specific Narrow Wavelength LED Light Regimes than under Conventional Fluorescent/Incandescent Light in Controlled Environments

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We have previously shown that specific narrow-band wavelengths of light from light-emitting diodes (LEDs) stimulate production of glucoraphanin and several other secondary metabolites that have significant dietary implications. The objective of this research was to determine the effects of different percentages of specific narrow wavelengths of light on glucosinolate production in broccoli microgreens (*Brassica oleracea*). Broccoli microgreens were sprouted on fiber pads submerged in deionized water. Following the appearance of the first true leaf, a 20% Hoagland's #2 solution was used to maintain saturation of the pads providing a nutrient source for the plants. After the first 24 h, light treatments were initiated on a 16 h photoperiod with a constant air temperature of 24 °C. Light intensity was maintained at 250 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for all light treatments. The following light treatments were applied: 1) fluorescent/incandescent light (control); 2) 5% blue (455–470 nm) and 95% red (627–630 nm); 3) 5% blue, 85% red, and 10% green (525 nm); 4) 20% blue, 80% red; and 5) 20% blue, 70% red, and 10% green. Each of the light treatments were replicated four times. Microgreens were harvested after 20 days under the light treatments, frozen, lyophilized, ground in liquid nitrogen and stored at $-80\text{ }^{\circ}\text{C}$. The plants were then extracted with methanol and analyzed for aliphatic, aromatic, indole and total glucosinolate content by HPLC using a water-acetonitrile mobile phase gradient. They were also analyzed specifically for glucoraphanin, an important dietary glucosinolate that has been reported to have anti-carcinogenic properties. Plants grown under the 20% blue, 70% red, and 10% green and the fluorescent/incandescent treatments did not differ in any of the glucosinolates measured. However, plants grown under all of the other narrow wavelength LED light treatments were significantly higher in glucosinolates than the fluorescent/incandescent control. The concentrations of glucoraphanin, aliphatic, indole, aromatic, and total glucosinolates were all 200% to 300% greater than that of plants grown under the control light treatment. Data from this experiment indicate that narrow wavelength specific LED light may be useful in improving the nutritional quality of broccoli microgreens and other leafy greenhouse vegetables grown in controlled environments.

Specified Source(s) of Funding: USDA SBIR and University of Tennessee Agricultural Experiment Station

8:30–8:45 AM

Comparison of LED Supplemental Lighting and High Pressure Sodium Energy Consumption and Plant Responses of Cucumber and Tomato Transplants

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Supplemental lighting is a key technology in vegetable nursery greenhouses to improve transplant growth and quality.

Light emitting diodes (LEDs) lighting technology is relatively new and must be evaluated in terms of economic feasibility and plant responses. We performed a side-by-side comparison of supplemental red-LED (632 nm), blue-LED (443 nm) and a conventional high pressure sodium lamp (HPS). The supplemental light provided $54 \pm 1.2\ \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF for 18 hours (2:00–20:00) or $3.5\ \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ DLI over the plant canopy. Growth and morphological parameters were recorded for cucumber (*Cucumis sativus* cv. Cumlaude) and tomato (*Solanum lycopersicum* cv. Komeett). After 38 days of seeding, cucumber shoot dry mass, leaf number and leaf area were 29%, 16%, and 27%, respectively, lower under the blue-LED and 27%, 13%, and 22%, respectively, lower under the red-LED compared to the HPS. Cucumber hypocotyl length was between 38% to 47% lower in the red-LED compared to the blue-LED and HPS treatments, respectively. After 40 days of seeding, tomato shoot dry mass was higher under HPS followed by red-LED (18% lower) and blue-LED (29% lower). Hypocotyl length was 18%–17% lower in the red and blue LEDs respectively, compared to HPS. The number of leaves under the first flower for red-LED was significantly less than those under blue-LED and was not different from HPS. Greater shoot dry mass in the HPS treatment can be attributed to the higher canopy temperature throughout the experiment due to the greater infrared radiation emitted by the HPS fixture. When considered a commercial scale application, we found that the blue-LED treatment consumed 13% less electric energy, and the red-LED treatment consumed 10% more energy than the HPS (the electrical energy consumption excluded that for fans and controllers). However, after calculating the dry mass per supplemental lighting power input (g/kWh) the HPS treatment was more efficient (tomato: 3.2; cucumber: 3.4 mg/kWh) than both LEDs, and the blue-LED (tomato: 2.5; cucumber: 2.7 mg/kWh) was more efficient than the red-LED (tomato: 2.3; cucumber: 2.2 mg/kWh). From this study it is evident that the selection of supplemental lighting should be species specific. Also grower's expectations and priorities have to be taken into consideration to decide appropriate lamp type and its light quality. Efficiencies of the LEDs, controllers, and cooling systems have to be improved to match HPS efficiency.

8:45–9:00 AM

Comparison of Light-emitting Diode Towers Versus High-pressure Sodium Lamps for Year-round Production of High-wire Greenhouse-grown Tomatoes

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Intensive year-round local production of greenhouse-grown vegetables requires the use of supplemental lighting to

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complement solar radiation in light-limited northern climates. Intracavity light-emitting diode (ICL-LED) towers were compared to overhead high-pressure sodium lamps (HPS-OH) as an alternative supplemental light source for high-wire greenhouse tomato (*Solanum lycopersicum* L.) production. Two consecutive experiments evaluating growth, yield, and energy consumption from winter-to-summer (increasing natural daily light integral (DLI); Expt. 1) and summer-to-winter (decreasing natural DLI; Expt. 2) were conducted in a northern climate (West Lafayette, IN, USA) to evaluate climatic responses to supplemental photosynthetic lighting. Cultivars Komeett and Success were grown in a glass-glazed greenhouse for five months. Plants were grown under one of three lighting treatments which included: 1000-W (Expt. 1) or 600-W (Expt. 2) HPS-OH lamps vs. LED-ICL towers (95% red and 5% blue) vs. no supplemental lighting (control). No differences were observed between cultivars for any of the parameters evaluated. Our findings indicate that equivalent increases in fruit number and yield can be achieved with the two supplemental light treatments compared to the unsupplemented control. Furthermore, significant energy savings can be achieved using the ICL-LED compared to the standard OH-HPS lamps (75% and 55% for Experiment 1 and Experiment 2, respectively). Our results suggest that ICL-LED is a viable alternative to the widely adopted HPS-OH lighting.

Specified Source(s) of Funding: NIFA SCRI grant 2010-51181-21369

9:00–9:15 AM

Oedema/Intumescence Injury on the Leaves of Potato Plants Is Mitigated by Calcium Nutrition

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Many plants, including potato, tobacco, tomato, and geraniums, are known to develop Oedema or intumescence injury. This injury develops exclusively on plants growing in controlled environment facilities compared to field grown plants. Early studies have suggested a link between light quality and Oedema. For example, UV and/or far-red wavelengths were found to mitigate this injury. Here, we report that Oedema can be mitigated by calcium nutrition. Plants of cultivars Russet Burbank and Atlantic were grown using in vitro shoot cultures in 20.4 L pots. Plants were irrigated daily to excess with a Peter's Professional Peat Lite Special 20N–10P–20K fertilizer. For this purpose 104 g of this fertilizer was mixed with 200 L of tap water. Two calcium treatments (1 mM and 10 mM) were evaluated with 13 replications per treatment. The source of calcium was calcium chloride. About 20 days after the start of these treatments the Oedema injury was observed only on plants of the cultivar Russet Burbank. Upper canopy leaves in the 1 mM treatment had an average of 64% of the leaf area covered

with injury. However, only 4% of the leaf area on average was covered with injury in the plants that received the 10 mM Ca treatment. Average leaf calcium concentration was nearly 2x in plants given 10 mM Ca as compared to the 1 mM Ca treatment. There were no other apparent growth and development differences among the two Ca treatments. These data provide evidence that Oedema injury can be mitigated by supplemental calcium and that 'Russet Burbank' is more prone to this type of injury compared to 'Atlantic'.

Specified Source(s) of Funding: USDA/NIFA grant

Tuesday, July 23, 2013

Desert Salon 1-2

Citrus and Other Fruit and Nut Crops

Moderator: Bhimanagouda S. Patil, b-patil@tamu.edu

8:00–8:15 AM

Influence of Ethylene Treatment on Bioactive Compounds of 'Rio Red' Grapefruit

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Influence of postharvest degreening treatment on 'Rio Red' grapefruit quality and bioactive compounds such as carotenoids, ascorbic acid, limonoids, flavonoids and furocoumarins was investigated. Fruits were degreened in commercial packing shed with 3.5 ppm ethylene at 21 °C and 80% RH. Non-degreened fruits were used as a control. Both degreened and non-degreened fruits were stored under simulated market conditions at 10 °C for 3 weeks and 21 °C for 2 weeks. Ascorbic acid content was significantly higher in degreened fruits after 35 days of storage, while non-degreened fruits had higher ascorbic acid levels at 7 days of storage. The levels of limonoids [deacetyl nomilinic acid (DNAG), limonin, nomilin], flavonoids (narirutin, naringin, neohesperidin, didymin, and poncirin), and furocoumarin (6,7-dihydroxycoumarin (DHB)) were quantified by HPLC in both the treatments. After 35 days of storage there was no significant difference observed in limonoids, flavonoids, and carotenoids, namely β -carotene and lycopene contents between both the treatments. In both treatments β -carotene and lycopene levels increased gradually up to 14 days and maintained their initial levels after 35 days of storage. DNAG, limonin and all flavonoids were significantly higher while DHB was lower in degreened fruits at 7 days of storage. DHB was significantly lower in degreened fruits after 35 days of storage. Overall eth-

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ylene treatment had a significant influence on certain bioactive compounds present in 'Rio Red' grapefruit. This project is based upon work supported by the USDA-NIFA # 2010-34402-20875 "Designing Foods for Health" through the VFIC and Research Grant Award No. TB-8056-08 from the Texas Department of Agriculture, Texas Israel Exchange and the United States-Israel Binational Agricultural Research and Development Fund.

8:15–8:30 AM

Potential Non-GMO Genetic Solutions to HLB for Sustainable and Profitable Citriculture in Florida

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The often repeated dogma regarding HLB (huanglongbing or citrus greening disease) and commercial citrus germplasm is that adequate tolerance or resistance does not exist. However, the UF/CREC citrus improvement broad-based germplasm collection is now undergoing a massive natural HLB screen due to the HLB epidemic currently underway in Florida, and potentially tolerant/resistant scions and rootstocks, some with commercial potential, are being identified. In addition, a robust rootstock HLB screening program is also identifying candidate rootstocks that may be able to protect susceptible scions. A few scion genotypes, including mandarins and pummelos, are still thriving in blocks that are devastated by HLB, with nearly 100% infection rates and most trees showing severe symptoms. Of particular interest is a sweet orange-like triploid hybrid that contains approximately 8% trifoliate orange parentage, produced via embryo rescue from an interplod cross. Remarkably, this hybrid produces seedless fruit that is not easily distinguished from true sweet orange, and its pasteurized NFC (not from concentrate) juice has a flavor profile in the range of 'Hamlin' and 'Valencia', the two most important processing oranges in Florida. The tree is productive and has yet to show any HLB symptoms, whereas adjacent trees have been devastated by HLB. Additional information on this selection and others showing tolerance/resistance will be presented, as well as their utilization in the CREC breeding program. Complex diploid and tetraploid rootstock candidates, not pre-selected for HLB tolerance/resistance, are also showing a differential response to HLB in field trials as compared to highly susceptible commercial rootstocks, with several showing significantly lower HLB infection rates, and less severe symptoms once infected. Field trial data will be provided. This suggests great potential for HLB pre-screening of complex rootstock germplasm, in hopes to identify rootstock candidates that can protect susceptible scions. We have developed a robust greenhouse/field

screening procedure that has been underway for the past two years, with promising results. The ultimate goal is to develop rootstocks that can be used to establish sustainable, productive groves without the current requirement of efficient psyllid (the HLB vector) control. Progress in such rootstock development will be presented.

Specified Source(s) of Funding: CRDF

8:30–8:45 AM

Jujube (*Ziziphus jujuba* Mill.) Cultivars in the United States

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Jujube cultivars were imported into the United States beginning in 1908 by USDA agricultural explorer Frank N. Meyer and jujube seedlings were introduced as early as 1837. Now, jujubes are planted in a number of states including California, Arizona, New Mexico, Texas, Oklahoma, Kansas, Tennessee, Georgia, Indiana, Mississippi, Florida, South Carolina, North Carolina, Pennsylvania, and Illinois. They grow well with high quality fruit in the south and southwest regions. Sixty-seven accessions were imported by F.N. Meyer in the early 20th century and all were planted first at the USDA Chico Station and then distributed to other USDA stations. The jujube research at Chico Station continued till the end of the 1950s. Jujube cultivars now in the United States are from several sources: Frank Meyer's imports, introductions from USDA's Chico Station, selections from across the states, recent imports by Roger Meyer, and others from China or other jujube growing regions in the world. From F.N. Meyer's importation, USDA formally recommended four of them: 'Mu Shing Hong' (P.I. 22684), 'Lang' (P.I. 22686), 'Shui Men' (P.I. 38245), and 'Li' (P.I. 38249). Now, 'Li' and 'Lang' are the two dominant cultivars commercially available and 'Shuimen', 'So', 'Mu' (Mu Shing Hong), and 'Yu' are also available in small quantities. At USDA's Chico Station, Ackerman and his colleagues selected/developed four cultivars: Chico, GI-1183, Thornless, and GA-866 before the station was closed in the late 1950s. There were also quite a few "cultivars" from across the country named after people or towns that could have been progeny of the 19th century imports, seedlings from the patent office jujube seed distribution in 1854 or remaining plants from Meyer's imports, for example: 'Abbeville', 'Redland', 'Sherwood', 'Texas Tart', 'Don Polenski', 'Fitzgerald', and 'Topeka'. Jujube lovers exchange resources and name them without much testing or research. There have been some recent introductions from China and other jujube growing regions: 'Shanxi Li', 'Winter Delight', 'Honeyjar', 'Sihong', 'Globe', 'Ant Admire', 'Black Sea', etc. NMSU's Alcalde Center also imported over 30 cultivars from China in 2011. There are a total of 60–70 jujube cultivars now in the United States. Most of them are not commercially available yet. Growers and home

gardeners are requesting more diversified cultivar options. Regional cultivar trials and evaluation are desperately needed for jujubes. With its high nutritional value and wide adaptation to a range of soil and weather conditions, jujubes would get more and more popular in the United States.

Specified Source(s) of Funding: USDA Speciality Crop Block Grant through NMDA

8:45–9:00 AM

Pollen Viability and Pollination in Sugar Apple (*Annona squamosa*) and ‘Gefner’ Atemoya (*A. cherimola* x *A. squamosa*) in South Florida

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Fruit set of commercial *Annonaceae* by natural pollinators is generally insufficient to produce commercially acceptable yields. In addition, several investigations have reported the pollen source and age of the pollen affects the potential percentage of fruit set of sugar apple and atemoya. The objectives of present investigation were to determine the effect of pollen storage durations on pollen viability, the percentage of fruit set by hand pollination of ‘Red’ sugar apple, ‘Lessard Thai’ green sugar apple, and ‘Gefner’ atemoya and the resulting fruit characteristics as a result of pollen source in South Florida. Five treatments were applied: (1) pollen collected from male stage flowers and hand pollination performed immediately and pollen collected from late female stage flowers in the late afternoon and hand pollination performed either the morning of the (2) next, (3) second, (4) third, or (5) fourth day. The pollen sources were collected from late female stage flowers as they were transitioning to the functionally staminate stage and stored in paper bags refrigerated at 5 °C. Hand pollination was made by using a number 2 water color paint brush. Pollen from three *Annona* cultivars and five pollination treatments were arranged in a completely randomized design with five replicates per treatment. In vitro pollen viability was determined by placing samples of pollen on a standard culture medium (5 g·L⁻¹ Agar, 1.27 mM Ca (NO₃)₂ 4 H₂O, 0.87 mM MgSO₄ 7 H₂O, 0.99 mM KNO₃ and 1.62 mM H₃BO pH 7.0) supplied with 10% sucrose. Data was analyzed by ANOVA and Tukey’s test (5% probability). The percentage of in vitro pollen germination was the highest for ‘Red’ sugar apple when pollination was used immediately after male flower

collection (26.5%), and when using female flowers collected late afternoon and pollination performed the next day (23%). For ‘Lessard Thai’ green sugar apple the best results were obtained in treatments 1, 2 and 3 with average of 33.1% in vitro pollen germination. ‘Gefner’ atemoya showed high levels of pollen germination (33.7%) in treatments 2, 3, and 4. The percentage of fruit set correlated to pollen germination. Hand pollination promoted high percentages of fruit set, > 80%. Fruit harvested as a result of the various pollen sources varied in fruit weight, fruit diameter, and number of seeds per fruit and will be discussed. Pollen from sugar apple and atemoya may be stored up to 2 and 3 days, respectively.

Specified Source(s) of Funding: CAPES and FAPEMIG

9:15–9:30 AM

Evaluation of Soil Steam Disinfestation on Early Growth of Almond (*Prunus dulcis*) Orchards with High Likelihood of Replant Disease and Confirmed Presence of Parasitic Nematodes

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Almond replant disease (ARD) can reduce early and cumulative productive potential of second and later generation orchards. Pre-plant soil fumigation can effectively control replant disease, however increasing regulatory restrictions are complicating use of these treatments. Strip or individual tree site fumigation treatments with methyl bromide or alternative fumigants can provide acceptable control of ARD while significantly reducing the amount of fumigant applied. However, non-fumigant alternatives are needed for areas where grower preference or regulations limit fumigant use. Steam and other forms of heat treatment have been used to effectively disinfest soil in greenhouses and some open-field situations, but have not been tested in almond replant situations. The objective of this research was to develop and test a steam injection system combining heat disinfestation with the principles of spot fumigation for management of ARD. Steam injection augers (24 and 36 inches in diameter) were built in 2010 and trials were initiated in orchards being replanted to almonds throughout the San Joaquin Valley in California. Small plot trials (2–4 trees per plot) were designed to compare varying levels of disturbance and disturbance plus steam. Treatments included the two augers with and without

An asterisk (*) following a name indicates the presenting author.

steam, a 4 x 4 x 2 ft. backhoe pit and an untreated control. Large plot trials (24 trees per plot) were designed to compare tree growth following treatment with the 36-inch steam injection auger or conventional fumigant treatments including methyl bromide, chloropicrin and 1,3-dichloropropene. Almond trees were planted 1–2 months after treatments were applied. In the small plot trial near Delhi, increases in trunk diameter after two years were similar ($P = 0.05$) among the untreated control (31 mm), auger-only (35–36 mm) or auger plus steam treatments (37–39 mm). The backhoe treatment (41 mm) was the only treatment with significantly greater increases in trunk diameter than the trees in the untreated control plots. In the large plot trials at the same site, increases in trunk diameter after two years were significantly greater in fumigated plots (50–60 mm) than the steam and untreated plots (41 mm) which were the similar ($P = 0.05$). These early growth data at this site suggests that tree site steam disinfection with a 36-inch injection auger does not provide acceptable control of the almond replant issues in this sandy soil. Tree growth and nematode re-infestation monitoring will continue and nut yield and economic analyses will be conducted as the orchard reaches the bearing phase of its lifespan.

Specified Source(s) of Funding: California Department of Food and Agriculture Specialty Crop Block Grant Program

some from LSU) were named the CARLA hybrids and included ‘Adelaide Pope’, ‘Autumn Sun’, ‘Carror’, ‘Cochran Lavender’, ‘Elaine’, ‘Emily’, ‘Fred D. Cochran’, ‘Tone Burden’, ‘Jan Cochran’, ‘Jane Spalding’, ‘Parlarge’, ‘Pink Camellia’, ‘Pink Cloud’, ‘Rachel’, ‘Steele Burden’, ‘Sunglow’, and ‘Wolfpack Red’. Robert E. “Buddy” Lee, Transcend Nursery, Independence, LA, has released many azaleas from years of development work beginning in the 1970s. Some of the Southern Indica types have included ‘North Lake Beauty’. He also is known for the development of the Encore azalea group—currently 29 cultivars being marketed by Plant Development Services, Loxley, AL. Rhododendron breeding has been conducted by John Thornton, Franklinton, LA, since the 1970s. His initial releases were ‘Charles Loomis’ and ‘Jim Lynch’. Newer releases are the Southgate series: ‘Southgate Divine’, ‘Southgate Brandi’, ‘Southgate Breezy’, ‘Southgate Radiance’, and ‘Southgate Grace’. These have a genetic base of *Rhododendron hyperythrum*. Richard Odom, Country Pines Nursery, Forest Hill, LA, has released crimson foliaged azaleas ‘Crimson Majesty’, ‘Crimson Queen’, and ‘Crimson Princess’. All are vegetative sports from ‘Red Formosa’. Margie Jenkins, Jenkins Farm and Nursery, Amite, LA, has been an active promoter of the Robin Hill azaleas, with approximately 15 cultivars in this group being grown at wholesale nurseries in the state. She has recently released a vegetative sport of the popular ‘Watchet’ Robin Hill azalea, ‘Freddy’.

Tuesday, July 23, 2013 **Springs Salon D/E**

Ornamental Plant Breeding

Moderator: Michele Scheiber, mscheiber@novaflora.com

8:00–8:15 AM

Historical Significance of Rhododendron Development in Louisiana

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Breeding, development, introduction and promotion of Rhododendrons in Louisiana has been significant since the 1970s. Accomplishments have come from university horticulturists and nursery industry members. Larry Brown, long time ornamental horticulture research at the LSU AgCenter’s Hammond Research Station, Hammond, LA, conducted azalea breeding that resulted in the release of ‘Southern Summer Rose’. Other selections from his program were not released but were considered for release as ‘Southern Summer Sun’ and ‘Flo’s Favorite’. Horticulture breeder Dick Stadtheer came to the LSU AgCenter’s Department of Horticulture from North Carolina State University (NC State) where he had begun a program on the development of summer and fall flowering azalea cultivars. The plants released from this effort (some from NC State and

8:15–8:30 AM

The Ornamental Plant Trialing Program at Star Roses and Plants

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Star® Roses and Plants (SR&P) is a leading breeder and distributor of perennials, shrubs and roses. Its products include the Knock Out® rose. NovaFlora is SR&P’s breeding division. Trialing is an integral part of the breeding process and comprehensive screening can be the difference between a financial success and failure. In addition, it builds a well-respected reputation for the company or institution that results in the consumer eagerly awaiting the next great product. The trialing process at SR&P is a multi-year, multi-region process involving numerous co-operators from industry, academia, and public gardens. SR&P has been trialing rose varieties for decades, and a program to evaluate woody and perennials was instituted in 2009. The trial has grown to evaluate more than 250 new varieties annually for landscape performance, grower traits, and overall aesthetic appearance. Varieties developed by NovaFlora and licensed-in from university and private breeders are evaluated and compared to industry standards both in containers and in-ground trials to provide the grower and consumer a thorough understanding of growth habits and aesthetic benefits from beginning to end.

An asterisk (*) following a name indicates the presenting author.

Information garnered benefits not just growers and consumers but can be utilized for patent-filing and marketing departments for promotion and distribution.

8:30–8:45 AM

Breeding Lance-leaved Caladiums

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Caladiums can be grown as container or landscape plants. Their ornamental values come primarily from their colorful and variably-shaped leaves. Three leaf types are recognized in caladiums. The demand for lance-leaved caladiums has been on rise, but the number of cultivars in this category has been limited. The main limiting factor has been the low tuber yield potential of many lance-leaved cultivars. Considerable efforts have been made over the past 35 years to produce new lance-leaved caladium cultivars with higher tuber yield potential and new leaf characteristics. ‘Florida Sweetheart’ and ‘Florida Red Ruffles’ have become important cultivars for the caladium industry. Several new lance-leaved cultivars have been introduced in recent years. ‘White Butterfly’ performs very well under partial shade; ‘Cherry Tart’, ‘Tricolor Butterfly’, ‘Fairytale Princess’, and ‘Red Hot’ perform superbly both under shade and in full sun. Inheritance studies show that the lance leaf phenotype results from a heterozygous genotype of the two co-dominant alleles that controls caladium leaf types. Further improvement of lance-leaved caladiums may rely upon the introduction of high tuber-yielding genes from fancy-leaved caladium genotypes.

8:45–9:00 AM

Improved Floral Characteristics of Tetraploid Stephanotis

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The stephanotis plant, *Marsdenia floribunda* (Brongn.), is an evergreen climber native to Madagascar that is cultivated in tropical and subtropical regions for its white fragrant flowers. In Hawaii, *M. floribunda* flowers are strung as lei lengthwise, requiring about 25 flowers, or they are pierced through the side of the corolla, utilizing up to 700 flowers, depending on style. A cultivar possessing larger flowers, such as a tetraploid form, would be beneficial to the lei industry, since fewer flowers would be required to produce a lei. The objective of this experiment was to create a tetraploid *M. floribunda* by treating seeds with colchicine. Seeds were treated in a 0.0%, 0.05%, 0.1%, 0.2%, or 0.4% colchicine solution for 24 or 36 hours before sowing in moist peat–perlite media. Based on visual inspection, suspected tetraploid seedlings were selected for screening using stomatal guard cell measurements, since guard cells of polyploid plants are usually larger than those of diploid plants of the same species.

Four plants were identified as possible polyploid plants based on guard cell measurements. Flow cytometric analysis was used to confirm the ploidy status of the 4 candidates, with 1 being diploid, 2 mixoploid and 1 tetraploid. The tetraploid plant has produced flowers about 33% wider, and with the corolla tube about 50% longer than the diploid control.

9:00–9:15 AM

Autotetraploid Induced Sterility in the Pink and White Shower Tree

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The copious production of messy and sometimes hazardous fruits and seeds make the normal diploid forms of many tropical landscape species high maintenance and potentially invasive. A sterile form of the prolific seed producing pink and white shower tree, *Cassia javanica* (L.), would be highly desirable for tropical landscapes. Triploid plants are usually sterile, and can be produced by crossing tetraploid and diploid plants of the same species. In a first step toward creating triploid *C. javanica* plants, several tetraploid and mixoploid individuals resulted from colchicine treatments on seedlings. Upon flowering, all four 5-year-old autotetraploid *C. javanica* plants were completely sterile, and remained sterile in their second year of flowering. Among 11 mixoploid plants that flowered, 10 were as prolific seed producers as the diploid control plants, and one individual was completely sterile both years of flowering. It is not uncommon for autotetraploid plants to have reduced fertility, but complete sterility, although welcomed, was unexpected. The sterile autotetraploid plants will be airlayered for introduction to the Hawaii landscape industry.

9:15–9:30 AM

The Female Fertility of Triploids in *Lilium*—Euploid and 5-Same-Genomes of Endosperm are of Essence

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Triploid is usually sterile because it has abnormal meiosis and mainly produce aneuploid gametes with wide range of chromosomes. However, a special phenomenon was observed in *Lilium* hybridizations, i.e., most triploid lilies can be used as maternal parents to cross with diploid or tetraploid ones while the triploids are completely male sterile. By analysis, it is concluded that lily tetrasporic embryo sac is the reason for that. From tetrasporic embryo sac formation, we can deduce that triploid lilies usually produced aneuploid eggs but invariably hexaploid secondary nucleus. After double fertilization with diploid or tetraploid lilies, their embryos are usually aneuploid but endosperm invariably euploid. Because euploid endosperm possesses balanced chromosome numbers and then, it usually develops well, thus it could make aneuploid embryos survive. From more allotriploid x diploid/tetraploid lily hybridizations,

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we observed that the endosperm usually develops well when it contains at least 5-identical-genomes, otherwise, it aborts or hard develop. Based on the experimental results and analyses, we proposed a new hypothesis that five same genomes of endosperms are essential for its development in triploid x diploid/tetraploid crosses of *Lilium*. The hypothesis can explain the success or failure of 3x x 2x/4x crosses in *Lilium* and is of importance for lily breeders who need to know the likelihood of success when producing new cultivars of this economically important horticultural crop.

Specified Source(s) of Funding: The National Natural Science Foundation of China (No. 30871730 and 31071821)

9:30–9:45 AM

Genetic and Phenotypic Characterization of Oriental Lilies Transformed with Genes of Herbicide Tolerance and Flavonoid Biosynthesis

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Oriental lilies ‘Marco Polo’ and ‘Sorbonne’ were transformed either biolistically or *Agrobacterium* mediated transformation method with a herbicide tolerance gene, bar, and pCAMBIA-3p, harboring Flavonoid 3’, 5’ Hydroxylase gene (f3,5h) genes. Fifty plates of 0.5 g suspension cells of ‘Marco Polo’ were bombarded with gold particle coated with pDM302 DNA and transformants were selected with 2 mg/L phosphinothricin and regenerated. Bar gene transgenic plants were grown repeatedly with new bulbs every year and challenged with 1% glufosinate herbicide. For the *Agrobacterium* transformation, 2 g of embryogenic callus of ‘Sorbonne’ were transformed with the plasmid and selection-cultured with subsequent exposure to 10 mg/L Hygromycin so to produce 167 plantlets. PCR analysis indicated that 60% of these plantlets contained the transgene. And, from the putatively-transformed plantlets, mGFP5 gene, a reporter gene in the transgene cassettes, was confirmed to express, which indicates that the protocols were very efficient and reliable for the transformation of lilies. One hundred twenty six plants of an Oriental lily ‘Marco Polo’ transformed with bar gene have been propagated vegetatively and those transgenic lily lines have been resistant to 1,000 mg/L of phosphinothricin over years. Those transgenic lines were used as parents in hybridization with other cultivars and their progenies expressed the inherited herbicide tolerance trait. To investigate the copy number and

sequences of flanking regions of the transgene insertion, inverse PCRs were conducted for the herbicide and f3,5h transgenic lines. Majority of the lines were found out to contain more than two copies, but some events were confirmed to have a single copy and their flanking region sequences were not matched with any reported coding sequences so far.

Tuesday, July 23, 2013

Desert Salon 9-10

Postharvest

Moderator: Yan Wang, yan.wang@oregonstate.edu

8:00–8:15 AM

Development of Novel, Antimicrobial Plant Essential Oil Treatments to Reduce the Postharvest Incidence of *Botrytis cinerea* on Strawberries

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Strawberry fruits are very fragile and have an extremely short shelf-life, making timely harvest, cooling, and marketing of the fresh fruits absolute necessities. *Botrytis cinerea* gray mold continues to plague the strawberry industry both in the field and during postharvest storage, shipment, and retail sale. Postharvest treatments available for berry preservation and disease management have been limited due to the reluctance to spray or wash the berries. Little information is available regarding the use of volatile essential-oil compounds for postharvest treatments on California strawberries to reduce the incidence of grey mold. Strawberries were obtained from commercial growers in the Santa Maria area of California. Volatile compounds were diluted in ethanol and applied to sachets affixed to the inner lids of clamshells, with one sachet per clamshell. Clamshells were individually overwrapped with a microperforated 1-mm polyethylene film to prevent excessive CO₂ buildup within the packages. The marketable shelf-life, percentage of rotted fruit, postharvest quality, and levels of oxygen and CO₂ within the packages were determined during 14 days storage at 40 °F. Strawberries treated with both methyl jasmonate (MJ) and ethanol (ETOH) had less rot and a longer shelf-life than the untreated control (UTC) fruit or those treated with MJ or ETOH alone suggesting a synergistic effect. A mixture of 3.5 µL MJ + 300–600 µL ETOH combined with 25–100 µL citral (CT) + 25–100 µL linalool (LN) or 100 µL carvacrol (CV) + 0.05 g thymol (TY) + 100 µL eugenol (EU) reduced rot and increased shelf-life significantly compared to the UTC, ETOH, or methyl jasmonate treatments; however, these combinations were found to be phytotoxic to both the strawberry calyx and the

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fruit when overall volume of essential oils per clamshell were 200 μL or higher. ETOH had a positively-correlated and rate dependent effect on strawberry respiration that lasted through the storage period. The combination of 400–600 μL ETOH + 25–50 μL CT + 25–50 μL LN + 3.5 μL MJ was most effective at reducing rot and increasing shelf-life compared to the UTC, and this combination did not affect organoleptic quality.

Specified Source(s) of Funding: California Agricultural Research Initiative

8:15–8:30 AM

The Importance of Leaf Maturity to Shelf-life and Quality of Fresh-cut Kale Stored at Two Temperatures

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Kale (*Brassica oleracea* var. *acephala*) prepared as fresh cut salads has increased in recent years due to its high nutritional content. An attribute that concerns the industry and consumers is the shelf life of the product, which directly affects the nutritional content and visual quality. Currently kale leaves at different maturity stages may be harvested, resulting in a heterogeneous product in terms of composition and shelf life. In the case of the fresh-cut salads this may be more critical due to enhanced deterioration caused by mechanical damage during processing. Changes in composition and visual parameters of fresh-cut kale leaves (var. *Lacinato*) were investigated for three maturity stages at harvest (immature, mature, overmature), two temperatures (0 and 5 °C) and five periods of storage (0, 14, 21, and 28 d; up to 42 d for 0 °C product). Product was cut manually into 2 cm strips, washed in chlorinated water, manually centrifuged, and packaged in unsealed LDPE bags. Total chlorophyll content (mg/g FW) decreased during storage, with the lowest concentration found in pieces from overmature leaves at 5 °C after 28 days, while the total carotenoid content did not vary among the different conditions studied. Ammonia content (mg/g FW), an indicator of membrane degradation caused by abiotic stress, remained low for pieces from all maturity stages stored at 0 °C during 42 days, but increased dramatically in pieces from mature and overmature leaves at 5 °C between 21 and 28 days of storage. Color (L^* , a^* , and b^* values determined with a reflectance colorimeter) as well as marketability indicators (off-odors, overall visual quality, yellowing, decay, and browning on cut ends based on rating scales) presented significant differences in response to the postharvest conditions studied. In general, the loss of composition and visual quality of fresh-cut kale leaves increased with temperature, leaf maturity stage at harvest and days of storage.

8:30–8:45 AM

Real World Evaluation of Packaging Strategies and SO₂ Fumigation for Shipment of Blueberry Fruit from Chile to North America

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Blueberry (*Vaccinium corymbosum* L. cv. Brigitta) fruit were harvested at commercial maturity (> 80% blue) from two different farms in the Maule region of Chile on January 9 and 10, 2013, and packaged the over the next two days using several different packaging strategies that included perforated and non-perforated films and fumigation with SO₂. Fruit from farm 1 were placed into: 125 g polystyrene clamshells sealed in low density polyethylene (LDPE) packages (VF101) containing a total of 1.6 kg fruit; 340 g clamshells (one dry pint) in LDPE packages (VF202) containing 4.1 kg fruit; loose fruit in LDPE packages (VF101) containing 1.6 kg fruit; and 125 and 340 g clamshells without packages. Fruit from farm 2 were placed into 125 g clamshells in LDPE packages (VF101) containing a total of 1.6 kg fruit; 340 g clamshells in LDPE packages (VF102) containing 4.1 kg fruit; 340 g clamshells in LDPE packages (VF103) containing 6.1 kg fruit; and 125 and 340 g clamshells without packages. Packages had 0 or 2 perforations for fruit from both farms and a portion of the fruit from farm 1 were fumigated with SO₂ for about 10 min prior to packaging. Fruit entered the refrigerated distribution chain for shipment to the United States upon packaging, were shipped by sea container from Chile about 11 days after packing, and arrived in the United States 28 days later. Transport through the U.S. distribution chain required an additional 8 days. Thus, fruit arrived in Michigan 40 days after harvest and were evaluated after an additional 2 days at 2 °C to simulate regional distribution. Fruit were evaluated at that time and after an additional 3 days at 12 °C to simulate retail holding. Assessments included fruit firmness, degree of internal discoloration, decay, and shrivel, and visual sensory analysis. Perforated packages had higher O₂ (14.6 vs. 8.9%, respectively) and lower CO₂ (4.8 vs. 6.6%, respectively) than non-perforated packages. The greatest effect on storability was the source of the fruit; fruit from farm 2 were in much poorer condition than those from farm 1. The retail holding period significantly reduced the quality of the fruit, especially for farm 2. Packaging tended to improve quality over non-packaged berries. Perforated LDPE packages performed similarly to non-perforated packages.

An asterisk (*) following a name indicates the presenting author.

Smaller clamshell containers yielded the highest quality fruit. Fumigation with SO₂ suppressed decay and improved visual appearance.

Specified Source(s) of Funding: Fondef Project D09R1008 and Orchard View Farms Inc., Chile

8:45–9:00 AM

The Effects of Low Oxygen on Chlorophyll and Glycoalkaloid Concentrations in Potato Tubers

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Light stimulates both chlorophyll and glycoalkaloid synthesis in potatoes through independent biochemical processes. Green potatoes are rejected by markets because of the expectation that the potatoes also have higher glycoalkaloid contents. To reduce potato losses caused by light exposure, the use of controlled atmospheres was investigated. Potato tubers (white skin varieties) were held in chambers with air or controlled atmospheres with four oxygen concentrations (i.e. 0%, 0.5%, 1%, and 3%) for 8 days with continuous light exposure at 3,000 lux and compared to potatoes held in chambers in the dark. Glycoalkaloid concentrations (determined spectrophotometrically on freeze-dried potato slices) in light-exposed potatoes increased from an average of 6 mg/g FW on day 0 to 18 mg/g FW on day 8. Glycoalkaloid concentrations of potatoes held in the dark or in any of the low oxygen atmospheres did not exceed 8 mg/g FW after 8 days. Only oxygen concentrations of 1% or lower were effective to inhibit greening (spectrophotometric determination of chlorophyll in peels). Although controlled atmospheres with oxygen lower than 1% inhibited both greening and glycoalkaloid synthesis, these atmospheres caused unacceptable anaerobic conditions (mainly increased ethanol concentrations with little change in acetaldehyde concentrations) and decay. The 3% oxygen treatment, though providing less inhibition of greening, caused no increase in fermentative volatiles. It appears that glycoalkaloid synthesis is more sensitive to lowering oxygen concentration than is chlorophyll synthesis.

9:00–9:15 AM

Firmness and Quality Changes in Broccoli Due to Dehydration and Hydration

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A major quality concern for the marketing of broccoli is head or crown softening associated with water loss, which can occur at various points in the postharvest handling chain. This research evaluated the influence of dehydration and hydration on head

and stem firmness and other quality attributes. Broccoli heads (cv. Ironman) were harvested at 6 am and immediately placed in plastic bags inside coolers containing ice for transport to the lab. Based on previous experiments, five treatments were performed after trimming stems to 18 cm: 1) control (as harvested); 2) short hydration (heads 30 min in 5 °C water); 3) long hydration (heads in water 2 h (firmness and weight loss) or 4 h (shelf-life and respiration)); 4) dehydration (heads allowed to lose 2% to 3% fresh weight at 5 °C); and 5) heads dehydrated 2% to 3% and then rehydrated for 30 min. Product was placed in perforated plastic bags in boxes to simulate commercial storage. Broccoli (12 heads per treatment) was evaluated before and after treatment and every 5 d for 20 d at 5 °C for weight loss and head and stem firmness (heads compressed 7.5 mm with a 50 mm flat cylindrical probe; stems compressed 5 mm on a three point bending rig). Shelf-life (15 heads per treatment) was determined as the days to show incipient yellowing during storage at 5 °C (product in bags on trays) and respiration was determined daily on broccoli in flow-through chambers by analysis of net CO₂ production. Hydration for 30 min or 2 h caused sharp and similar increases in fresh weight and head and stem firmness. Control broccoli lost 3% weight after 20 d, while the 30 min and 2 h hydrated heads had corresponding fresh weights 0.8% and 2.5% higher than initial. For dehydrated and rehydrated broccoli, weight loss was similar to that of control heads. The changes in head firmness were similar to the trends in stem firmness for the 5 treatments. Head firmness of control broccoli decreased from 80 to 50 N over 20 d; firmness of dehydrated heads decreased to 50 N and then was constant; head firmness of 30 min and 2 h hydration treatments reached 100 N and then decreased to 80 N after 20 days. Hydrated heads had a shorter shelf-life than heads from control, dehydrated, or dehydrated and rehydrated treatments. Broccoli hydrated 4 h had higher respiration rates than broccoli from any other treatment. Manipulation of the water status of broccoli has major consequences for head and stem firmness and other postharvest quality attributes.

9:15–9:30 AM

Evaluation of The Impact of Hot Water Treatment on the Antioxidant System of Fresh Tomatoes in Chilling and Non-chilling Storage

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Minimizing the effects of chilling injury during shelf-life is important for maintaining the sensory quality of fresh tomato

fruit. Postharvest hot water treatments within certain limits of exposure time and temperature have been shown to increase resistance of tomatoes to chilling injury. Breaker/Turning (BT) 'BHN-602' tomatoes harvested in Spring and Fall 2009 were submerged in water at 25 (control) or 52 °C for 5 minutes. The BT fruit were then stored at 5 °C (chilling), 12.5 °C (putative chilling threshold), or 20 °C (non-chilling). After 1 and 2 weeks, tomatoes were transferred from 12.5 and 5 °C to 20 °C until fully ripe. Ripeness was evaluated by measuring color (CIE a^*) on the blossom end of the fruit until a^* reached an acceptable value. When selected as fully ripe, physicochemical analyses (acidity, pH, total soluble solids, dry matter, and sugars) were conducted. The fruit antioxidant system was evaluated by measuring ascorbic acid, hydrophilic and lipophilic phenolics, lycopene, β -carotene, hydrophilic and lipophilic ORAC, and FRAP. Decay incidence was also determined. We found that the hot-water treatment resulted in significantly higher lycopene content at all storage temperatures ($P=0.0282$), whereas no other antioxidant or physicochemical measurement was found to be significantly affected by the hot-water treatment. In contrast, the storage temperature strongly affected most of the antioxidant and physicochemical analyses. We found that, in order to cope with chilling stress, tomatoes mainly increase their hydrophilic antioxidants such as ascorbic acid ($P = 0.0190$), hydrophilic phenolics ($P = 0.0006$), and total phenolics ($P = 0.0007$) and hence their antioxidant capacity (ORAC and FRAP, $P = 0.1608$ and $P = 0.0019$, respectively) and also their content of lipophilic phenolics, but to the detriment of their lycopene ($P < 0.0001$), β -carotene ($P < 0.0001$), sugar and dry matter content. It was observed that there was a reduction in the carotenoid content, especially lycopene, at the chilling temperature. BT tomatoes were somewhat resistant to chilling conditions, although we observed a high decay rate, particularly non-treated tomatoes at 5 °C for 2 weeks, which had 67% decay. Overall, the hot-water treatment induced an increase in lycopene content, especially at the chilling threshold temperature (12.5 °C) and had a protective effect, in terms of reduced decay, at the chilling temperature (5 °C).

9:30–9:45 AM

Extending Storage Life and Ensuring Arrival Quality of 'Bartlett' Pears after Long-distance Export by Maintaining Cold Chain and MA Chain

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There is a potential of using modified atmosphere packaging (MAP) to replace CA for long-term storage and to ensure arrival quality of pears after long-distance export. However, there are insufficient data on optimum MAP conditions for pears.

The objective of this research was to investigate the effects of MAP on extending storage life and maintaining fruit quality of 'Bartlett' pears at simulated transit conditions. 'Bartlett' pears harvested at commercial maturity were packed (20 kg/box) in four different MAP bags varying in gas permeability and stored in air at -1.1 °C for 5 months. Control fruit packed in standard perforated polyethylene liners lost fruit firmness (FF) and skin color at 3 months. MAP 1&2 achieved steady-state atmospheres of 5% to 12% O_2 + 4% to 6% CO_2 , inhibited ethylene production and ascorbic acid degradation, and extended 'Bartlett' pear storage life for 4 months with high quality and up to 5 months with certain skin green color loss. The head space atmosphere of MAP 3 equilibrated at $\sim 2\%$ O_2 + $\sim 6\%$ CO_2 , which resulted in fruit internal browning (IB) after 3 months of storage. MAP 4 with higher gas permeability ($\sim 18\%$ O_2 + 1% to 2% CO_2) had minimal effect on delaying fruit softening and yellowing in cold storage compared to control. After 3 months at -1.1 °C plus 3 weeks at simulated transit conditions, MAP 1&2 fruit maintained FF and skin color at transit temperature of 2.0 °C, maintained skin color but reduced FF to about 66.7N (the critical FF to resist scuffing) at 4.5 °C, and developed IB at 7.5 and 10 °C (6% to 8% CO_2 + $< 2\%$ O_2). The MAP 1&2 fruit could ripen to high eating quality after the simulated transit at 2.0 and 4.5 °C. In conclusion, MAP could increase the storage life of 'Bartlett' pears with high eating quality by up to 2 months and ensure arrival quality after long-distance export by maintaining cold chain and MA chain.

Specified Source(s) of Funding: Columbia Gorge Fruit Growers Association

Tuesday, July 23, 2013 Desert Salon 13-14

SCRI-MINDS Water Utilization and Management

Moderator: Olyssa Starry, olyssa@gmail.com

8:00–8:15 AM

Control of Poinsettia Stem Elongation: Height Limits using Deficit Irrigation

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Height regulation is crucial in poinsettia production for both aesthetics and transportation. Shorter plants are preferred by consumers and occupy less space during transport, allowing for more plants per truck. Controlled water deficit, reducing substrate water content in a controlled fashion when plants are too tall, offers an alternative to plant growth regulators (PGRs)

An asterisk (*) following a name indicates the presenting author.

for poinsettia height regulation. We have previously shown that a controlled water deficit can be used to regulate poinsettia stem elongation. However, it is not clear what the limits are for height control using deficit irrigation and how this affects aesthetic qualities, such as bract size. Our objectives were to determine how much shoot elongation can be inhibited using controlled water deficits and to investigate possible adverse effects of on shoot morphology. Rooted cuttings of poinsettia (*Euphorbia pulcherrima* 'Classic Red') were transplanted into 6-inch pots filled with peat:perlite (80:20) substrate. The plants were fertigated through drip irrigation system with 200 mg·L⁻¹ N of water soluble fertilizer (15N-2.2P-12.5K). Three target heights (43.2, 39.4, and 35.6 cm) were set at pinching and growth tracking curves were used to monitor plant height throughout the production cycle. Substrate water content (θ) was maintained at 0.40 m³·m⁻³ (approximately -5 kPa) during normal growth and reduced to 0.20 m³·m⁻³ (approximately -75 kPa) when plants were too tall, based on the tracking curves. When plant height was once again within the appropriate range, θ was increased again to 0.40 m³·m⁻³. Control plants were maintained at a θ of 0.40 m³·m⁻³ throughout the study. The θ levels were maintained using a soil moisture sensor-based automated irrigation system. Plant height in the 35.6 cm target height treatment remained above the upper limits of the tracking curve, despite being kept at a θ of 0.20 m³·m⁻³ for 70 days after pinching and the final plant height of these plants was 39.8 cm. However, we were able to achieve the target heights of 39.4 and 43.2 cm. Relative to control plants, bract area was reduced by 53%, 47%, and 31% in the 35.6, 39.4, and 43.2 cm target height treatments, respectively. Our results indicate that the minimum height that can be achieved using deficit irrigation is about 39–40 cm for 'Classic Red', but water deficit at that level may also decrease bract size.

Specified Source(s) of Funding: This research was funded by USDA-NIFA, SCRI (award no. 2009-51181-05768).

8:15–8:30 AM

Subirrigation Controlled by Capacitance Sensors for Citrus Rootstock Production

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Brazil is the world's largest orange producer. To produce high quality plants and to reduce pests and diseases spread, seedlings are produced in completely closed nurseries. However, little

attention has been paid to irrigation practices (sprinklers or manual), resulting in improper disposal of water with nutrients and pesticides into the soil. Subirrigation can reduce water and nutrients losses, allows nutrient solution (NS) recycling and reuse, decreases fertilizer use, and reduces the release of nutrients into the environment, while also reducing labor costs. Our objectives were to automate a subirrigation system using capacitance moisture sensors to monitor and control substrate volumetric water content (VWC), and to establish subirrigation water and nutrient management guidelines for Rangpur Lime production in cone-tainers with pine bark substrate. We tested four VWC thresholds as irrigation triggers (0.12, 0.24, 0.36, and 0.48 m³·m⁻³), three NS concentrations (25%, 50%, and 75% of recommended fertilization) and a control with manual irrigation and 100% of the recommended fertilizer rate (200 mg·L⁻¹ N). We used 56x70x6 cm ebb-and-flow benches with individual NS tanks and submersible pumps in a commercial nursery. The automation was accomplished by connecting capacitance sensors to a multiplexer, a datalogger, and relay drivers. Automated subirrigation worked properly throughout the experimental period: the substrate gradually dried out until the threshold for a specific treatment was reached, at which time the irrigation was performed automatically. Lower irrigation thresholds resulted in less frequent irrigation and reduced stomatal conductance, photosynthesis, water use efficiency, leaf area index, plant height, stem diameter, total leaf area, and shoot and root dry mass ($P < 0.001$ in all cases). The 50% NS treatment resulted in the best growth. There were no incidence of disease (especially *Phytophthora nicotianae* var. *parasitica* and *Xanthomonas axonopodis* pv. *citri*), and the occasional appearance of leaf miners and fungus gnats. Capacitance sensors were effective for monitoring and controlling subirrigation. Manual irrigation caused large VWC fluctuations (from 0.16 to 0.43 m³·m⁻³) and resulted in smaller plants (24.55 cm tall) than the 0.36 and 0.48 m³·m⁻³ VWC treatments. 50% of the recommended fertilizer and 0.36 m³·m⁻³ VWC reduced the number of irrigations and resulted in taller plants (44.63 cm) with greater stem diameter (3.46 mm) than control plants. Management of VWC and NS concentration gives growers better control over plant growth and can be used to produce Rangpur Lime rootstocks faster than with conventional methods.

Specified Source(s) of Funding: FAPESP (award n. 2012/01734-5) and CNPq (award n. 479.665/2009-5)

8:30–8:45 AM

Estimation of Green Roof Stormwater Efficiency using Sensor-informed Models

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Rates of plant evapotranspiration (ET) are difficult to predict for *Sedum* species on green roofs, due to the high variability in ET rates, morphological differences and photosynthetic performance between species. It may be possible to modify the standard FAO Penman Monteith reference equation used to predict ET for various crops species, but these model predictions must be calibrated against measurements of actual transpiration by each plant species. In this presentation, we describe how a wireless sensor network was used to measure ET from four replicate 1.3 m² platforms planted with three different *Sedum* species (*S. album*, *S. kamtschaticum*, and *S. sexangulare*) during 2011 and 2012. Stormwater inputs, substrate volumetric moisture content, and runoff were monitored continuously from each platform throughout the two years of the study, every 15 minutes. Environmental variables, i.e. air temperature, relative humidity, wind speed, solar radiation, and photosynthetic flux density were also collected every 5 minutes by the on-site weather station. Root biomass, field capacity, and plant coverage were quantified seasonally for each planted platform. In 2012, samples were also taken at three times during the year to determine leaf area for each species. Between March and November 2011, 985 mm (38 inches) of rain fell on the platforms. Runoff totals were 851, 791, and 817L for the platforms planted in *S. album*, *kamtschaticum* and *sexangulare*, respectively. For storms during which > 50% of the water was retained by the green roof platforms, ANCOVA analysis revealed a treatment effect ($P < 0.10$) while accounting for variability in the data associated with storm size. Ongoing data analysis will explain these findings by exploring relationships between runoff, morphological characteristics, and evapotranspiration and compare these among species for both 2011 and 2012. This information will be used to parameterize and evaluate the FAO Penman Monteith equation for green roofs and to, for example, establish a crop coefficient for the species in this study.

Specified Source(s) of Funding: USDA–NIFA, SCRI Award no. 2009-51181-05768

8:45–9:00 AM

Effects of Water Availability and Temperature on CAM Expression and Water Use Efficiency by *Sedum album* and *Sedum kamtschaticum*

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Though varying degrees of CAM have been documented for *Sedum* species, less is known about the implications of this variation for total water and carbon budgets. This study tracks the carbon gain and water use for the more extensively studied *Sedum album* and for *Sedum kamtschaticum*, for which CAM has been sparsely documented. Whole plant gas exchange chambers were used to document the diurnal flux of CO₂ and evapotranspiration from four replicates of each species. Plants were watered at the beginning of the experiment and again after 21 days. Whole plant gas exchange and evapotranspiration was continuously measured within eight acrylic chambers, placed in one of two Conviron (Winnipeg, Canada) growth chambers, using a datalogger (CR10T; Campbell Scientific, Logan, UT). Air flow through each gas exchange chamber (≈ 17 mmol·s⁻¹) was measured with mass flow meters (HFM200; Teledyne Hasting Inst., Hampton, VA) and the difference in CO₂ concentration between the air entering and exiting the gas exchange chambers was measured with an infrared gas analyzer in differential mode (LI-6262; LI-COR, Lincoln, NE). Most likely as a result of differential Crassulacean Acid metabolism (CAM), *S. album* fixed C at 2.55 (± 0.30) mmol and *S. kamtschaticum* fixed C at 4.68 (± 0.74) mmol. During this same period, *S. kamtschaticum* used 68.87 (± 8.15) grams of water in contrast to 45.82 (± 4.15) grams of water used by *S. album*. Malic acid analysis indicated that *S. album* was in CAM throughout the course of the study, but *S. kamtschaticum* only began CAM idling weakly around day 9. These findings suggest that *S. album* was the more drought tolerant species under the environmental conditions of this experiment. For geographic areas with extended dry periods, *S. album* may be the preferred species compared to *S. kamtschaticum*. In cooler, wetter climates, this species may not transpire water fast enough to contribute substantially to green roof stormwater efficiency. Nevertheless, having a species that can tolerate periods of drought stress is important for overall system function, especially when ongoing green roof management or renovation costs are considered.

Specified Source(s) of Funding: USDA–NIFA, SCRI Award no. 2009-51181-05768

9:00–9:15 AM

Carbon and Water Flux Responses to Physiology by Environment Interactions: A Sensitivity Analysis of Climate Impacts on Biophysical Model Parameters

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Leaf physiological traits are key factors in carbon and water exchange, providing important vegetation constraints on crop production. Sensitivity of carbon uptake and water use estimates to changes in physiology was determined with a coupled photosynthesis and stomatal conductance (g_s) model, linked to canopy microclimate with a spatially explicit scheme (MAESTRA). The sensitivity analyses were conducted over the range of physiology parameter variation observed for *Acer rubrum* L. (intraspecific) and woody deciduous C_3 (C_3) vegetation under different climate conditions. Five key physiological inputs [quantum yield of electron transport (α), minimum stomatal conductance (g_0), stomatal sensitivity to the marginal water cost of carbon gain (g_1), maximum rate of electron transport (J_{max}), and maximum carboxylation rate of Rubisco (V_{cmax})] changed carbon and water flux estimates $\geq 15\%$ in response to climate gradients; variation in α , J_{max} , and V_{cmax} input resulted in up to $\sim 50\%$ and 82% intraspecific and C_3 photosynthesis estimate output differences, respectively. Transpiration estimates were affected up to $\sim 46\%$ and 147% by differences in intraspecific and C_3 g_1 and g_0 values—two parameters previously overlooked in modeling carbon and water exchange. We show that a variable environment, within a canopy or along a climate gradient, changes the spatial parameter effects of g_0 , g_1 , α , J_{max} , and V_{cmax} in photosynthesis- g_s models. Since variation in physiology parameter input effects are dependent on climate, this approach can be used to assess the spatial importance of key physiology model inputs when estimating carbon and water exchange.

9:15–9:30 AM

Implementing Substrate Moisture Set-point Irrigation Control in Cut-flower Greenhouse Production

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We used a wireless substrate moisture sensor network, to compare the effect of time-based versus sensor-based irrigation scheduling on the water use, yield, and quality of *Antirrhinum major* (snapdragon) in cut-flower production. We calibrated soil moisture capacitance sensors (EC-5; Decagon Devices, Inc., Pullman, WA) for use in the perlite substrate (Pennsylvania Perlite Co., Bethlehem, PA), used by a commercial greenhouse operation in Jarrettsville, MD. Sensor-based control was achieved using a prototype nR5 radio node (Decagon Devices, Inc.), in concert with advanced control software (Sensorweb; Carnegie-Mellon Robotics Institute, Pittsburgh, PA), to independently control irrigation events using solenoids. This

was done using the average substrate moisture content data from the crop measured on a 15 minute basis at various positions on each production bench. The lower irrigation setpoint for the automated irrigation control was set at $0.28 \text{ m}^3 \cdot \text{m}^{-3}$, which was based upon the experience of grower and the water needs of the crop. The automated irrigation system only irrigated when the average substrate volumetric water content (VWC) from four sensors in different locations decreased below $0.28 \text{ m}^3 \cdot \text{m}^{-3}$. This sensor-based irrigation treatment was compared to the traditional, time-based irrigation schedule employed by the grower (typically 4–6 irrigation events of 3-minute duration) every day, measured independently using EM50R monitoring nodes with EC-5 sensors, as the control treatment. All the monitoring and control data was transmitted nodes to a base station located in the greenhouse office, and then relayed to the internet via a dedicated website. During eight-week growing period, the sensor-based irrigation irrigated only 28% of the manually-irrigated events, but applied 76% of the total irrigation volume (i.e. longer but less frequent irrigations). A repeated experiment with higher substrate VWC set-points ($0.30 \text{ m}^3 \cdot \text{m}^{-3}$) is currently under way, to increase the precision of VWC set-point irrigation scheduling and to evaluate potential savings in water, fertilizer and labor costs for greenhouse cut-flower production.

Specified Source(s) of Funding: USDA–NIFA, SCRI Award no. 2009-51181-05768

9:30–9:45 AM

The Costs and Benefits of Sensor Networks for a Cut-flower Greenhouse Operation

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Continuous cut flower production of snapdragons (*Antirrhinum* sp.) requires substantial inputs of energy and resources. The use of wireless sensor networks can benefit growers by cost reductions achieved through input reductions and potentially by reducing time to harvest and improving quality. Input reductions also have environmental value by reducing water and nutrient runoff and relieving pressure on scarce water supplies. We worked with a hydroponic wholesale snapdragon grower in Maryland to install a Decagon (Pullman, WA) wireless sensor network. Initially, substrate moisture levels were monitored, which provided information that was used to adjust irrigation flows. A second stage of the project added automated irrigation control to moisture status monitoring. The grower kept detailed records of production activities, including seed sowing dates and quantities, transplant dates and quantities, harvest dates and

An asterisk (*) following a name indicates the presenting author.

quantities, flower quality, and expenditures on energy and labor. We analyzed those records statistically to estimate changes in productivity, cost, and profitability from the use of the wireless sensor network in both phases of the project. Preliminary results indicate that the use of sensors reduced minimum time to harvest by 15% to 35%, median time to harvest by 10% to 20%, and maximum time to harvest by 5% to 10%. The use of sensors also resulted in improved flower quality and lower energy costs. We use the results of these statistical analyses to estimate the profitability of investing in a wireless sensor network in operations of this kind.

Specified Source(s) of Funding: USDA–NIFA, SCRI Award no. 2009-51181-05768

Tuesday, July 23, 2013 **Springs Salon A/B**

Floriculture

Moderator: James E. Barrett; jbarrett@ufl.edu

9:45–10:00 AM

Effects of Nitrogen Rates on Plant Performance and Nutrient Content in Reblooming Iris

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For its fragrance and showy display with multicolors, *Iris germanica* has great potential to serve as a specialty cut flower. Some cultivars of *Iris germanica* have the potential to rebloom in one growing season. However, limited research has been conducted concerning nitrogen (N) fertilizer guideline for these reblooming cultivars. The objective of this research is to investigate the optimal N management practices for promoting blooming performance of reblooming iris. The study was initiated in Spring 2012, using ‘Immortality’, a reliable reblooming iris cultivar, as the research material. Plants were grown in 1-gallon containers and treated with one of five N fertigation rates (N at 0, 5, 10, 15, or 20 mM) during the growing season. Results showed that higher N fertigation rates not only accelerated plant growth rate, but also promoted earlier first bloom and increased the number of flower stalks at second bloom. Plants received N at 0 and 5 mM rates did not produce any second bloom. Plants treated with N at 20 mM produced the most number of stalks at second bloom. The tissue nutrient analysis results showed that the N concentrations in root and rhizome in Winter 2012 increased with increasing N fertigation rates. The growth data in early Spring 2013 showed that plant height and number of fans per plant increased with increasing N fertigation rates in 2012. Results from this study suggested that increasing N fertigation rate can increase plant

nutrient concentration and improve plant growth and blooming performance. Plants treated with N at 20 mM have the potential to produce the most number of flower stalks.

10:00–10:15 AM

Changes in Nitrogen Partitioning to Inflorescence and Pseudobulbs during Various Growth Stages of *Oncidium* ‘Gower Ramsey’

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Oncidium (*Oncidium* spp.) is an important horticultural crop for both potted plant and cut flower production. A part of its stem becomes enlarged to form a pseudobulb, which serves as a storage organ for reserve nutrients and water. As a sympodial orchid, *Oncidium* extends its growth by producing one or more new shoots from the base of the current shoot. These characteristics make it difficult to study the nutrient requirement of *Oncidium* compared with monopodial orchids. In this study, we used the stable isotope nitrogen-15 (¹⁵N) as a tracer to investigate how fertilizer nitrogen (N) is partitioned to pseudobulbs and inflorescence in the various growth stages of ‘Gower Ramsey’. Results indicated that the fertilizer N supplied during the vegetative stage in the current generation was mostly stored in the pseudobulbs, and the fertilizer N supplied during the reproductive stage in the current generation was largely allocated to the inflorescence. During a single shoot growth cycle, the later was the application of ¹⁵N-labeled fertilizer, the less was the ¹⁵N detected in the pseudobulbs while the inflorescence by contrast received more ¹⁵N. During the next generation, the source of N for the development of new pseudobulb and inflorescence came partly from the fertilizer N applied during the previous reproductive stage. Therefore, it is important to continue the supply of N during the reproductive stage of *Oncidium* ‘Gower Ramsey’ to improve the quality of cut flower produced and the shoot development of the next generation.

Specified Source(s) of Funding: National Science Council, Taiwan (NSC 101-2313-B-002-002-MY3)

10:15–10:30 AM

Factors Affecting the Efficacy of Dikegulac Sodium on Poinsettias

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A better understanding of the variables in the use dikegulac sodium to promote branching of floriculture crops is needed. Four experiments were conducted with non-pinched poinsettias (*Euphorbia pulcherrima* Willd. ex Klotzsch). Time of application is given as days after planting (DAP) rooted cuttings. Dikegulac sodium (Augeo) was sprayed using a volume of 300 mL·m⁻², except where indicated. A surfactant was not used. Efficacy was determined as the difference in the heights of the tallest shoot (usually the main stem) and the second tallest shoot (usually a lateral branch). More uniformly branched plants have less difference in these shoots. For three cultivars sprayed 7 DAP with dikegulac sodium at concentrations of 0 to 1,600 mg·L⁻¹, response increased with concentration in all cultivars; however, efficacy was greater in 'Prestige Red' and 'Early Prestige Red' than in 'Jubilee Red'. Importance of spray volume was evaluated with 'Early Prestige Red' using volumes of 100 to 400 mL·m⁻². For both 800- and 1,200-mg·L⁻¹ concentrations, increased spray volumes increased the efficacy of the dikegulac sodium sprays. In a "wash off" experiment, dikegulac sodium was applied 10 DAP to 'Prestige Red' (1,200 mg·L⁻¹) and 'Early Prestige Red' (800 mg·L⁻¹), and then plants received overhead irrigation for 10 seconds. The timing of the irrigation event was from 1 minute to 24 hours after the spray. The control treatment was plants that were sprayed but not washed. The results for the two cultivars were similar. Overhead irrigation up to 1 hour after the spray greatly reduced efficacy, and irrigation at 4 hours reduced efficacy by about 50%. Plants irrigated 24 hours after the dikegulac sodium application were only slightly different from the control plants. In the fourth experiment, dikegulac sodium was applied to 'Prestige Red' using concentrations of 800 or 1,200 mg·L⁻¹. The application was made either 4, 7, or 10 DAP. This experiment included an additional set of plants that were not sprayed and another set that were pinched. All plants sprayed with dikegulac sodium were better than the non-pinched plants that were not sprayed. Efficacy was greater at the higher concentration for each application time. Efficacy at 7 and 10 DAP was similar and better than at 4 DAP. Plants in the 1200-mg treatments at 7 or 10 DAP were similar to the pinched plants.

10:30–10:45 AM

Paclobutrazol and Ancymidol Lower Water Use of Potted Ornamental Plants and Plugs

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A study was conducted to evaluate the effects of two plant growth regulators (PGRs), paclobutrazol, on potted sunflower (*Helianthus annuus* L.) and zinnia (*Zinnia elegans* Jacq.), and ancymidol, on marigold (*Tagetes erecta* L.), zinnia (*Zinnia elegans* Jacq.), impatiens (*Impatiens walleriana* Hook.f.), and petunia (*Petunia hybrida* Vilm.) plugs, on water use and growth control. Paclobutrazol was either applied as a drench at 0, 1.0, 2.0, or 4.0 mg per pot of active ingredient for sunflower, or 0, 0.5, 1.0, or 2.0 mg per pot for zinnia, while ancymidol was applied at 0, 40, 80, or 160 mg·L⁻¹ as a foliar spray. With an increase in paclobutrazol dose or ancymidol concentration, plant growth (fresh weight, dry weight, plant height and diameter) and total water use was lowered for all species tested. For potted sunflower, 2.0 mg of paclobutrazol resulted in 31.5% less water uptake compared with nontreated plants. For potted zinnia, plants treated with 1.0 mg paclobutrazol utilized 45% less water. For plugs, a foliar application of ancymidol at 80–160 mg·L⁻¹ lowered water use by 1% to 7% for marigold, 10% to 18% for zinnia, 6% to 15% for impatiens, and 17% to 25% for petunia. In summary, application of plant growth regulators not only controlled excessive plant growth, but also lowered water uptake by the plants and increased water use efficiency for potted plants. These results demonstrate that using plant growth regulators should be considered a best management practice for controlling excessive plant growth and improving water use efficiency.

Specified Source(s) of Funding: United States Department of Agriculture

10:45–11:00 AM

Reducing Evapotranspiration of Pansies: Efficacy and Duration of ABA and ABA-analog Spray Applications

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Abscisic acid (ABA) and synthetic analogs of ABA have the potential for use as holding agents for ornamental plants. Foliar applications of these compounds induce stomatal closure, preventing water loss through transpiration, and thereby extending the shelf life of treated plants. The purpose of this study was to compare the efficacy of ABA and a synthetic ABA-analog, 8' acetylene-methyl ester-ABA (PBI 429), on water and CO₂ exchange of pansies (*Viola xwittrockiana*) and to determine the duration of the effects of each compound. Plants were grown in a greenhouse and were well-watered and fertilized throughout the duration of the study. Spray treatments of a range of concentrations of ABA (0–2000 ppm) and PBI 429 (0–200 ppm) were applied to healthy mature pansies. Gas exchange parameters were measured using a CIRAS- 2 portable photosynthesis meter and leaf chlorophyll content was quantified using a Minolta SPAD meter. Spray applications of

ABA significantly reduced net photosynthesis for 20 d and stomatal conductance for 12 d after application in a rate-dependent manner. PBI 429 sprays also reduced stomatal conductance and net photosynthesis, but to a lesser extent than ABA. Plants treated with ABA had a rate-dependent decline in leaf chlorophyll, while PBI 429 did not affect leaf chlorophyll. In summary, ABA was more effective than PBI 429 at reducing stomatal conductance and net photosynthesis, but had the negative side effect of inducing chlorosis.

Specified Source(s) of Funding: Funding provided by Valent BioSciences

11:00–11:15 AM

Optimal Postharvest Handling Protocols for *Antirrhinum majus* ‘Chantilly Yellow’ and *Celosia Cristata* ‘Fire Chief’

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Snapdragon (*Antirrhinum majus* L.) and celosia (*Celosia cristata* L.) are commercially important specialty cut flowers, but postharvest handling protocols for extending vase life need to be optimized. Stems of snapdragon harvested when the lowermost florets started expanding, had 3.4 days longer vase life than stems harvested with three or more florets open at harvest, while celosia stems harvested when the flower heads were < 2 cm in diameter, had 14.0 days longer vase life than stems harvested with flower heads > 5 cm at harvest. However, visual quality of later harvested stems for both species was higher than early harvested stems. Harvest procedures, exogenous ethylene, and commercial hydrators had no effect on longevity of both species. For celosia, anti-ethylene agents also had no effect, however, for snapdragon, the anti-ethylene agent, silver thio-sulfate, increased vase life 3.2 or 3.7 days longer than deionized (DI) water or 1-methylcyclopropene (1-MCP), respectively. Dry-stored stems of snapdragon had longer vase life compared with stems stored in water, for not more than 2 weeks, whereas, celosia stems did not tolerate storage at 4 ± 1 °C irrespective of the storage methods, and if necessary, should only be stored in water, for not more than 1 week. Use of both hydrator and/or holding preservatives did not result in significant differences in vase life of both species; however, pulsing with 5% or 10% sucrose supplemented with the antimicrobial agent, Kathon (7 mg·L⁻¹), for 24 hours doubled vase life of snapdragon stems and increased flower bud opening and fresh weight of stems during the vase period. Stems of snapdragon kept continuously in commercial preservatives had 2-fold longer vase life than stems in DI water. Floral foam reduced vase life of snapdragon when saturated with preservatives, or had no effect when saturated

with DI water. Stems of celosia kept continuously in Floralife Clear Professional Flower Food with or without floral foam had longer vase life compared with Chrysal Clear Universal Flower Food or foam saturated with DI water.

11:15–11:30 AM

Determining the Effectiveness of Red and Blue Light-Emitting Diodes as Supplemental Lighting during Seedling (plug) Propagation

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Annual bedding plant seedlings (plugs) are considered high-quality when they are compact, fully rooted transplants with a large stem caliper and high root dry mass. The objectives of this study were to: 1) quantify the effects of light emitting diodes (LEDs) and high pressure sodium lamps (HPS) as supplemental light sources to produce annual bedding plant seedlings; and 2) determine what red (R) to blue (B) light ratio produces the highest quality seedlings. Ten bedding plant species (*Antirrhinum majus* L., *Begonia xsemperflorens* L., *Catharanthus roseus* L., *Celosia argentea* L. var. *plumosa* L., *Impatiens walleriana* Hook. f., *Pelargonium xhortorum*, *Petunia xhybrida* Vilm.-Andr., *Salvia splendens* Sellow ex J.A. Shultes, *Tagetes patula* L., and *Viola xwittrockiana* Gams.) were grown under 100 μmol·m⁻²·s⁻¹ delivered from HPS lamps or LED arrays with varying proportions (%) of red:blue light (100:0, 85:15, 70:30, and HPS) with a 16-h photoperiod. Seedling of *Antirrhinum*, *Begonia*, *Impatiens*, *Petunia*, and *Tagetes* grown under the 85:15 light treatment were generally more compact with a larger stem caliper and higher relative chlorophyll content than plants grown under HPS lamps. For example, stem caliper increased by 13.6%, 6.5%, 3.5%, 5.1%, and 11.5% compared to seedlings grown under HPS lamps for *Antirrhinum*, *Begonia*, *Impatiens*, *Petunia*, and *Tagetes*, respectively. Relative chlorophyll content of *Antirrhinum* and *Begonia* increased by 11.6% and 14.0%, respectively, compared to seedlings grown under HPS lamps. Stem length of *Antirrhinum*, *Impatiens*, and *Tagetes* was 5.7%, 30.6%, and 20.8% shorter, respectively, compared to seedlings grown under HPS lamps. Seedlings grown under LED light treatments generally had higher quality parameters than those grown under HPS lamps.

11:30–11:45 AM

Deep Simple Morphophysiological Dormancy in Seeds of *Adonis amurensis* Regel & Radde Native to Korea

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The Ranunculaceae is a family reported to have morphological dormancy (MD) or morphophysiological dormancy (MPD), with underdeveloped embryos. There are few reports on seed dormancy and germination in *Adonis amurensis*. This research was performed to determine the type of dormancy for *A. amurensis* seeds and its dormancy-breaking requirements. Phenology in field conditions, temperature requirements, and GA₃ treatment for embryo growth and germination were evaluated. Seeds had underdeveloped embryos that were about 8% of the length of fully matured seed. In phenological study, the embryos grew very little from June until September, while rapid growth was observed from October until November. Embryo growth was completed from late November until early December. Seeds sown on the field soil started to germinate from 24 February and 50% of them germinated by 17 March. In laboratory experiments, embryo growth occurred only in two sequences of simulated thermoperiods (25/15 °C → 5 °C and 25/15 °C → 15 °C), whereas embryos in constant temperatures (25 °C and 5 °C) grew very little. Therefore, it seems that a warm followed by a cold temperature sequence is essential for embryo growth. The GA₃ increased embryo growth in the seeds, but only 1% to 6% of them germinated at 5 °C or 25/15 °C with 100 mg·L⁻¹. To test low temperature requirements for germination after embryo maturation, the seeds in the field were transferred monthly to a growth chamber from 18 November to 14 February. In seeds transferred on 18 November, GA₃ was treated to determine whether it could substitute for cold requirements. When transferred to laboratory on 18 November, the seeds germinated 20% and 83% without and with GA₃, respectively. However, ≥ 82% of them germinated without GA₃ when the seeds were transferred from 5 January. Based on these results, seed dormancy of *A. amurensis* can be broken through warm followed by cold temperature sequence and classified as having deep simple morphophysiological dormancy (MPD).

Specified Source(s) of Funding: Korea Institute of Planning and Evaluation for Technology of Food, Agriculture, Forestry and Fisheries. Project No. 111158-03-1-CG000

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The potential of using plants as a renewable resource for energy and high-value products has fueled research in developing high-biomass dedicated feedstock crops for conversion to liquid fuels. Feedstock quality (cell wall composition and energy density) is a major component of liquid fuel yield from plant biomass. Variation in quality traits can significantly impact conversion efficiency and costs. Rapid and accurate characterization of feedstock quality in terms of the relative proportions of non-structural carbohydrates, cellulose, hemicellulose, and lignin is important in determining the suitability of different feedstocks for various biofuel conversion technologies. In this study, calibration equations for rapid, nondestructive estimation of feedstock quality using near-infrared spectroscopy (NIRs) were developed using cell wall composition data obtained from wet chemistry analysis. Ninety-six genotypes of energy grasses including *Saccharum* spp., *Miscanthus*, *Panicum virgatum*, and *Pennisetum purpureum* were used to develop calibration models which were subsequently validated with over one thousand samples from different genera. In all samples, cellulose was the dominant cell wall component with dry mass concentrations ranging from 32% to 46%. Hemicellulose and lignin concentrations ranged from 15–24 and 19–48, respectively. Energy grasses and hybrids from the *Saccharum* family had the highest lignin and cellulose concentrations. Least squares calibration equations relating NIRs spectra and wet chemistry data had high coefficients of determination ($R^2 > 95\%$) for cellulose and lignin. Factors affecting R^2 values included number of samples used to develop calibration models, species and genotype, sample age, and sample origin with respect to soil type and fertility management. Whereas high-lignin varieties would be suited for thermochemical conversions, those high in structural sugars would be more appropriate for biochemical conversion processes. The NIRs technique and calibration equations developed in this study are also useful in breeding programs for high throughput screening and genetic improvement of potential feedstocks.

10:15–10:30 AM

Phenotypic Diversity of *Jatropha curcas* L. Accessions under Warm Subtropical Conditions

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Tuesday, July 23, 2013

Springs Salon D/E

Bioenergy

Moderator: John L. Jifon, jljifon@ag.tamu.edu

10:00–10:15 AM

High-throughput Quality Characterization of Warm Season Lignocellulosic Feedstocks

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The phenotypic diversity of 15 accessions of jatropha (*Jatropha curcas* L.) during the first and second flowering periods under the warm subtropical south Florida climate was assessed by using multivariate analysis. Plants were established in field plots at the Tropical Research and Education Center (TREC), University of Florida, in Homestead, FL. Principal Component Analysis (PCA), cluster analysis, and phenotypic correlations between pairs of characters were estimated. A total of 180 jatropha inflorescences were tagged to evaluate the type of inflorescence. Inflorescences were subdivided into three types: female-type, male-type, and middle-type. A higher number of female-type inflorescences was observed during the summer. Field evaluations using 15 quantitative traits showed significant variation among accessions. The oil content ranged from 19.30% for TREC 45 to 35.62% for TREC 31. Seed dry weight had positive correlation with seed fresh weight, seed length, seed thickness, seed width, and 100-seed weight, and negative correlation with oil content. Based on the variations across the 15 morphological traits in the first and second flowering periods, the Average Linkage-Unweighted Pair Group Method with Arithmetic Mean (UPGMA) clustering mechanism divided all 15 jatropha accessions into five different clusters. The PCA reduced the collected data to three principal components that cumulatively explained 73.5% of the total variance observed. Based on UPGMA cluster and PCA assessments, accessions can be evaluated in the first period of flowering, corresponding to Spring. In addition, phenotypic characteristics, such as seed dry weight, 100-seed weight, total flowers per inflorescence, male flowers per inflorescence, and fruit set can be used to distinguish accessions. Accessions TREC 31 and TREC 55 had superior averages for almost all characters evaluated and could be likely used as parents in future breeding programs.

Specified Source(s) of Funding: Vecenergy Company, CNPq and FAPEMIG

10:30–10:45 AM

Differential Gene Expression in *Jatropha curcas* In Vitro Cultures Exposed to Microgravity

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Jatropha (*Jatropha curcas* L.) has been identified as a suitable species for biofuel production. However, the species is undomesticated and breeding and genetic improvement programs

are necessary. Microgravity offers a unique environment for assessment of genetic variation that can be used in genetic improvement programs. The objective of this study was to evaluate the differential gene expression of in vitro jatropha cultures exposed to microgravity. In vitro cultures of two jatropha accessions (Brazil, India) were initiated from cotyledon (CO), leaf (L) and stem (ST) sections. Different RNA isolation protocols were evaluated to assure sufficient RNA of good quality for subsequent microarray analysis. Groups of 10 petri dishes containing treatments (accession x explant tissue) were arranged in Group Activation Pack flight hardware (petriGAPs), previously validated for spaceflight experiments, and exposed to microgravity for periods varying from 14 to 125 days under different space shuttle missions (STS-133 and STS-135). Once returned, cultures were processed for RNA isolation and subsequent microarray analysis. Comparisons were performed between ground and orbit samples for the effects of medium and microgravity exposure time. The type of tissue influenced the efficiency of the RNA isolation and the Plant Reagent and Trizol protocols returned the best RNA quality and quantity. Microarray analysis revealed differential patterns of gene expression between ground and orbit samples and expression patterns were affected by accession and explant tissue. For all comparisons performed, between 9 and 522 genes were differentially expressed. Over 20% of those genes were expressed at higher levels by over 2-fold. Higher levels of differential gene expression were observed in orbit. Gene expression was also affected by exposure time to microgravity, with periods of 111 days showing higher expression levels. Specific groups of genes showing differential gene expression were grouped using a cluster analysis. The roles of different gene groups and the observed genetic changes are discussed for their potential impact on new cultivar development. Differential gene expression induced by microgravity may assist in future genetic improvement programs.

Specified Source(s) of Funding: Vecenergy, Inc.

10:45–11:00 AM

Elevated Salinity in Irrigation Water Reduced Growth of *Ricinus communis* L. Cultivars

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The greenhouse experiment was conducted to evaluate the salt tolerance of six castor (*Ricinus communis* L.) cultivars ('Brigham', 'Energia', 'Hale', 'HCastor', 'Memphis', and 'Ultra dwarf'). Plants were irrigated with nutrient solution at

An asterisk (*) following a name indicates the presenting author.

Tuesday, July 23, 2013

electrical conductivity (EC) of 1.40 dS·m⁻¹ or saline solution at EC of 10.0 dS·m⁻¹ for 69 days. All plants irrigated with saline solution were shorter than those with nutrient solution. The reduction in height was 40%, 39%, 44%, 38%, 51%, and 50%, respectively, for 'Memphis', 'Brigham', 'HCaster', 'Ultra dwarf', 'Energia', and 'Hale', compared to their respective controls. The fruit dry weight (DW) of 'Brigham', 'HCaster', 'Ultra dwarf', and 'Hale' irrigated with saline solution was significantly reduced by 65%, 66%, 60%, and 78%, respectively. Although a reduction of 57% and 55% in the fruit DW was recorded for 'Energia' and 'Memphis', respectively, there was no significance between saline solution and nutrient solution. Total DW of the plants irrigated with saline solution decreased by 60% for 'Memphis' and 70% to 78% for other cultivars as compared with those irrigated with nutrient solution. Based on the above results, 'Memphis' was more tolerant to salinity than other cultivars.

Specified Source(s) of Funding: Texas A&M AgriLife Research Bioenergy Initiatives Program

11:00–11:15 AM

Effects of Implementing Psi-light on Hydrogen Production via Biophotolysis in *Chlamydomonas reinhardtii* Mutant Strains

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A new strategy in hydrogen production via biophotolysis developed previously was implemented in mutant strains of *Chlamydomonas reinhardtii*. Implementing PSI-light (photosystem I light) successfully demonstrated improved hydrogen production in the wild type strain of *C. reinhardtii* in a previous study, however, the results also showed rapid attenuation of hydrogen production even under PSI-light due to inhibited hydrogenase activity caused by oxygen, which was simultaneously produced through the water splitting reactions of PSII (photosystem II) under radiation. In order to further decrease oxygen generation under PSI-light during the hydrogen production phase, use of some mutant strains of *C. reinhardtii*, that are known to show limited oxygen generation, were investigated. Continuous supply of PSI-light after a short anaerobic adaptation under dark conditions achieved significantly prolonged hydrogen production up to \approx 18 hours in a chlorophyll b deficient mutant (Cbn 1-48) and a very high light tolerant mutant (VHLR-S4) yielding H₂ at 220.33 and 175.64 μ L·mg⁻¹ Chlorophyll (= H₂ at 4243.05 and 8731.39 μ L·mg⁻¹ dry cell weight), respectively. In addition, by iterating light and dark every 1.5 hours with PSI-light, hydrogen production was successfully extended to

27 hours yielding H₂ at 365.61 μ L·mg⁻¹ Chlorophyll (= H₂ at 8812.12 μ L·mg⁻¹ dry cell weight) in cbn 1-48. Further, greater energy conversion efficiency from radiation energy to formation of hydrogen molecules was achieved with the combination of PSI-light and some mutant strains compared to alternate methods of biophotolysis.

Specified Source(s) of Funding: The University of Arizona

Tuesday, July 23, 2013

Desert Salon 1-2

Viticulture and Small Fruits

Moderator: Michele R. Warmund, warmundm@missouri.edu

10:15–10:30 AM

Spatial Distribution of Plant-parasitic Nematodes in Semi-arid Vineyards of the Pacific Northwest

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Plant-parasitic nematodes are commonly encountered in semi-arid vineyards of the Pacific Northwest; however, little is known about their distribution and pathogenicity. We investigated the spatial distribution of plant-parasitic nematodes in semi-arid vineyards to provide grape growers with information to better manage nematodes. Two vineyards in eastern Washington were sampled: 'Chardonnay' grown on a sandy loam soil and 'White Riesling' grown on silt loam soil. Nematode populations densities were determined horizontally by sampling five 152 x 213 cm sampling locations at 30 cm intervals to a depth of 45 cm. Vertical sampling was performed at another five sampling locations where five soil cores 91 cm deep were collected directly under an emitter and 30 cm to the N, S, E, or W of the emitter; collected cores were partitioned into 15 cm samples. The percentage of soil moisture and number of different plant-parasitic nematodes were determined for each soil sample. In addition, fine root biomass and AMF colonization were quantified in all horizontal soil samples. The plant-parasitic nematodes *Meloidogyne hapla*, *Pratylenchus* spp., *Xiphinema* spp., and *Paratylenchus* spp. were found at both vineyards, while *Mesocriconema xenoplax* was only detected in the 'Chardonnay' vineyard. At both vineyards,

An asterisk (*) following a name indicates the presenting author.

population densities of *M. hapla* were positively related to soil moisture and fine root biomass ($P < 0.0001$). The same trend was observed for *M. xenoplax* at the Chardonnay vineyard ($P < 0.0003$). The opposite was observed for AMF colonization of the roots, where less soil moisture corresponded with higher AMF colonization of roots ($P < 0.002$). Roots that were galled as a result of *M. hapla* infectivity had significantly less AMF colonization than non-galled roots ($P < 0.02$). The horizontal distribution of nematodes varied among the nematode genera with *M. hapla* and *M. xenoplax* concentrated in the row near emitters while *Pratylenchus* were aggregated at the vine row's edges. At both vineyards, *M. hapla* and *Pratylenchus* population densities were concentrated in the upper 45 cm of the soil profile; *M. xenoplax* followed the same trend in the Chardonnay vineyard. Conversely, *Xiphinema* was found throughout the soil profile at both vineyards. These results indicate that there is potential to reduce the treated area when targeting *M. hapla* and *M. xenoplax* in semi-arid vineyards in the Pacific Northwest. However, this strategy would not be effective against *Xiphinema* (found to a depth of 91 cm) or *Pratylenchus* (concentrated in the row edges).

Specified Source(s) of Funding: Washington Association of Wine Grape Growers

10:30–10:45 AM

Method for Producing Long-cane Blackberry Plants

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Blackberry plants have been propagated by tip-layering, soft- and hard-cane cuttings, root cuttings, and tissue culture (TC). In the last 20 years, long-cane blackberry plants for off-season fruit production have become popular. Long-cane blackberry plants have been produced from TC-plug plants that could yield as many as 20,000/ha of bare-root plants with four 1.5-m-tall canes. However, this system requires that the field be replanted annually with 8,000 fresh TC plug plants. A modified rotating cross-arm trellis system was used to produce over ~120,000 1.5- to 2.0-m-long cane 'Triple Crown' and 'Siskiyou' plants from stock plants established at a density of only 1,700/ha. Lateral canes that develop from horizontally trained primocanes were trained to grow upward on the wires positioned on a slanted cross-arm trellis and then down to the ground. Tips of lateral canes were inserted into pots for induction of adventitious roots. After 4 weeks, the entire lateral cane was detached from the stock plant and the proximal end also inserted into a moistened medium. Rooting occurred at that end. With this procedure, 3-m-long cane plants with roots at both ends of the cane were generated. Rooted cane plants were chilled and then grown in a greenhouse maintained at 17 to 22 °C during the day and 14 to 16 °C at night. In both cultivars, 70% of buds broke. Inflorescences developed on 68% and 46% of shoots on 'Siskiyou'

and 'Triple Crown' cane plants, respectively. Each inflorescence produced over 5 fruit averaging 7.1 g/fruit. Additional studies are needed to determine the effect of longer exposure to cold temperatures and dark, cold-room storage on the performance of long-cane blackberry plants. The cold-stored, containerized long-cane blackberry plants have potential for late-season fruit production. Additional methods of producing long-cane blackberry plants will be discussed.

Specified Source(s) of Funding: USDA–ARS

10:45–11:00 AM

Characterization and Population Genetics of a New Virus Infecting Blackberry

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A new virus belonging to the genus Ampelovirus in the family Closteroviridae was identified in blackberry in several states in the Southern United States (U.S.). Experiments were conducted to characterize the virus, investigate its distribution in the U.S., and study its population genetics. Virus-specific dsRNAs were extracted and genome sequences were obtained by random-primed cloning and 'next-generation' sequencing. Molecular analysis of sequences revealed a genome organization resembling GLRaV-3, a representative member of the subgroup I in the genus Ampelovirus. The sequenced genome contains 10 open reading frames (ORFs), which encode closterovirid signature replication and quintuple gene block proteins in addition to four proteins of unknown function. Genetic variation within the population was analyzed by amplifying and sequencing portions of the polyprotein (region between methyl transferase and helicase domains), HSP70 homolog (HSP70h) and minor coat protein (CPm) genes. Nucleotide and predicted amino acid sequences revealed significant diversity in the polyprotein (23%) and CPm (14%) compared to the HSP70h region (1%). The ratio of non-synonymous substitution per non-synonymous site and synonymous substitution per synonymous site indicated that these proteins are under stringent purifying selections. No predicted recombinational events were observed. Sensitive detection assays were developed based on a highly conserved region for both conventional and real-time reverse transcription PCR and were able to detect all sequenced isolates. Efforts are underway to identify potential transmission vector(s) for this new virus.

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11:00–11:15 AM

Characterization of Eriophyid Mites Inhabiting American Elderberry

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Identification and control of pests is important as American elderberry (*Sambucus canadensis* L.) production increases in the United States. Two genera of eriophyid mites, *Phyllocoptes wisconsinensis* (Keifer) and *Epitrimerus trilobus* (Nalepa) have been described taxonomically and are known to cause foliar damage on elderberry plants. However, mites have not been examined in commercial plantings in Missouri. Thus, specimens were collected from American leaflets at two locations, Mt. Vernon and Hartsburg, MO, from April 2012 to Spring 2013. Mite-induced damage varied by location. *P. wisconsinensis* collected from Mt. Vernon induced curling of leaflet margins with erineae (i.e., enlarged leaf trichomes). In contrast, mites from Hartsburg reduced leaflet size and induced interveinal puckering of plant tissue. Examination of these mites using environmental scanning electron microscopy revealed a previously undescribed fusiform eriophyid mite species. Key features used to identify mites included prodorsal shield anatomy, leg morphology, and genital cover flap structure. Overwintering mites remained on plants under bud scales at Hartsburg and were quantified by bud position. As many as 26 eriophyid mites per node were found in mid-January. The greatest average numbers of mites on buds were located at nodes 4 to 6 from the distal end of last season's growth. Terminal buds and those at nodes 12 and 13 (i.e., near the soil surface) had the fewest mites.

11:15–11:30 AM

Root Restriction Improved Anthocyanins Accumulation and Biosynthetic Genes Expression during Berry Development in 'Kyoho' Grape

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Root restriction could significantly improve grape coloration with increased anthocyanins content, however, less information involved in anthocyanins biosynthesis and related-genes expression in grape berry skin was available. In this study, four-year-old 'Kyoho' grapevines were planted in wooden boxes as root restriction and the conventional ground planting as the control. Compositional changes in skin anthocyanins and expression patterns of 15 genes in anthocyanin pathway were investigated. Our results showed that root restriction significantly increased the total and individual anthocyanins levels in berry skin. Gene expression patterns revealed that the increased anthocyanins coincide with the up-regulated expression of 14 genes [except chalcone synthase 1 (CHS1)] investigated, including Phenylalanine ammonia-lyase (PAL); 4-coumarate CoAligase (4CL); chalcone synthase 2 (CHS2); chalcone synthase 3 (CHS3); flavanone 3-hydroxylase 1 (F3H1); flavanone 3-hydroxylase 2 (F3H2); flavonoid 3'-hydroxylase (F3'H), flavonoid 3',5'-hydroxylase (F3'5'H), dihydroflavonol 4-reductase (DFR), leucoanthocyanidin dioxygenase (LDOX), O-methyltransferases (OMT), UDP-glucose:flavonoid 3-O-glucosyl-transferase (3'GT) and UDP-glucose:flavonoid 5-O-glucosyl-transferase (5'GT).

11:30–11:45 AM

Plant Architecture of *Vaccinium* Genotypes as Influenced by Soil Characteristics

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Vaccinium species vary in both canopy architecture and soil adaptation. For example, canopies of southern highbush blueberry (SHB, *V. corymbosum* L. hybrids), rabbiteye blueberry (RE, *V. virgatum* Aiton.), and sparkleberry (VA, *V. arboreum* Marsh.) range from multi-caned shrubs to monopodial trees. Optimum organic matter content, soil pH, and drought tolerance also vary between species. This variation may reflect differences in root architecture among *Vaccinium* species. To assess the effects of genotype and soil on plant architec-

ture of *Vaccinium* spp., we randomly selected nine seedlings from five populations and grew them in bench-top rhizotrons. The seedling populations were open-pollinated VA (G1) and controlled crosses of RE x RE (G2), SHB x VA (G3), SHB x (SHB x VA) (G4), and SHB x SHB (G5). G3 and G4 are expected to be comprised of 50% and 25% of the VA genome, respectively. Sixty days after germination, seedlings were transplanted to rhizotrons containing either sphagnum peat moss or a 3:1 mixture of sphagnum peat moss and perlite. Seedlings were destructively harvested 77 d after transplanting. Canopy architecture was determined using digital calipers and a LiCor LI3100C leaf area meter, and root architecture was determined using a scanner and WinRhizo Pro 2008a. Root-to-shoot ratio and average root diameter were similar for genotypes from different populations. Total root length, volume and surface area were greater in the G3 and G4 populations than in the others. The G2 population exhibited less root branching than the other populations. For above-ground measurements, the G5 population exhibited significantly greater number and length of first order lateral branches and a significant increase in leaf number compared to the other populations. Growth media also affected root and shoot architecture. Seedlings grown in the peat-perlite mix developed thinner root systems than seedlings grown in peat alone, as evidenced by their significantly higher specific root length and percentage of root length with diameters below 0.9 mm. Above ground, seedlings grown in sphagnum peat were denser and more leafy than seedlings grown in peat-perlite, as evidenced by their significantly greater plant height, total leaf area, and length of the main cane, and their significantly shorter internode length. These results indicate that plant architecture in *Vaccinium* species is influenced by interactions between genetic factors and soil characteristics. Additionally, these results suggest that RE and VA can be used as sources of different plant architecture traits in blueberry breeding.

Specified Source(s) of Funding: USDA-NIFA Specialty Crop Research Initiative Award No. 2009-51181-06021

11:45 AM–12:00 PM

Comparison of Bud Development Across Traditional and New Cranberry Cultivars

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Growers and industry predict yield of cranberry (*Vaccinium macrocarpon* Ait.) via visual assessments of terminal buds. This qualitative approach assumes large and round buds are mixed and consequently contain flower initials that contribute to next season's crop. Small and narrow buds, in contrast, are

assumed to be vegetative and non-yield contributing. Despite widespread use of this method, the margin of error between predicted and actual yields can exceed 15%. Such a large margin of error leads to questions about the reliability of this metric. An additional complication with this approach to yield prediction is the recent release of cultivars that have been reported to differ in bud development. The objectives of this project were to: 1) characterize bud development and flower initiation throughout two growing seasons; 2) compare bud development across several cultivars, including traditional and recently-released cultivars; and 3) determine the relationship between external appearance of buds and the presence/absence of flower initials. Samples of plant material were collected from commercial beds located in central Wisconsin during the 2011 and 2012 growing seasons. Cultivars sampled include Searles, Stevens, HyRed, and Crimson Queen. Collected material was separated based on growth type. Buds were subsequently dissected and analyzed for presence/absence of flower initials using light and scanning electron microscopy (SEM). Growth degree days (GDD) were calculated and used to determine the timing of floral initiation. Presence of flower initials was first observed 29 July 2011 and 10 July 2012. These dates coincide with 290 and 322 GDD, respectively. Dates of flower initiation did not differ across cultivars and types of uprights. Searles, the oldest cultivar included in the study, was the only exception to this finding. Lack of initiation data in 'Searles' was due to high mortality of buds during both years of the study. Analysis of descriptive bud data showed wider buds had a greater probability of containing flower initials and bud width was greater among recently released cultivars. Noteworthy was the discovery that biennial bearing tendencies were minimal among recently released cultivars. These new cultivars exhibited "rebud," which is an important trait that circumvents biennial bearing and has not been widely documented in the literature. Based upon the qualitative nature of bud appearance and variation observed across cultivars, we conclude visual appearance of buds is not a robust metric for yield prediction. Future work should consider quantifiable metrics when attempting to develop improved methods of yield prediction.

Tuesday, July 23, 2013

Springs Salon D/E

Fruit Breeding

Moderator: Ralph Scorza, ralph.scorza@ars.usda.gov

11:30–11:45 AM

Fruit Tree Domestication: The Evolution of Productivity

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Studies of fruit tree domestication are rather scarce and productivity issues have been barely addressed. In the present

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study fruit tree productivity has been analyzed in the broader, biological context of trees' sexual reproduction. The survival of individual trees does not depend upon regular, year-by-year flowering and fruiting. The irregular, fluctuating "masting" habit of forest trees probably represents the natural pattern of trees' sexual reproduction. In the wild, trees seldom reach their fruiting potential; environmental stresses and endogenous resource constraints preclude regular fruiting and limit fruitfulness. Consistent, year-by-year fruiting has been established in domesticated fruit tree crops through unconscious and conscious human selection. Advanced crop management eliminates or, at least, minimizes biotic and abiotic stresses, thereby enabling trees to approach their full fruiting potential. Examination of a broad range of wild, semi-domesticated, recently domesticated, and fully domesticated fruit tree species enables reconstruction of the evolutionary course of fruit tree productivity. Trees with a striking alternate bearing habit (olive, pistachio) represent, in our opinion, an intermediate position between wild and fully domesticated species. Alternate bearing appears to be a survival strategy for balancing reproductive and vegetative tree growth, in particular under sub-optimal conditions. The underlying genetic mechanisms are still greatly unknown. An evolutionary model of fruit tree productivity will be presented.

11:45 AM–12:00 PM

Prediction of Genetic Potential of Candidate Apple Cultivars for Fruit Quality from Unreplicated Multi-location Field Trials

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Evaluation of the phenotypic expression of traits under field conditions is a fundamental process for predicting the genetic potential of new candidate cultivars. However, the accuracy of genetic potential predicted from phenotypic observations is compromised by non-genetic effects. Replication of individuals through grafting and randomization may be employed to estimate the average effect of a candidate, from which genetic potential may be inferred. In this study, we describe the use of pedigree information in the analysis of unreplicated genetic trials as another method to improve the accuracy of predicting genetic potential from phenotypic records. The data in this analysis is from the pedigree-linked RosBREED apple reference germplasm set including trees planted at three locations: Wenatchee, WA (n = 284), Victoria, MN (n = 300), and Geneva,

NY (n = 170). There were less than five individuals that were in common among the trials. However, the deep pedigree relationships among parents and ancestors that spanned seven generations were used to establish genetic connections among trials and hence enabled genetic effects to be separated from non-genetic effects. This approach was also used to quantify the magnitude of genotype-by-environment interactions for several traits.

Specified Source(s) of Funding: University of Queensland and RosBREED

12:00–12:15 PM

Enabling Marker-assisted Breeding in Heterozygous Polyploid Species: The Strategy Used in Sour Cherry (*Prunus cerasus*)

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With heterozygous polyploid species, detecting quantitative trait loci (QTL) can be an arduous process, especially in segmental allopolyploids like sour cherry ($2n = 4x = 32$) where non-homologous pairing is common. In our sour cherry breeding and genetics program at Michigan State University, we have taken a QTL validation approach for identifying relevant QTLs, whereby QTLs more easily discovered in related diploid species are tested for their association in sour cherry. SNP markers on the Illumina 6K Infinium II array were used for genotyping sour cherry plant materials included in the USDA-SCRI funded RosBREED project (www.rosbreed.org). GenomeStudio polyploidy functionalities were used to score SNP genotypes, including dosage. Previously identified QTLs/candidate genes for several horticulturally important traits (fruit size, fruit flesh color, fruit acidity, fruit firmness, and bloom time) were identified from the peach (*P. persica*), almond (*P. dulcis*), and sweet cherry (*P. avium*) literature. SNP markers spanning the target QTL intervals were identified based on synteny with the peach genome sequence, and marker linkage phase was determined based on sour cherry progeny segregation. The different haplotypes identified for these targeted regions were then tested for haplotype trait association. Haplotypes with significant effect on phenotype were identified for marker-assisted breeding. In certain cases, the SNP haplotype was "converted" to an SSR marker to facilitate future genotyping. Not all regions found to be significant in diploid relatives were significant in sour cherry, indicating either they are absent, fixed or cannot be detected due to complexity of dosage and more allelic variants compared to diploid

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species. This approach has been successful for QTLs with fairly large effects, which are good targets for marker-assisted breeding.

12:15–12:30 PM

“FasTrack” Breeding to Produce New Plum Pox Virus Resistant Plum Germplasm and Cultivars

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Plum pox virus (PPV) is one of the most destructive diseases of plum and other stone fruits. The virus entered the United States in 1999 and currently appears to have been eradicated. In Canada after a decade-long unsuccessful eradication effort, PPV is under a monitoring and management program. Over the past 20 years an intensive international research project has focused on the development of genetically engineered (GE) resistance to PPV. This program has resulted in the development of a GE plum variety ‘HoneySweet’ that has been tested for 15 years in the United States and the European Union. It is highly resistant to PPV and it has received full regulatory approval in the United States. Resistance to PPV in ‘HoneySweet’ is RNAi-based and represents a new source of PPV resistance for breeders and for growers. ‘HoneySweet’ can be used in breeding programs to develop additional resistant varieties and/or rootstocks. To rapidly incorporate PPV resistance into new plum varieties requires novel approaches to breeding that can reduce or eliminate inherent tree breeding limitations, such as: long juvenility periods; the need for extensive and costly breeding plots; and yearly limitations on flowering and fruiting related to seasonal dormancy. To address these limitations we have developed a system to dramatically shorten the breeding cycle of plum. “FasTrack” breeding overcomes the juvenility and environmental limitations of flowering and fruiting by incorporating into plums the Poplar FT (PtFT) gene that induces plum trees to flower early

and continually. We have reduced the plum generation cycle from 3–6 years to less than one year. The “FasTrack” system allows for the rapid incorporation of the PPV resistance transgene into new hybrids. Hybrids containing the resistance-inducing transgene can be selected immediately following seed germination and an accelerated backcross program is being used to move PPV resistance from ‘HoneySweet’ into germplasm adapted to different growing areas such as California and the northern United States. Adapted PPV resistant cultivars that result from this preemptive breeding program will be available to growers in the event that PPV should reappear in the United States.

12:30–12:45 PM

Genome-wide QTL Detection of Individual Sugars, Sensory Sweetness, and Soluble Solids Content in Apples

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Apple (*Malus x domestica* Borkh.) is one of the most important fresh fruits in the world based on its annual production. Washington State is the leading apple producer in the United States, accounting for approximate 60% of the total production. The Washington State University apple breeding program was started in 1994 to develop new improved quality apple varieties focusing on fruit texture, flavor, and storability. The program uses DNA-based markers to assist in cross-planning and to improve the efficiency of selection, however, the number of available markers is still limited. Sweetness is an important but complex component of flavor, which has low heritability and is strongly influenced by environmental factors. As part of the RosBREED project, the phenotypic data of individual sugars (fructose, glucose, sucrose, and sorbitol), sensory sweetness, and soluble solids content (SSC) for 285 and 282 individuals were collected at harvest in 2011 and 2012, respectively. These individuals were genotyped with the RosBREED 8K apple SNP chip. FlexQTL™ software was used to detect QTLs in Washington apple germplasm. Putative QTLs for fructose in Chromosome 1, 2, and 7, glucose in Chromosome 1, 6, 8, and 16, sucrose in chromosome 13, and sorbitol in chromosome 16 have been detected. These QTLs will be further studied for the

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development of functional markers to enable easy application in the Washington apple breeding program.

Specified Source(s) of Funding: RosBREED funded by USDA and NIFA

12:45–1:00 PM

Genome-wide QTL Analyses Uncovers SNP Marker-based Functional Alleles for Apple “Fresh Sensation” Traits

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Crispness, juiciness, and acidity are traits that collectively determine the “fresh sensation” of apple flesh and greatly affect consumer liking of apple cultivars. Unfortunately, our lack of genetic understanding of these attributes has slowed progress in apple breeding programs. The RosBREED project has developed genotypic and phenotypic resources to enable DNA-informed breeding in apple and other Rosaceae crops. For example, an 8 K SNP chip for scanning genomes of approximately 1000 individuals of the U.S. apple breeding germplasm has been developed. Pedigree based analysis approach, using FlexQTL™ and Pedimap softwares, has been implemented for location specific (Washington, Minnesota, and New York) genome-wide QTL analysis for “fresh sensation” traits and linkage groups with significant QTLs have been identified for further analysis. LG02 and LG16 have QTLs for all three fresh sensation traits. We have also confirmed an additional QTL for acidity on LG08, crispness on LGs 05, and 12, and sensory juiciness on LGs 05 and 12. We have identified SNP based functional alleles and estimated effects of major “fresh sensation” loci for important breeding parents. Identified “fresh sensation” QTL variants would be useful for DNA-informed breeding and new cultivar development.

Tuesday, July 23, 2013

Springs Salon A/B

Herbs, Spices, and Medicinal Plants

Moderator: Valtcho D. Jeliaskov, vjeliask@uwyo.edu

1:45–2:00 PM

Essential Oil Yield, Composition, and Bioactivity as a Function of Distillation Time

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Researchers reporting data on essential oil content and composition of various aromatic plants are utilizing different extraction methods and duration time. The essential oil of a number of aromatic crops is traditionally extracted via steam distillation. However, the optimal distillation time for most crops is largely

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unknown. Our previous research has shown that distillation time (DT) can modify essential oil yield and composition of several crops such as coriander (*Coriandrum sativum* L.), oregano (*Origanum vulgare* L.), peppermint (*Mentha x piperita* L.), Japanese cornmint (*Mentha canadensis* L.), lemongrass (*Cymbopogon flexuosus* Steud.), and palmarosa (*Cymbopogon martinii* Roxb.), pine (*Pinus ponderosa* Dougl. ex Laws), of female and of male Rocky Mountain juniper (*Juniperus scopulorum* Sarg.). We conducted additional research on the effect of DT on other crops including anise (*Pimpinella anisum* L.), wormwood (*Artemisia annua* L.), fennel (*Foeniculum vulgare* Mill), and lavender (*Lavandula angustifolia* Mill.). Herewith, we are presenting data from all the DT studies on the above crops. In all these studies, DT significantly changed both the essential oil yields and composition. In general, there was a trend for the low boiling oil constituents to be eluted first, while the main essential oil constituents for most of the plants required longer DT. The antioxidant capacity of the essential oils from different DT within a plant species was also altered. For some plant species, we developed regression models that can predict essential oil yield, the concentration of individual constituents, and the yield of these constituents within DT starting at couple of minutes and finishing with 8, 10, and 14 hours (different DT range for different crops). These studies demonstrated that DT can be used as a tool for obtaining essential oils with different composition, moreover, in some instance a specific targeted composition can be obtained. These studies also established the optimum length of the DT for maximum essential oil yields of the selected crops. In most instances, the optimal DT for maximum yields and desirable composition for a given species was shorter compared to what is usually used and reported by researchers and processors. Apparently, these shorter DT may translate into significant savings of energy for producers and processors. The data demonstrated that researchers must report the DT when reporting essential oil and composition of these crops. The data from these studies can help researchers when comparing reports in which different DT for extraction of essential oil from a specific crop were used.

Specified Source(s) of Funding: University of Wyoming start up funds and Mississippi Specialty Crops Block Grant

2:00–2:15 PM

Drying and Shade Effects on Native Spearmint Oil Yields and Composition

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‘Native’ spearmint (*Mentha spicata* L.) is one of the two most widely grown spearmints in the United States and in other

countries. Recent studies demonstrated its feasibility as cash crop for north central Wyoming. The transportation and energy costs of commercial mint producers can be decreased by drying the spearmint in windrows out in the fields for few days after harvest. And this has been a common practice in the traditional mint producing regions. There is a knowledge gap regarding the effect of drying on ‘Native’ spearmint oil yields and composition. Field and laboratory experiments were conducted in Wyoming to evaluate the effects of drying in days after harvest, DAH (0, 1, 2, 3, 4, 7, 11 DAH) and drying condition (shade and sun) on the essential oil yield, and on the concentrations of beta-pinene, myrcene, limonene, eucalyptol, cis-sabinene hydrate, 4-terpineol, cis-dihydro carvone, cis-carveol, carvone, iso-dihydro carveol acetate, beta-bourbonene, beta-caryophyllene, alpha-humulene/trans-beta-far, and germacrene D in the oil. Treatments did not have significant effect on essential oil yield; the average oil content was 0.25%. The concentrations of myrcene (3% to 3.2% range) and germacrene-D (2.2% to 2.4% range) were greater in the oils from plants dried under a shade compared to the plants dried under direct sun, whereas the concentration of beta-pinene (0.85% to 0.96% range) was greater in plants dried under direct sun. The concentration of carvone (51% to 53% range in the oil) was greater in the plants dried for 1 and 2 days after harvest, and lower in plants dried for 7 days; the rest of the constituents were not significantly different. Drying of ‘Native’ spearmint under direct sun in Wyoming for up to 11 DAH can be practical in an effort to reduce transportation and energy costs without affecting oil yields or composition.

Specified Source(s) of Funding: SunGrant Initiative

2:15–2:30 PM

Study on Spearmint and Japanese Cornmint in Mississippi

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In previous studies, ‘Native’ spearmint (*Mentha spicata* L.) and Japanese cornmint (*Mentha canadensis* L.) have shown potential as essential oil crops for the southeastern United States. Follow-up field studies were conducted in 2011 and in 2012 at

An asterisk (*) following a name indicates the presenting author.

two locations in Mississippi (the North Mississippi Research and Extension Center at Verona, MS, and at Westside Farms, Friars Point, MS), with 'Native' spearmint and 'Arvensis II' of Japanese cornmint to evaluate the effect of nitrogen rate (150, 200, 250, and 300 lbs/ac.) and location of essential oil yield and composition. The N source was Urea (46-0-0); half of the N for each treatment was applied in early spring and the other half 7 days after the first harvest. Transplanting of mint in the field was done with a wagon wheel transplanter, rows were 38 inches apart, with the in-row plant spacing of 1 ft. Irrigation was used at both locations: low flow drip tape in Verona and flood irrigation at Friar's Point to apply approximately 1 inch/acre/week minus the rainfall. Harvesting was done at beginning of flowering, representative samples were weighed immediately and dried at shady place. Dried mint samples (250 g dried material), all in 4 replicates, were steam distilled for extraction of the essential oil. Overall, both mint species grew very well at the two locations. Nitrogen had some effect on oil yields at Friars Point and an effect on the concentration of carvone in 'Native' spearmint oil. 'Arvensis II' plants were taller (97 cm) than 'Native' spearmint plants (68 cm). Fresh herbage yields at both locations were similar to previous reports from trials conducted in 2007 and in 2008 at Verona with the same cultivars. The dry weight of the plants was greater at Verona (0.8 kg/6 foot of row) compared to Friars Point (0.6 kg/6 foot), and 'Arvensis II' provided greater dry weight (0.77 kg) than 'Native' spearmint (0.59 kg). Menthol was the main oil constituent of 'Arvensis II', whereas carvone was the main oil constituent of 'Native' spearmint. The concentration of both constituents was similar to previous reports from Mississippi, from trials conducted with the same species. The concentration of carvone in 'Native' spearmint oil was greater at Friars Point compared to the one in Verona. The results suggest 'Native' spearmint and 'Arvensis II' Japanese cornmint can be viable crops for Mississippi and provide essential oil with desirable composition.

Specified Source(s) of Funding: Mississippi Specialty Crops Block Grant

2:30–2:45 PM

Peppermint and Spearmint in Wyoming Can Survive the First Fall Frosts

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Peppermint (*Mentha x piperita* L.) is grown mainly in the northwestern United States, while spearmints ('Native' spearmint, *Mentha spicata* L. and 'Scotch' spearmint, *M. gracilis* Sole.)

are mainly grown in the Midwest. There is no information on how these crops would yield under the Wyoming short growing season conditions. Field experiments were conducted in 2011 to evaluate the effect of harvest time on peppermint 'Black Mitcham' and 'Native' spearmint oil content and yield. The Native spearmint plots were harvested every week commencing on September 14 and finishing on November 1. Whereas, the peppermint plots were harvested on September 20, September 28, and October 5, 2011, (peppermint plants were damaged and later killed by subsequent frosts). The last two harvests yielded reduced oil content and oil yield of 'Native' spearmint relative to the first two harvests. The concentration of carvone in spearmint was also reduced during the last two harvests. Harvest time did not change oil content or oil yields of peppermint. However, later harvests of peppermint resulted in greater accumulation of menthol in the oil relative to the first harvest. Overall, the concentration of menthol in peppermint oil was relatively high, and much more than menthol in peppermint grown in more southern latitudes, such as in Mississippi, as recently reported. This result supports the notion that for best oil quality, peppermint should be grown in more northern latitudes. Our preliminary results indicate that both peppermint and spearmint could be grown under the environmental conditions of north central Wyoming. Peppermint may be harvested after the first light frosts, but will be killed by late fall frosts. Native spearmint was much more resistant to frosts, it can be harvested after few fall frosts and just before the first snow.

Specified Source(s) of Funding: SunGrant Initiative

Tuesday, July 23, 2013 **Desert Salon 13-14**

Public/Commercial Horticulture/ Computer Applications in Horticulture

Moderator: Peter Ling, ling.23@osu.edu

1:45–2:00 PM

Community Engaged Collaborative Design of a New Children's Garden at a Public Garden

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The Elizabethan Gardens are on ten acres, situated on the Outer Banks in Manteo, NC. Located in a tourist destination, the Gardens have had difficulty expanding their membership base due to the transient nature of the surrounding population. Many public gardens have been successful in both expanding their membership and drawing in tourists by including a children's garden. Therefore North Carolina State University partnered with the Elizabethan Gardens to develop a conceptual design for a new children's garden. Several key partners have made this project possible. The North Carolina State Legislature provided tuition and a stipend for a graduate student. The Outer Banks Community Foundation agreed to provide grant funding for the design collaboration. The North Carolina State Horticulture Landscape Design Studio facilitated the community engaged design process and created conceptual designs. Community input was gathered during a four-hour workshop held at the garden in January 2013. Community members were divided into discussion groups and participated in three activities that helped them identify the children's garden program, theme and design elements. Utilizing the input from the community, six junior and senior North Carolina State University Horticultural Science Landscape Design students each created a design for the children's garden space, and then presented it to the Elizabethan Gardens' management team including administrators, staff, and board members. The management team identified the most desirable design program, theme and elements from the student's conceptual designs and contracted with a local design firm to combine them into one plan that will be used for fundraising and a phased installation.

2:15–2:30 PM

Consumer Preferences for Longevity Information and Guarantees on Cut Flower Arrangements

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The study evaluated consumer preferences for longevity labels and guarantees on cut flower arrangements using a choice experiment. Cut flower arrangements with varying longevity labels, guarantees, and use (self vs. gift) were displayed in 24 scenarios. A choice experiment was used to examine consumer preferences for the different attributes. A mixed logit model and Ward's linkage cluster analysis was used to analyze the data. Results revealed three consumer clusters and participants were willing to pay more for cut flower arrangements with longevity labels and guarantees. Results imply that there is

potential to use longevity labels and guarantees in floral retail settings to improve consumer confidence when selecting cut flower arrangements.

Specified Source(s) of Funding: American Floral Endowment

2:30–2:45 PM

Dynamic Plant Water Use Measurement using Data from a Low-cost Weighing Lysimeter

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Inexpensive, reliable ways to measure plant water use on short temporal scales are needed to improve irrigation efficiency. Apart from more expensive, accurate components, new data mining methods may be a way to extract more reliable data from a system with less precision. In this study, different time-averaging methods were applied to the data from a custom-built weighing lysimeter to determine the maximum amount of reliable water use information that could be determined. The relationship between data reliability and temporal resolution were examined based on error analyses, and a proposed dynamic time-stepping algorithm was used to optimize the temporal resolution and number of reliable data points obtained from the data set. The results given by the lysimeter system, and the data processing methods were verified using a precision laboratory balance as a reference. Separate month-long tests were performed, one with lettuce grown from seedlings, and another with small tomato and pepper plants. This paper aims to improve the quality and amount of information obtainable from a generic low-cost system with significant uncertainty.

2:45–3:00 PM

Building Database Resources for Translational Research in Rosaceae

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The Genome Database for Rosaceae (GDR, <http://www.rosaceae.org>) is an integrated database for genomic, genetic and breeding data. Rosaceae includes many economically important crops such as apple, peach, cherry, almond, raspberry, strawberry, pear, and rose. The GDR integrates genomic, genetic, and breeding data to facilitate data utilization across disciplines as well as across species. Current genomic data includes the annotated whole genome sequences of strawberry, peach, and apple that are available through GBrowse and download pages. In addition, all the Rosaceae sequences from NCBI have been anchored to the whole genome sequences of the closest genome where matches were found. New EST unigene sets have also been developed for major genera of Rosaceae. The predicted genes of the whole genome sequences, genes parsed from NCBI sequences, and EST unigenes have been further annotated by homology to genes in other species, InterPro protein domains, GO terms, and KEGG pathway terms provide a glimpse of the pathways and traits in which they are involved. The annotated sequence data can be browsed through the new species page or queried using various cat-

egories in the search sites. Pathway data can also be accessed through the GDR Cyc Pathways databases: FragariaCyc, AppleCyc, and PeachCyc. Synteny among the three sequenced genomes is also available through the graphic interface, GBrowse_Syn, to facilitate data utilization across species. Genetic data such as markers, QTLs, and genetic linkage maps are available through various search sites and graphic viewers. QTLs and markers from various maps can be compared using the comparative map viewer CMap and the markers that have been anchored to the genome can be viewed through GBrowse, facilitating the new marker development and the identification of underlying genes for the traits of interests. Breeding data, mostly from the RosBreed project, has also been integrated. The germplasm details and their phenotypic and genotypic data can be searched by datasets, germplasm names, trait thresholds, markers, and marker alleles. Tools that can facilitate Marker Assisted Breeding, such as Cross Assist, have also been developed.

Specified Source(s) of Funding: USDA Specialty Crop Research Initiative (SCRI), Tree Fruit GDR: Translating Genomics into Advances in Horticulture

3:00–3:15 PM

Development, Testing, and Application of a Process-based Crop Simulation Model for Garlic

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Crop simulation models are essential tools for assessing climate impacts on crops, assisting crop breeding and management decisions, optimizing agricultural inputs and resources, and forecasting crop yield for policy decisions, as well as developing adaptive cropping solutions in a changing climate. With a long history of cultivation, garlic (*Allium sativum*) is an important crop that has been incorporated into cuisines around the world and widely used as a health supplement and at times a panacea. It is critical to evaluate the impacts of climate change on garlic production with site specificity and develop climate adaptation strategies such as identifying suitable production sites under the future climate scenarios. We have developed a process-based

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crop model for simulating potential growth, phenology, and bulb yield formation of hard-neck garlic. The model responds to temperature, solar radiation, CO₂, and humidity in predicting crop development, biomass accumulation, growth, and bulb yield. Our model incorporates a modified beta function for modeling non-linear phenological responses to temperature, and applies a coupled photosynthesis and transpiration model for predicting crop carbon gain and water use. The model is designed based on the object-oriented scheme in which each organ is an object of a class with properties and methods. This scheme allows for tracking the development and growth of individual organs including leaves, roots, scape, and bulb, and examining the interactions between different organs. Expansion and senescence of individual leaves are simulated separately for each leaf as a function of cardinal temperature, physiological age, and carbon availability. The model has been calibrated and tested using experimental data from the greenhouse and field studies performed in the United States and Korea. We discuss a case study for linking the model with a GIS tool to evaluate site-climate-crop suitability in a changing climate.

Specified Source(s) of Funding: Cooperative Research Program for Agricultural Science & Technology Development (Project No. PJ006403), Rural Development Administration, Korea

3:15–3:30 PM

Building Capacity in Public Horticulture through Strategic Partnerships and Cooperative Education

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Without adding new interest and youthful minds to the ranks of our staff, membership, and visitation: the public gardens of today will tire, age, and near extinction. Longwood Gardens has recently launched a Co-Op Program in partnership with a local Technical High School and Trade College. The program is strategically aimed to build capacity in public horticulture, not only through opportunities with plants and gardening, but through other trades including carpentry, machinery, electrical, HVAC, security etc. This program allows for hands-on training with knowledgeable staff coupled with academic learning in the students' classroom at his/her home institution. Currently in its second year, this program has proven successful as the student satisfies a mandatory experiential learning requirement, the school gains a community partner, and the public garden profession is impressed on future generations as a potential career path. Not only does the Co-Op expose students to a public garden, but it allows them to connect with the larger context of a potential career in horticulture.

Tuesday, July 23, 2013

Springs Salon D/E

Propagation

Moderator: Chiwon W. Lee, chiwon.lee@ndsu.edu

4:00–4:15 PM

Adventitious Shoot Regeneration from Asiatic Lily

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Lily is a monocotyledonous species belonging to the Liliaceae, and one of the most important cut-flower species, mainly because of its large, attractive flowers. The Asiatic lilies are the hardiest of all the lily hybrids, they grow very well in USDA Zones 3–10, are easiest for the beginner to grow, and are the first to flower each season. In an effort to establish an Asiatic lily in vitro breeding system, we developed a highly efficient plant regeneration system for an elite Asiatic lily hybrid 'Jocelyn's Bouquet'. The 'Jocelyn's Bouquet' is an Asiatic hybrid with multi-bloom characters, reported to produce up to one hundred blooms on a single plant. Tissue culture experiments tested pedicel, immature seedpod, and bulb-scale explants, combined with MS basal medium supplemented with different levels of BA (0, 1, 2, 4, 8 mg/L) and NAA (0, 0.2, 0.5, 1 mg/L). It took 45 days for the explants to regenerate new adventitious shoots, with the bulb scale the best initial explant material. The BA at 1 mg/L combined with all levels of NAA produced high frequency regeneration. Regenerated plants were transplanted in the greenhouse, grew well and produced normal flowers when compared with the mother plant.

4:15–4:30 PM

Development of a Rooting Protocol for *Oenothera* Spp. Vegetative Cuttings

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Oenothera is a genus of brightly colored and phenotypically diverse flowers collectively known as evening primroses. This

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genus has seen limited cultivar development in commercial horticulture. By inducing genetic diversity through chemical mutation and hybridization, desirable traits can be produced. If a program for production of desirable mutant and hybrid cultivars is to be successful, a protocol for vegetative replication must be attained. When desirable evening primrose individuals are isolated, replication through stem cutting propagation is necessary. An experiment was devised to determine the best rooting media and hormone treatment for root initiation of *Oenothera* spp. Cuttings were taken from *O. speciosa* Nuttall and *O. missouriensis* Hooker. These 14-cm stem segments were put in 98-cell plug trays using either coarse perlite or fine vermiculite. For each media type, three commercially available formulations of indole butyric acid (IBA) were applied at a rate of 1000 ppm. The IBA products included Hortus® water-soluble salts, Dip'nGrow® liquid concentrate, and Hormex® rooting powder. Each treatment also contained a control group of untreated cuttings. Trays were then placed under intermittent mist irrigation set at 8 seconds every 2 minutes until root data was recorded 8 days later for *O. speciosa* and 2 weeks later for *O. drummondii*. Results showed a significantly higher average rooting percentage, number of roots, and root length for the vermiculite rooted cuttings. Indole butyric acid treatments had varying results among the media types and two species, as the hormone treatment did not have significantly greater rooting percentages than the control for *O. speciosa*. No significant difference was found between the IBA products alone, but an interaction was detected using Dip'nGrow for root length and Hortus® for number of roots using vermiculite for *O. drummondii*.

4:30–4:45 PM

Use of Unrooted Grafted Vegetable Cuttings: I. Effects of Healing Duration and Transportation Temperature

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Grafting of vegetable seedlings is a unique horticultural technology to overcome soil-borne diseases and pests and to add extra vigor to the plants under various environmental stress conditions. In order to advance the use of grafting in U.S. vegetable production in open fields, key issues to address include 1) increasing the propagation capacity to meet the expected large number of seedlings necessary to supply the demands of typically large farms and 2) reducing production costs. Traditionally, vegetable grafting is a labor-intensive process involving much training and

logistics. However, the seasonal nature of nursery operations due to the limitation of transportation of the grafted seedlings is problematic when nurseries are interested in introducing vegetable grafting to serve producers who are interested in using the technology. To address this issue, we examined factors affecting quality and growth of unrooted grafted cuttings as a means to improve the distribution of grafted materials and for nurseries to centralize the labor-intensive grafting operation to serve producers in various regions (i.e., various planting seasons). Grafted tomato and watermelon cuttings ('Durinta' tomato or 'Tri-X 313' watermelon scion with 'Aloha' tomato or 'Strong Tosa' interspecific hybrid squash rootstock', respectively) were harvested after 0, 1, 3, 5, or 7 days of healing after grafting and kept for 72 hours in a dark chamber maintained at 10 (tomato), 12 (watermelon) or 20 °C (both species). The results showed that it required a minimum of 3 and 5 days of post-grafting healing for tomato and watermelon, respectively, before harvest in order to maintain growth and development rates after 3-day simulated transportation, as equivalent to non-treated cuttings (control). Transportation at a lower temperature (10 °C for tomato or 12 °C for watermelon) seems to contribute to maintaining better visual cutting quality than 20 °C. Although more research needs to be done to establish protocols suitable for various species and scion-rootstock combinations, effective use of unrooted grafted cuttings in nurseries with and without grafting capabilities may become a breakthrough technology to advance the use of grafted plants in the United States.

4:45–5:00 PM

The Effect of Rootstock Age on Grafting Ability, Re-rooting, and Field Performance of Grafted Watermelon Transplants

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Fatty alcohol treatment is a useful technology that prevents rootstock regrowth in Bottle Gourd (*Lagenaria siceraria*) and Interspecific Hybrid Squash (*Cucurbita maxima* × *C. moschata*) rootstocks. During a three-week period after treatment, rootstock carbohydrates have been shown to increase. This increase could provide energy to improve graft healing and rootstock re-rooting. This positive effect on transplant quality could lead to an eventual improvement in overall fruit quality and yields. A greenhouse grafting experiment and an open-field trial were conducted to characterize this effect. Bottle Gourd (cv. 'Macis') and Interspecific Hybrid Squash (cv. 'Carnivor') rootstock seed were sown in subsequent weekly plantings to achieve rootstock ages of 1, 7, 14, and 21 days after fatty alcohol application. All rootstocks were grafted using Tri-X 313 scion. The age of the scion was the same for all rootstock types, and the grafting was done on the same day using the one-cotyledon grafting method. Two weeks after grafting, the percentage of

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healed grafts was calculated and scion fresh and dry weights were recorded. Rooting percentage, root length density (RLD), and surface area (SA) were also measured. Increases for both cultivars were observed as rootstock age increased. Grafted plants were also planted in a field at the Clemson University Coastal Research Station in Charleston, SC. Transplant survival was recorded and aerial tissue fresh and dry weights from two plants per plot were measured. Yield data, including number and weight of fruit produced per plot and number of harvests per plot, was also collected. Significant effects in both plant growth and fruit yields were observed depending on the age of the rootstock treatments.

Specified Source(s) of Funding: Development of Grafting Technology to Improve Sustainability and Competitiveness of the U.S. Fruiting Vegetable Industry project—USDA—SCRI PROJECT NO. 2011-51181-30963

5:00–5:15 PM

Germination Enhancement of Common Honeylocust (*Gleditsia triacanthos*) Seeds by Scarification

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There are numerous superior cultivars commercially available that are propagated by bud grafting to a seedling rootstock. This requires adequate germination and seedling production by commercial producers. Common honeylocust (*Gleditsia triacanthos* L.) requires scarification to break physical dormancy of the seed. The influence of various scarification methods on the germination of the common honeylocust seeds was investigated. Seeds harvested from a female plant grown as a street tree in Fargo, ND, were chemically scarified for 0, 1, 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20 hours in concentrated sulfuric acid and were germinated in peat-lite mix (Sunshine Mix #1) under intermittent mist. For comparison, two sets of seeds were also mechanically scarified or treated in boiling water. Seeds that were mechanically scarified or boiling water were germinated in the same root substrate under the same misting system. When scored for germination in 10 days under mist, germination of treated seeds was 0.3%, 98.0%, 98.0%, 99.9%, 88.0%, 80.0%, 33.0%, 8.05%, and 2.0% at 0, 1, 2, 4, 6, 8, 10, 12, 14, 16 hours, respectively. Seeds treated with sulfuric acid for 18 hours or longer were killed. Seeds scarified mechanically showed 98.0% germination, while those treated in boiling water showed 18.0% germination. Result of this study indicates maximum seed

germination can be achieved with a 1–4 hour treatment with concentrated sulfuric acid or mechanical scarification. Seed soaking in sulfuric more than 6 hours was undesirable. The possible use of diluted sulfuric acid during seed scarification was also tested for safety and practicality.

Tuesday, July 23, 2013

Desert Salon 1-2

Crop Physiology

Moderator: Charles A. Sanchez, sanchez@ag.arizona.edu

4:00–4:15 PM

Use of Pollen Vitality to Monitor the Nutritional Status of Flowers

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Analyzing tissues and soils are cultural practices routinely used to monitor the nutrient status in vegetative stages of commercially important crops. Flowers are a plant's reproductive apparatus. Following pollination and pollen germination, pistils provide nutrients to support pollen tube growth through the stigma, style, and ovary. Major problems with tissue analyses involve timing. Samples are taken in summer, months after pollination occurred and when it is too late to remedy floral deficiencies. At harvest, fruit and nuts are completely removed from an orchard; consequently, nutrients contained in them are deleted from the ecosystem months before pollination begins. In addition, leaves are shed and the nutrients they contain are lost. Paradoxically, tissues routinely used to monitor the status of essential nutrients for many crops are not even present during bloom when their contents are needed to optimize pollen vitality and pistil fecundity. Previously, no assays were available to categorize the status of floral nutrients to optimize fertilization of eggs and, consequently, fruit or nut set. Studies involving a multitude of plant varieties indicate that responses of pollen viability to different boron or calcium concentrations produce bell-shaped curves. With this knowledge, an in vitro nutrient bioassay was devised that involves pollen vitality. Pollen was suspended in increasing concentrations of nutrients: boron, calcium, copper, iron, magnesium, manganese, molybdenum, potassium, and zinc. Next, fluorescein diacetate was added as a vital stain. The amount of fluorescence produced was used as a criterion of pollen vitality. If pollen vitality increased in the presence of a nutrient, compared to controls, flowers were considered deficient. If vitality decreased, flowers were considered at excessive levels. If vitality remained the same as controls, flowers were considered near optimum levels. Pollen samples from commercial orchards revealed five categories of floral nutrients: excessive, near optimum, slightly deficient, moderately deficient, and extremely deficient. If pollen is deficient in any of those nutrients, it is logical that the flower that produced them is deficient, which includes the pistil. Samples near optimum levels ranged from 30% to 79%. Samples with excessive levels ranged

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from 0% to 18%. Therefore, routine applications of nutrients during bloom can cause toxic amounts to accumulate. Pollen bioassays accurately and rapidly measure the status of available floral nutrients so farmers can optimize flower fertility before bloom ends and their crop is set.

Specified Source(s) of Funding: Pollen Bank

4:15–4:30 PM

Response of AVP1-OX Romaine Lettuce to Phosphorus

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Crops produced in the desert receive large annual applications of phosphorus (P) fertilizer. However, declining P mineral reserves, erratic fertilizer costs, and concerns about water pollution, have created incentives for improved efficiency. While we have developed management practices, such as soil and plant tissue testing and improved fertilizer placement, the possibility of genetic modifications to crops for improved fertilizer use efficiency has received little attention. Recently, it has been shown that over-expression of type I H⁺-pyrophosphatase AVP1 (AVP, *Arabidopsis* vacuolar pyrophosphatase) contribute positively to many energetic plant processes including general growth, nutrient acquisition, and stress response. This genetic modification enhances nutrient uptake by affecting the abundance and activity of the plasma membrane H⁺-ATPase in a manner that correlates with apoplastic pH alterations and rhizosphere acidification. The objective of this project was to evaluate the potential for using AVP1 overexpression (AVP1-OX) modified romaine lettuce (*Lactuca sativa*) for improved P use efficiency under desert cropping systems. Greenhouse and field data show that AVP1-OX romaine lettuce outperformed conventional lettuce at all levels of P.

4:45–5:00 PM

Variations in Calcium Requirements for In Vitro Shoot Culture among Potato Cultivars

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Tissue cultures offer an accurate system for the evaluation of nutrient deficiency studies for immobile nutrients such as calcium. Calcium is an important plant nutrient and its role in plant growth and development is well known. In our previous studies, we have reported that a calcium deficiency in *in vitro* shoot cultures causes damage to potato shoot subapical expanding cells resulting in shoot tip necrosis and development of axillary shoots. This study was conducted using only potato cultivar Dark

Red Norland and shoot tip injury occurred when the media Ca was below 300 μM . The standard MS media for shoot cultures contains 3000 μM Ca. In the present study we investigated the variability of Ca requirements within potato cultivars *Solanum tuberosum* L. using an *in vitro* shoot culture system. Shoot cultures of three potato cultivars were grown in the standard MS media containing Ca concentrations from 50–3000 μM . Shoot tip health and axillary shoots development were evaluated after 20–30 days after transfer. The media calcium concentration varied for each cultivar to first observe (threshold) Ca deficiency symptoms. For example this threshold media calcium concentration was about 60 μM for the cultivar Snowden, 275 μM for cultivar Dark Red Norland, and 700 μM for the cultivar Burbank. Our results suggest that there is a genetic variation within potato cultivars for Ca requirement for healthy growth *in vitro*.

Specified Source(s) of Funding: In part by the University of Wisconsin-Madison

5:00–5:15 PM

A Continuous Canopy Photosynthesis Measurement System for CAM Plants

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Portable photosynthetic measurement based leaf gas exchange is one tool of most important photosynthesis research techniques. However, it is not suitable for CAM plants because of the main CO₂ absorption in dark period and CO₂ assimilation in photoperiod. Some facultative CAM plants always show certain amount of CO₂ uptake in photoperiod, therefore lead to incorrect determination of the gas exchange characteristics. Therefore, a canopy photosynthesis continuous measurement system based on two leaf canopy chambers was developed and tested for obligate CAM plant (*Kalanchoe daigremontiana*), facultative CAM plant (*Dendrobium officinale*), C₃ plant (*Fragaria ananassa* Duchesn), and C₄ plant (*Zea mays*) under artificial and natural lightings. The results show that the canopy photosynthesis continuous measurement is not only suitable for quantitative evaluation of gas exchange characteristics in CAM plants, but also suitable in C₃ and C₄ plants with weak photosynthetic capacity.

Specified Source(s) of Funding: This work supported by national advanced technology program (2013AA101002).

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5:15–5:30 PM

Steady-state Chlorophyll Fluorescence Measurement for Photosynthesis Research of CAM Plants

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Chlorophyll fluorescence measurement is one of most important techniques in photosynthetic research related to plant physiological ecology and stress physiology. Because of special photosynthetic carbon assimilation pathway of CAM plants, the CO₂ uptake and the assimilation has certain time and the stomata movements always show non-uniform closure phenomenon. In order to store water better and reduce transpiration and thereby improving light and water use efficiencies, facultative CAM plants often show non-uniform stomata closure movement and C3 and CAM pathways switching to eliminate various environmental stress influences and adapt better the environment changes. However, chlorophyll fluorescence measurement based on saturation pulse fluorescence or OJIP rapid fluorescent in CAM plants may not take linkage evaluation in photosynthetic electron transport and carbon assimilation in PS II and PS I because of the dark adaptation. Therefore, a steady-state chlorophyll fluorescence measurement method with the theory and instrument under light adaptation is proposed to apply in photosynthesis research of CAM plants and the plants with non-uniform stomata closure.

Specified Source(s) of Funding: This work supported by national advanced technology program (2013AA101005)

Tuesday, July 23, 2013 **Desert Salon 13-14**

Vegetable Breeding

Moderator: Haejeen Bang, hbang@tamu.edu

4:00–4:15 PM

Participatory Tomato Breeding for Virus Resistance in Central America

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Most of the tomato seeds of cultivars planted in Central America are imported. The imported hybrid cultivars are often adapted

to large-scale, high-input environments. Long-term investments required for breeding programs often preclude efforts in Central America to provide high-quality, low-cost seeds to small-scale farmers. In Central America, as well as other tropical countries, production losses up to 100% can occur due to geminiviruses transmitted by the white fly, *Bemisia tabaci*, in a persistent, circulative manner. Control of the whitefly vector often requires repeated applications of insecticides that may reduce the population size but also increase costs and selective pressure for resistance, frequently exacerbated by continuous sowing cycles. In participatory plant breeding with women's cooperatives in Nicaragua, Honduras, El Salvador, and Guatemala and in collaboration with local NGO's, we evaluated geminivirus resistant cultivars developed by the World Vegetable Center, Taiwan, ROC, which have the potential to provide a more sustainable solution for small-scale, rural farmers to reduce economical, environmental, and health risks. Different breeding lines were identified as superior by women's cooperatives in different regions reflecting variation in production environments and preferences in local markets.

Specified Source(s) of Funding: USAID HortCRSP

4:15–4:30 PM

QTL Analysis for Early Blight Resistance in Tomato

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Early blight (EB), caused by *Alternaria solani* and related fungi is a potentially devastating disease of tomato grown under humid conditions. Although it is controlled by fungicides, resistance can effectively lengthen spray intervals and reduce the amount of pesticides applied. Some quantitative trait loci (QTL) associated with resistance to EB have been reported but the location of those QTL on the tomato genome is still not precise. The objective of this study was to map the QTL associated with EB resistance within cultivated tomato genetic backgrounds. A mapping population (F_{2,3}) was derived from a cross of NC 1CELBR x Fla 7775. NC 1CELBR is resistant and Fla 7775 is susceptible to EB. A population of 250 F₂-derived lines with six plants per line were planted at the Mountain Research Station, Waynesville, NC, with two replicates. Natural inoculum provided disease pressure. Disease rating was performed at the scale of 0 to 5, where 0 = no disease symptom at all on the leaf surface, 1 = symptoms spread over about 20% of the leaf surface area, 2 = symptoms spread over 21% to 40% of the leaf surface

An asterisk (*) following a name indicates the presenting author.

area, 3 = symptoms spread over about 41% to 60% of the leaf surface area, 4 = symptoms spread over 61% to 80% of the leaf surface area, and 5 = symptoms spread over 100% of the leaf surface area. The population was genotyped with 384 single nucleotide polymorphic (SNP) molecular markers optimized for polymorphism rate in fresh-market tomato germplasm and assayed using the KASPAR platform, of which 183 were found to be polymorphic in this population. Composite interval mapping (CIM) using QTL Cartographer (version 2.5) revealed that there are three QTL on chromosome 2 located at 10cM ($R^2 = 4.6\%$), 13cM ($R^2 = 5.3\%$) and 35cM ($R^2 = 5.9\%$) positions, and one on each of chromosome 4 located at 55cM ($R^2 = 6.2\%$) and 12 located at 47cM ($R^2 = 41.3\%$) positions, respectively. Chromosome 6 may have an important genomic region which was detected by single factor analysis of variance (ANOVA) but not by CIM. Additional work on these chromosomes may provide precise mapping of QTL conferring resistance to EB in tomato.

4:30–4:45 PM

Identification of a New Begomovirus Resistance Locus, “Ty-6,” in Tomato

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Begomoviruses, including *Tomato Yellow Leaf Curl Virus* (TYLCV), are among the most important diseases of tomatoes grown in tropical and sub-tropical regions of the world. The development of resistance to the begomoviruses TYLCV and to *Tomato Mottle Virus* (ToMoV) has been a major breeding objective of the University of Florida tomato breeding program since the early 1990s. Resistance has been incorporated from the cultivar Tyking and from several *Solanum chilense* accessions, and resistance alleles of the major resistance genes *Ty-1* (and its allele, *Ty-3*), *Ty-2*, *Ty-4*, and *ty-5* are all utilized in the program. The resistance in some advanced lines, however, is not explained by these alleles. Fla. 8383 has a moderate level of resistance derived from *S. chilense* accession LA2779, but lacks all of the previously identified resistance loci. In Spring 2010, 203 plants of an F_2 population derived from the cross between Fla. 8383 and the susceptible breeding line, Fla. 7776, were inoculated with TYLCV and evaluated for disease severity. Each plant was genotyped with 158 polymorphic snps developed through the SolCAP project. Single marker analysis identified a major resistance allele on chromosome 10, tentatively named “Ty-6,” which functions additively. For confirmation, Fla. 8638B, which has a high level of resistance conferred by *ty-5* (derived from ‘Tyking’) and by one or more alleles derived from *S. chilense* accession LA1938, was crossed to the susceptible breeding line, Fla. 7804; 240 F_2 plants were inoculated with TYLCV and evaluated for disease severity in Fall 2012. Each plant was genotyped with a marker for the *ty-5* allele and with a marker for the “Ty-6” allele. Both loci were highly significantly associated

with resistance and together explained 73% of the phenotypic variation in the population. There was no epistatic interaction between *ty-5* and “Ty-6”.

4:45–5:00 PM

Alternative Splicing Variants and a New DNA Marker for an Allelic Selection of Lycopene Beta-cyclase in Watermelon

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The carotenoid biosynthetic pathway has been well studied in various crops. One of the pathway genes, lycopene beta-cyclase (*LCYB*), encodes an enzyme that converts lycopene to beta-carotene. Plants have chromoplast-specific and chloroplast-specific classes of *LCYB*. At least two copies were reported in tomato, orange, and papaya, but only one copy of *LCYB* has been identified in watermelon, to date. Our previous study showed that *LCYB* may be crucial for conditioning flesh color differences between red and canary yellow watermelon varieties. Two different splicing variants were identified during molecular cloning of *LCYB*. One variant retained an intron in the 5' untranslated region (UTR) and the other variant did not have an intron. In this study, quantitative real-time PCR (qRT-PCR) was carried out to determine if there was differential gene expression of the coding region. The promoter region was characterized and alternative splicing variants in the 5' UTR were examined using qRT-PCR. A significant difference in mRNA transcripts of the coding region of *LCYB* was observed between red and canary yellow watermelons. Moreover, it appeared that *LCYB* transcripts retaining an intron were more abundant than *LCYB* transcripts without an intron in both flesh colors. Both splicing variants were more abundant in canary yellow than red flesh varieties. Overall, the expression of *LCYB* in canary yellow was higher than in red regardless of splicing patterns or positions. When promoter regions of the two watermelon varieties were compared, polymorphic sequences were identified and developed into a PCR-based marker for *LCYB* allelic selection. Genotyping on genetic populations and other genotypes revealed perfect co-segregation of the marker with flesh colors, which indicated that polymorphic sequences in the promoter region may influence transcriptional regulation in red and canary yellow watermelon. Because this newly developed marker is PCR-based, it can be used in watermelon breeding with greater efficiency than our previously reported cleaved amplified polymorphic sequences marker.

Specified Source(s) of Funding: This project is based upon work supported by the USDA-NIFA# 2010-34402-20875 “Designing Foods for Health” through the VFIC

5:00–5:15 PM

A New SNP Marker for Allelic Selection of Carotenoid Isomerase in Watermelon

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Carotenoid isomerase (encoded by *CRTISO*) catalyzes an isomerization of cis-lycopene into all-trans form in conjunction with desaturations from phytoene to lycopene in the carotenoid biosynthetic pathway of plants. Limited sequence information on *CRTISO* in other species made it difficult to clone watermelon *CRTISO*. Over five kb of genomic sequence of watermelon *CRTISO* contains twelve introns in the coding region. It showed 80% amino acid sequence identity with tomato and 82% with *Arabidopsis CRTISO*. The sequences of the coding region were aligned between *CRTISO* of red watermelon and that of salmon yellow watermelon and two single nucleotide polymorphisms (SNPs) were identified. One SNP showed a conserved substitution from tyrosine to phenylalanine and the other SNP resulted in an amino acid substitution from leucine to proline. Alignment of the deduced amino acids showed that leucine is conserved in other crops. Genotyping was performed to validate whether they can distinguish flesh color differences. Different genetic populations and commercial varieties were tested using two SNP markers. One SNP co-segregated with salmon yellow flesh color. This suggested the newly developed SNP marker is very closely linked to causal mutations resulting in salmon yellow flesh color of watermelon and this marker may provide a useful tool for breeding novel watermelon varieties.

Specified Source(s) of Funding: This project is based upon work supported by the USDA-NIFA# 2010-34402-20875 “Designing Foods for Health” through the VFIC

5:15–5:30 PM

Isolation and Characterization of *DREB/CBF* Gene Orthologs in Lettuce

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Lettuce (*Lactuca sativa* L.) is one of the most consumed leafy vegetables in the world. Its productivity is dramatically decreased by environmental stresses, such as heat, drought, and high salinity. Improved stress tolerance is desirable in new lettuce cultivars. Isolation and characterization of genes involved in stress in this plant would help us understand the molecular mechanisms of stress response and to breed more tolerant lettuce using transgenic technology. *DREBs/CBFs* encoding DRE/CRT-binding factor proteins play important roles in plant responses to abiotic stress. In this study, the *DREB1* and *DREB2* orthologs *LsDREB1A* and *LsDREB2A*, respectively, were isolated from lettuce and their expressions and functions were analyzed. *LsDREB1A* and *LsDREB2A* encoded proteins with the conserved AP2 (apetala 2) domain, and they were classified into A-1 and A-2 subgroups of the *DREB* subfamily, respectively. Southern blot analysis indicated that there might be more than ten *DREB* homologs in the lettuce genome. Quantitative real-time PCR experiments revealed that the expression level of *LsDREB1A* was highest under cold conditions, followed by salt and abscisic acid stresses, while the expression of *LsDREB2A* was significantly induced by drought and high salinity treatment, but not cold, heat, or abscisic acid treatments. These results suggested that *LsDREB1A* and *LsDREB2A* play different roles during drought, cold, and high salinity stress responses. *LsDREB2A* could specifically recognize the DRE sequence in vitro as determined by an electrophoresis mobility shift assay. In a yeast one-hybrid assay, both *LsDREB1A* and *LsDREB2A* proteins specifically bound to the DRE sequence and activated the expression of both the *His3* and *LacZ* reporter genes. These results indicated that both proteins might function as transcription factors. Overexpression of *LsDREB1A* and *LsDREB2A* increased tolerance to salt stress in transgenic *Arabidopsis* plants, suggesting that these genes might show promise for producing transgenic lettuce that is tolerant to salt stress. This work was supported by Grant Number 1116 from the Salt Science Research Foundation and by JSPS KAKENHI Grant Number 25292022.

Tuesday, July 23, 2013

Springs Salon A/B

Environmental Stress Physiology

Moderator: Leo Gene Albrigo, albrigo@ufl.edu

4:00–4:15 PM

Physiological and Growth Responses of Two Sweetpotato Cultivars at Early Season Soil Moisture Deficit

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Even though soil moisture deficit is one of the important abiotic stresses causing reductions in growth and yield of several crops including sweetpotato [*Ipomoea batatas* L. (Lam)], limited quantitative information is available that can be used for irrigation management during the growing season. To quantify soil moisture stress effects on sweetpotato, an experiment was conducted by varying soil moisture levels, 0.256, 0.216, 0.164, 0.107, and 0.058 m³·m⁻³ soil, (representing 100%, 80%, 60%, 40%, and 20% of field capacity) from transplanting to 55 days on two commonly grown cultivars, Beauregard and Evangeline, for plants grown in pots under greenhouse conditions. Soil moisture treatments were imposed prior to planting and maintained throughout the experiment at the respective treatment levels through sensor-based programmed irrigation. Six pots were harvested at weekly intervals starting 15 days after transplanting and growth and developmental rates were determined from the destructive harvests. Gas exchange and other physiological measurements were recorded during the last two weeks of the experiment. Numbers of storage and non-storage roots were recorded based on their visual and anatomical features through microscopic observation of roots at each harvest. Although vine length was greater in 'Evangeline' than 'Beauregard' across all soil moisture levels, total leaf area, leaf number, and total biomass were not different between the cultivars and declined quadratically with decreased soil moisture. The rate of photosynthesis decreased in both cultivars with increasing soil moisture deficit and the magnitude of reduction was significantly different between cultivars at soil moisture levels below 0.164 m³·m⁻³ soil. Less time was required for 'Beauregard' to initiate storage roots than 'Evangeline', across all soil moisture levels. Storage root initiation of both cultivars showed a quadratic decline with decreasing soil moisture content. Soil moisture optima for storage root initiation were 0.168 and 0.199 m³·m⁻³ soil for 'Beauregard' and 'Evangeline', respectively. Even though more total and storage roots were produced in Evangeline than 'Beauregard' across soil moisture levels, storage root biomass was not different between the cultivars and the response to soil moisture stress was similar, which declined with declining soil moisture levels. The functional algorithms developed from these data will be useful in predicting sweetpotato growth and development under varying soil moisture levels.

Specified Source(s) of Funding: USDA-AFRI, Specialty Crops Block Grant Project

4:15–4:30 PM

Morphological, Anatomical, and Physiological Adaptations of Potatoes to a Simulated Heat Stress

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Potatoes are known to grow well in cool climates. Heat stress generally reduces foliage growth and partitioning to tubers. Our previous studies have shown that heat stress reduces leaf size by reducing cell division and cell enlargement. Most studies to date have documented the adverse impact of heat stress on potato plant growth and development. However, very little has been reported on the adaptation of potato plants to heat stress. The present study was conducted to study strategies employed by potato plants to acclimate to heat stress using five different commercially available cultivars. Shoot culture plantlets were grown in about 8-L pots containing an artificial soil mix (Metro Mix) in a temperature controlled greenhouse at the University of Wisconsin, Madison Biotron controlled environment facility using a 14-hour photoperiod. Six weeks after growing in cool (20 °C day/ 15 °C night) temperatures plants were transferred to a controlled environment room at the Biotron facility for heat stress treatment (35 °C day/ 25 °C night) under a 14-hour photoperiod. After 4–5 weeks after heat stress exposure, the leaves produced under heat stress were compared with the leaves on the same plants that were produced under cool temperatures prior to heat stress. In general as expected the leaves produced under heat stress were smaller. Heat stress adapted leaves had (i) dramatic increase in stomatal index and stomatal density, (ii) thicker and highly developed palisade cell layer, and (iii) over 2x increase in chlorophyll per leaf area. Infra-red leaf temperature measurements showed that heat stress adapted leaves maintained cooler leaf temperatures. These adaptations appear to help plants mitigate heat stress effects.

Specified Source(s) of Funding: USDA/NIFA grant

4:30–4:45 PM

Managing Drought Stress of Oranges to Optimize Flowering and Productivity under Sao Paulo–Mina Gerais, Brazil, and Florida Conditions

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Winter weather in the Sao Paulo–Minas Gerais (SP–MG), Brazil, and Florida citrus production areas often varies from adequate to inadequate cold for flower induction and excessive drought for induction in the north of the main Brazilian citrus production area. A program of monitoring winter temperature and rainfall data for farms from near Conchal, SP, to north of Frutal, MG, was instituted starting in 2008 and Florida winter weather for flower bud induction has been monitored since 1998. Controlled irrigation experiments were instituted in the northern third of Sao Paulo and at Lake Alfred, FL. Cool temperature induction hours (19 °C or less) ranged from less than 200 to more than 1300 hours by location and year in (SP–MG). Florida usually ranged from 600 to 1200 hours. Winter drought stress by withholding irrigation increased flower bud induction in Florida in years when winter rains were sparse. Based on an ultralow volume irrigation scheme (ULVI), deficits in cool temperature induction in SP–MG were compensated for drought stress management to achieve adequate flower bud induction without excessive drought stress. In an ULVI experiment soil moisture tensiometers indicated that the surface 20 cm could be kept at adequate moisture levels to prevent severe drought with less than 1 mm/day. This kept trees in adequate condition without initiating bud sprouting for up to 120 days, until normal timing of bloom could occur. The moderate stress could be released at any time in order to initiate an earlier bloom as long as water was available for normal irrigation until the rainy season started. Thirty-five to 40 days were required from initiating full irrigation until full bloom. Yields were very satisfactory under this program, which is now being used on over 10,000 hectares in SP–MG.

Specified Source(s) of Funding: University of Florida

4:45–5:00 PM

Mild Water Stress Affects Water Relations, Gas Exchanges and Vascular Flows of ‘Hayward’ Kiwifruit Branches during the Second Stage of Berry Development

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Kiwifruit production requires high amounts of water as this species is very sensitive to drought stress, especially during the initial stages of fruit growth and strategies to reduce the water use of *Actinidia* orchards are highly needed. This work investigates the physiological effects of reduced water supply to ‘Hayward’ kiwifruit vines to test the possibility to reduce water use during the second stage of fruit development. At 11 weeks after full bloom, the daily pattern of leaf gas exchanges, leaf and stem water potential, sap flow, fruit pressure potential, fruit growth, fruit vascular, and transpiration flows were compared between two irrigation regimes corresponding to a water restitution of 100% and 70% of the estimated Etc, respectively.

All physiological parameters were monitored simultaneously on one fruiting branch per vine, on three vines per treatment. Reducing irrigation decreased leaf carbon assimilation during the afternoon, following the decrease in stomatal conductance. Reduced irrigation vines showed lower stem and leaf water potentials, with no changes in the relative stem-to-leaf water potential gradient which, for both treatments, increased during the day, reaching a maximum around 15.00 hour. This was in accordance with sap flow, whose daily peak was reached at the same time, but showed lower values in 70% irrigated branches. Fruit daily growth pattern was highly affected by water shortage: stressed berries showed significant shrinkage during midday hours which was then recovered during the afternoon when higher growth rates were recorded. Berry shrinkage was due to strong xylem backflow from fruit to leaves, which along with transpiration determined berry dehydration and decreased its pressure potential during midday hours. Such decrease probably created favorable conditions for passive phloem unloading, as shown by the subsequent higher phloem flows to stressed berries. These latter re-hydrated in the afternoon thanks to the higher xylem flows recorded at this time of the day, which followed the afternoon peak in the branch sap flow. On a whole daily basis, reduced irrigation decreased the xylem but increased the phloem flows to the berry, with no apparent consequences in daily fruit growth which resulted similar between treatments. These data suggest that water restrictions at this time of the season may leave fruit growth apparently unaffected but it may reduce fruit Ca uptakes, while it may have positive effects on fruit dry matter concentration.

Specified Source(s) of Funding: PRIN 2009

5:00–5:15 PM

Chemical and Physiological Response of Turkish Red Pine (*Pinus brutia* Ten.) and American Red Pine (*Pinus resinosa* Ait.) Seedlings Exposed to Artificial Cold Temperature Treatments

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Determining the establishment success of tree species needs to be conducted before attempting to use a species in

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large-scale afforestation programs. In this study, the physiological performance of four Turkish red pine (*P. brutia* Ten.) provenances was investigated after their exposure to artificial cold temperature treatments. Seeds were sown and raised for 24 weeks, 28 weeks, and 32 weeks and exposed to decreasing temperatures in an artificial freezer. Relative electrolyte leakage, chlorophyll fluorescence, and carbohydrate concentrations were measured to determine the variability among *P. brutia* provenances and between species. Results showed that diameter and height growth of seedlings of *P. brutia* sources did not vary for each of the three seedling growth stages. Provenance affected stem and root electrolyte leakage, and our data revealed that cold stress effectively caused physiological damages when temperature decreased $-15\text{ }^{\circ}\text{C}$ during the early age of seedlings. The study also showed that in all provenances, roots were more susceptible to cold damage than stems. There were no significant differences of the chlorophyll fluorescence of *P. brutia* provenances. Carbohydrate concentrations were also very variable and varied significantly among growth stages and provenances. We could not find any clear trends related to provenance altitude. Further studies including more treatment and response variables are needed before any definite conclusion and recommendation can be made about the cold hardiness of this species.

5:30–5:45 PM

Mitigation of Salinity Induced Morphophysiological and Biochemical Effects by Seed Treatment with 28-Homobrassinolide in Pea (*Pisum sativum* L.)

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Salinity is very severe global problem so a study was carried out to investigate the response of pea (*Pisum sativum* L.) cv. Climax seeds imbibed with 28-homobrassinolide (HBL) and sodium chloride (NaCl) before sowing. The seeds soaked in two different concentrations of HBL (5 and 10 μM) for 4

hours, caused an increase in most of the aspects of shoot and root growth both at seedling stage and mature stage (90 days after sowing). At seedling stage, HBL (10 μM) significantly enhanced the fresh biomass by 19%, dry biomass by 31%, seedling height (shoot+root) by 14%, photosynthesis rate by 29%, stomatal conductance by 18%, total chlorophyll contents by 43%, superoxide dismutase (SOD) by 39%, nitrate reductase activity (NRA) by 28% and nitrite reductase activity (NiRA) by 29% in comparison to control (water soaked alone). However, at mature plant stage the plants grown from seeds pre-imbibed in HBL (10 μM) possessed 14% and 27% higher leaf NR and NiR activities, 23% increase in dry mass, 51% enhancement in nodule number, and 20% increase in nodule dry biomass, in comparison to water imbibed, control. Antioxidant enzyme superoxide SOD was 66% higher than control. The 28-homobrassinolide enhanced the photosynthesis rate (28%), stomatal conductance (31%), chlorophyll a (48%) and chlorophyll b (59%) as compared to the control. It was concluded that salinity induced drastic effects can be mitigated by the seed treatment with 28-homobrassinolide.

Specified Source(s) of Funding: Higher Education Commission of Pakistan

5:45–6:00 PM

Genetic Variability of Citrus Rootstock Cultivars under Saline Regime

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Using sand culture technique, an experiment was conducted to study the genetic variability of citrus rootstock varieties to salt tolerance. Ten different varieties of citrus rootstock (Rough Lemon, Bitter Sweet Orange, Carrizo Citrange, Yuma Citrange, Gada Dahi, Sanchton Citrumillo, Citrumillo-1452, Citrus Obvidea, Rangpur Lime, and Rubidux) acquired from different fruit research stations were grown in plastic pots having four salt treatments ie control (no salt application), 30 mM, 60 mM, and 90 mM of NaCl with five replications.

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After germination, the six-month old seedlings were transferred to 9-L plastic pots. The plants were allowed to grow with 0.5% Hoagland solution as a growth medium for 90 days. The salinity treatments were applied along with the Hoagland solution. Ten days after the salinity application, plants were harvested for the estimation of growth, physiological, and biochemical parameters. The fresh and dry weight per plant, number of leaves per plant, shoot and root length, chlorophyll content, photosynthesis rate, transpiration rate, stomatal conductance, total nitrogen (N), potassium (K), and phosphorus (P), contents decreased while sodium (Na) and chloride (Cl) ions increased with increase in salinity in all rootstocks studied. 'Rubidux' showed the maximum values for plant height, shoot fresh weight, tap root fresh weight, fibrous root fresh weight, shoot dry weight, tap root dry weight, fibrous root dry weight, photosynthesis rate, stomatal conductance, WUE, Chlorophyll a, chlorophyll b, and chlorophyll ab, N, K, and phosphorus as compared to the rest of the rootstocks. All the varieties gave variations in their morphophysiological attributes under saline conditions but 'Rubidux' and 'Rangpur Lime' attained the top position by giving the excellent performance at all salinity treatments especially the 90 mM. 'Carrizo Citrange' and 'Sanchton Citrumillo' are categorized as salt sensitive varieties because they failed to give satisfactory performance under salt stressed conditions. Therefore it is clear that 'Rubidux' and 'Rangpur Lime' are salt tolerant, 'Gada Dehi' and 'Rough Lemon' moderately tolerant, while 'Carrizo Citrange' along with 'Sanchton Citrumillo' are salt sensitive.

Specified Source(s) of Funding: Higher Education Commission of Pakistan

Wednesday, July 24, 2013 Springs Salon A/B
Plant Biotechnology

Moderator: Zong-Ming Cheng, zcheng@utk.edu

8:00–8:15 AM

Overexpression of the AtSHI Gene in Poinsettia (*Euphorbia pulcherrima*) Results in Compact Plants

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Euphorbia pulcherrima, poinsettia, is a non-food and non-feed vegetatively propagated ornamental plant. Appropriate plant height is one of the most important traits in poinsettia production and is commonly achieved by application of chemical growth retardants. To produce compact poinsettia plants with desirable height and reduce the utilization of growth retardants, the *Arabidopsis* SHORT INTERNODE (AtSHI) gene controlled by the cauliflower mosaic virus 35S promoter was introduced into poinsettia by *Agrobacterium*-mediated

transformation. Three independent transgenic lines were produced and stable integration of transgene was verified by PCR and Southern blot analysis. Reduced plant height (21% to 52%) and internode lengths (31% to 49%) were obtained in the transgenic lines compared to control plants. This correlates positively with the AtSHI transcript levels, with the highest levels in the most dwarfed transgenic line (TL1). The indole-3-acetic acid (IAA) content appeared lower (11% to 31% reduction) in the transgenic lines compared to the wild type (WT) controls, with the lowest level (31% reduction) in TL1. Total internode numbers, bract numbers and bract area were significantly reduced in all transgenic lines in comparison with the WT controls. Only TL1 showed significantly lower plant diameter, total leaf area, and total dry weight, whereas none of the AtSHI expressing lines showed altered timing of flower initiation, cyathia abscission or bract necrosis. This study demonstrated that introduction of the AtSHI gene into poinsettia by genetic engineering can be an effective approach in controlling plant height without negatively affecting flowering time. This can help to reduce or avoid the use of toxic growth retardants of environmental and human health concern. This is the first report that AtSHI gene was overexpressed in poinsettia and transgenic poinsettia plants with compact growth were produced.

8:30–8:45 AM

Proteomic Analysis of Gibberellins Increased Fruit Sink Strength in *Pyrus pyrifolia*

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Our previous work demonstrated that exogenous gibberellins (GAs) applications during rapid fruit growth significantly in-

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Wednesday, July 24, 2013

creases sink demand and results in a larger fruit in *Pyrus pyrifolia*. To better understand the sizing effect of GA on pear fruit, the pear fruit (*Pyrus pyrifolia* Nakai cv. Cuiguan) was treated with GA and differential protein expression were determined by proteome analysis. Differential in-gel electrophoresis (DIGE), Matrix-assisted laser-desorption/ionization Time of flight/Time of flight (MALDI-TOF/TOF) were performed. In this study, 66 proteins were successfully identified and assigned to 8 functional groups. Among the 66 identified proteins, 9 protein spots were related to stress response/defense, 7 were associated with expression regulation and epigenetic, 4 with cell structure, 23 with photosynthetic and energy, 3 with signal transduction, 4 with protein synthesis/fate; 11 with transport, and 5 with unknown function. According to the expression differences of the proteins, GAs had a significant influence on the abundance of differently-expressed proteins between core and sarcocarp. The present data will help to shed light on pear fruit ripening process.

8:45–9:00 AM

The Development of Cisgenic Grapevines

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Cisgenic technology differs from transgenic technology in that it uses only genetic elements from the host plant to improve/modify specific traits. Implementation of “cisgenics” requires availability of functional endogenous genes, promoters and terminators. In grapevine, the sequenced genome of *Vitis vinifera* ‘Pinot Noir’ provides a wealth of information with which endogenous genetic elements can be readily identified and utilized. We recovered and tested approximately 40 endogenous promoters. Several of these displayed constitutive activity comparable to the commonly-used d35S viral promoter. The *V. vinifera* thaumatin-like protein gene (VvTL-1) was shown to confer broad spectrum fungal disease resistance in greenhouse and field trials. Recently, a novel PR-1 protein gene, recovered from a *Vitis* hybrid, displayed very high bacterial disease resistance when inserted into tobacco and now is being evaluated in grape field tests. Efforts are ongoing to combine all of the endogenous elements necessary to create true cisgenic plants with improved agronomic performance.

9:00–9:15 AM

The Evolutionary History and Diverse Physiological Roles of the Grapevine Calcium-dependent Protein Kinase Gene Family

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Calcium-dependent protein kinases (CDPKs) are molecular switches that bind Ca^{2+} , ATP, and protein substrates, acting as sensor relays and responders that convert Ca^{2+} signals, created by developmental processes and environmental stresses, into phosphorylation events. The precise functions of the CDPKs in grapevine (*Vitis vinifera*) are largely unknown. We therefore investigated the phylogenetic relationships and expression profiles among the 17 CDPK genes identified in the 12x grapevine genome sequence, resolving them into four subfamilies based on phylogenetic tree topology and gene structures. The origins of the CDPKs during grapevine evolution were characterized, involving 13 expansion events. Transcriptomic analysis using 54 tissues and developmental stages revealed three types of CDPK gene expression profiles: constitutive (housekeeping CDPKs), partitioned functions, and pollen/stamen-specific CDPKs. We identified three duplicated CDPK genes that had evolved from housekeeping to pollen-specific functions and whose origin correlated with that of seed plants, suggesting neofunctionalization with an important role in pollen development and also potential value in the breeding of seedless varieties. We also found that CDPKs were involved in three abiotic stress signaling pathways and could therefore be used to investigate the crosstalk between stress responses.

Wednesday, July 24, 2013 **Desert Salon 4-6**

Vegetable Crops Management

Moderator: Ajay Nair

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8:00–8:15 AM

The Effect of Biochar on Sweet Corn Production

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Biochar is an organic amendment produced by a process called pyrolysis, which is the burning of biomass in a limited oxygen environment. In the recent past, agricultural use of biochar has been steadily increasing and attracting tremendous research interest. This study investigated the effect of biochar in sweet corn (*Zea mays* 'Temptation') production. The study comprised of a randomized complete-block design with following rates of biochar: 0, 6.2, 12.4, or 24.8 t/ha. Each treatment plot was 81 m² and was replicated four times. Biochar was applied and disked in on 12 April, 2012. On 17 April 2012, sweet corn ('Temptation', a bicolor sugar enhanced cultivar) was planted. Herbicide and fertilizer applications were made later in the season based on Midwest Vegetable Production Guide. Sweet corn was harvested on 5 July 2012 and data was collected on marketable and nonmarketable weight and number. Ten ears were randomly collected from each treatment to record husked ear weight, ear length, and diameter. Further, two husked ears were randomly selected and analyzed for sweetness. There was a general trend of increasing soil pH with increasing biochar rates; however, there were no statistically significant differences between treatments. Soil temperature measured 10 cm below the surface during the growing season did not show difference. Biochar significantly affected the number and weight of marketable ears. Higher rates of biochar, 12.4 and 24.8 t/ha, reduced number and weight of marketable ears, however, 6.2 t/ha rate did not reduce yield and was statistically similar to the control treatment (0 t/ha biochar). The effect of biochar on vegetable crop yields are not widely available, however, row crop studies have shown yield reductions in the first year of biochar use followed by increases in subsequent years. Increases in crop yields have been attributed to better water holding capacity, higher cation exchange capacity, increased nutrient retention, and the ability of biochar to reduce bulk density. In terms of fruit quality, we did not find any significant differences in husked weight, ear length, ear width, or sweetness (Brix). This was the first year of the study and it is early to speculate effects of biochar on soil properties, crop growth, and yield. Biochar could be a valuable tool for management of soils that are either degraded or have poor nutrient status; however, it could take time to observe significant changes in soil and crop attributes after biochar addition.

Specified Source(s) of Funding: ISU Research Funds

8:15–8:30 AM

Biochar Added to a Potting Mix Decreased Bell Pepper Transplant Size, While Increasing Nutrient Retention

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Biochar, a carbon rich material derived from the pyrolysis of biomass, has shown beneficial chemical and physical when added to the soil. Research into the use of biochar to increase plant productivity and growth has been on the increase over the past decade. Some research has focused on using biochar as an alternative to sphagnum peat moss, but little of this work has been done to determine if biochar can be used in vegetable transplant production. It was the goal of this project to explore the possibility of supplementing an over-the-counter potting mix (Jiffy Mix® Growers Choice #901, Lorain, OH) with biochar. Biochar was added to the potting mix at the following rates on a weight by weight (w/w) basis: 0%, 20%, 40%, 60%, and 80%. Bell pepper *Capsicum annuum* L. 'Paladin' was seeded and grown in three sizes of cell flats (50, 72, and 98) at each of the five biochar ratios. Plant height and biomass were reduced as biochar rates increased, as well as when the cell size was reduced. Growth decreased at differing rates within both factors, showing less reduction in smaller cell sizes and at the higher biochar rates. Nitrate found in the potting mix was leached except in the 60% and 80% biochar mixes. The 60% and 80% biochar mixes had higher levels of nitrates at the end of the experiment than in the beginning. These results indicate that both rate and cell size are important factors for consideration if biochar is used in transplant production.

8:30–8:45 AM

Trellising and Plastic Mulch Effects on Cucumber Production in High Tunnels

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Cucumbers (*Cucumis sativus* L. 'Dasher') are summer vegetables but are extremely frost-sensitive. Most vegetable growers in Iowa and other Midwestern states are exploring ways to start the crop early in the spring. One method to extend the production season and start early production of cucumbers is using a high tunnel. Although high tunnels are extremely useful in the spring to increase temperature, managing summer temperatures in them is a challenging task. This study investigated the use of plastic mulch color and trellising system to manage high temperatures in a high tunnel cucumber production system. The experimental design was a randomized complete block with four replications. Treatments comprised of: 1) black plastic mulch; 2) black plastic mulch + trellis; 3) white plastic mulch; and 4) white plastic mulch + trellis. Cucumber plants were transplanted on raised beds covered with black or white plastic mulch on May, 18, 2012. Data was collected on soil temperature, reflected light intensity off the plastic, crop yield, and fruit quality. Color

An asterisk (*) following a name indicates the presenting author.

of plastic mulch modified soil temperature at four inch depth. Average daily soil temperature was higher in the black plastic mulch as compared to white. Reflected light intensity was 44% higher from the white plastic mulch as compared to black. There were no significant differences in marketable number of cucumbers between black or white plastic mulches, however, within each mulch treatment, trellis treatment significantly increased yield over non-trellised treatment. The marketable numbers were almost one and a half times more when trellis system was used. Marketable weight followed the same pattern. There was no difference in marketable yield between trellised treatments of black or white plastic mulch. Non-marketable fruit weight was highest in trellised treatment, irrespective of plastic color. Fruit quality attribute with respect to average fruit length was highest in the black plastic mulch + trellis treatment. Results from this study indicate that trellising cucumbers in high tunnel production systems affects fruit length and yield higher number of marketable fruits as compared to non-trellised systems. Trellising allows for better air movement and heat dissipation and reduces the occurrence of fungal and bacterial diseases. Although white plastic mulch reflected almost double the amount of light when compared to black, it did not translate to enhanced yield or productivity. White plastic mulch kept the soil cooler than black and could be used in high tunnel production when crop plantings occur during peak summer.

Specified Source(s) of Funding: Iowa State Research Funds

8:45–9:00 AM

The Composition, More so than Yield, of Organic Field-grown Tomato Fruit Is Affected by Grafting and Rootstock

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Grafting and rootstock (RS) effects on the yield and composition of tomato (*Solanum lycopersicon* L.) fruit taken from open field, certified-organic plots were documented in 2008–10. Four- to five-week-old scion ('Celebrity') seedlings were grafted, using the cleft method, to seedlings of three experimental rootstocks (313, 314, 319) developed at OARDC and two commercial rootstocks ('Beaufort', 'Maxifort'). Ungrafted and self-grafted

control plants were also prepared. Grafted plants produced three to four new leaves during the healing phase and were scored and sorted according to quality and vigor. Thereafter, uniform subsets of high quality plants were set into single-row, raised-bed, drip-irrigated, 1 mL plastic mulch-covered, 7.2 m² field plots containing 10 plants of a single genotype. All RS-S combinations were replicated twice and four times in 2008 and 2010, respectively, and arranged in a randomized complete-block design (RCB); in 2009, an augmented RCBD with 1–3 replications per genotype was used. After being set, plants were pruned to the third node, trellised using a Florida stake and weave system, irrigated per the "hand-feel" method and protected from weed, pest, and disease pressure using approved and accepted materials and methods. Total and marketable yield (fruit number, weight) were calculated after removing and sorting all fruit at stage 5–6 ripeness from eight to ten plants per plot every one or two weeks approximately ten times annually until fruit production and ripening stalled. Soluble solids, pH, and titratable acidity were measured on a subset of ten marketable fruit per plot collected at harvests 4–6. Grafting influenced neither the timing of fruit production (onset, duration) nor the total or marketable yield as recorded over the entire season, regardless of whether yearly data were pooled or kept separate for analysis. In contrast, specific components of fruit composition were affected by grafting and RS. For example, total soluble solids differed by RS in 2008 and 2009 but not in 2010. In 2008 and 2009, fruit from ungrafted 'Celebrity' and SGH07-319-rooted plants had significantly higher soluble solids values than fruit taken from those grafted to 'Maxifort'. Fruit pH also differed by RS in all study years. For example, 319-rooted plants tended to produce fruit with a higher pH than other treatment plants. In 2009, titratable acidity tended to be highest in fruit taken from self-grafted plants and lower in fruit taken from ungrafted or plants grafted onto commercial or experimental RS. Four working hypotheses for the effects observed here are offered.

Specified Source(s) of Funding: The Ohio State University; USDA–NIFA Integrated Organic Program; USDA–NIFA Specialty Crops Research Initiative

9:00–9:15 AM

Commercial Extract from the Brown Seaweed *Ascophyllum nodosum* (Stimplex®) Improves Earliness and Yield of Hydroponically Grown Sweet Bell Peppers

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Sweet bell peppers are one of the leading greenhouse vegetables grown in North America and the world. Almost all greenhouse peppers are produced hydroponically using computerized production systems and grown in media such as rock-wool or coconut fiber. In the United States and Canada, growers typically transplant new plants into their greenhouses in December and the first ripe peppers are produced in late March. A greenhouse experiment at the Dr. James S. Craigie Research Center in Cornwallis, Nova Scotia, was designed to test the effects of Stimplex® extract (a derivative from *Ascophyllum nodosum*) on earliness and yield of hydroponically grown greenhouse sweet bell peppers. *Ascophyllum nodosum* seaweed extract (ASE) treatments in combination with a standard hydroponic fertilizer were applied to the root systems of sweet bell pepper plants (*Capsicum annuum* L. var. Morraine) through the irrigation system. The growth, flowering, and fruit production of the ASE treated plants was compared to fertilizer only treated plants. The yield of ASE-treated plants was shown to increase by up to 20% during the first 7 weeks of production. In addition, an increase in quality was observed in the ASE treatments, with a 37% increase in the number of peppers graded as being Fancy, as compared to the control. Also, a significant reduction in the incidence of blossom-end rot was measured in the ASE treatments. This was attributed to the higher calcium concentration measured in the tissue of the ASE-treated pepper plants. These results suggested that ASE applications promote earliness, increase yields, and improve the quality of hydroponically grown sweet bell peppers, which result in a higher economic return for the user.

9:15–9:30 AM

Cauliflower Yield, Biomass Accumulation as Affected by Nitrogen Rates and Irrigation Scheduling

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Irrigation and N-fertilizer management are important factors for cauliflower production. Cauliflower is a heavy water user and requires constant supply of water. Suitable management of irrigation and N-fertilizer are required to maximize plant growth, yield, N-fertilizer use efficiency. The objective of this study was to evaluate the N-fertilizer rates and irrigation scheduling on yield and biomass accumulation of cauliflower 'Snow Crown' cultivated on plastic mulch with drip irrigation.

The experiment was conducted in Hastings, FL, on a sandy, siliceous, hyperthermic Arenic Ochraquaf belonging to the Ellzey series with high water table, about 60 cm below the soil surface. A factorial design included irrigation and N-rate treatments. Irrigation treatments were: SMS, water application controlled by soil moisture sensor (SMS) with base irrigation set at 14% soil volumetric water content (VWC) which was allotted three irrigation windows daily and bypassed events if the soil VWC exceeded the established threshold and TIME, fixed time irrigation being applied three times a day. All treatments received 56 kg·ha⁻¹ of N pre-plant and additional N-fertilizer via fertigation at rates of 0; 112; 224 and 336 kg·ha⁻¹. The SMS reduced the number of irrigation events by 82% compared to TIME treatment. There was an interaction between irrigation and N-rate for total plant biomass at 14, 29, 43, 57, and 71 DAT. For SMS, the fertigation rates of 112 and 224 kg/ha N increased plant biomass compared to control (0 kg·ha⁻¹), at 14, 43, and 57 DAT. The application of 224 kg·ha⁻¹ of N for SMS resulted in higher plant biomass compared to control, at 71 DAT. Cauliflower yield was on average 41.5 and 34.5 Mg·ha⁻¹ for SMS and TIME, respectively, and the benefit the reduced irrigation water application with SMS treatment increased cauliflower yield and head weight by 17% on average. Use of N application rate above 280 kg·ha⁻¹ did not increase yield significantly for either irrigation treatment.

Wednesday, July 24, 2013 Desert Salon 9-10

Postharvest

Moderator: Jinwook Lee, Jinwook.Lee@ars.usda.gov

8:00–8:15 AM

Genetic and Environmental Variation in Southern Highbush Blueberry Flavor Components

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Among traits selected for in the University of Florida southern highbush blueberry (SHB, *Vaccinium corymbosum* L. hybrids) breeding program, flavor is one of the most subjective. In early stages of selection, flavor is judged in a non-quantitative manner by few individuals, while in later stages flavor is quantified by calculating sugar : acid ratios based on total soluble solids and titratable acidity measurements. Additionally, the high level of

An asterisk (*) following a name indicates the presenting author.

environmental variation for flavor components makes breeding evaluation challenging. To identify potential breeding targets for flavor, we measured flavor components of six SHB genotypes (FL06-377, 'Emerald', 'Farthing', 'Meadowlark', 'Primadonna', and 'Scintilla') grown in three locations at three different time points in harvest season. The three locations were chosen for differences in production and management styles: high tunnel evergreen production in Waldo, FL; very low chill production in Haines City, FL; and no use of hydrogen cyanamide in Citra, FL. Total soluble solids (TSS) and titratable acidity (TA) were measured, and individual sugars were quantified using Sucrose/D-Glucose/D-Fructose enzymatic reaction kits. In all samples, D-fructose was detected in higher amounts than D-glucose, and sucrose was not detected in any of the samples. 'Farthing' was least variable in TSS across all nine harvests, while 'Scintilla' and FL06-377 were least variable in TA throughout the season. When measurements were grouped by location, TSS were least variable at Citra, FL, while TA was least variable at Haines City, FL. In all but two cases, TA decreased throughout the season, and the lowest acid berries, excluding 'Farthing', were harvested from Citra, FL. In most cultivars, there was an increase in TSS as the harvest season progressed. However, at the third harvest in Waldo, FL, which was done during a rain, there was a drop in TSS for all samples. There was also a decrease in fructose and glucose present in all samples, except 'Farthing'. Although there was a high degree of variation for measured flavor components overall, potential parents could be selected that had less variation for individual components.

8:15–8:30 AM

Efficacy of 1-Methylcyclopropene (1-MCP) in Purple Passion (*Passiflora edulis* Sims) Fruits as Affected by Dosage and Maturity Stage

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An inhibitor of ethylene action, 1-Methylcyclopropene (1-MCP), has been widely used in many countries to slow down ripening and deteriorative processes climacteric fruits, thereby extending the postharvest shelf life. Its application in some countries like Kenya is limited due to lack of studies to determine its efficacy

and effect on fruit quality. This experiment sought to establish the efficacy of 1-MCP treatment in purple passion fruit (*Passiflora edulis*, Sims), one of the major fruits produced in Kenya for domestic and export market. The 1-MCP was separately applied following 2 regimes—2 ppm for 24 hours and 4 ppm for 12 hours to passion fruits—which were harvested at two stages of maturity. The stages of maturity were defined by the peel color as; stage 1, mature green (less than 25% purple) and stage 2 (50% to 75% purple). After 1-MCP treatments, fruits were left to ripen at ambient room conditions, 25 ± 1 °C and 60% ± 5% relative humidity (RH) alongside untreated controls. During the storage period, six fruits from each treatment combination were randomly sampled every two days to evaluate physiological changes including ethylene evolution, respiration rate, and weight loss. Physicochemical parameters associated with ripening including hue angle, total soluble solids (TSS), total titratable acidity (TTA), major sugars (glucose, fructose, and sucrose) and mineral nutrients (calcium, iron and potassium) were also evaluated. The experimental design used was a completely randomized design with a factorial arrangement. Results show that 1-MCP treatment (both regimes) significantly ($P < 0.05$) reduced the rate of most of the changes associated with passion fruit ripening, irrespective of stage of maturity. There was a delay in ethylene peaks by at least 3 days and reduced ethylene evolution rate in treated fruits. Similarly, significantly lower respiration rates and delayed respiration climacteric peaks (up to 4 days) were observed in 1-MCP treated fruits. Other ripening-related physicochemical changes correlated positively with ethylene evolution and the respiratory pattern. In 1-MCP treated fruits lower hue angle, higher TTA, and lower TSS were observed throughout the storage period. Additionally, 1-MCP treated fruits maintained relatively higher levels of calcium and generally higher calcium: potassium ratio. Overall, 1-MCP treatment extended the shelf life of passion fruits harvested at stage 1 and 2 by 3 and 4 days, respectively. However, at the end of the storage period, stage 1 fruits failed to achieve most of eating and aesthetic quality attributes known to be desired by consumers.

Specified Source(s) of Funding: International Foundation for Science (IFS)

8:30–8:45 AM

Starch Metabolism in Apple Fruit and Its Relationship with Maturation and Ripening

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The Starch Pattern Index is used to help assess fruit maturity. Iodine forms a tri-iodine complex with starch molecule amylose and produces a black-blue staining. However, since iodine only complexes with amylose the staining pattern can be misleading

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because its dependence on the ratio of amylose to amylopectin may make it less reliable for the assessment of the total starch changes over time. The cultivars 'Empire', 'Gala', 'Honeycrisp', and 'McIntosh' have been used to investigate relationships between the SPI, total starch and percentage of amylose. Starch concentrations are more variable at the lower SPI values where little hydrolysis has occurred. 'Gala', 'Honeycrisp', and 'Empire' show a wide range of starch concentrations at a SPI of 1, ranging from 100 to almost 400 mg of starch per gram (dry weight). The starch concentration shows a curvilinear relationships with the SPI for all four cultivars, but linear when plotted over harvest date. Later in the season the range of starch concentration at different SPIs varies among and within cultivars, and some of this variation can be explained by the changing percentage of amylose of total starch. The percentage of amylose decreases as the season progresses, in 'Gala' decreasing from 62% to less than 1% (average 33%), whereas 'Empire' changed from about 58% to 15% during ripening (average 46%). 'Honeycrisp' and 'McIntosh' averaged 26.7% and 35.35% amylose, respectively. Those differences in total starch at different SPI levels could therefore, be related to the ability to stain the starch. At a very low percentage of amylose the staining is less clearly visible. Overall, the results suggest that the iodine test can be less reliable as an indicator of starch in the apple especially later in the season.

8:45–9:00 AM

Fumigation of 1-Hexylcyclopropene Inhibit Ethylene Production in Climacteric Fruits at Ambient Conditions

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Postharvest losses in fresh horticultural produce account more than 30% in the world. The postharvest life of horticultural commodities is most affected by endogenous ethylene, exposure of produce to external ethylene, or both. Methylcyclopropene (1-MCP) is widely recognized as an ethylene inhibitor, but its application is cumbersome and expensive. Among other 1-substituted cyclopropenes, 1-HCP (1-hexylcyclopropene) is effective in extending vase life on kalanchoe flowers. We investigated the effects of different concentrations of 1-HCP and some other analogues of 1-MCP (isoprene oxide and 1-octyne) on ethylene production and modulation of ripening in climacteric fruits such as 'Kommeet' tomato; 'Black Amber' and 'Tegan Blue' Japanese plum; 'Fuji' and 'Crisp Pink' apple. The experiments were conducted on completely randomized design, with three replications and ten fruits in each replication. The treated fruits were kept at ambient conditions ($20 \pm 2^\circ\text{C}$ and $70\% \pm 5\%$ RH)

and data were collected on the ripening behavior and qualitative changes of the fruits. 1-HCP (1000 nL^{-1}) is more effective in suppressing climacteric ethylene production (1.5-fold) as compared to 500 and 2000 nL^{-1} in tomato. Ethylene production was also suppressed (1.5- to > 2-fold) in the plum fruits treated with 1-HCP (250 nL^{-1}), as compared to other 1-HCP treatments. The higher concentration (500 to 1000 nL^{-1}) of isoprene oxide and 1-octyne enhanced ethylene production ranged from 2.5- to > 370-fold more than 1-HCP treated fruit in 'Tegan Blue' plum. In 'Fuji' apple, the treatment of 125 nL^{-1} 1-HCP delayed the climacteric peak of ethylene up to three weeks as compared to all other treatments. The lower concentration of 1-HCP (125 to 250 nL^{-1}) substantially suppressed the ethylene production and respiration in both of the two and four-week cold stored fruit of 'Crisp Pink' apples. Our preliminary results showed that 1-HCP (125 to 250 nL^{-1}) is an effective anti-ethylene compound on a range of climacteric fruits kept at ambient conditions.

9:00–9:15 AM

1-MCP Differentially Affects Postharvest Physiological Attributes and Incidence of Internal Browning in Cold Stored 'Gala' Apples

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The risk of internal browning (senescent browning or stem-end browning) developing in 'Gala' apple [*Malus sylvestris* (L.) Mill var. *domestica* (Borkh.) Mansf.] fruit during cold storage increases with increased fruit size. The objective of this study was to further investigate relationships between fruit size and development of internal browning and other physiological characteristics of 'Gala' apples held in cold storage. Fruit segregated at harvest based on size (small: less than 200 g; medium: 200–240 g; large: 241–280 g; extra large: greater than 280 g) were untreated or treated with $1 \mu\text{L}\cdot\text{L}^{-1}$ 1-MCP and then stored at 0.5°C in air for 3 or 6 months. Internal browning was only detected in apples stored 6 months, regardless of 1-MCP treatment. In both control and 1-MCP treated fruit, browning incidence increased with fruit size while browning severity was less associated with size. Severity of internal browning in 1-MCP treated fruit greater than 240 g was lower compared with control fruit of similar size. However, browning symptoms were mostly senescent browning in the cortex tissues of control fruit but browning was primarily in the stem-end localized tissues of 1-MCP treated fruit. Internal ethylene concentration (IEC) decreased with increased fruit size in control fruit but IEC was not associated with size in 1-MCP treated fruit. Cortex tissue lightness (L^*) increased with fruit size irrespective of tissue localization (stem-end, equatorial,

An asterisk (*) following a name indicates the presenting author.

calyx-end) at harvest but during storage, L* decreased with increased fruit size in control fruit. In 1-MCP treated fruit, L* at 3 months was similar to that at harvest but at 6 months, L* was not associated with fruit size, regardless of tissue localization. Fruit fresh weight loss during storage increased with fruit size and storage duration more so in controls compared with 1-MCP treated fruit. Furthermore, fruit circumference increased with fruit size only for control fruit stored for 6 months. These physiological changes appear to contribute to the susceptibility of large fruit to internal (or senescence) browning more so than small fruit. Reduced browning incidence and severity in 1-MCP treated fruit may indicate browning is related to fruit senescence while stem-end browning results from a lack of ethylene action during cold storage.

9:15–9:30 AM

The Effects of ReTain, Harvista, and NAA on the Quality of ‘Mcintosh’ Apples

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It is recommended that fruit treated with NAA (naphthalene acetic acid) not be treated with SmartFresh™ (postharvest 1-MCP) because the former stimulates ethylene production. If fruit have already been treated with ReTain, it may be all right since the stimulation of ethylene production would be prevented. ReTain was sprayed 2 weeks prior to harvest, Harvista 1 week prior to harvest and NAA 3 days prior to harvest. In one year, there were 2 harvests of ‘McIntosh’, the second harvest 3 days after the first. In the second year, there was only one harvest. SmartFresh™ was applied to half the harvested fruit. In the second year, it was applied either on day 1 or delayed until day 5. In both years, the internal ethylene concentration (IEC) was higher, firmness lower and the starch index higher for untreated and NAA treated fruit. ReTain and ReTain + NAA treated fruit were similar to Harvista treated fruit for these assessments. After 8 months of controlled atmosphere (CA) storage, untreated and NAA treated fruit had the lowest firmness while Harvista treated fruit were the most firm. Use of SmartFresh™ made the ReTain and the ReTain + NAA fruit as firm as the Harvista fruit while the NAA treated fruit were softest. Delaying the SmartFresh™ treatment until day 5 lowered the firmness in all fruit except those treated with Harvista. In the first year, harvest 2 had higher levels of flesh browning than harvest 1 and the use of SmartFresh™ lowered the flesh browning, although not by much for the NAA treated fruit. External carbon dioxide injury was generally worst in ReTain and ReTain + NAA treated fruit and tended to be worse with SmartFresh™ use. There were low levels of senescent breakdown, mainly in harvest 1 NAA treated fruit and ReTain treated fruit without SmartFresh™. Low levels of core browning were present, but lowest with Harvista. In the second year, Harvista without SmartFresh™ had the highest level of external

carbon dioxide injury and this was reduced with SmartFresh™ use. Untreated, ReTain and ReTain + NAA treated fruit all showed higher levels of external carbon dioxide injury when SmartFresh™ was used. Combining ReTain with NAA resulted in fruit that behaved similarly to fruit treated with ReTain only.

Specified Source(s) of Funding: ARDP, NE 1036, Agrofresh

9:30–9:45 AM

Diphenylamine and Conditioning Affect Disorders in Controlled Atmosphere (CA) Stored ‘Honeycrisp’ Apples

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‘Honeycrisp’ apples store well at 3 °C in air after a conditioning week at 10 °C to reduce risk of soft scald development, but may become bland after several months. Controlled atmosphere (CA) storage maintains firmness and acidity but there is variation in susceptibility to internal carbon dioxide injury among orchards, making it too risky to recommend. We have investigated the effects of diphenylamine (DPA), with and without conditioning, on CA storage of ‘Honeycrisp’ from two orchard blocks in each of three growing regions in New York. In a separate experiment, fruit quality after CA delays up to 28 days along with the use of DPA, 1-MCP, or both has been investigated. Results indicate that the week of temperature conditioning is essential for maintaining fruit relatively free from soft scald (found only in some orchard blocks) and lowered the incidence of internal carbon dioxide injury if the fruit was not treated with DPA. DPA use strongly reduced or eliminated internal carbon dioxide injury. If DPA was used on fruit susceptible to soft scald, but without a conditioning week prior to CA, the soft scald was still present but less severe. However, DPA treatment increased the amount of decay and aerosol or thermofogging options for DPA treatment may be needed to avoid unacceptable losses.

Specified Source(s) of Funding: ARDP, NE1036, AgroFresh

Wednesday, July 24, 2013 **Desert Salon 1-2**

SCRI-MINDS Nursery Crops

Moderator: tba

8:00–8:15 AM

Development of an Advanced Sensor Network Node for Automated Monitoring and Control of Irrigation in Nursery and Greenhouse Production

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We have developed a smart wireless sensor (nR5) node that is capable of integrating outputs from a range of soil moisture and environmental sensors, and uses that information to determine when irrigations should be applied. This enables growers to implement irrigation set-point or model-based protocols, which are then executed by the sensor nodes, enhancing human decision-making. The nR5-DC version of the node can independently power a latching solenoid, allowing irrigation control in remote field situations. These nodes are low maintenance, have a reliable communications protocol, and a long battery life—greater than 6 months with five AA batteries during testing in 2012. To support node functioning and to allow growers to program the node, a web-based software program (Sensorweb) was also developed. Sensorweb has a sophisticated set of monitoring and control functions, enabling two-way communication and control of these wireless sensor networks in the field. The software fulfills three primary functions: 1) efficient management of nodes (configuration of sensors, set-points etc.); 2) organization of data transmitted from the sensor nodes in the field; and 3) display of that data in graphical form for quick decision-making by the grower. Each sensor network has a customized homepage in Sensorweb, which shows the unique farm layout and locations of the nodes in the network, allowing users to quickly view data “at a glance,” while also giving the ability to further analyze sensor data using easy-to-use charting functions. The software also has a wide variety of irrigation control functions based either on sensor “set-points” or more advanced model-based tools based on environmental sensors. This new wireless sensor hardware and software has allowed for the automated control of irrigation applications and a reduction in total water use of up to 75%, in a number of commercial nursery and greenhouse environments during 2012.

Specified Source(s) of Funding: USDA–NIFA, SCRI Award no. 2009-51181-05768

8:15–8:30 AM

Wireless Sensor Networks for Automated Irrigation Control in Container Nurseries: Implementation and Economic Impact

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The SCRI–MINDS project has developed hardware and software to efficiently irrigate ornamental crops. Two large demonstration projects were implemented in 2011 in commercial nurseries in the state of Georgia to assess the use of wireless sensor networks and associated software as a management tool for nursery irrigation systems. Two years into this cooperative project, we have been able to assess that growers: 1) can successfully adapt their management strategies using this technology and learn the system within a few months of use; 2) see documentable economic benefits; and 3) implement additional management changes that improve production as a result of using the network. Both growers found that using the system was beneficial to crop health, improved time management, and shortened production cycles. Irrigation water use was significantly reduced in both operations. The most dramatic results so far have been observed in *Gardenia jasminoides*, a crop that can be difficult to grow and suffers from serious disease losses (often causing shrinkage between 30% to 70%). Irrigation control using the wireless sensor network resulted in significant economic benefits. The economic analysis showed a 148% increase in annualized profits. This largely resulted from a shorter production cycle (decreasing production costs) and, to a lesser extent, from eliminating plant losses due to root pathogens. Based on these increased profits, the payback period for the sensor network was less than one month. Although the economic benefits will not be this high in all crops, this clearly shows the potential for wireless sensor networks to improve production efficiency of difficult crops. In addition to the benefits of automated irrigation control, one grower specifically reported on the importance of the weather station that is part of the system, for management decisions such as when to pull frost cloth, to relocate plants to a different production area, and for tracking heat-load in the production areas as a result of installing the system. Both growers have been increasing the production areas where irrigation is controlled by the sensor network, indicating that they trust the system to provide good irrigation control.

Specified Source(s) of Funding: USDA–NIFA, SCRI (award no. 2009-51181-05768)

8:30–8:45 AM

Sensor-Controlled Irrigation Scheduling for Pot-in-Pot Nursery Tree Production

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Irrigation scheduling in nursery tree production is a complex process, due to the large number of tree species grown, differ-

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ences in plant size, growth rate, and rooting volume (container size). To avoid the risk of plant water stress, irrigation requirements are typically overestimated by nursery growers. Sensor-controlled irrigation scheduling for two species of trees was independently compared to grower-scheduled irrigation in a pot-in-pot nursery from March–November 2012. Sensor-based control was achieved using a prototype nR5 radio node (Decagon Devices, Inc.), in concert with advanced control software (Sensorweb; Carnegie-Mellon Robotics Institute, Pittsburgh, PA), to independently control irrigation events using solenoids. One row within a block of dogwood (*Cornus florida*) and red maple (*Acer rubrum*) trees were retrofitted for independent control of irrigation with nR5-DC radio nodes, which allowed for direct control of a 12V-DC latching 25 mm solenoid (Baccara; ML Irrigation Inc., Fountain Inn, SC). Soil moisture sensors (10HS; Decagon Devices, Inc.) were inserted laterally at 15 cm depth in the root zone of 58 L containers (dogwood) and 116 L containers (red maple). Ten trees of each species were monitored in this fashion; five trees in the grower-scheduled row and five in the nR5-controlled row, using a custom sensor calibration for the pine-bark substrate used to grow both species. There were a total of 133 trees in each row for dogwood and 67 trees per row in the maple block. Irrigation water was applied by the nR5-DC node whenever the average substrate moisture content of the five sensors fell below a pre-determined set-point (46% VWC for dogwood and 49% for red maple). The grower-scheduled irrigation was typically 3 to 4 six-minute irrigations per day. Irrigation water was applied to each tree using a single micro-sprinkler spray-stake (Netafim Corp., Fresno CA). Irrigation application and leachate volumes were continuously recorded with flow meters (Badger Corp., WI) for each treatment. For dogwood, the grower-scheduled row received 2.69 times more water than the control row (averaging 3.49 L vs. 1.30 L per tree per day, respectively); for maple, this was 1.45 times greater (6.20 L vs. 4.29 L per tree per day, respectively). Tree height and diameter were measured for the five sensed trees in both rows every two months. Differences in plant height and tree diameter between treatments were not significant for both tree species after nine months, illustrating that sensor-controlled irrigation can achieve significant water savings in commercial production without affecting growth rates.

Specified Source(s) of Funding: USDA–NIFA, SCRI Award no. 2009-51181-05768

8:45–9:00 AM

The Implications of Minimum Stomatal Conductance on Estimating Water Flux in Containerized Tree Nurseries

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Mechanistic water use models represent a potential step forward for predicting irrigation scheduling in horticulture systems. The mathematical framework for transpiration estimates centers around stomatal conductance (g_s) submodels. Several of the g_s models contain a parameter that specifies the minimum g_s estimate (g_0). Sensitivity analyses with a canopy flux model (MAESTRA) identified g_0 to have the greatest influence on transpiration estimates (seasonal mean of 40%). A canopy spatial analysis revealed the influence of g_0 to vary (30% to 80%) with the amount of light absorbed by the foliage and to increase in importance as absorbed light decreased. The parameter is typically estimated by extrapolating the linear regression fit between observed g_s and net photosynthesis (A_n). However, our measurements demonstrate that the g_s – A_n relationship becomes nonlinear at low light levels and thus, extrapolating values from data collected in well-lit conditions resulted in an underestimation of g_0 in *Malus domestica* when compared to measured values (20.4 vs. 49.69 $\text{mmol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, respectively). In addition, extrapolation resulted in negative g_0 values for three other woody species. We assert that g_0 can be measured directly with diffusion porometers (as g_s when $A_n \leq 0$), reducing both the time required to characterize g_0 and the potential error introduced by statistical approximation. Incorporating measured g_0 into MAESTRA significantly improved transpiration predictions (6% overestimation vs. 45% underestimation, respectively), demonstrating the benefit in g_s models. Foremost, diffusion porometer measurements offer a viable means to quantify the g_0 parameter, circumventing g_0 estimate errors associated with linear extrapolation of the g_s – A_n relationship.

9:00–9:15 AM

A Comparison of the Potential for Scaling Up Irrigation Scheduling Techniques: Substrate Moisture Sensing Versus Predictive Water Use Modeling

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Evapotranspiration equations (e.g. Penman-Monteith) are widely used to estimate crop irrigation. However, crop coefficients that adjust potential evaporation to crop-specific transpiration are empirically derived, absent of physiological response descriptions. Although complex mechanistic models exist for predicting crop water use (e.g. MAESTRA), their application in commercial nurseries has, so far, only been conceptual. Alternatively, irrigation scheduling can take place by substrate moisture measurement, triggering irrigation based on predefined volumetric water contents (threshold method). In this study we grew trees in a containerized pot-in-pot production system and irrigated them with both scheduling methods. The threshold method maintained

An asterisk (*) following a name indicates the presenting author.

substrate volumetric water content between 35% and 42%. The modeling method used MAESTRA to estimate transpiration on a 15-minute time step, triggering periodic irrigation from crop water use estimates. Tree growth (stem caliper) and canopy development (m² of leaf area) were measured over the growing season. In addition, we monitored daily irrigation and leachate for water balance and irrigation application efficiency calculations. We tested the hypothesis that precise characterization of two physiology parameters [minimum stomatal conductance (g₀) and the marginal water cost per unit of carbon gain (g₁)] could yield accurate transpiration estimates (within 10%). Predictive water use modeling exceeded our 10% error window, but we were able to estimate irrigation within 20% of measured values. Overall, trees irrigated by the MAESTRA method developed more (up to 15%) stem caliper and accumulated up to an additional 25% of leaf area in one growing season. However, the modeling method applied more water (~20% across species). Despite the additional amount of water, we found the efficiency of applied irrigation (percentage of water that did not leach) to be similar between the two methods (within 10%). We conclude that MAESTRA holds promise as an effective means for scheduling irrigation with generalized physiology parameter sets.

9:15–9:30 AM

Water, Irrigation Costs and the Benefits of Sensor Networks: Results from a National Survey of Ornamental Growers

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The use of wireless sensor networks to determine irrigation timing and application rates can reduce water application rates and thus irrigation costs (including energy and labor in addition to direct expenditures on water). Sensor networks may also reduce disease pressure through more efficient irrigation, which can reduce or eliminate fungicide use. In addition, irrigation sensor networks have also been shown to accelerate growth in some instances. For society at large, greater precision in agricultural irrigation in general, and ornamental crops in particular can potentially reduce pressure on water supplies as well as environmental inputs of nutrients and pesticides. We conducted two national surveys in order to gather information on cost, perceptions of wireless sensor networks, and water management practices in greenhouse and nursery operations. The first survey asked for detailed information about a variety of on-farm costs and practices. The second survey focused on a subset of questions from

the first, targeting grower perceptions of sensor networks, and information on production costs and revenue. We have conducted preliminary analysis of the 176 surveys completed fully to date. Respondents represent 1713 acres of greenhouse, 11,372 acres of container production, and 20,576 acres of field production in 28 states. Fertilizer, disease management, and water account for relatively small shares of expenditures (averaging 2.2%, 0.7%, and 2.3%, respectively), suggesting that potential cost reductions from the use of wireless sensor networks may not constitute a strong incentive for growers to adopt them. The survey results also indicate that increased plant growth and quality, reduced labor expenses, and decreased losses due to irrigation and disease are likely to constitute stronger incentives for wireless sensor network adoption. We are currently in the process of estimating growers' willingness to pay for wireless sensor network base stations and expansion nodes using these survey data.

Specified Source(s) of Funding: USDA–NIFA, SCRI Award no. 2009-51181-05768

9:30–9:45 AM

Behind the Curtain: The Support Component of Wireless Soil Moisture Networks

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Wireless soil moisture sensors have been successfully used to manage water in greenhouses and nurseries settings, and have been shown to improve plant quality, save water, and reduce disease pressure. Most publications discussing progress in this area have focused on the sensors and wireless networks used to provide the data to growers. In order for the data from the systems to be actionable, key decisions must be made by personnel before the system is installed, during the configuration process, and after the data are provided to the grower. These decisions include, but are not limited to: 1) number of sensors used to schedule irrigations within a single zone, or plant species; 2) location of sensors within the root zone; 3) frequency of the sensor measurements, and how the data are reported; 4)

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data storage and graphic/text display; and 5) maintenance needs of the system. These unknowns represent potential barriers to adoption for growers that are interested in using sensors to monitor irrigation, but are unsure of the additional time and resources that implementation and management may entail. Our goals are to elucidate the decision and support process behind wireless sensor networks, and to recommend best practices to ensure optimum results for the end user and quick adoption by growers. We reviewed the configuration and support structure of 12 different locations where wireless soil moisture systems are used to monitor and control irrigation, including six commercial greenhouses and nurseries, which have been controlling irrigation for up to a year. We identified key areas where growers benefitted from external assistance in either setting up a wireless system or interpreting data collected by their sensors, which was mostly during system set up. Specifically, most growers needed external technical assistance setting up the Sensorweb software system. Growers also benefited from learning the functionality of the software from a software expert. However, after most growers learned the basic functionality of the software, they were able to use the features to learn about their irrigation strategies on their own. In addition, growers were unfamiliar with how and where to install the sensors for monitoring. A clear picture of the cost, limitation, and time requirements for setting up and running a network will help identify where technical resources should be focused to minimize installation problems, and aid in the adoption of this technology by growers.

9:45–10:00 AM

Fertilizer Rate and Irrigation Duration Affect Leachate Volume, Electrical Conductivity, and Growth of *Gardenia jasminoides*

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An increasing number of laws and regulations regarding runoff and water use are necessitating container nursery growers to irrigate more efficiently. However, over-irrigation and intentional leaching are still common in the industry. Leaching of fertilizers often leads to the need for additional fertilizer applications, which are costly for the grower and the environment. By reducing fertilizer application rates and irrigating more efficiently we believe that salable plants can be produced with little or no irrigation-induced leaching. In this study, we related fertilizer application rate and irrigation duration to leachate volume, leachate electrical conductivity, and plant growth. A soil moisture sensor-controlled irrigation system was used to irrigate *Gardenia jasminoides* 'Madga I' (sold as Heaven Scent). Controlled release fertilizer was applied at 100%, 50%, and 25% of the label rate and irrigation durations were 2, 3, 4,

or 5 minutes. All plants within an experimental block were irrigated when the volumetric water content of the control plants (2 minute irrigation duration, 100% fertilizer treatment) reached 35%. At that time, plants in all treatments were irrigated. This provided excessive irrigation to plants irrigated for 3, 4, or 5 minutes. Leachate was collected biweekly and included leachate caused by rainfall. Leachate volume was greatest for plants receiving the 5 minute irrigation for all fertilizer treatments. The cumulative leachate volume was 15, 12.5, 10.5, and 9 L/plant for the 5-, 4-, 3-, and 2-minute irrigation treatments, respectively. Electrical conductivity (EC) of the leachate was highest with the 100% fertilizer rate and decreased with reduced fertilizer rate. Fertilizer rate and the interaction of fertilizer rate with irrigation duration had a significant effect on shoot dry weight. Average shoot dry weight was 18.7, 25.3, and 27.3 g per plant for the 25%, 50%, and 100% fertilizer treatments, respectively. Using 3-minute irrigation cycles, shoot dry mass of plants grown with 50% fertilizer was only 0.2 g lower than that of plants grown with 100% fertilizer, while with 4-minute irrigation cycles, this difference was only 1.1 g. This shows the potential for reduced fertilizer use with moderate irrigation applications. In this study, we have shown that reduced fertilizer application rates can be used along with moderate irrigation durations to reduce leaching of nutrients, without negatively impacting plant growth.

Specified Source(s) of Funding: This research was funded by USDA–NIFA, SCRI (award no. 2009-51181-05768).

Wednesday, July 24, 2013 **Desert Salon 4-6**

Ornamentals/Landscape and Turf

Moderator: Donald R. Hodel, drhodel@ucanr.edu

10:15–10:30 AM

Research in Real Time: Integrating Social Media and Landscape Research

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Social media is becoming an increasingly important means for university extension and research personnel to disseminate research-based horticultural information to their clientele. Social media also provides an opportunity to increase the interactivity of information flow among researchers, extension specialists, and their audience. In Summer 2012, I solicited input for the design of a research trial on tree transplanting techniques from readers of the Garden Professors' blog, a multi-institutional blog focused on the science of gardening and landscaping hosted by four university horticulture professors: Linda Chalker-Scott (Washington State University), Jeff Gilman (University of Minnesota), Holly Scoggins (Virginia Tech), and myself. The overall objective of the project was to provide blog readers with an opportunity to participate in a landscape research project and gain insights into the research process. Garden Professors'

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blog readers were surveyed to identify topics or issues related to transplanting of container-grown shade trees. In an on-line Survey-Monkey poll, readers identified root-ball manipulation prior to planting (e.g., “shaving” root-balls) and fertilization at planting as their top research interests. An additional subject, mulching at planting, was added to the project based on subsequent discussion on the blog. The resulting project was installed in July 2012 as two separate experiments. In each experiment eight replications of #25 (105 L) container-grown shade trees (*Plantanus xacerifolia* ‘Bloodgood’) were assigned at random to one of six treatments. In Experiment 1 the treatments were arranged in a 3 x 2 factorial of three root-ball manipulation and two fertilization treatments. The root-ball treatments were: 1) root-ball shaved to remove outer, circling roots; 2) roots teased apart to eliminate circling roots; and 3) control. Fertilizer treatments were 1) 400 g of controlled release fertilizer (Osmocote Plus, 15N–4P–10K, 5–6 month release) per tree and 2) no fertilizer added. In Experiment 2 the treatments were arranged in a 3 x 2 factorial of the three root-ball manipulations and two mulching treatments (with or without 3” of pine bark mulch). During the growing season images and details of the plot establishment were posted on the blog as well as initial study results. Readers were able to post comments and questions on the blog about study installation, data collection and analysis. In this presentation I will present initial results from both tree planting experiments. In addition, I will discuss the logistics and pitfalls of interacting with the public while sharing ongoing research in real time.

10:30–10:45 AM

Genetic Characterization of Kyrgyzstan Fine-leaved *Festuca valesiaca* Germplasm for Use in Semi-arid, Low-maintenance Turf Applications

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Fine-leaved *Festuca valesiaca* Shleidcher ex. Gaudin (2n = 2x-4x) is native to heavily-grazed, cold, semi-arid, Asian rangelands. However, its potential for low-maintenance turf applications in the semi-arid western United States and its relatedness to other agriculturally important *Festuca* species has not been investigated. Therefore, a project was designed to identify *F. valesiaca* accessions that possess horticultural potential when grown under semi-arid growing conditions and to characterize their relatedness to other *Festuca* species. In

2008, 12 *F. valesiaca* accessions originating from Kyrgyzstan and eight U.S. cultivars were transplanted as replicated spaced plants to a field nursery at Blue Creek, UT. Relative vigor, height, width, total biomass (dry matter yield), seed weight, and seed number were evaluated between 2009 and 2011. Amplified fragment length polymorphism (AFLP) analysis (1,530 bands) was used to characterize *F. valesiaca* relatedness to other economically important *Festuca* species. Plant height, width, and total biomass of the *F. valesiaca* accessions examined were equal to the commercial control, ‘Cascade’ [*F. rubra* L. subsp. *commutata* (Gaudin) Markgr.-Dann.; 6x; chewing fescue]. Plant vigor and seed weight of *F. valesiaca* accessions PI 659923, PI 659932, W6 30575, and W6 30588 under semi-arid conditions (~300 mm annual precipitation) were significantly ($P < 0.05$) greater than ‘Cascade’. Moreover, principal component analysis using all traits as loading factors indicated that these *F. valesiaca* accessions were distinct from the majority of the other *Festuca* accessions examined. These *F. valesiaca* accessions produced abundant amounts of small seed, and this seed yield was significantly correlated with total biomass ($r^2 = 0.84$, $P < 0.001$), plant height ($r^2 = 0.58$, $P < 0.05$), and plant vigor ($r^2 = 0.83$, $P < 0.001$). An AFLP-based neighbor-joining cluster analysis defined five distinct groups consisting of diverse *Festuca* species (Outgroups; Group 1), *F. idahoensis* (Group 2), *F. rubra* (Group 3), *F. ovina* and *F. valesiaca* (Group 4), and *F. trachyphylla* (Group 5). The *F. valesiaca* accessions differed from U.S. *Festuca* cultivars examined, except for ‘Durar’ (*F. ovina* L.; 6x; sheep fescue), to which they had strong genetic affinities. Given their morphological attributes, *F. valesiaca* PI 659923, W6 30575, PI 659932, and W6 30588 should be considered for use in low maintenance, semi-arid turf improvement programs in the western United States.

Specified Source(s) of Funding: U.S. Federal Joint Research and Extension Programs in China (grant no. 2009-34613-20214) administered by Utah State University and the USDA–ARS Forage and Range Research Laboratory

10:45–11:00 AM

Easy Tea Hybrid Tea Rose Study: 2009–2012 Results

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Thirty cultivars of hybrid tea roses, determined from the results of a national survey of consulting rosarians with the American Rose Society, were evaluated under landscape growing conditions at the Gardens of the American Rose Center, Shreveport, LA, from 2009–12. The primary objective of this study was to monitor susceptibility of the selected cultivars for susceptibility to blackspot disease under low fungicide application conditions. Plants were grown using cultural practices adapted from Earth Kind rose recommendations (minimum fertilization, minimum irrigation, compost use in bed preparation). Grade 1 roses budded on ‘Dr. Huey’ rootstock were planted February 2009.

An asterisk (*) following a name indicates the presenting author.

Test plots were located in full sun and roses were spaced 4 feet apart within rows and 6 feet between rows. The experimental design was a randomized complete block with 4 replications of each cultivar. Plants were sprayed with consumer formulations of tebuconazole at the recommended rate in 2009 and 2011 and propiconazole in 2010 and 2012. Fungicides were applied each year in late February, mid to late April, mid June, and late August/early September. Plants were pruned according to recommended hybrid tea practices in February and late August each year. A slow-release 12–6–6 fertilizer was applied annually in late February at 1 lb. N/1000 sq. ft. bed area. Blackspot susceptibility ratings were taken in April, June, August, and October each year. Visual quality ratings to determine landscape appeal were taken at the same time each year. The best roses over the four year period in terms of visual quality were ‘Traviata’, ‘Tahitian Sunset’, ‘Frederic Mistral’, ‘Tropicana’, ‘Pink Traviata’, ‘Mister Lincoln’, ‘Olympiad’, ‘Tiffany’, ‘The McCartney Rose’, and ‘Chrysler Imperial’. The best roses over the four-year period in terms of blackspot resistance were ‘The McCartney Rose’, ‘Traviata’, ‘Pink Traviata’, ‘Tahitian Sunset’, ‘Tiffany’, ‘Frederic Mistral’, ‘Mister Lincoln’, ‘Midas Touch’, ‘Pope John Paul II’, ‘Electron’, and ‘Chrysler Imperial’. The American Rose Society will promote ‘The McCartney Rose’, ‘Pink Traviata’, ‘Traviata’, ‘Tahitian Sunset’, and ‘Frederic Mistral’ as Easy Tea Hybrid Tea Roses to their membership starting Fall 2013 and to gardening consumers Spring 2014.

Specified Source(s) of Funding: American Rose Society Research Trust Endowment

11:00–11:15 AM

Characterization of *Erwinia amylovora* Strains Isolated from Ornamentals

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Fire blight, caused by the bacterium *Erwinia amylovora*, is a serious and destructive disease of apples (*Malus* spp.) and pears (*Pyrus* spp.) but can also infect many ornamental species in the Rosaceae family. During 2007 and 2010, typical fire blight symptoms were observed on firethorn (*Pyracantha coccinea*), mountain ash (*Sorbus* sp.), Cotoneaster horizontalis, meadow-sweet (*Spiraea prunifolia*), and crabapple (*Malus floribunda*). Isolated sixty three representative bacterial colonies from the ornamentals in landscape areas were characterized on the basis of biochemical, physiological, and molecular properties comparing with two reference strains of *E. amylovora*. Pathogenicity tests of strains were performed on the host plants. All strains induced a hypersensitive response in tobacco (*Nicotiana tabacum* cv. White Burley) and produced ooze on immature pear fruits. Three primer sets, derived from PstI fragment of plasmid pEA29 and chromosomal ams region targeted, were used for PCR. The genetic diversity among the strains was investigated by random amplified polymorphic DNA (RAPD) analysis. The strains exhibited variability in susceptibility to fire blight among hosts and cultivars, and in virulence among strains of *E. amylovora*.

In addition, all strains were identified as *E. amylovora* by fatty acid methyl ester profiles with similarity indices ranging from 79% to 99%. Clustering of strains in the resulting dendrogram was not correlated with different hosts and *E. amylovora* strains were homogenous. Phytosanitary measures were taken to avoid spread of the pathogen to new rosaceous plants.

11:15–11:30 AM

New and Recently Introduced Bamboo Palms (*Chamaedorea*; *Arecaceae*) with Ornamental Potential

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Bamboo palms (*Chamaedorea*; *Arecaceae*) include over 100 species of small, unusually diverse, understory palms with neat, green, bamboo-like stems indigenous to rain forests from Mexico to northern South America. Two species, the parlor palm (*Chamaedorea elegans*) and the bamboo palm (*C. seifrizii*) are among the most popular and widely grown palms for decorative use in subtropical and tropical landscapes and indoors anywhere, and several other species are sometimes found in the trade. Recent exploration in Mexico and Central America and research and evaluation in the *Chamaedorea* Research Collection in Los Angeles have revealed several additional species that have great ornamental promise, including *C. benziei*, *C. frondosa*, *C. hooperiana*, *C. plumosa*, and *C. rhizomatosus*. Some of these have been in the trade for a few years, especially in California, and are proving to be outstanding ornamentals while others are waiting to be introduced. This presentation will illustrate and discuss these species, addressing their identification, uses, and cultural requirements.

11:30–11:45 AM

The Growth and Evaluation of Some Mexican Oaks and Other Trees in Los Angeles

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Mexico encompasses innumerable ecological zones stretching from deserts to tropical rain forests and is a meeting place of temperate vegetation from the north and tropical vegetation from the south. Thus, it is no surprise that Mexico is blessed with an incredibly rich and diverse flora. One of the groups of plants that is unusually diverse in Mexico is the oaks (*Quercus*). With more than 160 indigenous species, Mexico is the primary center

An asterisk (*) following a name indicates the presenting author.

of oak diversity in the world. In 2001 I traveled to northeastern Mexico and with Mexican botanists made collections of several, handsome oak and other tree species. The oaks included *Q. affinis*, *Q. crassifolia*, *Q. polymorpha*, *Q. rysophylla*, and *Q. sartorii*. The seeds were germinated, seedlings grown on, and small plants out of 3.8-L containers planted out in 2005 at the Los Angeles County Arboretum and Botanic Garden in Arcadia near Los Angeles where they have been evaluated for landscape suitability for 8 years. Nearly all of the oaks and other species have grown remarkably well, clearly demonstrating their adaptability and suitability to the southern California climate. They received no special care other than occasional irrigation. They were unpruned for the seven years after planting out and most had attained about 10–15 m in height, had branches and foliage to the ground or nearly so, had trunks 12–20 cm in diameter, and were flowering and fruiting. That most of the oaks had adequate, if not superb, conformation and structure without any pruning after seven years from planting is a testament to the trees' inherent ability to grow well without human intervention. Perhaps the most amazing tree, though, is a Mexican sycamore (*Platanus mexicana*) that after only six years in the ground is 17 meters tall and has a strong, straight bole, and has a 33-cm diameter trunk. These trees will be prized for their strong, robust growth of good to excellent conformation with few or no structural defects, handsome leaves, mostly evergreen habit, and suspected low-water use. This presentation will illustrate and discuss tree performance, cultural requirements, and landscape adaptability.

information to support this new emerging industry. Apples for hard cider are mechanically harvested in Europe, with shake-and-sweep equipment. This study investigated the use of an over-the-row mechanical raspberry harvester (Littau Model OR0012) with a trellised planting of 'Brown Snout' cider apple in northwest Washington. The region is a center for processing raspberry production and mechanical harvesters sit idle in the fall when apples are ready for harvest. The study was carried out in 2011 and 2012 at Mount Vernon, WA, trees were planted with 6-ft in-row and 12-feet between-row spacing, and there were two replications of M9 and M27 rootstock with 10 trees per plot. There were no differences due to rootstock ($P \geq 0.05$) and data were pooled. Total weight per plot of harvested apples did not differ between hand and mechanical harvest either year ($P = 0.6127$ and $P = 0.5666$, respectively), however yield was lower in 2011 than 2012 (100 kg and 26 kg, respectively; $P = 0.0002$); Brown Snout is alternate bearing and 2012 was an "off" year. Significantly less time was needed for mechanical harvest than for hand harvest in 2011 (40 hours and 7 hours, respectively; $P = 0.0018$), however there was no difference in 2012 (16 hours and 10 hours, respectively; $P = 0.1446$). Each year, there were almost twice as many broken spurs per tree with mechanical harvest (2.4 and 16.0, respectively) than with hand harvest (1.3 and 7.5, respectively); although these differences were not significant ($P = 0.3082$ and $P = 0.1064$, respectively), increased tree damage may lead to a decline in tree health and should be evaluated over the long term. Juice was pressed immediately after harvest and both years there were no significant differences due to harvest technique for Brix ($P = 0.9234$ and $P = 0.6830$, respectively), pH ($P = 0.1075$ and $P = 0.5055$, respectively), specific gravity ($P = 0.4950$ and $P = 0.9083$, respectively), malic acid ($P = 0.0823$ and $P = 0.9529$, respectively) and % tannin ($P = 0.5301$ and $P = 0.4309$, respectively). In 2011 fruit was placed in cold storage (32 °F) for 3 weeks, and in 2012 fruit was cold-stored for 2 and 4 weeks. Both years there were significant differences between juice at harvest and after cold storage for Brix ($P = 0.0006$ and $P = 0.0007$, respectively) and specific gravity ($P = 0.0003$ and $P < 0.0001$, respectively), while there were no differences in pH, malic acid, or percentage of tannin either year.

Specified Source(s) of Funding: Washington State Department of Agriculture

Wednesday, July 24, 2013 Desert Salon 9-10

Pomology

Moderator: Carol A. Miles

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10:15–10:30 AM

Mechanical Harvest of Hard Cider Apples

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Hard cider sales increased 40% in the United States in 2011, and there is a need to provide growers with production

10:30–10:45 AM

The Effect of Summer Hedging of Tall Spindle Apple Trees on Growth, Fruit Quality, and Flowering

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Mechanized sidewall shearing of the tree canopy of Tall Spindle apple orchards may offer the potential to reduce annual pruning costs of apple production. Although mechanical pruning was conducted in the 1960s and 70s, it was generally unsuccessful because it resulted in excessive regrowth and poor fruit quality due to vigorous rootstocks and the cutting of large limbs. However, current high-density Tall Spindle apple orchards are now more suitable to mechanized pruning due to the use of dwarfing rootstocks, a better managed and calm tree, and the presence of more small pendant fruiting branches (15–18 branches) when the tree is mature. We began 4 experiments in New York State in 2012 to evaluate the timing and severity of summer sidewall shearing on Tall Spindle and Super Spindle apple trees. Our main goal was to reduce pruning costs by 2/3 while maintaining a narrow fruiting wall with good light distribution but not create a vigor response in the tree. A second objective was to study the shoot response of several important apple cultivars in New York State to mechanized summer pruning timings and severities. Our results show that summer sidewall shearing was fast and left the trees with a “manicured” look. The cost and time amounted to a fraction of the time (5%) to do manual summer pruning. At each of the summer timings the shearing process cut an average of only 28% if the growing points on the tree (range 22% to 38%). When the sidewall shearing was done at bloom there were some flowers cut off. However, when the sidewall shearing was done in June, July or August 4% to 6% of the fruits were cut off. The regrowth response of 4 cultivars on M.9 rootstocks was about 12–15 cm in shoot regrowth. Most of the short regrowth shoots terminated in a flower bud. There was a nonsignificant reduction in yield and crop value and a nonsignificant improvement in fruit color from summer shearing.

Specified Source(s) of Funding: New York Farm Viability Institute

10:45–11:00 AM

Chemical Thinning of ‘Gala’ Apples with Treatments that Combine Sprays of NAA or BA during Flowering with Metamitron in Postbloom

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During the 2012–13 season, a trial was performed in ‘Gala’/M7 apple trees in Quinta de Tilcoco (VI R), Chile, in order to determine the effect of chemical thinning treatments that either

received or did not receive naphthalene acetic acid (NAA) (10 mg/L) or benzyl adenine (BA) (228 g/ha, 114 ppm) at bloom, combined with metamitron sprays (188 mg/L, 376 g/ha; Goltix® 70WG) at petal fall, 11 mm fruit size or both; additionally it was performed a control treatment, without any spray, and a treatment combining NAA at bloom (10 ppm) with carbaryl at petal fall and 11 mm fruit size (640 ppm; 1280 g/ha). Fifty days after full bloom, the effect of thinning was determined in two selected branches and expressed as fruit per cluster (F/C) and also as tree crop load, expressed as fruit per cm² trunk cross sectional area (F/TCSA). During harvest, yield efficiency (kg/TCSA) and mean fruit weight per tree was evaluated. All treatments differed from the absolute control (0.9 F/C, 10.71 F/TCSA). The more thinned trees were those which received two metamitron sprays (between 0.14 and 0.32 F/C; 2.72 and 4.13 F/TCSA). Metamitron sprays at petal fall (between 0.31 and 0.48 F/C, 4.11 and 6.44 F/TCSA) were generally more effective than sprays at 11 mm fruit size (between 0.42 and 0.59 F/C; 7.02 and 8.63 F/TCSA). According to the analysis of covariance, performed to remove the effect of crop load at harvest, fruit size and yield efficiency were about 30% higher in those more thinned treatments, showing the importance of early fruit removal in ‘Gala’ apples.

Specified Source(s) of Funding: Fundación para la Innovación Agraria, Chile

11:00–11:15 AM

The Effect of Timing and Rate of Metamitron Sprays on Chemical Thinning of ‘Brookfield Gala’ Apple Trees

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During the 2012–13 season a trial was performed in four ‘Brookfield Gala’/M9 orchards, located along the Chilean apple production area: Quinta de Tilcoco (VI R, 34°21’S, 70°57’W), Chimbarongo (VI R, 34°42’S, 71°02’W), Yervas Buenas (VII R; 35°45’S, 71°34’W), and Renaico (IX R; 37°48’S, 72° 3’W), with the aim of determining the effect of chemical thinning of different rates and application timing of metamitron (Goltix® 70WG). In each orchard, two trees were randomly selected and applied at 0, 85, 170 or 340 ppm of metamitron (0, 146.4, 291.6, or 582 g/ha), either at petal fall or 11 mm fruit size. Minimum and maximum temperatures and solar radiation were registered in each location in a period of 3, 6, and 9 days after the metamitron sprays. Response curves were established for each orchard, assessing the thinning effect in two selected branches fifty days after full bloom, and expressing it as fruit per cluster considering the control treatment as 100%. In all orchards the fruit thinning increased with metamitron concentration, reaching 50% of control, even though higher response rate was observed between 0 and 170 ppm. The most effective treatments were

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always those applied at petal fall (between 3% and 17% more than at 11 mm fruit size). Much less thinning was obtained in Renaico, and no climatic characteristic could be associated to this for the 9 days period after the metamitron spray.

Specified Source(s) of Funding: Fundación para la Innovación Agraria, Chile

11:15–11:30 AM

Genotypic Variation in Apple Rootstock Cold Temperature Tolerance

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One and two-year old shoots from 14 apple rootstock cultivars and selections were collected in late October 2012 and subjected to temperatures of -15 , -20 , -25 , -30 , and -35 °C, and in December to temperatures of -25 to -40 °C. M.7 was included for comparison. Cold temperature injury was measured as xylem browning using a rating scale of 0 to 5 with 0 indicating none and 5 indicating severe browning. In October, xylem injury was relatively minor until a temperature of -25 °C when G.4011, G. 4292 and G.4814 had significantly greater injury than M.7. Injury was significantly greater in G.4292 than all other genotypes tested at -25 °C. V.5, V.7, G.935, and G.4288 had less injury, and V.6, G.214, G.4013, G.5257, and G.6874 had similar injury as M.7. At -35 °C, V.5, V.7, G.4011, G.4013, G.4292, G.4814, and G.6874 had a similar level of injury compared to M.7, whereas, V.6, G.214, G.4288, G.935 and G.5257 had less injury. G.5257 had the least amount of xylem browning at -35 °C, which was significantly less than all other genotypes. In December, injury was relatively minor until a temperature of -40 °C when V.5, V.6, V.7, G.214, G.3902, G.4013, G.4292, and G.5257 had a similar level of xylem injury as M.7, but G.935, G.4011, G.4288, G.4814, and G.6874 had less injury. G.935 and G.4288 were consistently harder than M.7, whereas, G.4292 incurred the greatest level of tissue browning in both October and December. In October, shoot age had a relatively minor effect on xylem browning at temperatures of -25 and -30 °C, but a significant effect at -35 °C with a rootstock interaction. One-year-old shoots of V.7 and G.214 had greater xylem injury than 2-year-old shoots, and 1-year shoots of G.4011 had less injury than 2-year shoots. In December, xylem injury was generally greater in 2-year-old shoots compared to 1-year-old with no rootstock interaction. The 'Geneva' rootstocks tested in these experiments belonged to a full sib family that segregates for many traits. These results indicate that the genetic variation for early and mid-winter cold hardiness observed in these experi-

ments may be harnessed for genetic mapping and understanding the inheritance of cold hardiness in apple rootstocks.

Specified Source(s) of Funding: New England Tree Fruit Growers Research Committee

11:30–11:45 AM

How Long Should Apple Rootstock Trials be Conducted?

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Apple rootstocks are usually evaluated for 10 years, but there is an economic incentive to shorten the evaluation period. Data from the 2003 NC-140 Dwarf Apple Rootstock trial were used to determine the number of years required to separate rootstocks based on trunk cross-sectional area (TCA). 'Golden Delicious' trees budded on 11 dwarfing rootstocks were planted at 12 locations with 2 trees on each rootstock randomized within four blocks in a generalized randomized complete-block design. Annual TCA data from each location were analyzed with a repeated measures ANOVA with SAS's Proc Glimmix and the slicediff option was used to compare rootstock lsmeans within each year. Data for only 4 locations have been analyzed, but the relationship between TCA and year was linear in British Columbia and quadratic in Pennsylvania, Utah, and Wisconsin. Rootstocks were significantly different after 2 years in Utah, but 3 years were needed to separate rootstocks in the other locations. Depending on the location, the number of years to detect a difference between B.9 vs. M.26 was 3 or 4 years, 4 to 6 years for B.9 vs. T.337, 5 to 8 years for T.337 vs. M.26, 7 to 8 years for M.26 vs. Pajam2, and 6 to >10 years for T.337 vs. Pajam2. Although other characteristics may take longer to sort out, it appears that rootstock trial require at least 8 years to separate M.26 and M.9 Pajam2 into different vigor classes.

Wednesday, July 24, 2013 **Desert Salon 1-2**

Genetics and Germplasm

Moderator: Nahla Bassil, nahla.bassil@ars.usda.gov

10:15–10:30 AM

Genetic Control of Resistance to Anthracnose Crown Rot of Strawberry in Florida and North Carolina

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Anthraxnose crown rot is an economically important disease of strawberry in the southeastern United States and is primarily caused by *Colletotrichum gloeosporioides* in that region. However, no information on genetic control of resistance to this pathogen is currently available to guide breeding efforts. Our objectives were to estimate genetic parameters and gains for resistance, and to examine the effects of locations (Florida and North Carolina) and transplant types (plugs grown from seed and bare-root runner plants) on the estimates. An incomplete diallel mating design generated 42 full-sib families. Both seedling plugs and bare-root runner plants were established in field locations at Castle Hayne, NC, and Wimauma, FL. Conidia of *Colletotrichum gloeosporioides* were sprayed directly into the crowns, and plant collapse was recorded biweekly during the 2010–11 season. Heritabilities were higher in North Carolina ($h^2 = 0.34\text{--}0.58$ and $H^2 = 0.35\text{--}0.70$) than in Florida ($h^2 = 0.11\text{--}0.16$ and $H^2 = 0.25\text{--}0.26$). Likewise, the seedling tests showed higher genetic control than the runner plant (clonal) tests at both locations. Genotype by environment interactions were low, with few rank changes in parental performance across locations. ‘Pelican’ was the most resistant parent at both locations, and NCH09-68 was comparable to ‘Pelican’ at the North Carolina location but conferred less resistance at the Florida location. Selection and clonal deployment of the most resistant genotype within each of the five best families is estimated to produce average genetic gains of 37.4% and 34.9% in North Carolina and Florida, respectively.

10:30–10:45 AM

A Single Gene Confers Resistance to Bacterial Leaf Spot in the Lettuce Cultivar La Brillante

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Bacterial leaf spot (BLS) of lettuce caused by *Xanthomonas campestris* pv. *vitians* (Xcv) is an important lettuce disease. Host resistance is known in ‘La Brillante’; nothing is known about the inheritance of this resistance. In other crop species a rapid cell death at the infection site known as a hypersensitive response (HR) is a common mechanism of disease resistance. The objective of this research was to 1) determine if a HR confers resistance in ‘La Brillante’ and 2) determine the inheritance of BLS resistance in a F7 recombinant inbred line (RIL) population from Salinas 88 x La Brillante. Six plants from 90 RILs, ‘Salinas 88’, and ‘La Brillante’ were evaluated for a HR after infiltrating the leaves of four week old lettuce seedlings with a solution of approximately 1×10^8 cells/mL using Xcv isolate BS347. The same cultivars and RILs were evaluated for diseases severity (DS) on November 28 in a Salinas, CA, field experiment with natural infection and in two greenhouse

experiments (GH1 and GH2). The greenhouse experiments were inoculated by spraying four-week-old seedlings until runoff with a mixed solution of Xcv isolates BS339, BS340, and BS347 at approximately 1×10^8 cells/mL. The field, GH1, and GH2 experiments used a randomized complete-block design with three blocks. Disease severity was measured on individual plants using a 0 (low disease) to 10 (severe disease) scale at harvest maturity in the field and a 0 (no disease) to 5 (severe disease) scale in GH1 and GH2 one week after inoculation. Segregation of the HR was compared to known genetic models using chi-square. The mean DS of the HR and the non HR RILs and parents were calculated and compared using t-tests. ‘La Brillante’ expressed the HR while ‘Salinas 88’ did not. Disease severity means of ‘Salinas 88’ (field: 3.8, GH1: 3.3, GH2: 4.5) and ‘La Brillante’ (field: 0.2, GH1: 0.9, GH2: 2.2) were significantly different ($P < 0.01$) in all experiments. The RILs segregated 47 HR : 43 not HR, a good fit to 1:1 (χ^2 , 1 df = 0.2, $P = 0.7$), which indicates a single gene controlling the HR. The mean DS of RILs expressing the HR (field: 2.8, GH1: 1.4, GH2: 2.5) was significantly lower than the non-HR RILs (field: 9.8, GH1: 2.9, GH2: 4.0). Bacterial leaf spot resistance in ‘La Brillante’ is a simply inherited trait and should be useful for breeding resistant cultivars.

10:45–11:00 AM

Horticultural Trait-SNP Marker Association Study in a Collection of Lettuce (*Lactuca sativa* L.) Lines

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The U.S. lettuce (*Lactuca sativa* L.) germplasm collection is managed by the USDA–ARS Western Regional Plant Introduction Station in Pullman, WA. We recently genotyped approximately 1,200 accessions of cultivated lettuce with the Illumina’s GoldenGate assay for 384 SNP markers and created a special collection of 298 lines, each of which is derived from a single plant homozygous at 322 genotyped loci. This collection contains 122 butterhead, 63 crisphead, 53 romaine, 53 leaf, and 7 stem types. There are only 258 unique genotypes among the 298 lines since there are 26 pairs or small groups (a total of 66 lines) sharing identical genotypes. The average genetic

An asterisk (*) following a name indicates the presenting author.

similarity coefficient (GS) among the 258 unique genotypes was 63.9% with a range from 40.6% to 99.8%. Population structure analysis revealed that there are most likely six subpopulations corresponding more or less to the horticultural types with the crisphead types divided into two. We evaluated 10 phenotypic traits of these lines and conducted a preliminary genome-wide marker-trait association analysis using three different methods: single factor analysis, general linear model analysis and mixed linear model analysis. Nine significant marker-trait associations (SMTA) were revealed at $P < 0.0001$ level with all three methods and also when considering kinship and/or population structure for this collection. These marker-trait associations include five SMTAs for seed coat color, one for leaf margin undulation, two for leaf anthocyanin and one for stem anthocyanin. These marker-trait associations await validation with segregating populations before being used for marker-assisted selection.

Specified Source(s) of Funding: USDA-ARS, CRIS 5438-21000-026-00D

11:00–11:15 AM

What Have We Learned during Marker-locus Trait Validation for *Rpfl* Red Stele Resistance in Strawberry?

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Red stele (*Phytophthora fragariae* Hickman var. *fragariae*) is a devastating root rot disease in strawberries (*Fragaria* L.). Several sources for genetic resistance are exploited in breeding and several race-specific R-genes are known. Recently, a tightly linked SSR marker was found for the *Rpfl* gene at Wageningen-UR, The Netherlands. As part of the “RosBREED: Enabling Marker-Assisted Breeding in Rosaceae” project, 947 strawberry individuals were chosen to represent the breadth of relevant diversity used in breeding the domesticated strawberry. A simple sequence repeat (SSR) set composed of the SSR marker and

ARSFL007 was used to genotype the RosBREED strawberry germplasm for presence of the marker and for parentage confirmation. One hundred and fifty three (153) of the RosBREED individuals with known and unknown responses to the red stele pathogen were inoculated in bench tests to two races of this disease to validate this marker- association. The Microsatellite Allele Dose and Configuration Establishment (MADCE) technique was used to establish the allelic composition of three subgenomes in the SSR and each of the four subgenomes in ARSFL007. Using manual parentage verification followed by FlexQTL-based parentage check in the 947 individuals identified 42 progeny and 11 cultivars that did not segregate according to pedigree. Genotypes for 24 out of 84 parents used in crosses were inferred using FlexQTL and pedigree was corrected. The gene confers resistance to Canadian race 4 (Cdn-4) and is ineffective against Canadian race 5 (Cdn-5). Of the 153 inoculated individuals, 16 individuals, mainly of wild origin were identified as having other factors of resistance by exhibiting resistance to race Cdn-5 and may be valuable for widening the genetic base of resistance in commercial cultivars. To avoid epistatic effects, these individuals were excluded from validation along with 50 other individuals that were not replicated or that had borderline disease scores. For the remaining 87 individuals that showed severe disease scores for Cdn-5, 24 were resistant to and 63 were susceptible to both races. The SSR marker was present in 14 of 24 individuals that were resistant to and absent in 50 of 63 accessions that were susceptible to this disease. Causes for the 79.3% marker-trait association are being investigated and will be discussed.

Specified Source(s) of Funding: “RosBREED: Enabling marker-assisted breeding in Rosaceae” is supported by the USDA-NIFA Specialty Crop Research Initiative by a combination of federal and matching funds (grant number 2009-51181-05808).

11:15–11:30 AM

Characterization of Eight Novel Microsatellite Markers from *Viburnum rufidulum*

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Viburnum rufidulum resides in the Adoxaceae and is one of the fifteen species of shrubs within the genus that are native to the United States. *Viburnum rufidulum* can be distinguished from the closely related species *V. prunifolium* by the reddish pubescent petioles, leaf buds, and undersides of leaves. The attractive red pubescence gives *V. rufidulum* its common name of ‘Rusty Blackhaw’. Prior to this study, genetic diversity of the species

An asterisk (*) following a name indicates the presenting author.

has not been investigated. We report the results of a small insert GT-enriched genomic microsatellite library constructed from genomic DNA of *V. rufidulum*. Eight microsatellite loci were characterized and have successfully amplified DNA from 44 samples of *V. rufidulum* that were collected from individuals growing in close proximity to each other at Worthington Cemetery located in Oak Ridge, TN. Four to seventeen alleles were identified per locus, and the mean polymorphic information (PIC) content was 0.68. The range for allelic richness was 4–14 and gene diversity was 0.65–0.89. The inbreeding coefficient (Fis) mean for all loci was 0.4 and observed heterozygosity mean (Ho) was 0.44, which deviates from the expected heterozygosity (He) average of 0.73. The program STRUCTURE 2.3.4 was able to discern two discreet populations within the samples. These microsatellite loci also exhibit high cross-species transferability to other *Viburnum* species and genera in the Adoxaceae. The loci discovered in this study are expected to be useful in population genetic studies of this plant, and applicable to any population throughout the natural range of *V. rufidulum*. Moreover, these markers are expected to have utility in breeding programs, and also in refining and defining the phylogenetic relationship of *V. rufidulum* to other species within the genus, and to other genera within the Adoxaceae.

11:30–11:45 AM

Adaptive Differences Associated with Neutral and Non-neutral Markers in the Core Collection for North American Plums (*Prunus* spp.)

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North America is a center of diversity for *Prunus* L. species. The University of Florida Stone Fruit Breeding and Genetics Program in collaboration with the National Germplasm Repository and USDA–ARS (Project No. 5306-21000-018-00D) collected and identified ~400 genotypes of approx. 30 taxa native to the United States. A core collection of 13 species was used to compare the utility of selectively neutral sequences and sequences believed to be under selection pressure in the elucidation of phylogenetic relationships of North American plums. The core collection represented the major clades within subgenus *Prunus* section *Prunocerasus*. The American clade was represented by *P. americana* Marsh., *P. hortulana* L.H. Bailey, and *P. mexicana* S. Watson; the Chickasaw clade included *P. angustifolia* Marsh., *P. munsoniana* W. Wight & Hedrick, and *P. umbellata* Elliot; and the Beach clade was represented by *P.*

geniculata Harper and *P. maritima* Marsh. Outgroups included: *P. pumila* L. (subgenus *Cerasus* section *Microcerasus*), *P. persica* (L.) Batsch cv. Okinawa, AP05-18ws (UF peach haploid), 02-01c (UF peach haploid) (subgenus *Amygdalyus* section *Amygdalus*), and *P. fasciculata* (Torr.) A. Gray (subgenus *Emplectocladus*). A total of 41 simple sequence repeat (SSR) markers distributed across the peach genome (~15–25 cM), 7 chloroplast genome regions, nuclear ribosomal repeat ITS, and 55 candidate genes believed to be associated with flowering and plant architecture were used. A Neighbor Joining (NJ) analysis of the SSR markers yielded different species relationships than the results obtained using chloroplast DNA (cpDNA) regions, internal transcribed spacer region (ITS), and nuclear genes Maximum Parsimony (MP) and Maximum Likelihood (ML) analyses. Phylogenetic analyses using cpDNA regions, ITS and nuclear genes yielded some of the previously known species relationships. A total of 27,278 bp of sequence per species was used. The observed polymorphism rates were 3.67%, 10.82%, and 7.27% for the cpDNA sequences, ITS, and nuclear genes, respectively. Sequence variation in exon and intron regions of nuclear genes was 4% and 11%, respectively. Several highly informative regions were identified that will be used for larger phylogenetic analysis within *Prunus*.

Specified Source(s) of Funding: National Germplasm Repository and USDA–ARS Project No. 5306-21000-018-00D

11:45 AM–12:00 PM

Molecular Markers for Population Studies of *Cornus sanguinea*

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Cornus sanguinea is 4–5 m tall shrub and is distributed almost over the entire European continent and in some locations in Asia. The species can form hedges and grows along forest edges, riversides, and in floodplain forests. *Cornus sanguinea* occupies lowlands and terrain up to 1500 m in the Alps, and is often planted as an ornamental. To address some conservation issues with the species, genetic variation in natural populations has been assessed using isozymes and chloroplast markers. In these studies, genetic diversity was found to be relatively low compared to other tree species because of clonal reproduction. A more robust genetic marker system was needed to evaluate both large- and small-scale genetic diversity and differentiation. We developed microsatellite markers for the species from a small-insert GT- genomic library. Sixteen primer pairs were identified and optimized to amplify loci in 29 *C. sanguinea* individuals collected from nine populations in Germany and all loci were polymorphic. There were 5 to 16 alleles discovered per locus;

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HO ranged from 0.00 to 1.00, and HE ranged from 0.65 to 0.90. Tests of Hardy-Weinberg equilibrium were not conducted due to the small sample size and because plants often reproduce vegetatively. Understanding the extent of seed dispersal, genetic drift and how selection operates will require knowledge of population structure. Although we had only a limited number of samples in our study, the 16 polymorphic microsatellites will be sufficient for the population genetics studies underway in Germany and assessing the extent of clonal reproduction in *C. sanguinea*.

12:00–12:15 PM

Population Structure Analysis of Eastern Filbert Blight Resistant Hazelnut (*Corylus* spp.) Germplasm

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Eastern filbert blight (EFB) severely limits hazelnut production in the eastern U.S., and its spread to Oregon's Willamette Valley now threatens the primary U.S. commercial hazelnut production region. Work is currently being done at Rutgers University to develop commercially acceptable hazelnut cultivars with durable resistance to this disease. An important goal of the breeding program is the maintenance of genetic diversity within the breeding lines, which can be assessed using simple sequence repeat (SSR) markers. In this study, 170 newly selected EFB-resistant and tolerant seedlings from foreign germplasm collections, as well as 178 reference cultivars including EFB-resistant breeding selections representing a wide spectrum of geographic origins, were analyzed using 17 genomic SSR markers. Genetic analysis was performed using the program STRUCTURE 2.3.3 to confirm prior cluster analysis results, as well as to discern the most parsimonious number of populations present within the hazelnut germplasm. Results of the analysis grouped hazelnuts into 11 populations, and an AMOVA performed using GenAlEx 6.5 showed that the post-facto groups were all significantly different ($P \leq 0.001$). This analysis sheds light on the relationships of the new EFB-resistant

seedlings in comparison to known sources of resistance and other reference cultivars. Knowing these relationships can allow breeders to better utilize and maintain a high level of genetic diversity in their EFB-resistance breeding efforts.

Specified Source(s) of Funding: USDA-NIFA Specialty Crops Research Initiative Competitive Grant 2009-51181-06028

Wednesday, July 24, 2013 **Desert Salon 4-6**

Local Food Systems

Moderator: Mary E. Henry, mbhenry@ufl.edu

12:00–12:15 PM

Characterizing Polk Small Farms, as Compared to a Previous Florida Small Farms Survey

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A Small Farms Survey based on a previous statewide survey was mailed to 465 small farms in Polk County, FL. Lists used were from the Polk County Property Appraisers office lists. Those selected were listed as having agricultural exemptions on their property in several categories: cropland, poultry, bees, fish, and dairy. Those listed as having exemptions for land in citrus or pasture were not included in the survey, as the purpose of the survey was to perform a needs assessment of farms that would be served by the Polk Small Farms Program and farms in citrus and livestock production fall under the responsibility of other program areas. The survey was mailed twice in March 2011 using IRB approved protocol. An introductory letter was sent shortly before sending the survey the first time. The survey was sent again two weeks later to those that had not responded to the first survey. One-hundred and eighteen surveys were included. Not all respondents answered all of the questions. Response data were entered into the SAS statistical package. Data were analyzed using the FREQ Procedure. The survey consisted of forty questions and collected in depth information on the size, type, and income of small farm enterprises in Polk County. Farmers were also characterized by demographic, experience, education, motivation, and plans for the future. Overall, Polk County farmers are less educated and experienced than previous statewide data. Methods used and trends suggested by the data may be useful for others working to establish programs addressing small farms such as local and regional food systems development and Extension education. The data will be used as a benchmark for comparison to other existing populations and programs in addition to future changes in the population of Polk County farmers.

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12:15–12:30 PM

The People's Garden Initiative: Case Studies on the Mississippi Gulf Coast

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Secretary of Agriculture Tom Vilsack began the People's Garden Initiative—named in honor of President Lincoln's description of USDA as the "People's Department"—in 2009 as an effort to challenge employees to create gardens at USDA facilities. It has since grown into a collaborative effort of over 700 local and national organizations all working together to establish community and school gardens across the country. The simple act of planting a garden can help unite neighborhoods in a common effort and inspire locally-led solutions to challenges facing our country—from hunger to the environment. People's Gardens vary in size and type, but all are required to have three components in common. They must benefit the community, in some cases by creating recreational spaces and in others by providing a harvest for a local food bank or shelter. They must be collaborative—that is, the garden must be created and maintained by a partnership of local individuals, groups, or organizations. And third, they should incorporate sustainable practices. The gardens might use compost or mulch made by participants. They might contain native plants or encourage beneficial insects. They also might exemplify water conservation, for instance, capturing rain in a barrel to water the garden. Many areas of coastal Mississippi are considered food deserts. This fact along with the slow economy, make the time right for increasing home gardening and community garden programs. Current garden projects include East Central Lower Elementary School (ECLC), the Armed Forces Retirement Home (AFRH), and Mississippi State University's Coastal Research and Extension Center (MSU-CREC). The garden at ECLC was initiated by kindergarten teacher, Lisa Koen, in 2011. Her students grow vegetables that they eat in the classroom. They also utilize a rain barrel for irrigation and learn about sustainability in the garden. The garden at the AFRH is actually a green roof occupying nearly two acres of rooftop area. The roof is accessible to residents and serves as a recreational area as well as a storm water management tool. The garden at MSU-CREC consists of raised beds, each of which are used to demonstrate a different irrigation practice. This garden is accessible to the public, and serves as a demonstration of small-scale,

sustainable food production. Each of these gardens exemplifies the People's Garden Initiative's objectives while providing learning and teaching opportunities for clients of all ages.

12:30–12:45 PM

Global Sustainable Food Systems for Urban Environments

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The limited water situation, rising health costs both at the local and global arena have forced its population to find alternative technologies for sustainable and local healthy safe food production systems which uses less water. Burgeoning population growth is a significant driver of change in the urban US and many other cities of the world. The overall challenge is to create a sustainable and integrative urban food system using innovative science and technology approach. The concept of "greening the city and feeding the world" is the driving force to set up a "Agriculture Innovation Lab" at the Colorado State University to support the sustainable food system in the urban environment by developing new innovative food production kits. This way the communities in small town and cities will have access to local fresh, nutritious and safe food. Such systems can be placed in indoors or outdoors or can be expanded as an enterprise. These kits work on a principle of providing safe and clean breathing space and produce nutritious and healthy food as well as also provide a clean, green and safe environment. The innovative indoor energy smart food production technology is developing as a prototype and soon will be provided to the communities and roll out as a horticulture venture. This sustainable 21st century technology idea is to promote entrepreneurship and sustainable food production opportunity at local, regional and global marketplace. In best of our knowledge, this is the unique integrated science; engineering and technology based solution for healthy food production system follows the triple bottom line principles, conserves limited natural resources (energy, water) and provides opportunity for new horticulture enterprise for economic development. Our focus for integrating technology to reduce local and global hunger and develop a possibility of safe food close to the doorstep which also helps as a one stop shop of learning entrepreneurship model for creating a sustainable environment, communities, and regional economic development.

12:45–1:00 PM

Designing in Systems: Using Engaged Design to Incorporate Permaculture Solutions

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Community gardens offer positive impacts for individuals and neighborhoods, but are often difficult to maintain. Permaculture is a design framework based in ecological systems that can increase sustainability and reduce the need for maintenance of garden spaces. Community engaged design strives to involve people in shaping and managing their environment by incorporating participant ideas into design decisions. This method can be especially useful in public spaces. Permaculture based, community engaged-design could increase community garden longevity both by designing a more efficient, easier to maintain garden space and by increasing gardeners' personal commitment to care for a site. A permaculture based, community engaged design process was developed and piloted as a part of a re-design of an inner-city community garden. Four different workshops were presented over a six month period. Workshops included 1) permaculture principles, elements, and systems; 2) an inventory of existing permaculture elements in the pilot garden; 3) design decision activities based in permaculture principles; 4) images and discussions of possible permaculture solutions. The outcome was a final vision statement, priorities list and concept design for the re-design project. Hosting four different workshops led to clear communication and trust that resulted in participants' sharing honest opinions about garden design decisions. Workshops successfully taught permaculture principles, elements, and systems. All participants expressed confidence that the re-designed space will better represent permaculture and model earth stewardship. Most participants also believed the re-designed space will do a better job of welcoming community members. Permaculture based community engaged-design activities were developed and documented.

Thursday, July 25, 2013

Desert Salon 4-6

Vegetable Crops Management

Moderator: Gordon C. Johnson, gcjohn@udel.edu

8:15–8:30 AM

Subsurface Drip Irrigation Affects Water Usage and Yield in Acorn Squash

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Subsurface drip irrigation (SDI) has been successfully utilized for the production of processing tomatoes. It allows for efficient water use as well as a reduction of in-row weed growth due to a

reduced wetting of the soil surface. However, significantly less is known about the impact of SDI on growth of vegetables in the humid southeastern United States. To evaluate the suitability of SDI for vegetable production, a two-year trial was conducted to determine the effects of SDI on water use efficiency as well as productivity of acorn squash (*Cucurbita pepo*) grown in Lexington, KY. Six-week-old plants of acorn squash, 'Table Queen', were transplanted in July and June of 2011 and 2012, respectively, into bare-ground plots with surface and SDI. The SDI drip tubing was placed at a depth of 15 cm below the soil surface. In addition to irrigation type, 2 moisture regimes were evaluated using automated tensiometers for irrigation. Irrigation levels were on/off –30/–10 kPa and –60/–10 kPa, representing well-watered and relatively dry irrigation regimes, respectively. The trial was 2 x 2 factorial arranged in a completely randomized design. In 2011, SDI irrigation regimes used significantly less water than the comparable surface irrigation treatments, while achieving higher yields. In 2012, however, yields were significantly higher in the –30/–10 kPa surface irrigation treatment than all other treatments. In 2012 the –30/–10 kPa irrigation treatment irrigated frequently, but for a relatively shorter period of time than other treatments and used about 17% less water than the comparable SDI treatment. Water use was significantly greater in the SDI treatments than in the comparable surface treatments in 2012. There were no quality differences in fruit among the irrigation treatments in either year. It was noteworthy that the growing season in 2012 was significantly warmer with less rainfall than in 2011, suggesting that weather conditions could influence the response of a crop to irrigation method. Results suggest that SDI may provide some benefits over traditional surface applied drip irrigation, but that climate can also significantly interact with irrigation method.

Specified Source(s) of Funding: Kentucky Agriculture Development Board

8:30–8:45 AM

Onion Variety Response to Plant Population and Irrigation System

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Changing market opportunities for smaller size onion bulbs and the availability of new onion varieties, necessitate evaluations of yield and bulb size response to plant population for onion production in the Treasure Valley of eastern Oregon and southwestern Idaho. These evaluations can aid growers in making planting rate decisions. The objective of this trial

An asterisk (*) following a name indicates the presenting author.

was to evaluate the response of four onion varieties to plant population under “conventional” drip irrigation, “intense bed” drip irrigation, and furrow irrigation. Conventional drip irrigation had 4 onion double rows and two drip tapes on a 2.2 m bed. Intense bed drip had 6 onion double rows and three drip tapes on a 2.2 m bed. Furrow irrigation had 4 onion double rows and two furrows on a 2.2 m bed. Four onion variety split plots were planted in each irrigation plot. Each variety split plot was thinned to four plant population split-split plots in 2011 (296,000, 395,000, 494,000, and 593,000 plants/hectare), and five plant population split-split plots in 2012 (222,222, 296,000, 395,000, 494,000, and 593,000 plants/hectare). Irrigation system was not a statistically significant factor in the response of bulb size to plant population. In 2011, averaged over irrigation systems and varieties, marketable yield increased with increasing plant population over the full range of populations tested. In 2012, averaged over irrigation systems and varieties, marketable yield showed a quadratic response to plant population with a maximum marketable yield at 483,766 plants/hectare. In 2011 and 2012, averaged over irrigation systems and varieties, yield of bulbs larger than 10 cm in diameter decreased and yield of bulbs smaller than 7.6 cm in diameter increased with increasing plant population. In 2011 and 2012, yield of bulbs 7.6 to 10 cm in diameter increased or decreased with plant population according to the variety. Optimal population varied with growers’ marketing opportunities, with lower populations best for onion rings and populations with 400,000 plants or more per hectare when a mix of medium and jumbo onions are to be marketed.

8:45–9:00 AM

Cultivar Adaptability for Midwest Sweetpotato Production

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Sweetpotato, *Ipomoea batatas* L., is a warm-season vegetable crop that is widely grown mainly in the southern parts of United States. In the Midwest, short growing season often limits the production of this crop. Cultivar selection and management practices could play an important role in the proper establishment, growth, and development of sweetpotato crop. This study investigated the role of cultivar selection for sweetpotato production in Iowa. Study was conducted at the Horticulture Research Station, Iowa State University, Ames, and was set up as a randomized complete-block design with four replications. Treatments comprised of five sweetpotato cultivars: Beauregard, Covington, Diane, Evangeline, and Hernandez. Sweetpotato slips were planted on raised beds covered with black plastic mulch on 1 June 2012. Each treatment had three 6-m long beds. Beds

were spaced 183 cm center-to-center. Spacing between plants was 23 cm. Roots were harvested on 5 October, 2012, and cured at 27 °C and a relative humidity of 80% to 90% for 14 days. Yield of Jumbo grade and Grade 1 roots were higher for ‘Beauregard’ (16,432 kg/ha) and ‘Evangeline’ (20,284 kg/ha) as compared to other cultivars. ‘Beauregard’ has been a standard workhorse cultivar in sweetpotato growing areas of United States. ‘Evangeline’ is a relatively new cultivar with characteristics similar to those of ‘Beauregard’ but with southern root-knot nematode resistance and higher sucrose content. For Grade 1 roots there was no statistically significant difference between ‘Covington’ and ‘Beauregard’. ‘Diane’ produced the lowest yield for Grade 1 roots (7530 kg/ha). There were no statistically significant differences in yield for grade 2 roots among treatments. Cull yield was lowest for ‘Covington’. Roots with odd or abnormal shapes were higher in ‘Hernandez’ and ‘Diane’ as compared to ‘Covington’ or ‘Evangeline’. Root quality in terms of average root length indicate no statistically significant difference among cultivars, however, average root width was significantly different among cultivars with highest width for ‘Beauregard’. Average root width was lowest in ‘Diane’. Laboratory analysis of crushed sweetpotato roots showed highest sugar concentration in the cultivar ‘Hernandez’. ‘Beauregard’ had the lowest sugar content. Results from this study indicate that cultivar selection is critical when considering sweetpotato production in the Midwestern region. ‘Evangeline’, ‘Beauregard’, and ‘Covington’ seem to be promising cultivars for sweetpotato production in the Midwest region

Specified Source(s) of Funding: Iowa State University Research Funds

9:00–9:15 AM

Improving Lima Bean (*Phaseolus lunatus*) Productivity in the Mid-Atlantic Region

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Lima bean (*Phaseolus lunatus*) is the cornerstone crop of the vegetable processing industry in the Delmarva area of the Mid-Atlantic region with green baby lima beans being planted over 8000 hectares in the area. Productivity of the crop is affected significantly by heat and water stress. Flower and pod loss can be severe during high temperature periods and split sets are common. Because of these abiotic stress factors, yields have plateaued over the last decade. The general practice to reduce losses to heat has been to plant the crop to flower and mature in the cooler periods of late summer and early fall. This limits the amount of weeks that companies can process the crop. Cooler periods also are conducive to several diseases (downy mildew, pod blight, and white mold) that further limit the productivity of the lima beans. Research on variety improvement, stress mitigation, tillage, multiple cropping, and irrigation is being

An asterisk (*) following a name indicates the presenting author.

conducted in an effort to improve lima bean productivity and increase the potential harvest period. A Delaware-based breeding program has shown yield increases of over 30% compared to currently available varieties with improved yield stability by utilizing heat tolerant materials in crosses; stress mitigation studies have shown increases of 35% with the used of particle films, strobilurin fungicides, and cytokinin applications in combinations; tillage studies are being conducted to determine the potential for reduced tillage in production; multiple cropping studies where the crop is harvested then allowed to regrow for a second harvest have achieved overall yields over 6000 kg/ha and irrigation studies are underway to better understand water needs of the crop. Preliminary results from this research show great promise for improving overall productivity of lima beans for the eastern U.S. production area.

Specified Source(s) of Funding: USDA/DDA Specialty Crop Block Grants

9:15–9:30 AM

SWOT Analysis of the Vegetable and Fruit Programs in Texas

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The analysis of internal and external forces affecting the Vegetable and Fruit (V&F) programs in Texas A&M AgriLife and the current state of the Texas V&F industry is the first step in the development of a strategic planning for the Vegetable and Fruit Industry in Texas. First, internal knowledge-based regional workshops were conducted at Uvalde and College Station and a consolidated online survey was developed for research and extension faculty engaged in V&F programs. Second, external regional industry workshops were conducted in four important V&F growing areas in Texas: McAllen (Lower Rio Grande Valley), Uvalde (Wintergarden), Lubbock (High Plains), and El Paso (West Texas). The internal survey questions were grouped by the level of activity engaged by faculty, by top priorities issues that needed additional resources to increase AgriLife impact, and by the specific SWOT components (S = strengths, W = weaknesses, O = opportunities, T = threats). Furthermore, the internal survey also provided categorical information of the respondents such as department affiliation, location, primary discipline, and professorial rank. The external survey provided data on specific crops grown, area per crop, type of production (conventional and/or organic), annual gross sales, marketing channels and SWOT components. Other data obtained included: familiarity of growers with Texas A&M AgriLife Research and Extension, technical assistance sources, programmatic values

of research, extension and educational programs, future breeding, and growers support for programs. Finally, the survey gave demographic information of the respondents such as age, gender and number of years in business. A total 87 participants and 80 stakeholders responded the internal and external survey, respectively. The external survey instrument was successful in identifying an important segment of the V&F industry (95,000 acres) in Texas with a distribution of 75% to 25% of conventional-organic growers. This presentation will discuss the level of programmatic pre- and postharvest activities, top priority issues, competitive advantages of the Agency (strengths), conditions favorable to achieve goals (opportunities), internal limitations that hinder the Agency progress (weaknesses), and external conditions harmful in achieving goals (threats). We will present the main strengths that contribute to the success of the V&F industry and the broad opportunities for achieving success (i.e. technology advances applied to agriculture, applied long-term research, education and outreach, pre- and post-harvest technology advances). We acknowledge J. Landivar, P. Rosson, and M. Dozier as planning committee members and B. McCutchen, Executive Associate Director, Texas A&M AgriLife Research.

Thursday, July 25, 2013

Desert Salon 1-2

Viticulture and Small Fruits

Moderator: Wei Qiang Yang, wei.yang@orst.edu

8:00–8:15 AM

The Effect of Terbacil, Root Injury, and *Rhizoctonia fragariae* on Strawberry and the Development of Black Root Rot

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Black Root Rot (BRR) is a disease complex of strawberry plants in the mid-Atlantic region. Multiple factors have been implicated in disease development such as *Rhizoctonia fragariae*, *Pythium* spp., *Pratylenchus penetrans*, and environmental and cultural stresses. There is anecdotal evidence that strawberry plants treated with the herbicide terbacil may be more susceptible to BRR. The effect of terbacil at 0 and 160 mg·L⁻¹, a.i., and *R. fragariae* anastomosis groups A, G, I, and an uncharacterized strain, from Pennsylvania, were

An asterisk (*) following a name indicates the presenting author.

observed on 'Jewel' strawberry plants and development of BRR symptoms. Plants inoculated with AG-A had more leaves with phytotoxicity symptoms when terbacil was applied than other inoculation treatments. Terbacil and inoculation did not reduce leaf (including petiole), crown, root, and total dry mass, and final crown number. In another experiment, the effect of root injury and inoculation with *R. fragariae* strains were observed on 'Jewel' strawberry plants. Roots were injured by scraping or crushing then before inoculation with isolates of *R. fragariae* strains, AG-A and AG-G, from Pennsylvania and Connecticut. Plants inoculated with CT-A, CT-G, and PA-A had higher plant survival than non-inoculated or PA-G inoculated plants, and uninjured plants had higher plant survival than injured plants. Plants inoculated with PA-A and crushed roots had more primary roots than uninjured plants, and inoculated plants had a higher percentage of primary roots with lesions except for plants inoculated with PA-A. Plants inoculated with CT-G and PA-A had higher leaf, crown, root, and total dry mass than non-inoculated plants, and dry mass of plants inoculated with CT-A and PA-G was intermediate.

Specified Source(s) of Funding: North American Strawberry Growers Association

8:15–8:30 AM

Genetic Parameter Estimates for Resistance to *Colletotrichum gloeosporioides* and Comparisons with Production Traits in Strawberry

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The fungus *Colletotrichum gloeosporioides* infects the crowns of strawberry plants, causing wilting and death that may result in significant losses in the field. Cultivars developed at the University of Florida show variable levels of resistance to this disease. Thus, genetic parameters for resistance to *C. gloeosporioides* were estimated in this study to aid in the selection of breeding practices that would improve resistance. About 13 seedlings were randomly selected from each of 76 families obtained from a circular diallel mating design, with one runner plant per seedling in each of four blocks. Plants in two of the blocks were inoculated by spraying the crowns with 2 mL of a spore suspension of *C. gloeosporioides*. The remaining two non-inoculated blocks were utilized for measuring production traits including average fruit weight, marketable yield, proportion of unmarketable fruit, and soluble solids content. Broad-sense heritability for resistance to crown rot was estimated as 0.38 ± 0.05 suggesting moderate genotypic control. Improvement in resistance to crown rot will be possible through recurrent selection, as narrow-sense heritability was also moderate

(0.49 ± 0.12), suggesting a lack of non-additive variance for this trait. For production traits, narrow-sense heritability estimates ranged from 0.12 ± 0.04 to 0.53 ± 0.04 whereas broad-sense heritabilities ranged from 0.19 ± 0.03 to 0.67 ± 0.03 . Estimates for the production traits were similar to those obtained in previous studies, except those for soluble solids content ($h^2 = 0.12 \pm 0.04$, $H^2 = 0.19 \pm 0.03$) which were lower than in previous reports. Broad-sense heritability estimates for all traits except soluble solids were moderate to high, suggesting that gains can be obtained from clonal selection in this population

8:30–8:45 AM

Extending the Strawberry Season: High Tunnels, Low Tunnels, and Targeted Supplemental Heating

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Demand for fresh local strawberries continues to increase with the expanding local food movement. However, environmental conditions in many areas are less than ideal for strawberry production. In many regions of North America with a continental climate, frequent spring frost events result in loss of early blossoms. In the arid Intermountain West, sprinkler irrigation is not a frost protection option. The effects of five frost protection methods were compared over two seasons for plug, bare-root dormant, and fresh dug plants of 'Chandler' and 'Seascape' strawberry in North Logan, UT (lat. 41.74°N, 1460 m elevation). Treatments were: high tunnel, low tunnel, high tunnel + low tunnel, low tunnel with in-ground supplemental heating, and high + low tunnel with in-ground supplemental heating. Plants were evaluated for runner and branch crown formation, as well as early and total yields. Highest total yields were achieved in the high + low tunnel combination with no significant difference between those with and without supplemental heating. 'Chandler' plug, 'Chandler' dormant, and 'Seascape' dormant gave the highest total yields, with no significant difference among the three. Fresh dug plants yielded far below both plug and dormant plant types in all treatments, most likely due to insufficient crown development (2.3 crowns/plant compared to 5.4 and 6.0 crowns/plant for plug and dormant, respectively). 'Chandler' early yields (before 22 May) were higher than 'Seascape' for both plug and bare-root dormant plant types in all treatments. In-ground supplemental heating of 15 °C moved production 5 weeks earlier than the unheated high tunnel treatment and 9 weeks earlier than the outside control. For Utah cold-climate production, a combination of high and low tunnels is most effective in providing frost protection and advancing the season. In-ground supplemental heating can widen the production window but analysis is needed to determine the economic viability of this option.

An asterisk (*) following a name indicates the presenting author.

Specified Source(s) of Funding: Utah Department of Agriculture and Food Specialty Crop Block Grant

8:45–9:00 AM

Specific Changes in the Expression of Cell Wall Carbohydrate Metabolism Related Genes during Fruit Abscission in Rabbiteye Blueberry

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Organ separation through abscission occurs at abscission zones (AZs) and involves the breakdown of cell walls. During abscission, the AZ cells respond to the various signals, and activate cell wall loosening enzymes. The spatial and temporal regulation of the dissolution of primary cell wall polysaccharides and middle lamella is not completely understood. The focus of this study was to obtain a comprehensive understanding of changes in the expression of cell wall metabolism related genes during abscission in rabbiteye blueberry. In blueberry, fruit abscission occurs primarily at the pedicel-peduncle junction (PPJ). Next generation sequencing (454) was performed on a pool of potential AZs for identification of AZ related genes. Twenty eight cell wall carbohydrate metabolism related genes were selected using Blast2GO analysis to further study the changes in their expression in response to abscission agent applications. Control (only adjuvant), Ethephon (1000 ppm + adjuvant) and Methyl Jasmonate (MJ; 20 mM + adjuvant) treatments were performed on rabbiteye blueberry. Approximately 60% of the berries abscised at the PPJ in response to Ethephon and MJ within 48 h. PPJ and fruit-pedicel junction (FPJ) tissue were collected at 0, 24 and 48 h after treatment. In the PPJ, expression of POLYGALACTURONASE and POLYGALACTURONASE ISOZYME increased by 4- to 5-fold, while PECTATE LYASE, BETA-GLUCANASE, and BETA-GALACTOSIDASE expression increased by more than 8- to 10-fold at 48 h after treatment with MJ and ethephon. Expression of PECTIN METHYLESTERASE and INVERTASE PECTIN METHYLESTERASE INHIBITOR was down-regulated by 2- to 7-fold as a result of MJ and ethephon treatments. Also, the expression of CELLULOSE SYNTHASE decreased as a result of the abscission agent applications. Overall, cell wall carbohydrate metabolism related genes appear to play an instrumental role in abscission, resulting in detachment of the berry. Together, these data suggest that blueberry fruit abscission is mediated by specific changes in the composition of the cell walls at the PPJ.

9:00–9:15 AM

Effect of Rootstock and Soil Amendment on Three Highbush Blueberry Cultivars

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A grafted blueberry research plot was established at the North Willamette Research and Extension Center in Aurora with a split-split plot design with soil treatments and root types as sub plots respectively. There were two root types (own roots vs. grafted) and three highbush varieties ('Draper', 'Liberty', and 'Aurora') growing in two soil treatments (sawdust amended soil vs. no amendment). Leaf tissue analysis found that grafted plants had higher tissue N, P, K, and Mn, but lower Ca, and Mg than own-root plants, indicating rootstock affected key nutrients uptake. Sawdust amendment reduced foliar Fe concentration. Foliar P concentration in 'Aurora' was higher than that in both 'Liberty' and 'Draper', while 'Liberty' has a lower foliar K concentration than both 'Draper' and 'Aurora'. Fruit firmness was not affected by grafting and sawdust amendment and differed as expected among three highbush blueberry varieties. Yield and other growth parameters among cultivars, root types, and soil amendment will be determined in future years.

Specified Source(s) of Funding: SCRI and Oregon Blueberry Commission

9:15–9:30 AM

The Effect of Timing and Intensity of Summer Pruning on Vegetative and Reproductive Traits of Southern Highbush Blueberry

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Summer pruning is a major practice for blueberry management in the southeastern United States, but research-based recommendations are lacking. The objective of this study is to determine the effects of timing and intensity of summer pruning on vegetative and reproductive growth, and the incidence and severity of leaf spots in 'Jewel' and 'Emerald' southern highbush blueberry. The following treatments were applied to mature plants of both cultivars for two years: 1) control—no pruning; 2) control—detailed hand pruning; 3) pruning 30% of existing foliage in early June (30% June); 4) pruning 30% of existing foliage in mid-July (30% July); 5) pruning 30% of existing foliage in early June followed by shoot tipping in mid-July (30% June+tip); and 6) pruning 60% of existing foliage in early June, followed by shoot tipping in mid-July (60% June+tip). Plant volume was similar across years within treatments for both cultivars, with the non-pruned plants having the greatest canopy volume

An asterisk (*) following a name indicates the presenting author.

at the end of each growing season, averaging 1.57 m³ and 1.26 m³ for 'Jewel' and 'Emerald', respectively, across both years. However, regrowth volume of the non-pruned plants decreased significantly from the first to second year, while regrowth in the other treatments either increased or had no differences between years. Flower bud formation in 'Emerald' started in early August for the non-pruned plants, but not until late August for the other treatments. For 'Jewel', flower bud formation began in mid-October for all treatments. Flower bud number per shoot was least in the 30% July pruning, reflecting decreased regrowth compared with the other treatments. The non-pruned and the 60% June+tip had the greatest average number of flower buds per shoot. Full bloom (50%) in 'Jewel' occurred 3 days earlier in the hand-pruned compared with the 30% June and 60% June+tip treatments and one week earlier than in the other treatments. Leaf spot in 'Jewel' non-pruned plants was greater than in the other treatments, which likely resulted in the greatest defoliation for this treatment. 'Emerald' was not affected by leaf spots. Shoot length in the non-pruned plants was reduced by 30% to 50% and flower bud number by 50% from the first to second year, while the other treatments were stable or increased for these traits, reflecting the reduction of vigor caused by the lack of pruning. Early pruning (June) resulted in increased vegetative growth and flower bud number compared to later pruning (July), regardless of severity and tipping.

Specified Source(s) of Funding: Florida Blueberry Growers Association and USDA Specialty Crops Block Grant program

Thursday, July 25, 2013 Desert Salon 9-10

Consumer Horticulture and Master Gardeners

Moderator: Lucy K. Bradley, lucy_bradley@ncsu.edu

8:00–8:15 AM

Increasing Confidence in Diagnosing Plant Problems with Diagnostic Updates

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Extension offices around the country utilize Master Gardener Volunteers to assist clientele in diagnosing plant problems. One of the challenges for these volunteers is the lack of training and confidence when it comes to identifying plant problems. A 2009 survey by the North Central Consumer Integrated Pest Management working group showed that Master Gardener Volunteer (MGV) responses indicated that their confidence level in identifying and diagnosing plant problems needed

improvement. More than 72% of the respondents noted that face-to-face training would be very helpful. With this in mind, Extension Educators and Specialists developed a Diagnostic Update for MGVs and presented this program in five areas of the state with the goal of raising participant's confidence level in the area of diagnosing plant problems. This program was modeled after a successful program for the green industry that has been presented yearly since the early 1990's. The format is a morning session of classes and presentations and an afternoon session of hands-on diagnostic training. Live plant samples are displayed and participants are given time to attempt to answer the diagnostic question that ranges from identifying the plant to the actual pest problem. After participants have an opportunity to go through the samples, they then have the opportunity to learn about each one as the educators go through the samples, identify the specific problem or answer the question, and tie the samples to the general diagnostic process. As a result of these updates, MGV participants indicated an increase in their diagnostic skills. For instance, 56% indicated that there were not confident at all prior to the class; this dropped to 24% indicating that they were not confident after the class. There were 0.0% of the participants with lots of confidence prior to the class and 29% with lots of confidence after the class. Ninety-four percent of the participants indicated that they strongly agreed or agreed that they would use the knowledge learned and 100% of the participants planned to put the knowledge gained into practice immediately, either on the County horticulture helpline or in their own gardening practices. Additional skills learned as a result of these workshops include: examine the entire specimen as there can be several things happening at the same time; pay attention to the history of the specimen; where to start the diagnostic process; diagnostics is an ongoing process; and ask more questions before making a diagnosis.

8:15–8:30 AM

Making Meaning Out of Science: Using Nature's Notebook to Engage Citizens in Exciting and Relevant Research

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Many site-based educators (nature centers, Cooperative Extension, schools, arboretums) struggle with developing and implementing cohesive projects into their existing programming. Moreover, projects that are not meaningful to participants often have little or no long-term impact. The USA National Phenology Network's (USA-NPN) Education Program provides phenology curriculum and outreach to educators in formal, non-formal, and informal settings. Materials are designed to serve participants in grades 5–12, higher education, and adult learners. Phenology education can inform science, environmental, and climate

An asterisk (*) following a name indicates the presenting author.

literacy. Education and educator instruction materials were designed and field-tested to implement a long-term phenology-monitoring program, Nature's Notebook (NN), at sites. Materials demonstrate how to incorporate monitoring for public visitors, long-term volunteers, and school groups, while meeting the goals of USA-NPN and the site. Materials encourage long-term data collection, interaction between educators, and offer information about how educators can ask and answer science questions. Do site-based NN training materials engage students and meet NN and Master Gardeners (MG) objectives? Phenology monitoring was added to Pima MG Training during 2012 and 2013. MGs receive 40–50 education hours and return 40–60 volunteer service hours annually. Using this case study as an example, this talk will demonstrate how to successfully implement NN at a site. The course was changed during the second year to better reflect participant needs. Year one content included phenology and observation using NN. Second year additions included ecology, biogeography, climate, and garden phenology applications. Both classes collected weekly data for NN and were offered an opportunity to review data during a follow-up lesson. Thirty percent of year one participants were very likely to continue NN observations while 48% of year two participants were very likely to continue. Forty percent of participants were very likely to attend an advanced training on NN and 55% of second year participants responded positively. Evaluations from year one indicated a need to be more explicit about phenology application in gardening. Comments included: "This does not seem helpful for MG, but ... interesting," "...information not relevant to helping...community garden." Conversely after year two, students better understood phenology's relationship to gardening. Comments included: "...makes you more aware," "Very informative...motivate(s) me to record more than...when I hear the first cicada," and "Phenology touches everything...brings to light...connecting you already know...tests your new insights [that will] make it more meaningful." In conclusion, effective education materials holistically and explicitly incorporate personal meaning. Directed content creation helps form an engaged volunteer corps.

8:30–8:45 AM

Permaculture in Community Gardens: A Systems-based Approach to Engaged Design

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Community gardens have positive impacts for individuals, cities,

and the environment. However the challenges of maintaining these spaces are also significant. Many communities have tried and failed to sustain gardens, often due to a lack of appropriate planning, resources, and labor. Permaculture is a framework that can help promote long-term sustainability by designing systems that create more regenerative landscapes. Permaculture gardens are designed to work with nature to more efficiently use resources, time, and energy. The goal of this project was to: 1) design a tool to assess the level of permaculture design present in community gardens; 2) pilot the tool in eight community gardens; and 3) use the tool as the framework for community engaged redesign of an existing garden. There has been minimal research on permaculture in community gardens. Therefore, the first goal of this project was to determine a strategy to assess the level of permaculture in community gardens. An assessment tool was developed and piloted in eight community gardens. The tool identifies six key permaculture systems within community gardens: soil, water, energy, materials, plants/animals, and community/people. Within each system, core elements are listed creating a checklist for assessment. Three of the eight gardens evaluated were implementing permaculture. Subsequently, the permaculture assessment tool was incorporated into a community engaged design process to redesign an existing community garden while teaching participants permaculture principles, systems and elements. A series of four workshops were facilitated culminating in a new permaculture design for the space. Stakeholders were surveyed to assess impact. In addition to designing a more manageable space, one of the goals was to facilitate learning of permaculture principles. Findings show success in teaching permaculture principles and elements using community-engaged design. Success in teaching permaculture systems was present, but not as prevalent. The assessment tool increased participants' confidence in identifying permaculture, but was less successful in making participants comfortable applying permaculture. Participants believe that the re-designed space will reflect permaculture and model earth stewardship. The actual ability of the permaculture-focused re-design to ease management stress will need to be assessed over time. The project underscores a need for more research on the impacts of permaculture in community gardens, and supports community-engaged design as one effective model for implementing this work.

8:45–9:00 AM

Organic Gardening Educational Materials for Extension Master Gardener Volunteers

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Horticulture Agents in North Carolina supervising Extension Master Gardener Volunteer (EMGV) programs were surveyed to identify their need for additional training materials on Organic Gardening as well as their preference for format and content of materials. In a 65% response rate, North Carolina Extension agents, managing 33 of the 51 active EMGV counties, 47% reported daily or weekly requests for organic/sustainable consumer horticulture information and 53% reported monthly requests. The survey outcome revealed a strong preference to provide value-added content within the current curriculum and products. In addition, State Extension Master Gardener Coordinators across the country were surveyed to identify the structure of their advanced training programs for volunteers. Twenty states have advanced certification in their EMGV program and the survey documented that the design and structure of advanced certification differs in each state in order to meet the needs of volunteers, the public, and extension programs. Based on the results of these two surveys, a chapter on Organic Gardening was created for the NC-EMGV Manual. It includes sections on organic management of top disease, weed, and insect pests of ornamentals, lawns, and vegetable gardens.

9:00–9:15 AM

The 40 Gallon Challenge: A Simple Effective Educational Tool

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The growing population and subsequent water demand have coincided with several high impact droughts in the southeast, increasing the pressure on limited water supplies. Water conservation throughout the region is a necessity and a challenge. The 40 Gallon Challenge web site was created (www.40GallonChallenge.org) to encourage people to pledge to save 40 gallons of water a day. Essentially a self-audit checklist, the Challenge provides an estimate of water savings resulting from the implementation of conservation practices. Total daily savings are estimated when the practices are selected. Participants choose practices that fit their lifestyle, and then pledge to implement them. In the process of choosing, participants learn how to conserve water and how much water is used in routine activities. The challenge targets water conserving horticultural practices including use of rain

barrels, composting, and mulch. It also focuses the participants' attention on low water-use landscaping, irrigation systems and watering. The tool is effective in changing behavior; 86% of the respondents to a follow-up survey reported following through with at least 75% of their pledge. Extension Master Gardeners have used the Challenge as an educational tool in many venues. The Challenge may serve as a model for other educational activities. It is flexible and easy to use. It encourages personal reflection of educational messages. Finally, it calculates the impact of the educators' efforts at the county, state and national level.

Specified Source(s) of Funding: Southern Region Water Program

9:15–9:30 AM

Virtual Volunteers: Expanding Extension's Reach with a National EMG Social Media Certification

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As extension horticulture programs seek to use social media to connect or expand their reach with the general public, it should seem no different that EMGs could be helpful in using social media to reach the gardening public or service existing clientele. Yet, who a volunteer represents (themselves or extension) is often blurred in social media since creating separate accounts or social media entities is often unrealistic. In some cases, volunteers are asked to manage group social media accounts on behalf of their local extension program. In other cases, individuals may participate in online Twitter discussions as an individual, but may be unclear if or how they should represent the knowledge they share on behalf of extension. Recently EMG Coordinators gathered by web conference to discuss these issues. One of the main ideas discussed was this: volunteers have other identities and responsibilities outside of extension, and extension has specific needs for extending research, credibility, consistency, reputation, control, and verification of research-based information. In both cases, simple, clear expectations, guidelines, support and reinforcement may help volunteers and extension become successful in understanding how to extend extension information through online social networks in a reputable and helpful manner. Thus, a task force was assembled to devise a way to equip local programs and volunteers with training and support resources that would meet the needs of both Extension and EMG volunteers. The task force identified several key training modules to be developed, specifically—what social media is; social media identity and accountability; social media etiquette and customer service; writing for the web; common social media platforms (e.g. Facebook, Twitter, Pinterest, YouTube); and analytics and reporting. A needs assessment was also conducted to understand which training modules, desired training formats, specific social media platforms or tools, and type of skills would

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Thursday, July 25 2013

be most helpful for volunteers to attain through a National EMG Social Media certification program.

9:30–9:45 AM

Seeing in Systems: Helping Community Gardeners Build Resilience and Reduce the Need for Maintenance by Making Permaculture Connections

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Many communities have tried and failed to sustain community gardens, however, permaculture is a framework that can help promote long-term sustainability. Permaculture gardens are designed to work with nature to create efficient, resilient spaces saving time, energy, and money. Despite the potential for positive impact, minimal research has been conducted on permaculture in community gardens. In order to assess the use of permaculture in community gardens a two-part tool was developed to identify whether and how permaculture is being used in existing gardens. The tool identifies six key permaculture systems within community gardens: soil, water, energy, materials, plants/animals, and community/people. Within each system core elements are listed creating a checklist for assessment. In the second part of the tool, connections between elements and systems are identified in a diagram. These interconnections between elements and systems are the basis of garden resilience and the ultimate goal of permaculture. The assessment tool was piloted in existing community gardens and used as a teaching tool in permaculture workshops. Surveys showed that the tool increased participants' confidence in identifying permaculture elements and systems.

Thursday, July 25, 2013 **Desert Salon 13-14**

Teaching Methods

Moderator: James A. Robbins, jrobbins@uaex.edu

8:00–8:15 AM

Effectiveness of Online Laboratory Experiences

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Online education in the laboratory sciences creates a milieu of questions and problems. The efficacy of the hands-on experiences developed by faculty members for distance learners requires student and instructor ingenuity and flexibility. Previous research has determined there is more individual interaction between the faculty member and the online student when compared to traditional courses. However, the effectiveness of these types of activities has not been quantified. By comparing the laboratory results and laboratory reports of on-campus students completing the exact same activities as the distance learners, the nature of the difficulties experienced by the online learners may be determined. This project provides some examples of “what works” and “what doesn't work” with regard to distance laboratory exercises using live plant material.

8:15–8:30 AM

Creating Virtual Nursery Trips to Improve On-campus and Distance Education in Nursery Production

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A national survey conducted in 2009 of instructors of nursery production indicated a need for multimedia resources to supplement in-class instruction and field trips. Finances, logistics, and geography limit the scope of nursery production operations that students can view on field trips. The objective of this project was to document nursery production operations with video footage and create virtual nursery trips to improve on-campus and distance education in nursery production. For the first year of this project, digital HD video footage was captured at nurseries around the country. From October 2010 to November 2011, video footage was collected using a professional videographer at 42 nursery businesses in 22 states. Total travel included 65 days over 18 trips covering almost 43,000 miles. Almost 25 GB or approximately 26 h of video footage was collected. Video footage collected was inventoried and archived, and appropriate clips were selected for inclusion in final product. Video footage selected for each topic was edited together by the videographer. Narration for selected video footage was written, and a professional narrator recorded all narration for each topic. In the final product, videos were arranged by topic for a total of 20 “chapters”. Video segments within each chapter or topic range from

An asterisk (*) following a name indicates the presenting author.

a few seconds to several minutes. The finished product has been transferred to a single USB drive and contains 444 individual topic videos (total time about 10.75 h) and 28 company profiles for a total size of 29 GB. In Spring 2013 USB drives containing all videos and company profiles were provided to instructors of horticulture at over 100 land grant institutions (1862, 1890, and 1994) who submitted a request form. Product users will be surveyed to document content, organization, accessibility, and ease of use, and implementation of the product.

Specified Source(s) of Funding: NIFA Higher Education Challenge Grant

8:30–8:45 AM

Using an Extraordinary Combination of In-person Education and Distance Learning to Help Women Producers Create Business

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It is a little known fact that the majority of women in agriculture do not have business plans. When women farmers were surveyed in New Jersey, only 2 out of 137 farm women had current business plans for their agricultural enterprises. Whether they are partners or sole proprietors, it is evident that women need to be more aware of the importance of the business and financial management components that impact the very success of their farms. Our Women in Agriculture program—Annie's Project New Jersey—created a comprehensive educational program and support network for women farmers that educated them about

understanding and managing their farm businesses with a focus on farm and family financial management. The primary goal was to provide a collaborative outreach and assistance program for traditionally underserved farmers (women) in throughout New Jersey and across the mid-Atlantic region. A unique combination of in-person meetings and distance-learning technology was utilized to deliver the program via webinars, webcams, and wireless microphones to “connect” 75 women and 24 presenters in three locations across New Jersey. Participants (n = 42) out of the 137 women in the Annie's Project New Jersey programs 2011–12 were surveyed within a year after the coursework to determine adoption of business practices that would help to improve their farm business operations. Results indicated that 97% developed a mission statement; 92% developed their business description; 64% wrote a farm description to be used for marketing (or another purpose); 70% developed a management plan; and 68% developed a production plan. In addition, several participants have used their business plans as part of their applications for funding from the USDA's Farm Service Agency (FSA). In total, 70 of the 137 women completed business plans as a result of the course. The live sessions were broadcast and recorded each week, allowing women to watch a lecturer from over 100 miles away as well as the opportunity to watch the video again. Once the “live” course was completed, these videos, handouts, and Power Point Presentations were archived online under the Resources and Articles tab on the Annie's Project New Jersey website: <http://aesop.rutgers.edu/~farmmgmt/anniesproject.html>. There they remain available to anyone to view to broaden their knowledge on a specific topic or learn something new about successful agricultural business management practices.

Specified Source(s) of Funding: USDA National Institute of Food and Agriculture Risk Management Agency and Rutgers Cooperative Extension. Cooperating agencies include Rutgers, The State University of New Jersey, the U.S. Department of Agriculture and County Boards of Chosen Freeholders

8:45–9:00 AM

Climate Change Literacy in the U.S. Undergraduate Horticulture Curriculum

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Weather extremes consistent with predictions from climate change and global warming models are already impacting horticulture. Weather extremes will become more frequent and destructive if global temperatures rise as rapidly and as far as the models currently predict. These will force us to change how we live and function. To determine the extent to which higher educational institutions across the United States are preparing students for such a future, a survey was conducted to gather information on the incorporation of climate change literacy in horticultural curricula. While most programs do not

currently offer classes with “climate change” or “global warming” in the formal title or description, a few are beginning to do so. Nearly all respondents reported including at least some information related to climate change in the specific courses they teach. Examples of content include discussions related to the revised USDA Cold Hardiness map, carbon sequestration, equipment fuel consumption, effects of increased carbon dioxide, crop scheduling, and environmental stresses, such as drought and heat. Most instructors also said they have been increasing such content over time. Details from the survey will be presented.

9:00–9:15 AM

Using Different Teaching Methods to Enhance Student Learning of Climate Change

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Improving student learning in the classroom can be achieved by using multiple teaching methods in order to reach to students with varied learning styles. Two general learning styles are visual and auditory. In order to appeal to these learning styles, class materials on the climate change section of an environmental physiology class at the University of Georgia were presented via lectures, assigned readings, discussion, and on-line materials. Environmental physiology is an upper level class consisting mostly of juniors, seniors, and graduate students. Three lectures were given within the broad topics of: 1) how current climate change differs from historical climate change; 2) predicted climate changes; and 3) how climate change will effect plant growth and production. Eight short papers were assigned within the previously mentioned topics. Students were asked to read these papers and develop questions for use in in-class discussions. Discussions were led by student groups. Prior to covering the topic in class, a survey was given to the students to self-assess their knowledge of various topics related to climate change. The survey asked students to rate whether they agreed or disagreed with a statement from 1 to 10. The same survey was then given to students a week after the climate change section was concluded in class. Students were also asked to rank the four teaching methods by how effective they felt the methods were in enhancing their knowledge of climate change. The self-assessment of the students indicated that their understanding of 10 of the 30 topics surveyed was significantly improved. The self-assessment also indicated better understanding of all other topics, although that improvement was not statistically significant for 20 of the 30 topics. The two topics where students indicated their largest increase in understanding (response averages changed by 3) were: 1) You understand the physical process that causes increased CO₂ concentrations to raise the earth’s temperature and 2) There is much scientific controversy about whether climate change is

actually happening. Ranking of teaching methods found student preference to be: 1) lectures; 2) readings; 3) online materials; and 4) in-class discussion. However, rankings showed that each teaching method was preferred by at least one student. This shows the benefit of using a variety of teaching methods to best meet student learning goals.

9:15–9:30 AM

A Syllabus Rejig: Aligning Course Goals, Learning Objectives, Assignments, and Assessment

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Well-defined course goals and learning objectives should be the guiding force in developing or redesigning a course. Once these are determined then the types of assignments, how the assignments will be assessed or evaluated, and which teaching and learning strategies will be most appropriate can be developed. When all of these elements are linked the course becomes a cohesive whole. Most importantly, students will be provided with opportunities to demonstrate how their learning matches the overall intent of the course. In 2012 the syllabus for Horticulture 481, Advanced Garden Composition at Iowa State University was redesigned to align all of the course components. As a result of this thoughtful realignment, many changes were made to the types of assignments and how they were assessed or evaluated. Different teaching and learning strategies were also employed in the course. Student feedback through mid-semester formative evaluation and end of semester teaching evaluations showed a positive correlation between many of these changes and student satisfaction with the course. Reviewing the syllabus with this type of whole course alignment in mind has resulted in a more unified and successful course.

9:30–9:45 AM

Continuing Agricultural Education: Relationship between Adult Learning Styles and Educational Delivery Method Preferences

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The Yuma County Cooperative Extension service plays a significant role in providing a range of information sources to the agricultural industry through outreach and Extension programming. Littlefield (2000) noted that Arizona vegetable growers are the main clientele in Cooperative Extension programming, specifically in desert vegetable research. In addition, agricultural pest control advisers (PCAs) are provided essential continu-

An asterisk (*) following a name indicates the presenting author.

ing education credits from university programming. Further clientele who are kept abreast of current research include industry personnel such as crop production consultants, seed, fertilizer, and agrichemical industry representatives, pesticide applicators, equipment manufacturers, storage operators, and truckers (Littlefield, 2000). The purpose of this study was to identify the learning styles and preferred methods of receiving agricultural information on new or innovative farming practices among Yuma, AZ, area growers, pest control advisors, and industry personnel. A review of the literature suggested there is a continual need for evaluation of instructional methods and technology in adult education (Martin & Omer, 1990). Most studies in adult education in agriculture have focused on the need for adult education (Creswell & Martin, 1993). Those studies which have focused on instructional methods recommended further study was needed on the appropriate methods and tools to use in adult education programs in agriculture (Creswell & Martin, 1993). As non-experimental correlational research, relationships were examined between learning styles and selected demographic characteristics (age, profession, number of years in the agricultural industry, education, and gender) of adult continuing agricultural education learners. Relationships were examined between preferred delivery method and selected demographic variables (age, profession, number of years in the agricultural industry, education, and gender) of adult continuing agricultural education learners. Moreover, relationships were examined between learning styles and preferred delivery methods of adult continuing agricultural education learners. Conclusions from the study indicated the following: a moderate correlation (Davis, 1971) exists between learning styles and the demographic characteristics of age, education, and profession. A moderate correlation (Davis, 1971) exists between the demographic characteristic, profession, and preferred delivery methods of adult continuing agricultural education learners. A moderate correlation (Davis, 1971) exists between VARK learning styles (visual, aural, read/write, and kinesthetic) and preferred delivery methods of adult continuing agricultural education learners with a grower or industry personnel profession. Research implications concluded that Extension agents and instructors of adult continuing agricultural education learners should focus on the demographic characteristic (profession) when seeking to develop program delivery methods that will effectively meet the needs of these adult learners.

9:45–10:00 AM

North American Horticulture Graduate Program Survey: Demographics, Policies, Finances, and Metrics

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A comprehensive survey of American and Canadian university departments/colleges was conducted resulting in responses from twenty seven programs reporting graduate degrees in the field of Horticulture at the masters or doctoral level. Units were surveyed regarding the types of degrees offered, admissions policies, demographic characteristics of the students, financial assistance provided to students, faculty ranks and salaries, and metrics by which the programs were evaluated. About 80% of the programs resided in 1862 land grant institutions with the remainder housed in other state or provincial institutions. Thirty eight percent of reporting land grant programs existed as stand-alone Horticulture departments, whereas Horticulture programs were combined with other disciplines in the remainder. Admissions criteria consisting of applicants' prior grade point ratios (averages), verbal and quantitative GRE scores, letters of reference, statements of purpose or essays and, for international students, TOEFL or similar English language competency assessment scores were typically required. Participation in distance programs was low, but growing. Fifty-five percent of the programs permitted direct enrollment in PhD programs without a prior Masters degree. On average, 84.3% of graduate students at 1862 land grant schools received institutional support, while only 66.1% at non-land grant schools received institutional support. Most schools offered some sort of tuition reduction to those students on assistantships/fellowships and offered available health insurance. Payment of fees was rare and the level of stipends provided varied substantially among programs. Mean international student enrollment was 34.8% of students at 1862 land grant schools, but was only 19.4% at non-land grant institutions. Most graduate students at 1862 land grant schools were non-Hispanic White (63.2%) with Hispanic (6.8%), Black (3.0%), Asian (14.0%), Indian/Pakistani (4.9%), Native American (0.3%), and other (6.1%) reported as minority constituents. Professors (46.7%) and Associate Professors (28.3%) dominated the faculty ranks while Assistant Professors (19.3%) and lecturers/instructors (5.7%) constituted a much smaller portion of the faculty. Faculty salaries varied tremendously among institutions, especially for senior faculty. Doctoral student enrollment and total graduate enrollment were the top metrics used to evaluate many graduate programs, while student authored peer-reviewed publications, scientific presentations and awards were of secondary importance. Summary data on student remuneration and faculty salaries will be discussed.

Thursday, July 25, 2013 Desert Salon 1-2

Ornamentals/Landscape and Turf

Moderator: Erin E Agro, agroee@uoguelph.ca

9:45–10:00 AM

Pine Wood Chips as an Alternative to Perlite in Horticultural Substrates: Physical, Chemical, and Cultural Parameters

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The past decade has seen an increase in the potential uses of fresh wood in horticultural substrates. During this time numerous academic researchers, substrate (potting mix) manufacturers, and independent growers have tested various wood components and formulations in an attempt to stretch/extend peat or pine bark supplies in both the nursery and greenhouse industries. Loblolly pine has been proven to be the best tree species to make substrates or substrate components. When processed pine wood is amended in peat substrates it has been observed and noted that due to increased air space (porosity) it is likely that perlite is not needed in greenhouse substrates. Perlite serves as an aggregate in greenhouse substrates and, depending on the specific substrate, is incorporated at rates of 10% to 40% most commonly. Perlite, being expensive, nonrenewable and inorganic has led to interest in finding suitable replacements. Until recently no protocols or specifications have been used to process pine wood, which has resulted in inconsistent and varied end products (substrate components). Recent advances in wood processing procedures have resulted in pine wood chips (PWC) that are nonfibrous, structurally similar to perlite, consistently reproduced, cost effective, and broadly accessible. Freshly harvested pine trees were chipped and then further processed in a hammer mill through a 6.35 mm screen yielding PWC. Over a two-year period, PWC aggregates were processed and trialed in comparison to perlite at ratios of 10% to 30%. Experiments were conducted to test/compare: 1) substrate physical properties; 2) chemical properties; 3) fertility requirements; 4) liming requirements; and 5) plant growth regulator (PGR) efficacy/requirements. All laboratory and plant growth trials that were conducted indicate that substrates amended with 10%, 20%, or 30% PWC compared to perlite at the same percentages had no differing effect on substrate physical properties. Plant trials in substrates amended with 10%, 20%, or 30% PWC compared to perlite at the same percentages also showed no difference in lime, fertility, or PGR requirements for optimal plant growth.

During greenhouse trials (ranging from four to 15 weeks) PWC did not decompose, shrink, or even change color. These results provide evidence across a broad range of cultural parameters that PWC can successfully be used as a replacement to perlite with little to no changes to a grower's production system.

10:00–10:15 AM

Effect of Vermicompost-amended Media on Container-grown Miniature Roses

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An experiment was conducted to evaluate earthworm castings (vermicompost) as an amendment to a peat-based potting media for container-grown miniature roses. Bare-root roses of 'Crackling Fire', 'Feisty', or 'Hot Tamale' were planted in 3-gallon containers of potting media containing 0%, 5%, 10%, 20%, or 40% vermicompost and maintained in an outdoor nursery area during the growing seasons of 2009 and 2010. Height, width and quality ratings for flower quantity and quality, foliage quantity and quality and vigor were collected monthly from May through October. Chlorophyll content was measured using a SPAD meter. Volume was derived from height and width measurements. Each cultivar responded very differently to the vermicompost treatments. For 'Crackling Fire'—height and volume increased during the growing season; width increased during the season for all treatments, but the increase was less as the vermicompost content increased from 0 to 40%; flower quality ratings declined during the peak summer months, but improved during the fall; and chlorophyll content decreased as vermicompost increased from 0% to 40%. For 'Feisty'—height, width and volume for increased during the season for all media treatments and declined as vermicompost increased; flower quality ratings declined throughout the growing season; and chlorophyll content was greatest during the peak summer months for all treatments, but declined as vermicompost increased. Foliage quality and quantity was greatest in May for 0% followed by 40%, but whereas roses grown in 0% vermicompost declined through the season, roses grown in 40% vermicompost rebounded in the fall. Vigor followed a similar pattern with some fall improvement for both 0% and 40% treatments. For 'Hot Tamale'—height and volume increased through the season with growth decreasing from 0% to 40% vermicompost in May. However, by October, plants increased in height and volume as the vermicompost content increased. Plant width increased both from May through October and as the vermicompost content increased from 0% to 40%. Flower quantity and quality decreased linearly and chlorophyll content increased linearly through the season. Foliage quantity and quality and vigor slightly decreased from 0% to 40% vermicompost in May, but maintained quality well until late summer

An asterisk (*) following a name indicates the presenting author.

when quality declined through fall with the greatest decline at 0% compared to 40%.

Specified Source(s) of Funding: Mississippi Agricultural and Forestry Experiment Station

10:15–10:30 AM

Determination of Optimal Controlled Release Fertilizer Rates for Container Nursery Crop Production in Cold Climates

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Region specific trials examining optimum controlled release fertilizer (CRF) rates for the Canadian climate are limited. Most studies are conducted in temperate to warm regions of the United States and use a limited number of plant species and growing substrates. Accordingly, this study was conducted to evaluate the effect of CRF application rates on the release of nutrients and on the growth of 17 economically important container-grown ornamental shrubs, using three growing substrates and fertilizer types at three southern Ontario nurseries. Five different fertilizer rates, ranging from N at 0.60 kg·m⁻³ to 1.95 kg·m⁻³ for each fertilizer type, were incorporated during potting of plug-rooted liners between 29 June and 10 July 2012. Plant performance (i.e., shrub height and growth index) and leachate EC and pH were evaluated once every three to four weeks during the growing season. There were significant differences ($P < 0.05$) in shoot dry weight, leaf area, and the concentration of nitrogen (N), phosphorus (P), and potassium (K) in the shoots and root ball between the different fertilizer rates and substrate types. Of the 17 species observed in the trial, none performed best at the highest or second highest CRF rate (i.e., N at 1.95 kg·m⁻³ and 1.80 kg·m⁻³, respectively). *Buxus* ‘Green Velvet’ achieved optimum growth at the third highest CRF rate (i.e., N at 1.65 kg·m⁻³) and *Hydrangea macrophylla*, traditionally classified as a heavy feeder, performed best at a fertilizer rate with a low level of N at 0.75 kg·m⁻³. Both species were grown in a substrate containing no compost (i.e., 3 parts aged pine bark, 1 part Canadian sphagnum peat moss, and 16%–17% perlite). The remaining 15 trial species had optimum fertilizer rates at or below N at 1.35 kg·m⁻³. Given a growing substrate with 15% compost, there was no statistical difference in growth between different fertilizer rates for *Thuja plicata* ‘Whipcord’, *Euonymus fortunei* ‘Harlequin’, *Forsythia x intermedia* ‘Fiesta’, *Weigela florida* ‘Variegata’, *Cornus sericea* ‘Kelsey’, and *Cotoneaster dammeri* ‘Coral Beauty’. Significant differences ($P < 0.05$) in growth occurred between fertilizer rates for *Salix purpurea* ‘Nana’, *Cornus sericea* ‘Cardinal’, and *Hibiscus syriacus* ‘Ardens’ grown in a substrate containing 60% composted pine bark, 10% compost, and 30% peat moss. Nitrogen balances for all species were also calculated.

Specified Source(s) of Funding: Canadian Agriculture Adaptation Program, Agrium Advanced Technologies and Landscape Ontario Growers Group

10:30–10:45 AM

Impact of Biopots on Landscape Plant Performance and Pot Degradation

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Horticulture industry professionals and consumers are interested in biodegradable pots as alternatives to plastic pots given their perceived environmental sustainability. The impact of biopots on plant performance and pot degradability after being planted in landscapes has been investigated in Texas, Mississippi, Illinois, Kentucky, and West Virginia. This abstract reports the results from two growing seasons for Texas. In the first year, the impact of seven plantable biopots and one plastic pot on the performance of three ornamental species, Impatiens x ‘Sunpatiens Compact Magenta’, Cleome x ‘Senorita Rosalita’, Lantana x ‘Luscious Citrus’ and the degradation of these biopots at the end of the growing season was quantified. In the second year, the same pot types were used but the plant species were Lantana x ‘Luscious Citrus’, Buddleia ‘Nanho Blue’, and Artemisia ‘Silver Mound’. The seven biopots were Jiffy pot (peat moss), SoilWrap (biopolymer), Fertilpot (wood pulp), coir (coconut fiber), Cowpot (composted cow manure), NetPot (slotted pressed rice hulls), and straw pot (rice straw). As a comparison, 4-inch plastic pot was included. In the first year, cleome and impatiens did not perform well, which was not related to pot type. Lantana shoot dry weight was greater in Soilwrap, while no differences were observed among other pot types. In the second year, the effect of pot type on plant performance varied with species. In both

An asterisk (*) following a name indicates the presenting author.

years, plant species did not affect pot degradation, which varied with pot material and there were differences in pot degradations in the two growing seasons in some pots.

10:45–11:00 AM

The Effects of Lawn Plant Diversity on Arthropod Diversity

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The impact of lawn plant diversity on arthropod diversity was assessed in 40 residential lawns in Raleigh, NC. This experiment used a factorial design to examine the effects of both lawn plant diversity and vegetative diversity surrounding the yard (vegetative complexity). Arthropods were collected using pitfall and vacuum sampling methods, respectively, identified to the family level, and then assigned to functional groups (pests, beneficials, nonpest herbivores). Diversity, evenness and abundance of functional groups and selected insect families were compared across treatments. Abundances of ground-dwelling granivorous beetles and spiders were not influenced by lawn plant diversity or vegetative yard complexity; however, spider egg parasitoid abundance was greater in diverse lawns with simple yards and cricket abundance was greater in diverse lawns with complex yards. Diverse lawns with complex yards hosted more diverse communities of foliar beneficial insects and the highest diversity and abundance of pest and nonpest insect species. Abundances of selected beneficial families of parasitoid wasps (ichneumonids, mymarids, and scelionids) and selected pest families (membracids and phytophagous mirids) were higher in diverse lawns with complex yards. Increased plant species diversity in lawns influences arthropod species diversity and abundance, however, only when vegetative yard complexity surrounding the lawn is high. Findings of this study suggest that low-maintenance, organic, or conventional lawn management strategies will not inherently require more pest management and that lawn pest management may depend on the vegetative complexity of the yard.

Specified Source(s) of Funding: North Carolina State University, Department of Biology

Thursday, July 25, 2013 **Desert Salon 9-10**

Plant Biotechnology

Moderator: Ioannis Tzanetakis, itzaneta@uark.edu

10:30–10:45 AM

Development and Preliminary Evaluation of the IStraw90 Axiom® Array in Cultivated Strawberry (*Fragaria ananassa*)

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The RosBREED consortium has focused on developing high-throughput genome scans for apple, cherry, peach, and strawberry to facilitate quantitative trait locus (QTL) discovery and further develop the infrastructure for enabling and implementing marker-assisted breeding. This goal was met by the public release of three Illumina® Infinium® arrays for apple, peach, and cherry (8K, 9K, and 6K, respectively) that are being used by the worldwide scientific community. Development of a high-throughput genome-scanning array in strawberry has lagged behind mostly due to the challenges caused by its allo-octoploid genome. We describe the development of the International Strawberry 90K (IStraw90) Affymetrix Axiom® genotyping array. Approaches to address the allo-octoploidy challenges included a large number of SNPs (> 90,000) to compensate for potential low conversion of candidate to functional SNPs, and bioinformatic extraction of regions of reduced ploidy. This reduction of effective ploidy levels was the direct result of targeting subgenome-specific sites. We also report results of the preliminary evaluation of this array in 384 strawberry samples consisting of mapping populations, breeding populations and their founders, in addition to few diverse strawberry individuals. We expect this array to enable genome-wide scanning in the octoploid strawberry and to facilitate QTL discovery for many traits of economic significance in this important fruit crop.

10:45–11:00 AM

Transcriptome Analysis of *Vernicia fordii* Seed in Three Development Stages

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To investigate the profile of gene expression in *Vernicia fordii* and elucidate its functional gene, Illumina HISEQ 2000 sequencer was used to produce a substantial expressed sequence tags dataset from the seed of 'Pu tao tong' in three development stages, fruit-inflating stage (sample 1, 60 days after flowering), lipid synthesis early stage (sample 2, 120 days after flowering), and lipid synthesis peak stage (sample 3, 150 days after flowering). Totals of 61,001 unigenes, 54,679 unigenes, and 44,495 unigenes were obtained from 3 samples, respectively. A total of 58,439 unigenes with average length of 889nt and 41,059 unigenes with protein function annotations were generated. The Nr annotation of tung tree unigenes showed that the biggest number (64.04%) among all unigenes could find homologous genes of *Ricinus communis*, followed by *Populus trichocarpa* (17.4%), *Vitis vinifera* (8.98%), *Glycine max* (1.81%), *Jatropha curcas* (1.08%), and others (6.69%). All unigenes can be classified into 25 functional-categories, of which 4,865 unigenes were related to the general function prediction only, and then 2,403 unigenes were related to transcription, 639 unigenes were related to lipid transport and metabolism. All unigenes were queried against the KEGG pathway database, and 22,134 unigenes were given the pathway annotations and related to 128 pathways, including metabolism, biosynthesis of secondary metabolites, fatty acid biosynthesis, biosynthesis of unsaturated fatty acids and so on. Analysis of different expression genes showed that the up-regulation and down-regulation genes have significant difference in 3 development stages of *Vernicia fordii* seed. Between Sample 1 and Sample 2, 9,057 up-regulated unigenes and 4,531 down-regulated unigenes were revealed. Between Sample 1 and Sample 3 there were 21,972 up-regulated unigenes and 2,938 down-regulated unigenes, and 1,468 up-regulated unigenes and 14,069 down-regulated unigenes between Sample 2 and Sample 3. Data presented in the study will constitute an important resource for the data mining of important genes and the research of regulation and expression mechanism. This study also provides scientific evidence for breeding of *Vernicia fordii*.

Specified Source(s) of Funding: This work was supported by the

An asterisk (*) following a name indicates the presenting author.

projects of state forestry research and public service industry (200904023), Hunan Provincial Natural Science Foundation of China (10JJ4022), Scientific Research Foundation of Central South University of Forestry & Technology

11:00–11:15 AM

An Automatic Bioinformatics Tool to Detect and Discover Plant Viruses

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The speed of plant virus discovery has been further accelerated by the emergence of high throughput sequencing techniques. As the large volume of pyrosequencing and de novo synthesis sequence data has made processing a burden for scientists, we have designed bioinformatics pipelines to analyze the data automatically. Different samples were extracted, reverse-transcribed and PCR-amplified with up to 48 barcodes (expandable) before sequencing. The pipelines, written in Perl and Shell scripts and making use of NCBI Blast tools, Fastx-Toolkit and an ORF finder, were able to identify barcodes, sort the data to original samples, clip adapters, filter sequence quality, collapse identical sequences, detect known virus/viroid, and remove plant sequences using Blastn and subsequently Blastx. Sequences without similarity to known organisms were subject to a Python script to identify potential ORFs. The pipelines were tested successfully and independently by users with beginner bioinformatics knowledge to detect viruses from virus-infected samples extracted by total/double-stranded/small RNA extraction methods.

11:15–11:30 AM

Rapid High-level Transient Expression of Vampire Bat Plasminogen Activator (DSPA α 1) in Plant for Stroke Treatment with a DNA Replicon System

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A stroke is a medical emergency that can cause brain damage within minutes. Plasminogen activators (DSPAs), enzymes from the saliva of blood-feeding vampire bats, have been found to act only on fibrin without excess brain bleeding. Currently, recombinant DSPA α 1 are produced in transformed yeast, animal, and insect cells. However, the yields of recombinant

DSPA α 1 are relatively low. We developed suitable rapid and robust geminivirus-based expression transformation vectors for the full length and mature length of DSPA α 1 gene respectively. Fibrin plate tests showed that both the full length and mature length of DSPA α 1 can degrade fibrin. In vitro blood clot lysis tests indicate that the mature DSPA α 1 can break down the blood clots. Our research indicates that the replicon system represents an important method to produce active, safe, and inexpensive DSPA1 for stroke patients.

Specified Source(s) of Funding: NIH/INBRE:8P20GM103447

Thursday, July 25, 2013 **Springs Salon D/E**

Weed Control and Pest Management

Moderator: Harlene Hatterman-Valenti,

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10:15–10:30 AM

Evaluation of Herbicide Damage to Grapes in a Unique Growing Season

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The 2012 growing season presented a rare combination of extremes, a record mild winter followed by the earliest date for spring bud break on record. Bud break of three to four weeks before normal averages recorded for numerous locations in Nebraska contributed to serious problems related to early bud break. In a few parts of the state, a cold temperature event caused damage to shoots that had broken bud, but the most serious problem for many vineyard locations was damage to shoots from herbicide drift of volatile herbicides. In most cases, this damage was attributed to 2,4-D. This was the case for one of our research vineyard locations and led to our evaluating relative damage among a range of 5-year-old grape cultivars and genotypes. Shoots were rated for foliar damage and stunting of shoots, and following a second herbicide drift occurrence ratings for damage to flower clusters and fruit set were also recorded. Significant differences were found for different cultivars and genotypes. The most severe damage was sustained by 'Sabre-vois', 'Marquette', and MN 1235. The least injury was noted for 'Chambourcin', 'Seyval Blanc', 'Vidal Blanc', and MN 1258, with 'Frontenac', MN 1220, 'Valiant' and 'Saint Croix' intermediate in their symptoms. In most cases, yield reductions were consistent with the damage ratings, i.e., the most yield depression was experienced by the genotypes that had the most severe damage ratings and the genotypes with the least damage rating produced a nearly full crop.

Specified Source(s) of Funding: University of Nebraska

An asterisk (*) following a name indicates the presenting author.

Agricultural Research Division, State of Nebraska Grape and Wine Board

10:30–10:45 AM

Composting as an Alternative Management System for Wild Taro (*Colocasia esculenta*) and Brown Algae (*Sargassum fluitans* and *Sargassum natans*)

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The purpose of this study was to investigate the large-scale compost management of 3 aquatic species that pose threats to local ecosystems in Texas: *Colocasia esculenta* (wild taro), *Sargassum fluitans*, and *Sargassum natans* (brown algae, collectively). To conduct this study, species were collected from Spring Lake in San Marcos, TX, and along the Gulf of Mexico shoreline in Corpus Christi, TX. Three cubic yards of each species were incorporated as feedstocks into various large-scale compost piles and tested for plant viability and compost composition. Results indicated that each species can be utilized as an effective feedstock source in future composting operations in Central Texas. This study also supports compost management systems as an effective alternative system of invasive species management by rendering propagules of these species unviable, while creating a marketable byproduct for use in agriculture, horticulture, and related markets.

10:45–11:00 AM

Early-season Weed Control in Direct-seeded Onion

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Field research was conducted at the Oakes Irrigation research center near Oakes, ND, on ‘Sedona’ onion. Micro-rate applications of bromoxynil and/or oxyfluorfen were compared to preemergence treatments using ethofumesate at 1.1 or 2.2 kg/ha or DCPA at 14.9 kg/ha for early season broadleaf control. Clethodim plus a petroleum oil surfactant, was added to each micro-rate application for grass control. Onion seed was planted May 14 and harvested October 3. Herbicide applications were made May 22 (PRE-A), June 4 (flag leaf-B), June 12 (1.5 leaf-C), June 21 (2 leaf-D), June 27, (3 leaf-E), and July 2 (4 leaf-F) using a CO₂ pressurized sprayer equipped with 80° flat fan nozzles with a spray volume of 20 GPA and pressure of 40 psi. Treatments that included micro-rate bromoxynil during

at least one of the application timings provided better common lambsquarters control throughout the trial compared to treatments without bromoxynil. In contrast, treatments with the micro-rate oxyfluorfen applied alone had poor common lambsquarters control. However, applying bromoxynil at the 70 g/ha followed by tank mixes of bromoxynil and oxyfluorfen at 70 g/ha provided the best common lambsquarters control compared to all other treatments. Applying bromoxynil at the 35 g/ha followed by tank mixes of bromoxynil and oxyfluorfen at 70 g/ha had significantly less control of common lambsquarters. The highest yielding treatment was when bromoxynil was applied at 70 g/ha followed by tank mixes of bromoxynil and oxyfluorfen at 70 g/ha with 82.3 T/ha. The lowest yielding treatment besides the untreated, which didn’t produce any marketable bulbs, was when bromoxynil was applied at 35 g/ha followed by tank mixes of bromoxynil and oxyfluorfen at 70 g/ha with 26.8 T/ha. The preemergence conventional treatment of ethofumesate at 1.1 kg/ha had the second highest yield of 70.6 T/ha.

11:00–11:15 AM

Successful Control of the Erythrina Gall Wasp in Hawaii

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The invasion of the Erythrina Gall Wasp (EGW), *Quadrastichus erythrinae* (Kim) in 2004 threatened the existence of *E. sandwicensis* in Hawaii. A promising biological control agent was collected in Tanzania and underwent rigorous risk assessment at the Hawaii Department of Agriculture insect containment facility. In November 2008, *Eurytoma erythrinae* (Gates & Delvare) was approved to be released into the environment to control EGW. Pre- and post-release evaluations were initiated to evaluate the impacts of the biological control agent on the gall wasp and the Erythrina trees. Regular sampling and gall dissections showed that the wasp became established within 6 months of its release. Results from post-release monitoring indicate that *E. erythrinae* is successfully controlling gall wasp populations in foliage at most sites, whereas infestation levels in inflorescences remain still high at some sites. Surviving wiliwili trees are recovering from gall wasp damage. Post-release monitoring continues in order to determine the impact that *E. erythrinae* will have on the species’ long-term viability.

An asterisk (*) following a name indicates the presenting author.

Thursday, July 25 2013

11:15–11:30 AM

**Research on the Quarantine Pathogen
Phytophthora ramorum at the National
Ornamentals Research Site at Dominican
University of California (NORS-DUC)**

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Phytophthora ramorum, the causal agent of Sudden Oak Death and *Ramorum* blight, can infest several dozen host plants, among them many important ornamental plants like Rhododendron, Viburnum and Camellia. Federal and state regulations require the destruction of nursery plants infected by *P. ramorum* and treatment of contaminated soil. Infected nursery material is also a possible factor in the long-range spread of *P. ramorum*. The National Ornamentals Research Site at Dominican University of California (NORS-DUC) was founded in the year 2009 by a Farm Bill grant to study *P. ramorum* in a sophisticated research nursery that reflects an authentic commercial nursery setting (www.dominican.edu/norsduc). NORS-DUC goals are to develop practical solutions for containment, remediation, and eradication of quarantine pathogens in nurseries, reducing the risk of long-range spread of pests through infested nursery stock shipments. Research at NORS-DUC is conducted by a team of permanent staff as well as by *P. ramorum* experts from other institutions who can apply for grants to work at NORS-DUC. The research site offers a unique opportunity to study different aspects of *P. ramorum* diseases of ornamentals that has not been accomplished previously. First results from research on the eradication of *P. ramorum* from soils using steam sterilization, solarization and bio-control using a new Trichoderma isolate indicate they were effective; and these methods are being reviewed by USDA APHIS as approved for soil treatments in infected commercial nurseries. Ongoing research is focusing on

the disease epidemiology in nurseries, the genetic plasticity of *P. ramorum* on different host plants and the effects of fungicides and physiological stress on symptom development.

Thursday, July 25, 2013

Desert Salon 4-6

Water Utilization and Management

Moderator: Oleg Daugovish, odaugovish@ucdavis.edu

10:15–10:30 AM

Differential Susceptibility of Strawberry to Salts

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Strawberry is a primary crop in five counties in coastal California, with an annual value of \$1.4 billion. Strawberry is sensitive to injury from salts, abundance of which is measured with soil electrical conductivity (EC). Even though current EC threshold for yield reduction is 1 dS/m, several strawberry fields have excellent production in soils with EC 4–6 dS/m. Thus, we investigated the specific salt and ion effect on strawberry in summer and fall-planted bare-root strawberry in typical 1.2 m-wide raised beds covered with plastic mulch in clay loam soil near Santa Paula, CA. Four plants were watered by hand nine times during initial 3-week establishment period with 250 mL/plant of one of the four salt solutions (each salt at EC 5, 10, 15, or 20 dS/m) or with distilled water. At EC 5 dS/m potassium sulfate or sodium sulfate did not significantly reduce plant size or fruit production in summer or fall strawberry, while plants irrigated with sodium chloride or calcium chloride were 65% or 85% smaller than distilled water irrigated plants. At greater EC values plant size declined 50% to 80% for the sulfates and no live plants were observed in plots irrigated with chlorides at EC >5 dS/m. A similar trend was observed for fruit production. The negative effects of all salts were more pronounced in summer, likely due to higher evapotranspiration rates, lack of rain and greater susceptibility of proprietary variety to salt damage compared to fall-planted 'Benicia'. The study identified specific salt and ion effects on strawberry and emphasized the need for testing of the irrigation water for those ions instead of relying solely on EC measurements for production management decisions.

An asterisk (*) following a name indicates the presenting author.

10:30–10:45 AM

Physiological Responses of Citrus to Partial Rootzone Drying Irrigation Strategies

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The effect of partial rootzone drying (PRD) on growth and physiological responses of 2-year-old grapefruit trees was studied in two experiments under greenhouse conditions. First, we studied the effect of different irrigation volumes, including irrigation above and below tree evapotranspiration (ETc) requirements, in order to determine how trees respond to excess of irrigation or to PRD + deficit irrigation (DI) strategies. Four treatments were applied for 12 weeks: 1) control (100% ETc was applied, 50% on each pot); 2) PRD 100–0 (100% ETc on one side, no water on the other side); 3) PRD 200–0 (200% ETc on one side, no water on the other side); and 4) PRD+DI 50–0 (50% ETc on one side, no water on the other side). All trees had their root system split in two halves and established in adjacent pots. Soil water content, tree water status, stomatal conductance, leaf ABA concentration, chlorophyll fluorescence and tree growth were measured. PRD 200-0 trees used 70% more water than control trees whereas PRD 100-0 and PRD+DI 50-0 trees decreased water use by 18% and 79% compared to control trees, respectively. PRD 100-0 or PRD 200-0 did not affect tree growth or any physiological parameter compared to control trees. Although tree growth was not affected by PRD+DI 50-0, leaf ABA concentrations and stomatal closure increased after 10 weeks of the experiment. In the second experiment, we studied the effect of alternate irrigation between each side of the tree root system. Three treatments were applied for 10 weeks: 1) control (100% ETc, 50% on each pot); 2) alternate PRD1 100–0 (alternating irrigated/dry rootzones every month); and 3) alternate PRD2 100–0 (alternating irrigated/dry rootzones every two months). Tree establishment, growth conditions, and all parameters measured were the same as the first experiment. Trees under alternate PRD used 5% to 8% less water than control trees without decreasing growth or showing any changes in physiological parameters. Nevertheless, the timing of the alternation did not cause any differences in tree water use.

Specified Source(s) of Funding: Texas A&M University-Kingsville

10:45–11:00 AM

Irrigation and Nitrogen Management Web-based Software for Lettuce Production

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Lettuce growers on the central coast of California are under increased regulatory pressure to reduce nitrate loading to ground and surface water supplies. Two tools available to farmers to improve nitrogen use efficiency of lettuce are the soil nitrate quick test (SNQT) for monitoring soil mineral nitrogen levels and weather-based irrigation scheduling for estimating water needs of the crop. We developed a web-based software application, called CropManage (<https://ucanr.edu/cropmanage>), to facilitate the implementation of both of these tools. Users can access the software through a web browser on their smart phones, tablet, and desktop computers. The software allows growers to quickly determine an optimal fertilizer N rate based on the SNQT and N uptake curves for lettuce. In addition, the software estimates the water requirement of the crop using evapotranspiration data from the California Irrigation Management Information System and models of canopy development. Preliminary field testing of the software in commercial fields demonstrated that growers can significantly reduce N fertilizer and water use without reducing quality and yield of lettuce. A demonstration trial comparing the CropManage fertilizer N recommendation with the grower standard practice resulted in similar commercial yields using almost 30% less N fertilizer. The other trial comparing the irrigation recommendation of CropManage with the grower standard practice resulted in a 25% savings in water following the CropManage irrigation schedule during the drip phase of the crop, and equal commercial yields between treatments.

Specified Source(s) of Funding: CDFA Fertilizer Research and Education Program

11:00–11:15 AM

The Effects of Crop Load and Water Stress on Yield and Fruit Quality of Sweet Cherry Cultivars

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Snow pack water supply in western North America is increasingly unreliable but improvements in drought forecasting could allow management using planned water deficits. Crop reduction is also a potential tool to manage the effects of water stress for sweet cherry cultivars. The effects of water supply and crop load management were assessed in two experiments. Experiment 1—‘Skeena’ and ‘Cristalina’ on Gisela 6 received 100% ET replacement atmometer-scheduled drip irrigation either 4 times/day or every second day in 2009–11. In 2011, crop load was either 100% or blossom cluster-thinned to 50%. Experiment 2—‘Lapins’ on Gisela 5 received daily, atmometer-scheduled, small-radius micro-sprinkler irrigation: 1) 100% ET replacement; 2) 100% ET replacement reduced to 57% ET replacement from 21 days preharvest; and 3) 100% ET replacement reduced to 57% ET replacement postharvest. In 2011, crop load was either 100% or blossom cluster-thinned to 50%. In 2012, crop load [fruit/cm² trunk cross-sectional area (TCSA)] effects were assessed using tree natural variability. High frequency irrigation increased yield in ‘Skeena’ and ‘Cristalina’ in 2010–11 and fruit size in 2010. Cluster-thinning in 2011 did not significantly affect yield, fruit size, or fruit quality for either cultivar. Preharvest water deficits applied to ‘Lapins’ on Gisela 5 were mitigated by cool weather in 2011 and wet weather in 2012. Midday stem potential of –1.5 to –1.6 MPa in preharvest deficit trees had no effect on yield or fruit quality in either year. Midday stem water potential reached –2MPa by the end of the season in deficit trees. Cluster-thinning in Spring 2011 reduced yield but did not affect fruit size or fruit quality. Cluster-thinning and preharvest water deficits in 2011 reduced crop load and increased fruit size in 2012. In 2011 and 2012, crop load in all trees was compared to fruit quality. In both years there were strong inverse relationships between crop load and fruit size ($R^2 = 0.85$ and 0.78) for unstressed trees, respectively. Soluble solids content, titratable acidity and stem pull force were also reduced as crop load increased. In 2012, preharvest deficits, resulted in significantly smaller fruit when adjusted for crop load as a covariate. Crop loads of 12 fruit/cm² TCSA and 22 fruit/cm² TCSA in unstressed trees and 10 fruit/cm² TCSA and 18 fruit/cm² TCSA in stressed trees resulted in average fruit sizes of 12 g and 10 g, respectively, indicating that crop load adjustment and planned deficits could be useful tools for coping with drought.

Specified Source(s) of Funding: Agriculture and Agri-Food Canada and Okanagan Kootenay Cherry Fruit Growers Association

11:15–11:30 AM

Performance of Landscape Trees in the Semi-Arid Southwest under Three Irrigation Regimes

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Nine species of landscape trees commonly planted in the semi-arid Southwest were irrigated with three different regimes to determine their growth response and aesthetic functionality. Irrigation treatments started in May 2010 and were based on applying 80% (wet), 60% (medium), and 40% (dry) of reference evapotranspiration (ET_o) from May to October and half of that (40%, 30%, and 20% of ET_o) from November through April. Soil moisture data was collected by time domain reflectometry from three species irrigated with the medium treatment. Soil moisture data were used to calculate crop coefficients (K_c) which ranged from 0.2 to 0.4 for *Prosopis* hybrid (palo verde hybrid), 0.3 and 0.6 for *Cupressus arizonica* (Arizona cypress), and 0.3 to 0.7 for *Fraxinus velutina* ‘Rio Grande’ (Rio Grande ash). The three irrigation treatments resulted in different irrigation frequencies. Plants in the wet treatment received about twice the number of irrigations compared to plants in the dry treatment. In summer, irrigation was applied every five, six and seven days, and in winter the longest interval between irrigations was 77, 94, and 136 days for the wet, medium, and dry treatment, respectively. Fast growing species in descending order were palo verde hybrid, *Prosopis velutina* (mesquite), *Chilopsis linearis* (desert willow), and Pistachio x ‘Red Push’ (pistache) based on their growth index. Trunk area was largest for palo verde hybrid trees, followed by pistache, mesquite, desert willow, and *Pinus elderica* (Afghan pine). Smallest trees based on growth index and trunk area were *Quercus virginiana* (live oak) and Rio Grande ash. Although all species increased in height, growth index, and trunk surface area, no significant differences in growth of the same species receiving the different irrigation treatments were recorded by October 2012 with the exception of growth index for live oak. Symptoms of deficit irrigation started to develop on some species in spring and progress through the summer as marginal leaf burn, foliage dieback, terminal branch dieback, or loss of interior foliage. Overall quality of some trees such as Arizona cypress, Afghan pine, and Rio Grande ash started to decline due to reduced foliage cover. After 30 months of treatments trees of similar size can be grown with half the amount of water that is applied to a tree of the same species in the wet irrigation treatment without detrimental consequences for several species.

An asterisk (*) following a name indicates the presenting author.

11:30–11:45 AM

Evaluation of a Vegetative Landform Cap to Reduce Water Percolation

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Industrial wastes can pose significant environmental, health, and ecological concerns. A study was conducted at a Solid Waste Surface Impoundment (SWSI) in Baton Rouge, LA, to assess conventional and alternative landfill caps and their effects on water percolation. The objectives of this study were to evaluate the establishment of common bermudagrass (*Cynodon dactylon* L.) soil caps, and evaluate chemical and physical properties of clay and topsoil and their ability to restrict water movement through soil profiles. Sixteen treatments of clay, topsoil, and/or combinations of the two soils at various capping depths up to 90 cm (36 inches) in depth were constructed in 15-cm (6-inch) clay lifts over the entire test area with the exception of control plots of exposed filter cake and topsoil-only capping treatments. All capping treatments were seeded with common bermudagrass. Data was subjected to analysis of variance and means were separated using Tukey's Studentized Range Test at a significance level of 0.05. Impounded waste had a high salt content, and excessive levels of calcium, magnesium, and chloride were detected. As clay and topsoil depths increased bermudagrass coverage increased, and water percolation to the impounded waste was reduced. Soil caps comprised of 61 cm (24 inches) of clay, and ≥ 31 cm (12 inches) of clay with topsoil maintained a greater barrier that limited capillary rise of salts and had $\geq 90\%$ bermudagrass coverage. Soil caps composed of 61 cm (24 inches) of clay with or without topsoil, and 31 cm (12 inches) of topsoil over 31 cm (12 inches) of clay had a cumulative total of ≤ 2.40 mL of water percolate to the impounded waste over 16 months. Based on 16 months of monitoring, cap composed of 15 cm (6 inches) of topsoil over 61 cm (24 inches) of compacted clay maintained soil stabilization, increased evapotranspiration, minimized water percolation, and contained impounded wastes.

11:45 AM–12:00 PM

Sustainable Water Management Strategies for California Table Grapes

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Water scarcity, impaired water quality, decreased soil quality, and aberrant weather are listed among the top risks to grape production in the western United States (Thrupp et al., 2008). Grapes are the highest value fruit crop produced in the United States, and all grape products combine to generate an estimated \$162 billion impact on the American economy each year. Perhaps the most important issue associated with global warming for California is related to water availability (Weare, 2009). California's warmer winters and springs have led to reduced snow-pack, increasing the seasonality of water flows and directly affecting the ability to grow plants, produce food, and support growing populations (Allen-Diaz, 2009). This report describes results from two years of deficit irrigation of table grapes grown in the San Joaquin and Coachella Valleys. The objective was to determine the effects and limits of deficit irrigation strategies on vine development, yield, and grape quality for table grape production. Starting in 2011, two 0.9 ha plots in California were selected, one in Delano in a 'Crimson Seedless' late maturing table grape and, the other one in an early season table grape, 'Sugraone' in Mecca. Rows (west–east oriented) contain 32 vines spaced 2.1 m apart within the row and 3.6 m between rows. The plots contained 3 rows with the middle row being the data row. The vines are drip irrigated with one lateral on each vine row with three emitters per vine each discharging 3.8 L/hour. Three irrigation treatments were used: T1 as the normal grower practice (GP) and two deficit irrigated treatments, T2 and T3, as a percentage reduction of GP during specific growth stages. In 2011, no differences between treatments in terms of yield were achieved in any location even with reductions of applied water of 5% and 10% for T2 and T3, respectively, for both varieties. During 2012, the 'Sugraone' harvest data demonstrated largest yields for T2 and no effect in 'Crimson Seedless' even with reductions near to 22% less water in the entire season. In terms of fruit quality, positive effects were found for deficit treatments, achieving highest values for soluble solids in 'Sugraone' T2, both years, and 'Crimson Seedless' T3 in 2011. Improvements in color development were also significant in this late season table grape both years, parameter extremely important in this variety.

Thursday, July 25, 2013

Desert Salon 1-2

Nursery Crops

Moderator: Alison Stoven O'Connor,
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11:15–11:30 AM

Landscape Transplant Success of Chanticleer® Pear Grown in Three Container Types

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Thursday, July 25 2013

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The most commonly used container type for nursery tree production is the black plastic (BP) container. The longer trees remain growing in BP, the greater the potential for the development of circling and malformed roots. Root injury sustained during production may negatively affect tree health when planted in the landscape. Research at Colorado State University used *Pyrus calleryana* Decene. 'Glen's Form' (Chanticleer®) to compare tree production using two non-conventional, fabric container types, Root Pouch® (RP), and Smart Pot® (SP), with BP containers to determine the effects of container type on tree roots following transplant in the landscape. After growing in a nursery production setting, trees were planted into bluegrass turf in Fall 2010 and Spring 2012. Post-transplant success of trees was determined during the growing season using pre-dawn leaf water potential and infrared leaf canopy temperature to detect stress. Trees were harvested in Fall 2011 and 2012 using an air spade (after one and two growing seasons) to evaluate transplant establishment using growth measurements (e.g. root and shoot re-growth, leaf area, height, caliper, and branching). In 2011 and 2012, there were no significant container effects on height, caliper, root:shoot ratio, and dry leaf, shoot, and root weight. In addition, there were no container effects on pre-dawn leaf water potential and infrared canopy temperature. In 2012 there were significant container effects for average root re-growth beyond the original root ball: BP had 17.5% root re-growth compared to 30.2% and 29.4% for RP and SP, respectively. There were no significant differences for root re-growth in 2011 (8.4% BP, 10.6% RP, and 10.2% SP). Though there were no significant differences in 2012 for above-ground growth, nor dry root weight, root re-growth and visual root architecture differed among the three container types. One preliminary conclusion from this study is that you cannot predict below-ground establishment potential based on above-ground growth. Another conclusion is that using best management practices when planting is unlikely to correct problems caused by container type in the nursery.

Specified Source(s) of Funding: Colorado Nursery Research and Education Foundation, CSU Agricultural Experiment Station, CSU Department of Horticulture and Landscape Architecture

11:30–11:45 AM

Plant Growth and Water Use in Plastic, Fiber, Keratin, and Root Pouch Containers

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This one-factor completely randomized experiment was conducted in Michigan, Kentucky, Mississippi, and Texas, in order to test plant growth and water use in containers made from material other than virgin plastic. From July 2011 to June 2012, *Euonymus fortunei* 'Roemertwo' were planted in three types of #1 (~3.8 L) containers (treatments) and evaluated. Container treatments were: 1) polyethylene PF400-SM (control); 2) Western Pulp 7X7RD (WP); and 3) Kord 07.50 Fiber Pot (Kord). From June 2012 to May 2013, *Buxus* x 'Green Velvet' were evaluated in four types of #1 containers: 1) control; 2) WP; 3) root pouch 15–20 month (RP) 4) keratin pot (KP). Substrate volumetric moisture content (SVMC) was determined by EC-5 moisture sensors in 2011, GS3 and EC-5 sensors in 2012 (Decagon Devices, Inc., Pullman, WA). Plant daily water use (DWU) was calculated as SVMC 5 minutes after irrigation

An asterisk (*) following a name indicates the presenting author.

minus SVMC immediately before the following irrigation period multiplied by container volume. Plants were irrigated to replace 100% DWU. For *E. fortunei*, in all states, plant growth and biomass were not different between treatments. A higher mortality rate in plastic than Kord and WP container was observed at the end of 2011 growing season. The DWU for WP and Kord varied by states in both years. The root zone temperature of KP was similar to control, and for WP and RP was 9% and 15% lower than control in Michigan, container temperature in other states varied. Mortality of *Buxus* was 0% for all states by October 2012; mortality will be evaluated in May 2013.

11:45 AM–12:00 PM

Photosynthetic and Morphological Response of *Abies fraseri* (Pursh) Poir to the Combined Effect of Irrigation and Fertilization in Controlled Environment

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Three-year-old (plug+2) Fraser fir [*Abies fraseri* (Pursh) Poir.] seedlings were grown under three irrigation (375, 750 and 1500 mL/week) and fertilization levels (2.5, 5.0, 10 g N/L) in the greenhouse, with the goal of determining the interactive growth and physiological response to irrigation and fertilizer application rates. Physiological variables measured included chl concentrations (Chl a, b, total chl and carotenes), gas exchange parameters [photosynthesis (A), stomatal conductance (Gs), transpiration rate (TR), water use efficiency (WUE), and stem water potential (Ψ S)]. Growth variables included height growth (HG) and root collar diameter (RCD). Irrigation had the largest impact on HG and RCD. Water stress had a significant impact ($P < 0.05$) on gas exchange parameters for all three-measurement dates. The interaction of irrigation and fertilization on photosynthesis was statistically significant on the September 18 measurement and not significant for the other two measurement dates (August 5, and August 28). Gs and WUE showed similar seasonal trend throughout the measurement period. Even though irrigation had a positive effect on A, Gs, WUE, and TR, fertilization had a negative correlation with those variables. As expected midday stem water potential (Ψ md) values were generally lower than the predawn (Ψ pd) values. Photosynthetic pigments (Chl a, chl b, total chl, and carotenes) generally increased throughout the treatment periods. However, the interaction of irrigation and fertilization on photosynthetic pigments was not significant ($P > 0.05$). Our results suggest that the plant's water condition is critical to physiological processes measured in the study.

12:00–12:15 PM

Determining the Carbon Footprint of Tree Production System Components in Field Nurseries using Life Cycle Assessment (LCA)

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Life cycle assessment (LCA) applies international standards in determining the carbon footprint of products and processes. LCA was used to determine the carbon footprint of production system components of field-grown, 5-cm-caliper trees in the midwestern United States. The production systems of a representative genus of deciduous shade trees and evergreen trees have been analyzed for their impact on the balance of atmospheric greenhouse gases (GHG) during production and during the trees' useful life in the landscape. Input products and the use of machinery during the life cycle of tree production result in GHG emissions and constitute a global warming potential (GWP), or carbon footprint (CF). The dominant contributor to the CF during production of all trees studied to date was equipment use and the majority of that occurred at harvest. As an example, the CF of *Picea pungens* (Colorado blue spruce) from seed to landscape was calculated to be 13.558 kg carbon dioxide equivalents (CO_2e). During a 50-year life in a favorable landscape site, the weighted positive impact of carbon sequestered by this tree was estimated to be -593 kg CO_2 . After considering the emissions resulting from tree take down and disposal at the end of its life, the net positive impact on GWP of this evergreen tree would be about $-431 \text{ kg CO}_2\text{e}$.

Thursday, July 25, 2013

Desert Salon 9-10

Environmental Stress Physiology

Moderator: Craig Ramsey, craig.l.ramsey@aphis.usda.gov

12:30–12:45 PM

Do Canker Pathogens Limit the Supply of CO_2 for Photosynthesis? Estimation of Stomatal and Internal Limitations in Maple Leaves in Response to *Phytophthora cactorum* Inoculations

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Phytophthora diseases are a major limiting factor to crop, forest, and amenity plant growth worldwide. Canker pathogens can affect net CO_2 assimilation (An) through phloem and xylem infections. While prior studies have shown that *Phytophthora*

canker infections limit An, reports regarding the underlying mechanisms are variable. One possible pathway is through lowering CO₂ supply by reduced stomatal (gs) and mesophyll conductance (gm). Our objective of this study was to quantify CO₂ supply limitations in response to *P. cactorum* inoculations in red maple (*Acer rubrum*). We hypothesized that the inoculated plants will reduce both gs and gm, compared with the non-inoculated controls. We tested this hypothesis using the two methods to determine gs and gm: 1) a method combining leaf gas exchange, chlorophyll fluorescence, and the biochemical model of photosynthesis; and 2) a method utilizing the photosynthesis model with leaf gas-exchange measurements made at the two O₂ concentrations (2% and 21%). Our results show that gs and gm in the maple leaves decreased due to *P. cactorum* inoculations, leading to the limitation of CO₂ supply to the site of carboxylation. The two different gm estimation methods produced comparable gm values and similar response patterns.

Specified Source(s) of Funding: The F.A. Bartlett Tree Expert Company

12:45–1:00 PM

Biochar Amendment Alters the Effects of Phytophthora Cankers on Leaf Physiology of *Acer rubrum*

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Previously we have shown that biochar amendment in potting mix significantly reduced the size of necrotic lesions caused by *Phytophthora* spp. on *Acer rubrum* and *Quercus rubra* seedlings. In addition, we have shown that biochar amendment mitigated the negative impacts of inoculation on biomass in *A. rubrum* and on plant water status in *Q. rubra*. In this study, we present the findings of a subsequent two-year experiment conducted with *Acer rubrum* with an emphasis on leaf physiological responses. Specifically, we examined maximum CO₂ assimilation rates (A_{max}), maximum photochemical efficiency of PSII (F_v/F_m), stem water potential, leaf phenolic content, leaf starch content, and leaf chlorophyll content (SPAD measures) in order to gain an understanding of the underlying physiological mechanisms associated with the increased pathogen resistance conferred by biochar amendment. When data from both years were combined, multiple measures indicated that leaf physiological performance was improved in inoculated plants that had been amended with 5% biochar compared to the inoculated plants with no biochar amendment. Biochar amended plants showed reduced canker expansion, higher A_{max}, higher stomatal conductance to water vapor, higher F_v/F_m, and higher chlorophyll content over the course of the experiments. These differences were significant in some weeks ($P < 0.05$), and the trend was consistent throughout the experiments. Foliar starch content, stem water potential,

and systemic phenolic content data were inconclusive. While the exact physiological mechanisms remain unclear, it is likely that the lower CO₂ assimilation rates observed in inoculated plants were due to a reduced stomatal conductance resulting from a pathogen derived signal and/or hormonal response to wounding, leading to limitations in the supply of CO₂ at the site of carboxylation, rather than a reduced demand for CO₂ resulting from feedback inhibition. Reduction of stem lesions observed in biochar treatment compared with the inoculated control is likely a result of systemic resistance associated with higher photosynthetic productivity. Further studies will be needed in order to determine the exact mechanisms underlying the induced resistance against lesion development in biochar amended seedlings.

Specified Source(s) of Funding: The F.A. Bartlett Tree Expert Company

1:00–1:15 PM

The Effects of Chlorine Dioxide on SAR Plant Immunity Responses to a Bacterial Wilt Infection

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The objective of this study was to determine the plant immunity effects of two oxidant disinfectants on kidney bean seedlings that were inoculated with a bacterial wilt [*Curtobacterium flaccumfaciens* pv. *flaccumfaciens* (Cff) (bacterial wilt of common bean)]. Research has shown that chemical signals can increase the Systemic Acquired Resistance (SAR) plant response to plant pathogens and insect herbivory. Oxidants such as chlorine dioxide and hydrogen peroxide may act as signals to increase SAR activities that help defend plants from biotic stressors. The study factors for the kidney bean growth and morphology responses were: 1) oxidants applied either four days before plants were inoculated with the wilt, or four days after plants were inoculated; 2) non-inoculated plants and plants inoculated with Cff; and 3) four oxidant treatments. The four oxidant disinfectant treatments were ClO₂ at 200 ppm (Electrobiocide) and H₂O₂ at 100 ppm (Oxidate) with each oxidant mixed with two different surfactants (EA and Sarc.). The kidney bean plant growth and morphology responses were total leaf area, specific leaf area, total fresh weight, total oven dry weight, and relative growth rate, as averaged across the six plants. The plants were harvested at 48 to 51 days after planting to take the growth and leaf morphology data. Each of the study factors (chemical

An asterisk (*) following a name indicates the presenting author.

treatment, inoculation date, and inoculation status) interacted with each other (two, 2-way interactions) in three out of the six main plant growth responses. The total above-ground dry biomass response increased by 35% and 24% for the non-inoculated and inoculated plants, respectively, when the plants were sprayed with EB plus sarcosinate surfactant, at nine days after planting. The study results show that oxidant disinfectants sprayed before the plants were inoculated had increased plant growth. Also, the oxidant disinfectants show some promise for signaling/stimulating natural plant defenses against foliar injury from the bacterial wilt. Future studies should focus on the most effective treatments and increase the number of plant replications in order to reduce variation between treatments.

1:15–1:30 PM

A Soybean β -Expansin Gene GmEXPB2 Involved in Root System Architecture Responses to Abiotic Stresses in Transgenic *Arabidopsis*

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Root system architecture determines the relative distribution of plant roots in different soil layers and may respond plastically to different abiotic stresses including phosphorus (P) deficiency, iron (Fe) deficiency, salt stress, and water deficiency, but its response mechanism is still unclear. Previously, we cloned and characterized a vegetable soybean β -expansin gene, GmEXPB2, from a Pi starvation-induced soybean cDNA library. This gene was mainly expressed in roots, and was highly induced by Pi deficiency. In this study, we found that GmEXPB2 was also induced by Fe deficiency, salt stress or drought stress. *Arabidopsis* was transformed with a construct containing the GUS reporter gene driven by GmEXPB2 promoter for the gene localization analysis or the 35S promoter to drive the overexpression of the Open Reading Frame (ORF) of GmEXPB2 for the gene function analysis. Five-day-old seedlings were harvested and incubated in a GUS staining solution for three hours at 37 °C, and the expression pattern of GmEXPB2 under different abiotic stresses was confirmed by GUS staining in transgenic *Arabidopsis*. Three overexpression lines were selected using q-PCR analysis for further study. Seven-day-old seedlings were transplanted and subjected to different abiotic stresses for ten days. The overexpression lines of GmEXPB2 showed significant increases in primary and lateral root length and lateral root number under low P and water deficiency, while slightly increase under low Fe stress, but no difference under salt stress. Taken together, our results suggest

that GmEXPB2, a root β -expansin gene, is involved in root system architecture responses to abiotic stresses and plays an important role in regulating adaptive changes of the root system architecture. The use of GmEXPB2 gene expression may be an effective tool to identify root characteristics, and have a great potential for improving crop productivity under stress environments.

1:30–1:45 PM

Abscisic Acid Inhibits Leaf Expansion by Limiting Cell Expansion But Not Cell Division in *Arabidopsis*

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Abscisic acid (ABA) accumulation during water stress inhibits leaf expansion to limit plant water loss. When this acclimation is induced by exogenous ABA, we have previously shown that it is followed by rapid leaf expansion, with leaf area eventually recovering to the control level. We therefore hypothesize that ABA inhibits cell expansion but not cell division, and the maintenance of cell division enables such recovery of leaf expansion after ABA degradation. To test this hypothesis, we treated *Arabidopsis* (*Arabidopsis thaliana*) plants with 0 or 1 mM ABA at the rosette stage with 7–8 leaves. During 6 days following the treatment, ABA inhibited expansion of 5th and 7th leaves by 10% and 53%, respectively, while it had no effect on older leaves. Regardless of leaf age, epidermal cell number per leaf was unaffected by ABA, suggesting that ABA inhibits leaf expansion solely by limiting cell expansion. In addition, ABA affected neither number of stomata per leaf nor guard cell length, which regulate the rate of gas exchange and transpiration. These results suggest that ABA-induced inhibition of leaf expansion is a mechanism to conserve water by limiting increases in non-stomatal evaporative area, as opposed to stomatal closure that reduces transpiration. This mechanism may not limit plant growth and photosynthetic capacity, as leaves maintain both cell division and stomatal formation.

1:45–2:00 PM

Growth and Physiological Responses of Bermudagrass to Salinity Stress

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The need for salinity-tolerant turfgrasses is increasing owing to increased use of reclaimed or saline water for irrigation. The objective of this study was to investigate the salinity tolerance, growth, and physiological responses of four bermudagrass (*Cynodon* spp.) cultivars with different salinity tolerances. The salinity treatments (in Hoagland's nutrient solution) were 0, 100, 200, 300, and 400 mmol·L⁻¹ NaCl. The reduction in relative shoot growth with increasing salinity indicated a salinity tolerance decreasing in the order of 'Riviera' > 'Blackjack' > 'Savannah' > 'Sundevil 2'. Shoot and root growth of all cultivars were significantly affected by NaCl stress. However, root length and root dry weight of the salt-tolerant cultivars Riviera and Blackjack increased significantly compared with the control. Tissue Na⁺ and Cl⁻ concentrations in all cultivars increased with increasing salinity. The most salt-tolerant cultivar, Riviera, accumulated less Na⁺ and Cl⁻ in leaves and roots and more K⁺ in leaves than the least tolerant cultivar, Sundevil 2. All cultivars had bicellular salt glands. 'Riviera' excreted more Na⁺ and Cl⁻ than the other cultivars through these glands. All grasses exhibited complete osmotic adjustment, and osmotic adjustment of 'Riviera' was less than other cultivars under salinity stress. Cultivars exhibited marked differences in their responses to salinity. Our results indicate that the salinity tolerance of bermudagrass is associated with leaf and root Na⁺ and Cl⁻ regulation, in conjunction with the maintenance of high leaf K⁺ levels and efficient excretion of Na⁺ and Cl⁻ by leaf salt glands.

Thursday, July 25, 2013

Desert Salon 4-6

Organic Horticulture

Moderator: Brian Ward, bw@clemson.edu

12:30–12:45 PM

The Effect of Biochar and Fertilizers Made from Plant Extracts on Crop Growth and Nitrogen Leaching with Containerized Greenhouse Plants

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Consumers' increased awareness of the environment and sustainability has created new markets for the floriculture industry. Floriculture growers are increasingly adopting sustainable agricultural practices to meet market demands. Organic fertilizers are considered sustainable because of their low energy consumption and impact on the environment. Biochar is presumed to be sustainable because of its carbon sequestration properties. The objective of this investigation was to evaluate fertilizers derived from plant extracts (Bombardier 8–0–0 liquid amino acid and

Espartan 2.70–3.03–2.60 humic acid) on the growth of marigold (*Tagetes erecta* L. 'First Lady') and nitrogen (N) leaching and to evaluate the effect of biochar on the fertilizer performance. Two greenhouse experiments were conducted, and plant extract fertilizers were evaluated against chemical fertilizer (20–2–20) and another organic fertilizer, Sustane (4–4–4), derived from turkey litter and feather meal. In Experiment 1, chemical, Sustane and Bombardier were used with or without biochar. In Experiment 2, chemical, Sustane and Espartan were used with or without biochar. Plants received the same amount of N from all treatments. Leachate was collected at 10-day intervals and analyzed for ammonium (NH₄⁺) and nitrate (NO₃⁻). At the end of the experiments (62 d after transplanting), plant growth was measured. In Experiment 1, Bombardier resulted in highest shoot dry weight after chemical fertilizer, which gave the greatest growth. Sustane produced the lowest dry weight among all treatments. Bombardier resulted in the highest N leaching, mostly as NO₃⁻-N. Sustane resulted in the lowest N leaching, also mostly as NO₃⁻-N. Biochar had no effect on the fertilizers' performance with regard to shoot dry weight. Biochar also had no effect on N leaching from Sustane but reduced NO₃⁻-N leaching from chemical and Bombardier pots. In Experiment 2, there was no significant difference among treatments with regard to shoot dry weight. Among all treatments, Sustane resulted in the lowest N leaching, mostly as NO₃⁻-N. No differences occurred among the other treatments. In terms of shoot dry weight, biochar had no effect on the performance of fertilizers. In terms of N leaching, biochar had no effect of the performance of chemical but reduced NO₃⁻-N leaching from Sustane pots and increased NH₄⁺-N and NO₃⁻-N leaching from Espartan pots. Results indicate that both Bombardier and Espartan have performance limitations in terms of plant growth or N leaching. Biochar did not affect the performance of fertilizers in terms of plant growth and its effect on N leaching depended on the fertilizer used.

12:45–1:00 PM

Influence of Organic versus Synthetic Nitrogen Fertiligation on Sweet Corn Yield, Quality, and Nutritional Quality

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Consumer awareness and demand for fresh, high quality and nutritious organic sweet corn (*Zea mays* L. convar. *saccharata* var. *rugosa*) has led to great consumer demand from organically certified farms. Our objectives were to determine yield, quality, and nutritional content of sweet corn fertigated with organically derived nitrogen (N) versus synthetically derived N under conventional cultural practices to examine the effects of the N source exclusively. A four factor completely randomized block design experiment including planting date, cultivar, fertilizer source and rate was conducted under two separate soil conditions at Clemson Coastal Research and Education Center, Charleston SC. Two sweet corn shQ cultivars 3175 and 378a were grown with synthetic and organic N sources at 84,

An asterisk (*) following a name indicates the presenting author.

168, and 336 kg·ha⁻¹ N, respectively, at two empirically chosen planting dates. Data collected included cobs/ha and kg·ha⁻¹, quality, nutritional content including mineral, phenolic acid and carotenoid contents were determined. Of the two planting dates, it was determined that the 23 Mar. 2009 planting date was superior in yield to the 20 Apr. 2009 planting date. Synthetic N at the 4x rate produced greater yields on depleted soils when compared to organic N at the 4x rate on enhanced soils. On enhanced soils, synthetic N at the 1x rate nearly equaled the 4x organic N rate. The lowest yielding were control plots without N on depleted soils, followed by the organic N source at the 1x rate on depleted soils. The greatest yielding plots were synthetic N source at 4x rates on depleted soils followed by organic N at 4x rates on the enhanced soils. Phenolic acid content mg·g⁻¹ did not differ for either cultivar on depleted soils; however, cultivar 378a contained 11% more phenolic acid mg·g⁻¹ on enhanced soils when compared to depleted soils. The contrary was observed for carotenoids for lutein, zeaxanthin, and β-cryptoxanthin, which was 21%, 31%, and 12% μg·g⁻¹ greater in depleted soils compared to enhanced soils, respectively. Lutein increased with fertilizer rate with the 336 kg·ha⁻¹ N rate producing the greatest lutein content of 0.99 μg·g⁻¹. There was no conclusive evidence that organic N fertilized sweet corn was superior to synthetic N fertilized sweet corn with regard to yield, quality, and mineral, phenolic acid, and carotenoid contents.

1:00–1:15 PM

Organic Agriculture in the Kingdom of Saudi Arabia

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The organic agricultural sector in the Kingdom of Saudi Arabia is young and dynamic. All information contained in this report has been compiled by the authors within the framework of the “GIZ/MoA Organic Farming Project.” Global markets for certified organic products have been growing rapidly over the past two decades. Growth has mainly been driven by the increasing health awareness among consumers. In consonance with global trends, Saudi Arabia is seeing a growing consumer demand for healthy and high-quality foods. Domestic organic markets are emerging in the Kingdom. However, in search of high-quality, healthy products, some segments of Saudi society have shifted their consumption patterns toward imported organic foods. Organic agriculture offers substantial opportunities for small farmers in the Kingdom. The shift from severe competition at local conventional markets to an organic niche market offers attractive price premiums in a growing market environment. However, the benefits of organic agriculture are not confined to business opportunities. In addition to market considerations, organic is environmentally friendly and protects the Kingdom’s valuable resources by strengthening soil fertility, biodiversity, and other ecosystem services. In mid 1425H–2005G, the Ministry of Agriculture commissioned GIZ to support the development of the organic agriculture sector in Saudi Arabia, bringing in

extensive international expertise in organic sector development. Over the past 7 years, the Organic Farming Project has established governmental structures and support services to expand organic production and foster the further development of this sector. To help meet the high standards for quality, the Ministry of Agriculture introduced its own Saudi National Organic Regulation and Standards in 2010. Standards include guidelines for production, processing, trade, and the import of organic products. However, organic market development in the Kingdom is largely dependent on consumer trust in certified organic products. As a result, the Ministry of Agriculture is safeguarding consumers’ interests via its national organic control system. Its thorough implementation, together with the monitoring and surveillance of all organic-sector activities, is the core function of the Department of Organic Agriculture (DOA). This first Organic Sector Study offers an overview of a young but steadily growing organic sector. I hope this study will provide not only comprehensive insight into the current status of organic agriculture in the Kingdom but also an understanding of the potential health, economic and environmental benefits of this important segment of agriculture in the Kingdom.

1:15–1:30 PM

Assessing the Suitability of Biofumigation and Anaerobic Soil Disinfestation to Improve Vegetable Crop Performance in Michigan

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Pressure to improve alternative pest management practices has risen in intensive cropping systems due to the loss of broad-spectrum fumigants. Adding to this is the variable and inconsistent efficacy of alternative management including biofumigation (BF) and anaerobic soil disinfestation (ASD). These practices were selected for evaluation based on amenability to environmental conditions of the upper Midwest. Biofumigation and ASD can be combined through the use of brassica cover crops and virtually impermeable films (VIF). Used in concert, these practices have the potential to confer the advantages realized from each system separately, including: improved nutrient cycling, soil warming, water retention, and disease suppression. The objective of this study was to evaluate the impact of BF and ASD on vegetable crop yield/quality while monitoring soil temperatures, nitrogen and CO₂ concentration. In 2012, a field experiment was conducted at the Horticulture Teaching and Research Center (HTRC) in Holt, MI. Fifteen treatments were evaluated as a fully factorial combination of 5 cover crops [oilseed radish (*Raphanus sativus* ‘Defender’), Oriental mustard (*Brassica juncea* ‘Pacific Gold’), yellow mustard (*Sinapis alba* ‘Ida Gold’), oat (*Avena sativa* ‘Excel’) and a bare ground control] with 3 mulching practices applied following cover crop incorporation (standard black plastic film (BP), VIF, and no mulch (NM)).

An asterisk (*) following a name indicates the presenting author.

Prior to incorporation, the cover crops were evaluated for dry biomass and nutrient content. Following mulch application, soil temperature, CO₂ concentrations, and soil nitrogen were monitored. Fresh-market tomato (*Lycopersicon lycopersicum* cv. 'Big Beef') was then transplanted, grown, and evaluated for plant biomass and crop yield/quality. Cover crop (and residual weed) biomass at incorporation was 1939, 1229, 1210, 2030, and 651 kg/ha for *R. sativus*, *B. juncea*, *S. alba*, and *A. sativa* and bareground treatments, respectively. No differences were observed in yields among cover crop treatments, possibly due to lower than normal biomass accumulation. During ASD, soil nitrate and ammonium were higher under plastic treatments while CO₂ levels were highest under VIF and lowest under NM. Tomato fruit yield and shoot biomass was significantly lower on BP and VIF treatments compared with NM. Mulch treatments provided favorable soil temperatures early in the growing season, however, unusually high mid-season temperatures led to root-zone temperatures above optimal for tomato growth. Our initial results suggest that under low disease pressures and high temperatures, combining practices may result in lower yields

Specified Source(s) of Funding: The Ceres Trust

1:30–1:45 PM

Investigating Vermicompost as the Primary Fertilizer Source in Organic Vegetable and Flower Transplant Production

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Fertility management in production of organic transplants can be difficult. Transplants are grown in containers with a small substrate volume and most substrates have a low nutrient holding capacity. Organic fertilizers often have low levels of plant available nutrients that are not supplied in the correct proportion to plant needs. Composts are commonly used in organic substrates but they may be low in plant available nutrients and microbe mediated nutrient release happens slowly. Commercially produced dairy manure vermicompost (Worm Power, Avon, NY) is a worm processed form of compost that can be used in organic production. Our first objective was to determine the seed germination and plant growth response of pepper ('Calwonder'), tomato ('Rutgers 39'), petunia ('Celebrity White F1') and snapdragon ('Rocket Mix F1') to vermicompost (VC). Germination trials were conducted using 0%, 4%, 8%, or 12% VC by volume incorporated into the peat-perlite substrate prior to seeding or topdressed at the same rates after 2 weeks. Incorporating the VC into the substrate did not significantly affect germination percentage of any of the species tested. Dry weight (DW) was increased for 8% and 12% compared to 0% VC for tomato, petunia, and snapdragon. Pepper DW was significantly larger for 8% than 0% or 4% VC. Topdressing VC as opposed to substrate incorporation allowed all species to better

utilize the vermicompost and produce larger plants. When VC was topdressed, a significant enhancement in growth compared to control (0% VC) was apparent at 4% VC; whereas 8% VC was required for a significant growth benefit when incorporated. Our second objective was to determine the effect of VC on the same species when transplanted into 4-inch (500 mL) containers. VC was incorporated into a peat-perlite substrate at rates of 0%, 5%, 10%, 15%, 20%, or 30% by volume. Four-week-old seedlings were transplanted into the substrate and harvested after 5 weeks. The addition of VC at 10%–30% increased the DW of tomato and pepper plants as compared to the control substrate. For petunia and snapdragon transplanted into 4-inch containers, 10% appears to be optimal, additional VC led to a decrease in DW. Weekly leachate samples exhibited an increase in pH and a decrease in EC over time. Nitrate concentration in leachate decreased over time and was completely depleted by week 3. Ammonium also decreased over time but was still present in low quantities at weeks 3 and 4 for 10% to 30% VC treatments.

Specified Source(s) of Funding: NRCS Conservation Innovation Grant

1:45–2:00 PM

Exploring Best Organic Soil/Pest Management Practice through Farm Systems Analyses (FSAs) of Organic Vegetable Farms

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The goal of this project is to improve the environmental, economic, and social sustainability of organic vegetable farms by facilitating the understanding and adoption of effective, research- and farm-based, systems approaches to soil and pest management. These methods are needed to manage critical and seemingly intractable soil/pest problems such as aphids, nitrogen supply, diseases, and weeds, as well as interrelationships amongst these factors. Draft FSAs have been developed of two Oregon and one Montana organic vegetable farms that a) are pushing the envelope on "systems management;" b) have successfully managed common pest and soil management problems through systems management; c) have at least 15 years of detailed farm records; and d) have partnered with university researchers in on-farm research studies. FSAs were developed by the farmers in cooperation with research/extension faculty with expertise in pests and soils and with eOrganic, the national organic agriculture information portal at eXtension.org/organic_production. The FSAs include: 1) intensive interviews with each farmer to

An asterisk (*) following a name indicates the presenting author.

document farm history and farming practices, how their farming philosophy and practices have changed over time, pest and soil challenges they have overcome (or not), and trends they have observed on their farm; 2) detailed farm maps; 3) aggregation and analysis of farmer- and researcher-collected data sets; and 4) literature reviews. Problem-focused cross-farm “stories” (for example, on suppression of caterpillars and aphids) are also developed to describe trends that are observed on multiple farms. Farm systems analyses and stories will be published at http://eXtension.org/organic_production. Trends and research questions emerging from the FSAa will be described. The most obvious cross-farm trend is that aphids and caterpillars on brassicas were but are no longer a problem on these farms (and it is not clear why), while brassica flea beetles, onion thrips, and cucumber beetles remain problems. Overall, the farmers report that crop health and quality seems to be improving over time; the exception is that winter squash losses during storage are increasing (and it is not clear why). The FSAs have inspired researcher-led projects on mechanisms of suppression of caterpillars and aphids as well as squash storage diseases, and farmer-led projects on nutrient management in high tunnel tomatoes and nutrient balancing and insectary plantings in onions for thrip and downy mildew management.

Specified Source(s) of Funding: USDA Western SARE Research and Education Grant SW09-031

Thursday, July 25, 2013 **Desert Salon 13-14**

Plasticulture

Moderator: Jeremy Cowan, jeremy.cowan@wsu.edu

12:30–12:45 PM

New Jersey’s Agricultural Plastics Recycling Program

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The New Jersey Department of Agriculture’s (NJDA) first efforts at recycling agricultural plastics started in 1991 with baling greenhouse and nursery film. The effort was not successful as the results of an inadequate long-term market. NJDA accepted the role as facilitator in 1997 to develop a statewide program in an effort to recover an estimated one million pounds used each year by growers. From 1997 through 2004 the program was seasonal and collected on average 350,000 to 500,000 pounds annually. Each year participation increased and in 2005 expanded to a year round program collecting from 547,000 to a high of 1.1 million pounds per year. Through 2012, New Jersey has recycled almost 10 million pounds of nursery and greenhouse

film. Growers have modified traditional round balers to accommodate baling film. Others have purchased specifically designed balers that compact plastic into square 1,000 pound bales. These machines can save 75% in labor when removing plastic from overwintering structures and keeps the plastic clean. Three workers can remove film from four structures in 15 minutes where using traditional manual labor would take 7–8 workers 90–120 minutes. A pesticide container recycling program was initiated in 2002 with the cooperation of the Ag Container Recycling Council. The first year 676 containers were collected from 40 participants. NJDA determined that the program was not cost effective and only one location continued to accept containers. The program expanded in 2008 to three locations with a private public partnership. In 2012, the program had 242 participants and approximately 110,000 containers were collected. Mulch film and drip tape recycling has been a challenge since it is “dirty stuff.” Mulch film can contain between 50% to 60% contaminants comprised of soil, plant material, and other foreign matter. There are more than 10,000 acres where plastic is used for vegetable production in New Jersey. Each year farmers landfill this material and pay more than \$65 to \$100 per ton for tipping fees for the estimated six million pounds of material. In 2012, two firms began an economic development project to establish a facility in Northern and Southern New Jersey to collect, wash and recycle mulch film, drip irrigation tape, bunker silo plastic, peat moss bags, and other agricultural films that may be contaminated. If this project is successful growers will be able to recycle most of their mulch film and drip tape, save money, and prolong the life of landfills.

12:45–1:00 PM

Impacts from Three Years of an Integrated High Tunnel Project in Mississippi

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High tunnels are unheated structures for growing high value crops over an extended season. Over the past few years, researchers at Mississippi State University (MSU) have studied several aspects of high tunnel production. Our program started out with a grant to investigate using secondary covers in tunnels for production of warm season crops over the winter. The research portion of this study included three replicate tunnels at two university locations, plus training tunnels at two grower sites. A critical aspect of this research was strict adherence to the temperature

An asterisk (*) following a name indicates the presenting author.

control protocol for venting the tunnels and using the secondary covers. The main research finding was that we could significantly improve crop survival and overall performance with secondary covers in our climate. We also learned that proper management of the openings of the tunnels could reduce but not eliminate high wind damage to these temporary structures. The project was successful in terms of its extension and teaching outcomes and impacts. It resulted in thousands of contacts, more than a dozen field days, several individual tours. The state of Mississippi now has more than 200 high tunnels at least in part due to this project, and several enduring partnerships between MSU scientists and those in surrounding states were forged out of this project. The project PI has appeared on national television, and the team has partnered in the creation of several web outreach sites and publications, and made over twenty scientific presentations to five different scientific societies.

Specified Source(s) of Funding: USDA NIFA Grant # 2009-55618-05169

1:00–1:15 PM

Deterioration of Three Biodegradable Plastic Mulches before and after Soil Incorporation in a Broccoli Production System

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Deterioration of three potentially biodegradable plastic mulch products, BioAgri, Crown 1, and SB-PLA-11, was evaluated before and after soil incorporation over two growing seasons, 2011 and 2012, with broccoli (*Brassica oleracea* var. *italica*) as the test crop. In-season mulch deterioration was evaluated during both growing seasons by estimating the percentage of visual deterioration (PVD). The PVD at the end of the growing season differed significantly by mulch product in both 2011 and 2012 ($P < 0.0001$), and was greatest for Crown 1 both years (63.8% and 71.3%, respectively). The PVD for BioAgri (11.8% in 2011, 10.5% in 2012) was greater than for SB-PLA-11 both years (1.3% in 2011, 0.5% in 2012). Mulches were incorporated into the soil at the end of the first growing season and soil samples were collected every three months for 13 months. Fragments of mulch recovered from each soil sample were photographed, and mulch deterioration was evaluated based on average area per fragment, total number of fragments, and total fragment area, using ImageJ software. The average area per fragment decreased over time after soil incorporation for all mulch products. The total number of mulch fragments initially increased for all mulch products, with the number of fragments

of Crown 1 and BioAgri reaching a maximum at 132 and 299 days after incorporation, respectively. As the number of fragments declined for these two mulches, the average area of each fragment did not change, suggesting that a threshold fragment size may exist for biodegradation during this time period. At the end of the study, 397 days after soil incorporation, Crown 1 and BioAgri had deteriorated 100% and 65%, respectively, whereas SB-PLA-11 showed no appreciable deterioration based on total fragment area. Broccoli yield was only measured in the second year, after mulch had been soil-incorporated. When compared to non-mulched subplots, mulch increased total and marketable crown weights 36% and 30%, respectively ($P = 0.001$ and $P = 0.04$, respectively), and decreased days to harvest by 6% ($P = 0.0002$). There was no impact on broccoli yield due to mulch product.

1:15–1:30 PM

Plasticulture Grown Cabbage: Effects of Plant Population and Planting Dates on Crop Yield

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Growers in the major cabbage producing regions in Florida rely on seepage irrigation achieved by the upward movement of water from capillarity resulting from an artificially maintained water table just below the root zone. The water use efficiency of seepage irrigation is typically lower than 50%. Therefore growers are seeking more efficient irrigation methods to reduce crop losses, increase yield, and improve water/nutrient use efficiency. Plasticulture, or the use of drip irrigation and plastic mulch, offers approximately 95% water use efficiency, increased plant population per area, and reduced weed and possibly disease pressure. Cabbage 'Bravo' was grown on 48-inch wide raised beds with black plastic mulch and drip irrigation. A split plot design with randomized complete blocks and four replications was used. Main plots consisted of three or four rows of plants per bed and the subplot factors were in-row plant spacing (6, 8, 10, 12, and 14 inches), the final plant population ranged from 16,802 to 52,272 plants per acre. The trial was planted on two dates, 25 Oct. and 06 Dec. 2012. The October planting yielded 15% more marketable cabbage than the December planting. There were significant interactions between planting date and in-row spacing ($P = 0.01$) and number of rows per bed ($P = 0.02$) for marketable yield. Wider in-row spacings performed

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better for the October compared to the December planting. For the earlier planting (October), treatments of 10, 12, and 14 inch averaged 41,700 lb/acre and were significantly greater than 6 and 8 inch in-row spacings. In the later planting (December), in-row spacings of 12 and 14 inch averaged 41,770 lb/acre, which was 17% and 50% higher than the 10 and 8 inch in-row spacings, respectively. The 3 plant rows per bed treatment was unaffected by planting date, whereas the 4 plant rows per bed treatment yielded significantly lower for the December planting. Marketable yield for the 4 plant row per bed treatment averaged 36,960 lb/acre for the October planting, while 27,839 lb/acre for the December planting. In general, higher cabbage marketable yields were obtained with a plant population in the range of 16,802 and 39,204 plants/acre for the October planting and 16,802 and 26,136 plants/acre for the December planting.

Specified Source(s) of Funding: USDA FDACS Specialty Crop Block Grant

1:30–1:45 PM

Evaluating Visual Assessments of Mulch Deterioration to Predict Changes in Mulch Mechanical Properties

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Visual assessments can be a quick and inexpensive tool to evaluate mulch deterioration in the field. Laboratory evaluation of mulch mechanical properties provide an objective measure of the physical status of mulch, but the equipment necessary is inaccessible to growers and some researchers. Unfortunately, no comprehensive comparison of these methods has been reported. This study evaluated the relationships between visual assessments and mulch tensile properties. Using tomato (*Solanum lycopersicum* L.) as a model crop, visual assessments of five mulch treatments were made twice monthly over the 2010 through 2012 growing seasons at Mount Vernon, WA. Mulch treatments included black polyethylene plastic and four biodegradable mulches: BioAgri, BioTelo, WeedGuardPlus, and an experimental spun-bonded polylactic acid (SB-PLA) non-woven fabric. Mulch samples were extracted from field

plots at three times: mulch installation, tomato first flower, and tomato final harvest. For each sample, breaking force and elongation at break in the machine and transverse directions were measured in the laboratory. Regression analyses evaluated the linearity of relationships between visual assessment parameters and mulch tensile properties. The strongest relationship overall ($P < 0.0001$; $r^2 = 0.41$) was between the percentage of initial breaking force in the machine direction (BF-M-PD) and log₁₀ of the percentage of visual deterioration (PVD-L10). For each unit of increase in PVD-L10, BF-M-PD decreased by 31.78%. However, when analyzed separately by mulch treatment, the relationship between BF-M-PD and PVD-L10 was only statistically significant for WeedGuardPlus ($P = 0.0001$; $r^2 = 0.30$). The strongest relationship for BioAgri and BioTelo was between elongation at break in the machine direction (EI-M) and PVD-L10 ($P \leq 0.03$; $r^2 = 0.10$ and $r^2 = 0.22$, respectively); for WeedGuardPlus the strongest relationship was between elongation at break in the transverse direction (EI-T) and the percentage of visual deterioration (PVD; $P = 0.009$; $r^2 = 0.42$); and for polyethylene the strongest relationship was between the percentage of initial elongation at break in the transverse direction (EI-T-PD) and log₁₀ of the area under the deterioration progress curve (AUDPC-L10; $P = 0.002$; $r^2 = 0.22$). No statistically significant ($P > 0.05$) relationship was identified for SB-PLA. While moderate relationships were detected overall, it is important to note that visual assessments and tensile tests each measure different properties of the mulch materials, and thus are measures of different factors of deterioration. To better assess the ability of visual assessments to predict mechanical properties, independent evaluation of mulch products and increased sampling frequency is recommended

1:45–2:00 PM

The Evolution of Ohio Strawberry Plasticulture Production (2001–2013)

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Strawberry plasticulture has been researched under southern Ohio conditions since 2001. Our goal was to determine if strawberry plasticulture would be a viable strawberry season extension technique for Ohio growers. There were several potential benefits identified to growing strawberries in plastic covered raised beds over the traditional matted row culture system, such as an earlier harvest, cleaner fruit, ease of picking, and higher yields. A two-year on farm non-replicated trial was set up by authors with two southern Ohio growers. Results of these observation trials were mixed, with more questions being raised than answered. What are the correct planting dates for our area? What types of row

An asterisk (*) following a name indicates the presenting author.

covers are needed for winter protection? What varieties perform well under southern Ohio conditions? In Fall 2001, replicated trials were established at the Ohio State University Piketon Research and Extension Center to study winter protection covering materials, cultivar evaluations and dates of planting. This paper will share the results of our 12 years of replicated strawberry plasticulture research and the lessons we have learned. Our last 12-year average replicated trial results have shown an optimal planting window for southern Ohio being September 10–20, with Chandler variety being the most consistent yield performer with yields as high as 23,799 kilograms per hectare. Trial results have also indicated that row cover management is required for winter protection of strawberry plants in Ohio with the heavier 1.5 ounce floating row covers showing the least winter plant damage and higher yields.

Specified Source(s) of Funding: Ohio Vegetable and Small Fruit Research and Development Program

Thursday, July 25, 2013 **Desert Salon 1-2**

Floriculture

Moderator: Alicain S. Carlson, ascarlso@ncsu.edu

12:30–12:45 PM

The Effect of Nitrogen and Potassium Fertilization on Growth and Nutrient Content of Container-grown Dahlia ‘Magic Moment’

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Dahlias are a popular floriculture crop and are grown as herbaceous perennials, potted plants, cut flowers and for tuber production. Specific nutritional guidelines have not been developed in order to optimize container production. Proper information on fertilization rates and tissue nutrient concentrations are required to maximize productivity and quality for growers. The objectives of this research were to establish base line nitrogen (N) and potassium (K) fertilization rates as well as tissue nutrient concentrations to maximize plant quality while minimizing over fertilization. Dahlia ‘Magic Moment’ plants were field produced from cuttings in 15 L containers outdoor in Kennett Square, PA, starting May 13, 2010, for 106 days. On weekdays, plants received fertilizer treatments, which were a factorial arrangement of three N rates (50, 200, and 350 ppm) and three K₂O rates (50, 200, and 350 ppm). There was also a control treatment of 0 N and 0 K giving a total of 10 treatments with 4 replications. Tissue N concentration increased and tissue K concentration decreased as N fertilization rate increased. This is likely the result of nutrient antagonism where higher concentrations of positively charged ammoniacal N in the fertilizer suppress uptake of K. Tissue K

concentration increased significantly as K rate increased. The effect of K fertilization rate on tissue N concentration was non-significant. Shoot fresh weight, tuber fresh weight, and the shoot to tuber weight were all unaffected by K. As N fertilization rate increased, shoot weight increased significantly. However, just the opposite occurred for tubers, where tuber weights increased 170% and 487% when N rate decreased from 350 ppm to 200 and 50 ppm, respectively. When comparing the results for tubers with tissue N concentrations, there is an apparent shift in resource allocation when tissue N drops below approximately 4%. This is further supported by the shoot to tuber ratio increase of 687% and 791% when fertilization rate increase from 50 ppm to 200 and 350 ppm, respectively. Further research is needed to determine the critical tissue concentration of N where dahlias shift growth partitioning toward or away from tubers. However, this data does indicate fertilization of dahlias with high N can reduce tuber production while limiting N can promote tuber production. There was no effect of three K rates on growth of dahlia shoots or tubers, which indicates regular fertilization with 50 to 100 ppm K₂O should supply sufficient K for production.

Specified Source(s) of Funding: Longwood Gardens, The American Dahlia Society and USDA ARS

12:45–1:00 PM

Growth Regulators Applied to Poinsettias in Production Affect Cyathia Drop and Bract Edge Burn in Postproduction

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In the production of poinsettias (*Euphorbia pulcherrima* Willd. ex Klotzsch), the use of a combination of 6-Benzylaminopurine and Gibberellins A4&A7 (BA/GA) for expanding bract size and the use of paclobutrazol are expanding. Preliminary studies indicated that these chemicals may be affecting the occurrence of cyathia drop and Bract Edge Burn (BEB), which is often associated with Botrytis. Two experiments were conducted in 2012 to further evaluate this relationship. For both, plants were grown using standard production procedures. The BA/GA (Fascination) was applied at a concentration of 5 mg·L⁻¹ for each chemical using a spray volume of 200 mL·m⁻². At the end of the production phase, the plants were sleeved and moved (shipping) to a dark room for 3 days. Then plants were unsleeved and placed in a postproduction room with 12 hours of lights. In postproduction, the numbers of cyathia that were developing and still attached to the plant were counted on 2 laterals on each plant. With ‘Early Prestige Red’ 7 days after shipping (DAS), the numbers of cyathia per shoot on control plants, on plants only drenched with paclobutrazol (1 mg·L⁻¹) and on plants sprayed with only BA/GA were 3.6,

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6.1 and 0.8, respectively. Paclobutrazol and BA/GA applications were 7 days before shipping (DBS). For plants sprayed with BA/GA and drenched with paclobutrazol, the number of cyathia were 1.3, 2.6, 2.0, and 3.2 when the drench was applied 1, 7, 14, or 21 DBS, respectively. For plants sprayed with BA/GA and with paclobutrazol ($20 \text{ mg}\cdot\text{L}^{-1}$) 7 DBS, the number of cyathia was 6.1. With 'Prestige Red' 10 DAS, plants sprayed with paclobutrazol ($30 \text{ mg}\cdot\text{L}^{-1}$) had more cyathia than did plants drenched with paclobutrazol ($1 \text{ mg}\cdot\text{L}^{-1}$). Paclobutrazol reduced cyathia drop better when applied 5 or 14 DBS compared to 2 DBS. Plants given BA/GA and sprayed with paclobutrazol had twice as many cyathia compared to plants only sprayed with BA/GA. Occurrence of BEB was determined using a whole-plant rating scale with 1 = best and 5 = worse. BEB ratings for control plants and ones sprayed or drenched with only paclobutrazol were similar. Rating for control plants and plants sprayed with BA/GA 14 DBS was 1.8 and 3.4, respectively. Paclobutrazol sprays 5 or 14 DBS did not reduce the occurrence of BEB in plants sprayed with BA/GA.

1:00–1:15 PM

Evaluation of Heliconia Cut-flower Production under Shading

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Most *Heliconia* species are found as understory plants, and occasionally in small open spaces of tropical forests in Central and South America. Despite this fact, cut flower *Heliconia* growers in these regions typically grow them in open, non-shaded production areas with higher levels of irradiance. The present study is being conducted to evaluate the flower productivity and quality of soil-grown heliconia (*H. psittacorum* L.f. X *H. spathocircinata* Aristeguieta 'Golden Torch Adrian') exposed to five levels of artificial shading: 0%, 35%, 50%, 70%, and 90%. Data from 19 months after planting indicate that days to bloom, number of flower shoots per plant, inflorescence length, number of bracts per inflorescence, and the bracts color (parameter a* only) decreased with increasing shading level by a total of 19%, 61%, 13%, 11%, and 6.8% respectively. Flower shoot fresh

weight and length, peduncle length, inflorescence width, and basal bract length were the lowest at full sun and at the 90% shading level. The number of leaves per flower shoot, peduncle basal and distal diameter, and the length of the second to fifth bracts were not affected by shading level. There was a positive correlation of flower shoot fresh weight with peduncle length and basal diameter, inflorescence length and width, and number of bracts per inflorescence. Flower shoot length was positively correlated with peduncle length but not with inflorescence length. The longest flower shoots, which had the longest peduncles, also had the widest inflorescences and the longest bracts.

Specified Source(s) of Funding: CONACyT, Colegio de Postgraduados (Campus Córdoba y Líneas Prioritarias de Investigación LPI-12, LPI-13)

1:15–1:30 PM

Developing Production and Postharvest Protocols for Cut *Penstemon grandiflorus* 'Esprit'

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The effects of production temperature and transplant stage on stem length and caliper of cut stems and postharvest treatments on vase life of penstemon (*Penstemon grandiflorus*) 'Esprit' were examined. Plugs transplanted with 8–9 sets of true leaves had a longer stem length (64 cm) at harvest than those transplanted with 2–3 sets (58 cm) or 5–6 sets (61 cm). Flowering time decreased as production temperature increased and when transplants had a greater number of true leaves. The addition of 2% or 4% sucrose with $7 \text{ mg}\cdot\text{L}^{-1}$ Kathon CG as a vase solution resulted in the longest vase life (9.4 d) of all treatments compared to the control (4.5 d). Commercial holding solutions significantly increased vase life, while hydrators had no effect. The use of floral foam or anti-ethylene agents, ethylene exposure, or sucrose pulses also had no effect on vase life. Wet or dry cold storage of cut stems for more than one week reduced vase life. Penstemon may be suitable for heated greenhouse production and has acceptable commercial potential as a specialty cut flower as long as a floral preservative (holding or vase solution) is used.

Specified Source(s) of Funding: Hill Foundation and AFE

1:30–1:45 PM

Development and Evaluation of Injection-molded Bioplastic Container Prototypes

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Thursday, July 25 2013

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Sustainability and environmental impacts of container-crop production are important to producers and consumers. While the performance, productivity, and low cost of petroleum-plastic containers have led horticultural industries to rely heavily on containers made of these unsustainable materials, emerging bioplastics technologies provide alternative container materials that may perform as well or better than petroleum plastics, yet are renewable and degradable. We created prototype containers of 14 injection-moldable bioplastics and biocomposites and evaluated their effectiveness during greenhouse production of marigold, petunia, salvia, pepper, and tomato and during establishment of those plants outdoors with the container removed, crushed, and installed near plant roots. Materials evaluated were Mirel® PHA formulations P1003, P1004, P1008, and P4010, and composites of P1003 and P1004 with dried distillers grains with solubles (DDGS); Ingeo® PLA and composites of PLA with DDGS, corn stover, and nano-clay; two high-percentage soy materials (SP and SP.A); and two soy-PLA formulations (SP-PLA and SP.A-PLA) blended 50:50 by weight. All materials except high-percentage SP and SP.A processed well on standard plastics-processing equipment, and composites of PHA and PLA with DDGS or corn stover processed better than their base resins without composite materials. After 5 weeks of greenhouse production, plants grown in containers made of blended SP.A-PLA and SP-PLA were healthier, larger, and of better quality than plants grown in control containers made of petroleum plastic, and with the exception of containers made of high-percentage SP and SP.A, plants grown in all other bioplastic containers were of similar health, size, and quality as those grown in control containers. Grower rating of functionality, durability, and appearance was highest for containers made of PHA materials P1003, P1004, P1008, PHA composites with DDGS, and for controls. Grower ratings were lowest for high-percentage SP and SP.A containers, which failed structurally in the greenhouse. In the garden trial, plants grown for 8 weeks with bioplastic pieces installed near their roots were of similar health, size, and quality and showed similar fruit production as plants grown with petroleum-plastic containers removed and discarded, with the exception of those in the SP.A-PLA treatment, which were larger, of better quality, and produced more fruit than controls. Our results demonstrate the potential to utilize injection-moldable bioplastics and biocom-

posites as replacements for petroleum plastics in specialty-crop containers that can improve sustainability and reduce environmental impact without sacrificing performance or productivity.

1:45–2:00 PM

Identification of the Rose Rosette Disease Agent

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Rose rosette disease (RRD) was first described in the 1930s. Symptoms of RRD include mosaic and mottling patterns on leaves, reddening on newly emerging shoots, excessive thorniness on stems, and witches' broom. A new Emaravirus, Rose rosette virus (RRV) was characterized and found in perfect association with RRD. Molecular detection methods including RT-PCR and qRT-PCR as well as immunological tests have been developed to aid screening roses for RRV. Past research has established that RRD is spread by the eriophyid mite *Phyllocoptes fructiphilium* and we were able to detect RRV in mites. Mites were individually collected from RRV-positive roses and transferred to RRV-free roses. Two months post infestation, material was tested positive for RRV. The typical symptoms of RRD, described above later developed. Total nucleic acids from diseased plants was subjected to deep sequencing and no other viruses were detected in diseased roses proving that RRV causes RRD.

2:00–2:15 PM

Global Gene Expression Changes in Response to Bent Neck and Petal Blueing in Cut Roses 'Freedom' and 'Forever Young'

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Rose bent neck and petal blueing are major problems that decrease cut rose postharvest quality, but the molecular mechanisms that occur during these processes are unknown. To begin to understand the changes, we compared gene expression patterns using RNA-sequencing (RNA-seq). The cDNA libraries of Rosa 'Freedom' and 'Forever Young' were synthesized from both healthy cut rose flowers and flowers that were at different stages of bent neck and petal blueing. The cDNA libraries of 'Freedom' healthy neck (DHN) and 'Freedom' bent neck stage 1 (DBN) were sequenced by Illumina® GAIIX sequencing platform. Contigs were assembled de novo from expression sequence tags of DHN and DBN and compared. Initial analysis showed an increased expression of cell wall degradation, abscission and stress related genes indicating that rose bent neck might be a combined effect of water stress and accelerated abscission of the peduncle.

Specified Source(s) of Funding: Dole Fresh Flowers, Dept. of Horticultural Science and College of Agriculture and Life Sciences

2:15–2:30 PM

The North Carolina Cut Flower Industry: Results of a Production and Marketing Survey

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The cut flower industry is a small segment of North Carolina's floriculture industry, currently valued by the USDA Economic Research Service at \$4.2 million in annual sales on 128 farms. In 2003, an economic and cost analysis survey of the industry was conducted by Megan Weddington, an MS candidate at North Carolina State University (NCSU). There has been little information collected about cut flower production and marketing since. A survey was conducted among cut flower growers in Spring 2012 and 2013 to determine their production and marketing practices and to identify their biggest concerns. Forty-five responses were recorded from a representative sample of North Carolina growers from different areas of the state. Results were analyzed to obtain a current portrait of the growing industry. Many farms did not produce cut flowers in 2003 when the last industry survey was conducted. Seventy percent of farms have been growing cut flowers commercially for less than 10 years. The majority of farms are small; 64% are under an acre in cut flowers. 84% hire less than two workers per year. However,

many also produce fresh fruits, vegetables, potted plants, meat, or eggs. On average, 43% of surveyed farms' income is from cut flowers. 75% of farms are organic, but only 14% are certified organic or certified naturally grown. By far, most of production (81%) is field grown in open ground. Crops are diverse: growers produce on average 40 varieties or cultivars of cuts from 22 different species. From this list, the top 50 most commonly grown cultivars were identified for field and postharvest trials in the 2012 and 2013 NCSU summer cut flower trials. Annuals comprise over half of all cuts grown, followed by bulbs at 20%, herbaceous perennials at 14%, and woody perennials at 8%. Most farms trial new varieties yearly, but only 25% make significant changes to what they grow on a yearly basis. Weed control is the number one production challenge listed by growers. Many use plastic or organic mulches, hand weeding, and flame weeding to control infestation. Most farms have cold storage facilities (71%) and use commercial floral preservatives (56%), although only 37% use hydrating solutions. 79% of farm sales are retail, and 66% of retail sales are made at farmers markets. 80% of farms utilize social media or an online farm blog to promote their flowers. Production and marketing challenges were identified and will guide future research.

Specified Source(s) of Funding: NCDA/USDA Specialty Crop Block Grant

Thursday, July 25, 2013 Springs Salon D/E

Marketing and Economics

Moderator: John L. Griffis, Jr., jgriffis@fgcu.edu

12:30–12:45 PM

Partial and Enterprise Budgets for Growing Hard Cider Apples in Virginia

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Hard cider is a burgeoning part of the alcoholic beverage industry. To make a premium hard apple cider product, commercial cider-makers desire apple cultivars with high tannin, high acid, and/or high sugar content. Some commercially grown apples, such as 'Albemarle Pippin', 'Winesap', and 'Granny Smith' can serve these purposes. However, many cideries are also seeking specialized apple cultivars with high tannin content or other characteristics that make them unfit for most other market destinations. To help growers outline the major revenues, expenses, and risk associated with producing special apple cultivars, a partial budget for growing multipurpose apples (defined as apple cultivars that potentially have multiple market destinations, e.g.

An asterisk (*) following a name indicates the presenting author.

hard cider, fresh market, or processing) and an enterprise budget for planting and growing specialized hard cider apples were developed. Both budgetary decision aids were created using Microsoft Excel® and are available as a free download that includes a built-in user's manual. The budget workbooks can be filled in by growers to calculate their production costs and make a well-informed business decision to plant multipurpose and/or hard cider cultivars. By using data collected through surveying commercial apple growers and published apple orchard budgets, assumptions were made about the production costs and returns that allowed the exploration of alternative scenarios for Virginia orchards using sensitivity analyses. These analyses are built into the downloadable Excel worksheets and provide users with a starting point for customizing their own budgets. The partial budget analysis suggests that growers would need to receive a median return of (U.S. dollars) \$0.63/kg at a yield of 28,245 kg·ha⁻¹ to show a net change in profits when growing multipurpose apples instead of mainstream cultivars. Using a \$0.79/kg selling price and mature yields of 36,485 kg·ha⁻¹, our enterprise budget estimated the first year establishment cost at \$35,635/ha, with annual variable costs at maturity of \$8,080/ha, and total variable costs over 25 years of \$215,930/ha. Assuming a discount rate of 12%, which reflects the rate of return a model operation could have earned if it had invested in its next best alternative investment, the cumulative net present value of net income before taxes becomes positive in year 11. Since commercial production of hard cider apple cultivars is limited in the United States, let alone Virginia, our analyses might be limited by unknown production risks and changes in the market structure.

Specified Source(s) of Funding: Virginia Department of Agriculture and Consumer Services

12:45–1:00 PM

Relevance of Apple Quality Traits for Consumers

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Since breeders face a long list of quality traits to focus on in their breeding programs, information on how consumers value these may help breeders better establish trait priorities and make the breeding process more efficient. This study investigates the marginal values consumers place on apple quality traits, including internal and external quality traits. This is part of a larger SCRI project that aims to increase the long-term economic sustainability of Rosacea crops by increasing the U.S. per-capita consumption of fruits. We conducted a second-price auction along with a sensory tasting of apples with consumers in November 2012. The studies took place in Pullman, WA; St. Paul, MN; and Portland, OR. Three censored Tobit models are used to analyze the data where the bid is the dependent variable. External quality traits evaluated by consumers, internal quality traits instrumentally measured, and both sets of quality traits were used as regressors in the first, second, and third model respectively. All three models include demographic and purchase habits variables as regressors. Our goal is to find what group of attributes consumers value more, explicitly, external or internal quality traits, but also to estimate the marginal values consumers place on each apple quality trait.

1:00–1:15 PM

Consumer Characteristics Affect on Local and Organic Purchasing

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The terms local and organic are becoming common in most retail environments, especially in the merchandising of produce. Recent studies have examined the perceptions and misperceptions of these terms, as well as shown that consumers are willing to pay price premiums for produce. Another area of research has focused on the consumer characteristics that drive increased purchasing of local and organic. However, little to no research has examined how consumer characteristics are impacting the tradeoffs between local and organic purchasing in the marketplace. The objective of this study was to understand how various consumer characteristics, purchasing behaviors and environmental concerns (i.e. being egotistic, altruistic, or biospheric) impact local and organic purchasing, especially with regard to what causes consumers to purchase more local and less organic, and vice versa. Using a 2010 U.S. and Canadian survey, we categorize local and organic purchasing into 9 groups representing each combination of local (none/seldom, sometimes, most times/always) and organic (none/seldom, sometimes, most times/always). Using a multinomial logit model, and its corresponding marginal effects, we are able

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to identify the impact of various consumer characteristics and behaviors on category assignment. Preliminary results indicate a difference between U.S. and Canadian consumers. Furthermore, results indicate that certain consumer characteristics and purchasing behaviors do impact whether a consumer purchases more local and less organic as well as more organic and less local. We also see that consumers' environmental concerns play a role in which labeled produce they purchase, especially with respect to consumers that are egotistic and altruistic. These results will allow for a better understanding of what is driving purchasing and will allow businesses to adopt strategies to be more competitive in the marketplace.

1:15–1:30 PM

Look at What Is Important: Eye-tracking Research on Plant Displays

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Prior research has demonstrated that consumers vary in the value they assign to product attributes. Our study sought to investigate the relationship between product attribute relative importance and visual activity. We photographed plant displays and showed them to 330 volunteer (compensated with \$30) participants at six North American universities or research institutions. Displays were constructed to quantify relative importance for 4 (plant types) x 4 (production practices) x 3 (prices). Visual data was collected with a Tobii X1 Light Eye Tracking device, extracted with Tobii Studio 3.0.2.218, manipulated in Microsoft Excel 2007 and analyzed with Stata 12. The conjoint analysis showed that the model was significant. Moderately priced products (\$2.49) were preferred over both lower and higher priced products, unlike prior studies. Modest price premiums ranging from \$0.04 to \$0.09 were attributed to the non-conventional production practices with the greatest premium for water-saving production practices. We subsequently identified 3 consumer groups (plant focused, production method focused, and price focused). Consistent with the central gaze theory, most consumers looked at (total visit duration) the central sign longest. However, no sign captured as much visual interest (total visit duration) as the plant material. Attention to plant material was 2x to 4x the attention to any one sign. Results can be helpful to professionals, especially retailers, construct more effective plant displays.

Specified Source(s) of Funding: USDA–FSMIP

1:30–1:45 PM

Market Viability of Native Central Texan Plants as a Food Source

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The purpose of this study is to test the consumer willingness to pay rate of a native Texas plant fruit product for the restaurant industry as well as for the consumer market. Farmers' markets and restaurants specializing in either local and/or organic foods were the focus of the market samples. The survey to determine market viability was two-fold: the first part was an intercept survey of farmers' markets in multiple cities where individuals were asked to participate in the survey, and the second part was a lead-user interview survey with restaurateurs in the same cities as the farmers' markets. Five cities all located in the geographic area of Central Texas were included: San Marcos, Austin, New Braunfels, Wimberly, and Bastrop. Approximately 400 responses were gathered from farmers' markets during market days at market locations. Ten surveys of restaurateurs provided more in-depth qualitative data on the value of the product to specialty restaurants. Results indicate whether native plant food products represent a viable horticulture industry.

1:45–2:00 PM

Gender Analysis of Labor and Resources in Greenhouse Vegetable Production in Turkey

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The aim of this study was to identify existing gender roles in greenhouse vegetable production in Turkey. For this purpose, we conducted face-to-face interviews with the owners of 50 vegetable-producing greenhouses to understand the average household structures, activity profiles, information sources, training needs, access to resources, control over resources, and intra-household income stream. Activity profiles reflected the hours per day men and women spent on specific greenhouse production and household tasks. We observed access to and control of production resources for men and women and contrasted the two genders. We also contrasted the intra-household income streams for the two genders. Compared to men, women had higher illiteracy rates and lower levels of education. They also had heavier workloads, the difference resulting from household (reproductive activities) activities that were carried out mainly by women. Women's and men's workloads in the

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greenhouse (productive activities) were almost equal. Women received most agricultural information from neighbors, while men obtained most information from chemical salespeople. Notably, men received some information from the agricultural extension service—women received none. Women also had less access to and control over production resources. Furthermore, the intra-household income streams in the selected households benefited men more than women. The results of this study provide evidence for an unequal social structure and show that efforts should be made to increase women's access to and control of production resources, including information from the extension service.

Specified Source(s) of Funding: Scientific Research Projects Administration Unit of Akdeniz University

2:00–2:15 PM

Economic Potential of Producing Tahiti Limes in Southern Florida in the Presence of Citrus Canker and Greening

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Currently the United States is the largest single country importer of fresh 'Tahiti' limes, absorbing close to 20% of the global trade of limes and lemons in 2009. Of the 365 thousand metric tons of limes consumed in the United States in 2010, imports accounted for about 99%. The vast majority (more than 90%) of the lime import is supplied by Mexico—the world leading producer and exporter of 'Tahiti' limes—with the remainder being sourced from suppliers in Central and South America countries. The overwhelming dependence on imports to satisfy domestic demand for fresh limes was not always the case. As recently as 1990 the United States satisfied more than half of its domestic needs from local production with production occurring in the extreme parts of south Florida (Miami Dade County) and parts of southern California. The noticeable shift in degree of lime self sufficiency is attributed to several factors. Among such factors were increased foreign competition, devastating hurricane and outbreaks of pests and diseases. The latter, considered to be the worse of the three, involved the discovery of two devastating citrus diseases present in Florida, namely citrus canker and citrus greening. Efforts to rid the production areas of citrus canker led to an aggressive program of eradication beginning in 2002 involving the destruction of all citrus trees grown in Miami Dade County and enforcement of regulations prohibited the growing of any citrus trees (commercial or otherwise). Although since 2006 the program has been abolished, after being deemed cost-ineffective, and production restrictions removed, growers have been reluctant to restart

production because of substantial losses they incurred and uncertainty surrounding growing the crop in the presence of the diseases. Given the renewed interest in 'Tahiti' lime production, the aim of this paper is to assess the downside risk involved in producing limes in the southern Florida region in the presence of these two invasive species. To account for the uncertainty associated with the presence of the diseases use is made of stochastic budgeting technique and Monte Carlo simulation involving the modeling of stochastic prices and yields. The investigation is carried out for a hypothetical 5-acre lime orchard in southern Florida. The results suggest that production of 'Tahiti' limes can be profitable if steps are taken to manage the diseases, but contrary to popular view, it might be better to wait until the trees become fully unproductive before replacing them.

2:15–2:30 PM

Commercial Development of an Underutilized Fruit Crop: Purple-Fruited Pitanga (*Eugenia uniflora* L.) – A Case Study

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Thousands of species of plants produce various industrial, edible or medicinal components, but fewer than 80 species yield almost all of the food products available on a commercial scale worldwide. Why is it so difficult to introduce and commercialize other crops? Examination of an ongoing crop development project of purple-fruited pitanga (*Eugenia uniflora* L.) in Hawaii yields some explanations that may aid others in developing new crops in the future. Pitanga is not an entirely new crop. It has been spread throughout the tropics by various means, but it has seen only limited commercialization of the fruits and foliage in its native Brazil. Factors that may have limited further development of pitanga include considerable variation among seedlings and their fruits, difficulty in clonal propagation, lack of recognizably superior cultivars, limited production information, lack of pest and disease control recommendations, difficulty in determining when to harvest the fruits or foliage, lack of postharvest handling information, lack of nutritional content information, lack of marketing, limited development of commercial uses for the fruits and foliage and lack of research funding. Our research project attempts to address

An asterisk (*) following a name indicates the presenting author.

many of these factors as the development and commercialization of the crop moves forward. Comparisons to the recent successful introductions of other fruit crops into the U.S. market are useful.

Specified Source(s) of Funding: Hawai'i Tropical Specialty Fruit Research and Development Grant

Thursday, July 25, 2013 Springs Salon A/B
Produce Quality, Safety, and Health Properties

Moderator: Touria E. Eaton, eaton@umext.umass.edu

1:45–2:00 PM

Mineral Nutrient Density of Cabbage in Response to Cultivar Selection and Nutritional Regimes

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Mineral nutrient deficiency in vegetable-based foods is a substantial concern in human diets. Depleted soil fertility and high-yielding cultivars have been associated with low nutrient contents in vegetables. Research is needed to develop systems that introduce nutrient-dense crops to the markets. This study explored if mineral nutrient densities of cabbage (*Brassica oleracea* var. *capitata*) can be increased through selection of cultivars and nutritional regimes. Nineteen cultivars of cabbage were studied in field experiments. Conventional fertilizer (10–10–10), compost, and an organic fertility regime of soybean meal, bone meal, and potassium sulfate were assessed. Compost was applied at 40 Mg/ha, and chemical or organic fertilizers provided 75 kg N–75 kg P₂O₅–75 kg K₂O/ha. Elements in cabbage heads were determined by plasma spectrophotometry. The organic fertility regime resulted in higher yield (fresh or dry weight) than compost, but lesser yield than chemical fertility regime. Chemical and organic fertility regimes resulted in about 12% higher Mg, 17% higher Cu, and 9% higher Zn than compost fertilization with lower but significant differences occurring among most of the other elements. Differences among individual cultivars for each element were large with

some cultivars having nearly three times the concentrations of nutrients of others and with considerable uniformity in cultivar rankings among the elements. This work suggests that cultivars and nutritional regimes can be selected for production of nutrient-dense cabbage.

Specified Source(s) of Funding: Massachusetts Agricultural Experiment Station

2:00–2:15 PM

Enzyme, Temperature, and Processing Effects on the Percentage of Juice Recovery and Anthocyanin Changes in Blueberries

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A small-scale fruit press (5.5-L Ferrari stainless/aluminum) plus and minus heated mash treatments with two pectinase enzymes was utilized to determine the percentage of juice recovery (%JR) in fresh vs. frozen rabbiteye (RAB) and southern highbush (SHB) blueberries. To determine optimal large-scale juicing protocols, a press sack was produced using a medium-weave polyester mesh (#2636) that was also used in follow-up pilot-scale hydraulic pressing on a Goodnature X-1. All presses were at least triplicated. Lack of gelling and %JR served as the critical processing points of interest. In the Ferrari, 500, 750, and 1,000 g fruit were initially tested using frozen, thawed 'Tifblue' (RAB), not heated, no enzymes, and %JR was 73.1% (± 1.9), 72.7 (± 1.6), and 74.4 (± 0.4 %), respectively. Although numerically indifferent, the 1,000 g presses were easier to press, and delivered the most uniform cakes. Using 1,000 g berries heated to 85 °C marginally increased %JR (76.9 ± 1.1 %). Then, commercial-like mixes of 1,000 g SHB ('Columbus', 'Montgomery') and RAB ('Magnolia', 'Biloxi') were evaluated fresh, frozen, via heated mashes (95 °C for 3 min.) \pm enzymes (AB Enzymes Rohapect 10L and Novozyme Pectinex BE XXL). In fresh SHB pressed at room temperature %JR was low (42.1 ± 4.6 %) due to gelling yet, increased markedly when mash was heated to 95 °C (71.1 ± 1.8 %). RAB and SHB delivered different %JR when pressed after thawing at ambient temperatures (45.9 ± 6.0 % vs. 61.4 ± 7.4 %). Heating markedly improved %JR in both RAB and SHB to 60.8 ± 6.3 % and 68.6 ± 2.6 %, respectively. Adding either enzyme after heating did not significantly improve %JR in RAB or SHB. Heating mashes increased Brix released (about 3° to 4°), and adding enzymes resulted in the highest sugar content in RAB (15.6) and SHB (17.4 °Brix) mixtures, and in 'Tifblue' (14.1). 'Tifblue' fruit (27.5 Kg) was heated in a 40-L steam-jacketed kettle up to 95 °C for 2 min and %JR was 74.0 ± 1.0 %. Raw blueberries, press cakes, and clarified and non-clarified juice samples were analyzed for anthocyanidins. Cyanidin, delphinidin, malvidin, peonidin, and petunidin were recovered in

An asterisk (*) following a name indicates the presenting author.

all processing steps, with the press cake having the highest anthocyanidins, especially cyanidin, while the clarified NFC (not-from-concentrate) pasteurized juice contained the least. The common 15 sugar-anthocyanin conjugates in blueberries were recovered along with several already reported acetyl glucosides, and additional acetyl and coumaroyl glucosides that have not been reported in the literature.

2:15–2:30 PM

Field Based Evaluations of Trace Element Transfer from Contaminated Urban Garden Soils to Vegetables

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Tens of thousands of brownfields can be found in cities, towns, and rural areas across the United States. Our work has focused, in part, on the conversion of brownfields to garden areas and is motivated by the increasing interest in locally produced foods. Challenges of converting brownfields to community gardening sites will be discussed using three urban–community garden sites located in Kansas City, MO; Tacoma, WA; and Indianapolis, IN, as examples. The Kansas City site had mildly elevated levels of lead (Pb); the Tacoma site had mildly elevated levels of Pb and arsenic (As) and the Indianapolis site had elevated levels of polycyclic aromatic hydrocarbons (PAHs), in addition, to mildly elevated levels of Pb and As. Suitable safety/corrective measures were suggested and implemented after thorough evaluation of soil properties. Measures focused on reducing both direct (soil–human) and indirect (soil–plant–human) exposure of Pb, As, and/or PAHs to the gardeners and their children. In addition, field test plots were established within the community gardens, and three vegetable crop types with three very different growth and contaminant uptake patterns were planted. Effectiveness of selected site-specific soil amendments to reduce bioavailability of Pb, As, and/or PAHs was evaluated. Different methodologies will be utilized, throughout the project, to understand the significance of potential soil–plant–human exposure pathway of contaminants while gardening on mildly contaminated sites. Efforts were also made to understand relationships between key soil properties and contaminant bioavailability.

Specified Source(s) of Funding: U.S. Environmental Protection Agency

2:30–2:45 PM

Developing an On-farm Decision Tree for Fresh Produce Growers to Assess Risks and Prioritize Implementation of Food Safety Practices

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Food safety is every growers' responsibility, however, identifying and prioritizing food safety risks on the farm is often difficult. While there are many food safety resources and templates offering guidance on practices to reduce risks, most do not explain how to assess risks or how to prioritize which food safety practices should be put in place first. Not all risks are the same and farm resources are limited. Understanding how to prioritize the implementation of food safety practices that reduce the biggest risks is important to farm viability and safety. In this project, Decision Tree Portfolios were developed to help fruit and vegetable growers assess on-farm risks and write farm food safety plans that guide and prioritize the implementation of Good Agricultural Practices (GAPs). Microbial contamination of fruits and vegetables in the field and packinghouse can come from many sources, such as wild and domestic animals, water, soil amendments, workers, and adjacent land. To address the diversity of risks, ten Decision Tree Portfolios were developed: Worker Health and Hygiene Training; Wildlife and Animal Management; Biological Soil Amendments; Non-biological Soil Amendments; Agricultural Water for Production; Agricultural Water for Postharvest Use; Previous and Adjacent Land Use; Sanitation Practices; Transportation; and Traceability. Each Decision Tree Portfolio contains an overview of the topic, a decision tree for assessing risks, food safety template language, sample standard operating procedures, sample log sheets for recording food safety practices, and references for additional resources. Initial development and review of the Decision Tree Portfolios was guided by an advisory group of growers, extension educators, topic-specific experts, and government personnel. Focus groups were conducted with growers in Minnesota, New York, and Tennessee to evaluate the final Decision Tree Portfolios for usability and functionality. Educational materials will be disseminated through nationwide train-the-trainer workshops for agricultural extension educators as well as through workshops with fruit and vegetable growers, with particular emphasis on small and medium scale growers, including Amish, organic, and direct-to-market growers.

Specified Source(s) of Funding: USDA–NIFSI

An asterisk (*) following a name indicates the presenting author.

2:45–3:00 PM

In Vitro Antioxidant Activities of *Annona squamosa* Leaf and Identification of Bioactives by LC-ESI-MS-Qtof

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Annona squamosa Linn. (Family; Annonaceae) commonly known as custard apple. A bark and root is used to prevent diarrhea and dysentery. A decoction of the leaves is used for cold and also recognized for several medicinal properties. The present study reports the antioxidant potential of various fractions isolated from leaves of custard apple and their chemical constituents were identified by liquid chromatography with high resolution mass spectral analysis. Dried leaf powder was successively extracted with various solvents including hexane, ethyl acetate, acetone, methanol, and water by increasing polarity at 60 to 80 °C. All lyophilized extracts exhibited wide range of free radical scavenging (DPPH and ABTS) activity and antioxidant capacity by phosphomolybdenum method. Acetone extract showed the highest antioxidant activity (73% to 88% at 35 ppm) in DPPH and ABTS methods among tested fractions. The same trend was observed in phosphomolybdenum method. The degree of radical scavenging activity was comparable to total phenolics present in each extract. Further, the acetone fraction was separated on C18 column with gradient mobile phase and analyzed for their active constituents by rapid and high sensitive liquid chromatography-electrospray ionization-quadrupole-time of flight-mass spectrometry (LC-ESI-Q-TOF-MS). We have identified two compounds using accurate mass spectral data as methy armapavine and xylopinine. The results of the present study provide the use of best solvent to isolate antioxidant rich fractions which might provide potential biological properties. Further studies are needed to establish effectiveness of the health benefits in in vivo models. This project is based upon work supported by the USDA–NIFA # 2010-34402-20875 “Designing Foods for Health” through the Vegetable & Fruit Improvement Center.

Specified Source(s) of Funding: USDA-NIFA # 2010-34402-20875

3:00–3:15 PM

Studying Quality Attributes of Grafted Specialty Melons using Both Consumer Sensory Analysis and Instrumental Measurements

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Grafting is an effective approach to controlling soilborne diseases and alleviating abiotic stresses in cucurbits. Previous research revealed mixed results regarding rootstock impacts on fruit quality. However, few studies evaluated fruit quality attributes using both consumer sensory analysis and instrumental measurements. In grafted specialty melon production, the rootstock effect on fruit quality deserves more attention as specialty melons are marketed for outstanding taste and unique fruit flavor. In this field study conducted during the 2012 spring season in Citra, FL, galia melon ‘Arava’ (*Cucumis melo* var. *reticulatus*) and honeydew melon ‘Honey Yellow’ (*C. melo* var. *inodorus*) were grafted onto commercial rootstock ‘Strong Tosa’ (*Cucurbita maxima* x *C. moschata*) (Ar/St and HY/St) and root-knot nematode resistant *Cucumis metulifer* (Ar/Cm and HY/Cm). Ar/St and HY/St were grown in fumigated vs. non-fumigated conventional fields, while Ar/Cm and HY/Cm were grown in organic vs. non-fumigated conventional fields. Non-grafted (NAr and NHY) and self-grafted (Ar/Ar and HY/HY) melons were used as controls. At harvest, eight to ten melon fruit with similar size and ripeness were selected for both consumer sensory analysis and instrumental assessment. Two consumer taste tests (96–100 panelists) were conducted for each melon cultivar at two harvest dates. A 1–9 hedonic scale (1 = dislike extremely, 9 = like extremely) was used in evaluating all the sensory attributes. Regardless of the production systems, Ar/St received significantly lower scores in consumer overall acceptability, flavor, and firmness liking compared to NAr. Reduced total soluble solids (TSS) content and flesh firmness of Ar/St were detected by the instrumental measurements. Grafting with *Cucumis metulifer* significantly decreased consumer overall acceptability and flavor liking for organically grown ‘Arava’ fruit, but the difference between grafted and non-grafted treatments was not detected in melons produced from the non-fumigated conventional field. Interestingly, the instrumental measurements did not show any significant differences in TSS and flesh firmness between Ar/Cm and NAr from either field. However, more consumers detected off-flavor in Ar/Cm than in NAr. Across different production systems, few differences were detected from the instrumental assessment between non-grafted and self-grafted ‘Arava’ fruit, whereas inconsistent results were observed in the consumer sensory analysis. Different from ‘Arava’, grafting did not exhibit any significant effect on TSS, flesh firmness, and consumer perceived sensory attributes of ‘Honey Yellow’ melons. The influence of scion-rootstock interactions on fruit quality in relation to consumer perceived sensory properties of grafted melons deserves more comprehensive studies.

Specified Source(s) of Funding: SARE

An asterisk (*) following a name indicates the presenting author.

3:15–3:30 PM

High Throughput Screening of Pyruvic Acid in Onions using Microplate Reader

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Onions are valued for their distinctive flavor and recognized for their potential health benefits. Pungency of onions is a major criterion for economic remuneration and it can be quantified by measuring the enzymatically produced pyruvic acid. The pyruvic acid content is significantly influenced by the variety, location, and their interaction with the environment. Approximately, 80% of the total variation is caused is due to genetic differences in the onions. This is a major problem to the cultivators in maintaining the produce quality of mild onions. Therefore, accurate measurement of pyruvic acid is critical. In the present study, a rapid colorimetric method using automated microplate reader was developed to determine pyruvic acid in onions. In brief, onion samples were treated with 2,4-dinitrophenylhydrazine followed by potassium hydroxide (KOH) to produce a colored adduct. The absorbance of the colored complex was read at λ 485 nm using a micro plate reader. KOH enhanced the stability of the colored complex up to two hours. The developed method is simple, robust, economical and reproducible for routine determination of pungency in large number of onions. The method can be applied to determine the level of pyruvic acid content in different onion cultivars. This project is based upon work supported by the USDA–NIFA # 2010-34402-20875 “Designing Foods for Health” through the Vegetable & Fruit Improvement Center, Texas.

Specified Source(s) of Funding: This project is based upon work supported by the USDA–NIFA# 2010-34402-20875 “Designing Foods for Health” through the Vegetable & Fruit Improvement Center-TX

3:30–3:45 PM

Electron Beam Irradiation of Fresh Cut Cantaloupe under Modified Atmosphere Extends the Shelf Life and Maintains the Quality

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Maintaining the postharvest quality (including health promoting properties) of fresh cut cantaloupes is essential for both the consumers and the produce industry. Fresh cut cantaloupe fruits were packed in ambient, modified atmosphere (MA) and treated with or without low doses of electron beam irradiation (0.82 kGy). The treated cut fruits were analyzed for quality parameters including titratable acidity, color, Brix, sugar content, and microbial bio-burden at periodic intervals during storage at 4 °C. Modified atmosphere and e-beam irradiation treatments had a significant effect on the quality of fruits during the storage period. Sugars (glucose and fructose) were significantly higher in e-beam treated fruit packed under MA than the untreated fruit packed under ambient conditions. No significant variation in the color and titratable acidity were observed during storage. However, low dose e-beam treatment of fresh-cut cantaloupe reduced the microbial load (by 1–2 logs) compared to the control samples. When MA was coupled with e-beam treatment, the cut fruit maintained a lower microbial load for over 8 days compared to the irradiated samples in ambient conditions. E-beam treatment and MA together showed the greatest potential to reduce bio-burden and extend shelf life of fresh-cut cantaloupe without affecting quality. This project is based upon work supported by the USDA–NIFA # 2010-34402-20875 “Designing Foods for Health” through the Vegetable & Fruit Improvement Center, Texas.

Specified Source(s) of Funding: This project is based upon work supported by the USDA–NIFA# 2010-34402-20875 “Designing Foods for Health” through the Vegetable & Fruit Improvement Center-TX.

3:45–4:00 PM

Microgreens: Assessment of Nutrient Concentrations

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Microgreens (seedlings of green vegetables and herbs) are gaining in popularity as a new culinary ingredient, providing intense flavors, vivid colors, and crisp texture when added to salads and other food preparations. Although microgreens would inherently be regarded as a healthy addition to the diet, no information is available on their nutritional content. The present study determined the concentrations of essential vitamins or provitamins A, C, E, and K1 in 25 commercially available microgreens. Results showed that different microgreens provide widely varying amounts of the four vitamins, but regardless they generally have significantly higher concentrations of these phytonutrients in comparison with mature leaves from the same plant species. These phytonutrient data provide the first scientific basis for evaluating nutritional benefits of microgreens and, when included in the USDA food composition database, can be used by health agencies and consumers to make educated choices about inclusion of microgreens as part of a healthy diet.

Thursday, July 25, 2013 Desert Salon 4-6

Vegetable Crops Management

Moderator: Derek D. Woolard, derek.woolard@valent.com

2:15–2:30 PM

Growth Control of Leafy Vegetables with S-Abscisic Acid (S-ABA) for Improved Quality and Harvest Management

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Consumption and therefore production of leafy green vegetables and salad mixes has been increasingly popular. Grower price of leafy vegetables, e.g., spinach, for fresh consumption is primarily determined by leaf size. Higher commercial value is associated with smaller leaf size (< 3 inches), known as baby leaf. Larger leaf size is of reduced commercial value and prone to mechanical injury. Optimum harvest time is very narrow in leafy vegetables due to their fast growth (23–38 day production cycle). Warm/hot growing temperatures that is characteristic of the major growing areas of the United States (i.e., California, Arizona) often speeds up maturity to faster than planned. There is a strong need to hold leaf size for several days to keep value (i.e., in baby leaf stage) and time harvest. Recently, S-ABA has been proven to effectively control leaf growth and keep leaf size of spinach at high commercial value level for 3–5 days, without side effects. There is an excellent crop safety with other leafy green vegetables with spray applications of S-ABA up to 2,000 ppm concentration (e.g., red leaf lettuce, baby green Romaine, Lolla rosa, mizuna, tango, beet tops, Swiss chard, and parsley). This study gives a detailed report on the potentials of S-ABA use in leafy green vegetables from a series of field trials conducted under commercial production conditions. S-ABA, that has just recently received federal registration, may become an important tool for leafy green vegetable producers to control leaf size, time harvest and ultimately improve grower profitability.

2:30–2:45 PM

Downy Mildew of Basil in Illinois: Occurrence and Management

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Downy mildew of basil, caused by *Peronospora belbahrii*, was first diagnosed in Illinois in 2009. Since then, this disease has occurred in Illinois every year. *P. belbahrii* infects leaves, rapidly multiplies and spreads, and can cause total crop loss. Infection of basil by *P. belbahrii* in Illinois can occur from late April until about the middle of October, but it is more common during August–October. Trials were conducted during 2009–12

An asterisk (*) following a name indicates the presenting author.

in commercial basil fields near Momence (Kankakee County, IL) to evaluate efficacy of 14 fungicides for conventional production and eight compounds for organic productions of vegetables for control of downy mildew of basil. The plots were sprayed using 60 gallons of water/A at a weekly schedule. None of the compounds for organic production provided effective control of downy mildew in basil plots. In contrast, most of the fungicides applied, either alone, combined together, or combined with spreader-sticker Induce 90 (0.125% at v:v) provided effective control of downy mildew. The most effective fungicides were: chlorothalonil (Bravo Weather Stik 6F, 2 pt/A); dimethomorph (Forum 4.16SC, 6 fl oz/A); mancozeb + zoxamide (Gavel 75DF, 2 lb/A); fluopicolide (Presidio 4SC, 4 fl oz/A); azoxystrobin (Quadris 2.08SC, 15.5 fl oz/A); cyazofamid (Ranman 400SC, 2.75 fl oz/A); mandipropamid (Revus 2.09SC, 8 fl oz/A); famoxadone + cymoxanil (Tanos 50DWG, 10 oz/A), ametoctradin + dimethomorph (Zampro 525SC, 14 fl oz/A), experimental fungicide-I (38.6 fl oz/A); and experimental fungicide-II (38.6 fl oz/A). The severity of downy mildew in the plots that received any of above-mentioned fungicides combined with phosphonate (ProPhyt 4L, 3 pt/A) and Induce 90 did not exceed 5%; while the severity of the disease in control plots and plots that received compounds for organic production was 85% and greater than 75%, respectively. Currently, basil growers in Illinois apply Quadris plus ProPhyt alternated with Ranman plus ProPhyt alternated with Revus plus ProPhyt under special permit of section 18.

2:45–3:00 PM

Growth, Yield, Fruit Quality, and Verticillium Wilt Tolerance of Grafted Watermelon and Tomato in Field Production in the Pacific Northwest

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Growth, yield, fruit quality, and potential tolerance to Verticillium wilt were compared among non-grafted, self-grafted, and grafted triploid watermelon ‘Crisp’n Sweet’, and heirloom tomato ‘Cherokee Purple’. Watermelon rootstocks were bottle gourd and ‘Strong Tosa’ while tomato rootstocks were ‘Beaufort’ and ‘Maxifort’. Field trials were carried out in 2010 and 2011 at Hermiston and Eltopia (eastern Oregon and Washington, respectively), and Mount Vernon (western Washington). At Mount Vernon, watermelon grafted onto ‘Emphasis’ and ‘Strong Tosa’ had significantly larger stem diameter than non-grafted and self-grafted plants both years, while there were no

differences at Hermiston or Eltopia. In 2011, ‘Cherokee Purple’ tomato grafted onto ‘Beaufort’ and ‘Maxifort’ had significantly larger stem diameter than non-grafted and self-grafted tomato at Eltopia and Mount Vernon, and ‘Beaufort’-grafted plants were significantly taller than other treatment plants at Mount Vernon. Grafting did not impact watermelon or tomato fruit yield or quality at any location either year. Foliar symptoms of Verticillium wilt were not observed on ‘Crisp’n Sweet’ watermelon at the Columbia Basin locations either year, however at Mount Vernon, ‘Emphasis’ and ‘Strong Tosa’-grafted watermelon had significantly lower Verticillium wilt severity than non-grafted and self-grafted watermelon both years. Microsclerotia were observed in all recovered watermelon stems sampled at Eltopia and Mount Vernon. *V. dahliae* was isolated from non-grafted and ‘Emphasis’-grafted ‘Crisp’n Sweet’ stems at Eltopia, and non-grafted, self-grafted, and ‘Strong Tosa’-grafted stems at Mount Vernon. Foliar symptoms of Verticillium wilt and microsclerotia in stems were not observed on ‘Cherokee Purple’ tomato at either location both years.

Specified Source(s) of Funding: WSU CSANR, ORFR, WSCPR, NARF, WSU Dept. of Horticulture

3:15–3:30 PM

Efficient Intercropping for Biological Control of Aphids in Organic Lettuce

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Organic lettuce growers in California typically use insectary strips of alyssum [*Lobularia maritima* (L.) Desv.] to attract hoverflies (Syrphidae) that provide biological control of aphids. A two-year study with transplanted organic romaine lettuce in Salinas, CA, investigated agronomic aspects of lettuce monoculture and lettuce-alyssum strip intercropping on beds in replacement intercropping treatments where alyssum transplants replaced 2% to 8% of the lettuce transplants, and in additive intercropping treatments where alyssum transplants were added to the standard lettuce density without displacing lettuce transplants. Alyssum and lettuce dry matter were determined at lettuce maturity. Alyssum transplants produced less shoot dry matter in the additive than in the replacement intercropping treatments. The number of open inflorescences of alyssum increased with alyssum DM, and among treatments ranged from 2 to 15 inflorescences per lettuce head. Compared to monoculture lettuce, lettuce heads on intercropped beds were slightly smaller and had with lower nitrogen concentration in the both additive treatments and in some replacement treatments. This research provides the first information on a novel additive intercropping approach to provide alyssum floral resources for biological control of lettuce aphids, and suggests that this approach may be more land-efficient, particularly for producing slightly smaller lettuce heads for romaine hearts or for local markets with less strict size requirements. Additional research is needed to determine if the increased competition between alyssum and lettuce in additive intercropping would reduce lettuce yields for wholesale

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markets with larger head size requirements. Practical aspects of implementing the various intercropping arrangements and alternatives will be discussed.

3:30–3:45 PM

Intercropping to Mitigate Salinity Stress on Watermelon: Halophyte Performance in a Greenhouse Pot Study

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Increased continuous irrigation due to drought conditions and above average temperatures, and resulting salt buildup in soils, can lead to a decline in yields in salt-sensitive species such as watermelon. This greenhouse investigation is phase one of a two-phase study aimed at assessing the potential benefits of utilizing halophytic species as companion crops to watermelon in salt-affected soils. From this initial screening, two species will be selected for intercropping with watermelon in a field setting. Based on a set of criteria, the six species chosen for this screening were four-wing saltbush (*Atriplex halimus*), barley (*Hordeum vulgare*), garden orache (*Atriplex hortensis*), purslane (*Portulaca oleracea*), saltwort (*Suaeda salsa*), and wheat (*Triticum aestivum*). Treatments of 0, 3, and 6 dS/m irrigation water were applied to plants over a 5-week period and plant species were replicated 5 times within each treatment level in a randomized complete-block design. Preliminary results from soil bulk electrical conductivity averaged over the entire 5-week period indicate that barley had the lowest soil EC in the 3dS/m treatment level at 0.30 dS/m followed by garden orache, wheat, and four-wing saltbush (0.41, 0.43, and 0.47 dS/m, respectively). In the 6 dS/m treatment level, garden orache had the lowest soil EC at 0.55 dS/m followed by wheat, four-wing saltbush, and barley (0.61, 0.67, and 0.69 dS/m, respectively). Purslane and saltwort consistently had the highest soil bulk EC at both salt treatment levels (0.71 and 0.65 dS/m at 3dS/m, and 0.90 and 0.83 dS/m at 6 dS/m, respectively) and, therefore, may not be taking up and accumulating as much salt as the other species. Plant growth data indicate garden orache was unaffected by salt treatments. It had the highest average absolute growth rate of all 6 species and was the only species to exhibit significantly higher absolute growth when treated with salt when compared to no salt treatment. These preliminary results suggest wheat, barley, four-wing saltbush, and garden orache, in particular, may be well-suited as companion plants to watermelon. Due to its slow growth rate, however, four-wing saltbush may not be practical for use in a field production setting. Plant tissue analysis of Na⁺ and Cl⁻ accumulation as well as total root and

shoot biomass will further help us determine which species we will select for phase two of our study.

Specified Source(s) of Funding: Texas Department of Agriculture: Specialty Crop Block Grant Program

Thursday, July 25, 2013 Desert Salon 13-14

Human Issues in Horticulture

Moderator: Candice Shoemaker, cshoemak@ksu.edu

2:15–2:30 PM

People's Psychophysiological Responses to Tropical Urban Tree Pruning in Hawaii

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Plants are a vital component of the social and economic health of our cities. Previous studies have shown how plants and natural landscapes can have significant impacts on people's attitudes as well as physiological states. Through this study, the visual stimuli shown to participants focus specifically on trees in the Hawaiian landscape that are subjected to proper and improper pruning practices. Results obtained from analysis of physiological measures recorded (ECG, GSR, EMG, and EEG) indicate clear trends in peoples' psychophysiological, cognitive and emotional responses.

Specified Source(s) of Funding: Kaulunani Urban & Community Forestry Program

2:30–2:45 PM

Exercise Intensities of Gardening Tasks as a Physical Activity in Children and Adults by using Mets

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For health benefits, the Centers for Disease Control and Prevention and the American College of Sports Medicine suggested physical activity recommendation based on many research evidences. In adults, at least 30 min of moderate intensity physical activity and at least 60 min of moderate to high intensity physical activity for children on the most days of the week are recommended. To utilize gardening as a physical activity for health benefits, there is limited information regarding metabolic equivalents for various gardening tasks especially in children and adults. Therefore, this study was to investigate the metabolic costs of 10 gardening tasks in children and adults. Fifteen Korean children aged 13 to 14 years and 15 Korean adults in the twenties in the community of Cheongju, South Korea were volunteered in this study. All participants were conducted a total of 10 gardening tasks such as digging, raking, hand weeding, mulching, transplanting plants, harvesting, watering, etc. in a community garden, Cheongju, South Korea that was previously prepared for this study. A 5-min for each gardening task and a 5-min for resting time between each activity were provided. The participants wore a portable calorimetric monitoring system (Cosmed K4b2) with radiotelemetry (Polar T 31) to measure oxygen uptake and heart rate. As the results, the gardening tasks performed by the children and adults in this study were moderate to high intensity physical activities. Gardening program with moderate to high intensity can be expected to lead the same health benefits from other types of typical physical activities in children and adults.

2:45–3:00 PM

School Gardening Program for Improving Social Relations of Elementary School Students

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In our lifetime, we establish various relationships with different people from different groups. Building and maintaining desirable social relations is a key to living a happy life. In the case of senior elementary students, amicable peer relationships help them to fulfill developmental goals such as socialization. However, if they are rejected by their peers, it could lead to serious maladaptive problems. Thus, in this study, we will assess the effectiveness of school gardening program (from sowing to harvesting) for promoting social relations among

elementary students in the fifth and sixth grades. The sample used for this study included fifth and sixth grade students from 4 elementary schools in Wonju, which have similar environmental conditions. The experimental group consisted of 123 students (62 boys, 61 girls), four 5th and 6th grade classes. The control group included 123 students (boy 62, girl 61), four 5th and 6th grade classes. This gardening program included activities from sowing through harvesting and was designed to develop peer status, peer relationships and sociality. The program was embedded in the school curriculum and included 90 minutes per week for 10-week, from April 16 through June 25. Classrooms and outside school garden (about 70 m²) were used for the program. The treatment students were divided into groups (5 to 6 members) by pre-peer status. Results were analyzed using SPSS 19.0. ANCOVA (Analysis of covariance) was conducted to test difference of sociality scale, peer relation scale between the experimental and control groups. Frequency analysis was used for peer status scale. Firstly, the school gardening program brought about meaningful differences in both durability of friendship ($P < 0.039$) and adaptability between friends ($P < 0.029$), subfactors of peer relationship, of the experimental group. Secondly, there was significant improvement in sociality ($P < 0.000$), especially in law-abiding ($P < 0.000$), collaboration ($P < 0.000$), subcategories of sociality. With regard to peer status, in the experimental group the number of popular children increased while the number of neglected and rejected children decreased. In contrast, in the control group, the number of neglected and rejected children increased while the number of popular children decreased. In conclusion, school gardening programs for promoting social relations among elementary students give a positive influence on peer relationship, sociality, and peer status. Implementing and expanding a garden program at school will effectively contribute to developing social relationship of the elementary school students.

3:00–3:15 PM

An Evaluation of the Fayetteville School Landscape Project

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Contemporary children's gardening began in 1993 when the American Horticultural Society held its first symposium based on youth gardening entitled "Children, Plants, and Gardens: Educational Opportunities" (Sealy, 2001). Since that symposium,

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thousands of school gardens have appeared across the country (Robinson-O'Brien and Story, 2009). Two such examples are "The Edible Schoolyard Project", in Berkley, California and the "Growing Up Green Charter School" in Long Island City, NY. Benefits that have been reported include increases in teamwork, improved nutrition and environmental attitudes, and respect, both for self and others (Edible, 2010; Growing Up Green, 2009). While school gardens are generally accepted as beneficial, few peer-reviewed studies have been conducted to examine school garden programs (Ozer, 2007; Robinson-O'Brien and Story, 2009). Since January 2009, Fayetteville School (FHS)—a K–12 school in Fayetteville, AL—has been involved in a landscape project that has transformed the school's campus. So far, an expansive children's garden and over 400 trees and shrubs have been installed. Many of Fayetteville's community, staff and students have been involved in the project, with each of Fayetteville's 650 students having the opportunity to be a part of planting, while many have been much more involved. This study evaluated the landscape project using a case study method. Semi-structured interviews lasting 30–60 minutes were conducted with 14 faculty and staff at Fayetteville School. Several themes were observed including an overall positive view of the project, an increase in school pride, and an increase in use of the school grounds for both recreation and education. Challenges reported included lack of time to maintain the grounds and a lack of time to incorporate the grounds into school lessons. These results may offer the school insight into ways they can improve the ongoing landscape project. They may also benefit other schools hoping to implement a similar project, as these other schools can learn from the successes and struggles of the landscape project at Fayetteville.

3:15–3:30 PM

Can Locally-grown Crops Replace Nonfat Dry Milk in Ready-to-Use-Therapeutic Foods? Innovative Malnutrition Solutions for Haiti

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Ready to use therapeutic foods (RUTFs) are employed when individuals reach levels of malnourishment that are immediately

life-threatening or that undermine long-term quality of life. RUTF formulation, preparation, distribution, and administration is complex, technically demanding, and input specific. It can also engage horticulturists operating in multidisciplinary, outcome-oriented teams. Nourimanba—effective but expensive—has been prepared, distributed and administered by Abbott Nutrition and its partners in Haiti. Nonfat dry milk (NFDM) is the most expensive of the four ingredients in Nourimanba and it is imported. At Abbott Nutrition's invitation, this team set out to identify a crop-based alternative to NFDM that can be grown in or near Haiti's Central Plateau. Our specific objectives were: 1) identify candidate crops with a composition profile that may qualify them for use in a re-formulated Nourimanba; 2) identify a smaller subset of candidate crops that also appear to be adapted to the production conditions of Haiti's Central Plateau; and 3) estimate the amount of acreage required to produce one or more candidate-adapted crops in quantities allowing for a substantial reduction in NFDM use and related increases in Haitian farm-based income opportunities. Objectives one and two were met by employing research-based data in a two-stage screening process. First, the universe of available crops (nearly 7000 as listed in the USDA Nutrient Data Laboratory nutritional database) was narrowed to twenty candidate raw crops calculated to possess a weighted, unit-less, four-component "formulation potential index" value equal to or greater than NFDM. Next, consulting authoritative texts and reference information and employing information therein in calculating a weighted, unitless, seven-component "crop potential index" revealed that four crops (teff, chickpea, sesame, and winged bean) may be most adapted to production conditions common to Haiti's Central Plateau. Finally, consulting publically available, coded satellite images and references regarding land use patterns in areas near an existing Nourimanba manufacturing facility and assuming certain levels of crop use (NFDM replacement) and yield suggested that land availability near the facility is unlikely to limit efforts to develop a lower-cost and locally-enriching reformulated version of Nourimanba.

Specified Source(s) of Funding: Abbott Nutrition and The Ohio State University

3:30–3:45 PM

Career Exploration of Horticultural Therapy Professionals

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The profession of Horticultural Therapy (HT) in the United States is considered an emerging profession yet one can find historical reference to the use of gardening and farming in health care in the early days of our country. Limited research has been reported on the profession, including studies

An asterisk (*) following a name indicates the presenting author.

on the characteristics and HT professional aptitudes. The purpose of this study was to investigate the current conditions of the HT profession including demographic characteristics, employment, education, certification procedure, job satisfaction, and career aptitude. The target population was the membership of the American Horticultural Therapy Association (AHTA). The membership was surveyed through an online questionnaire which was available from October to December 2012 via Axio Survey. An email was sent to all members with an email address (n = 584, 30 members did not have an email on record with AHTA and were not included in this study) that explained the survey and provided a direct link to the online questionnaire. The questionnaire included items from earlier studies on the profession and adapted questions from studies in other allied therapies. A total of 238 completed the survey for a 40% response rate. The demographics are similar to earlier studies with the majority being married (64%) females (81%), over 50 years of age (60%) and white (94%). The majority of the respondents graduated college (84%) with 12% reported their highest level of education being an associate's degree, 39% earning a bachelor's degree and 36% earning a Master's degree. Most respondents had been a member of AHTA for 10 years or less (71%), with 37% of those being members less than 5 years. Twelve percent of respondents had been members for more than 20 years. AHTA offers a voluntary professional registration program based on academic requirements and professional training. Sixty percent of respondents indicated they were professionally registered through AHTA, 27% had been registered for less than 5 years, 35% had been registered for 5–10 years, and 16% had been registered for more than 20 years. The respondents' view of employment conditions was that jobs are not easy to find, there are few jobs, and pay is not comparable to peer professionals. The respondents indicated that the profession needed a competency-based certification and certification testing procedures. The results of this study are more similar than different from earlier studies thus many of the needs in establishing the profession have yet to be met.

3:45–4:00 PM

Integrating Schools, Community, and Family to Effect Sedentary Behavior, Fruit and Vegetable Consumption and Physical Activity through Gardening

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This project tested the feasibility of using a school garden to integrate youth, community, and family to promote healthy lifestyle choices for overweight prevention. There were several components to this project. We 1) developed and tested a theory-based after-school gardening program that promoted healthy lifestyle choices through targeting fruit and vegetable consumption, physical activity, and gardening behaviors, self-efficacy, and proxy-efficacy; 2) developed and evaluated a volunteer program to build community support for the after-school garden program and for garden maintenance; 3) built high tunnels and established school gardens for year-round food production; 4) developed biweekly family guides linked to the after-school gardening program to improve healthy lifestyle choices at home; 5) developed monthly volunteer guides to foster community development; and 6) developed an assessment for self-efficacy and barriers to self-efficacy for gardening. The after-school gardening intervention targeted 4th and 5th grade children attending schools in a Kansas school district and their parents. Participation in the program was compared pre- and post- program through youth surveys, parent surveys, volunteer surveys, and interviews of youth, school administrators, and volunteers. The after-school gardening program succeeded in increasing gardening time of the children, gardening self-efficacy and gardening barrier self-efficacy compared to children attending control sites. Parents of children attending garden club increased in gardening social support after intervention compared to control sites. Although we were able to see differences in gardening behavior and self-efficacy, we did not see changes in the healthy lifestyle choices also targeted in the intervention. We theorized that through gardening children would increase their physical activity, reduce their sedentary behavior, and increase their fruit and vegetable consumption. We saw no differences in physical activity behavior and fruit and vegetable consumption of children attending garden club compared to control sites and saw an increase in sedentary behavior of children attending garden club. Accelerometer data from after-school hours indicated that moderate to vigorous physical activity (MVPA) was significantly higher during garden club than non-garden club after-school hours and that children obtained about 30 minutes of MVPA during garden club and about 15 minutes MVPA on non-garden club after-school hours. Additionally, children participating in garden club were more physically active and less sedentary on garden club days than non-garden club days. Results demonstrate that an after-school gardening club can serve as a venue for obtaining MVPA, particularly for youth that may not participate in other forms of physical activity.

Specified Source(s) of Funding: USDA–NRI

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Thursday, July 25, 2013 Desert Salon 9-10

Pomology

Moderator: Clive Kaiser, clive.kaiser@oregonstate.edu

2:15–2:30 PM

Impacts and Outcomes of Integrated Pest Management Extension Programs in Umatilla County, Oregon

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Umatilla County is the breadbasket of Oregon generating the most revenue from specialty crops and commodity agriculture out of all the counties in Oregon. The fruit industries of the Walla Walla Valley in northern Umatilla County generate more than \$85 million per year. Codling moth, apple maggot, and cherry fruit fly are major quarantine obstacles to national and international exports. In 2004, the “third strike” for codling moth in Taiwan came from fruit produced in the Milton–Freewater area. This shut down the entire United States apple market prematurely and cost the Pacific Northwest more than \$26 million in lost revenue in the form of foreign exchange. Extension programs in the Walla Walla Valley have aimed at monitoring for key pests while preventing the introduction of new ones. Daily reporting of pest counts together with interactive real time mapping of the traps with current and historical counts have proven to be invaluable tools for helping growers eliminate and reduce “hotspots” in the Valley. Control programs have focused on best management practices, using softer chemistries and collaborating with other non-profit agencies to reduce toxic levels in the rivers and streams. Indeed, maximum in-stream concentrations of an insecticide of concern for water quality have been reduced by over 90% from 2006. Similar significant reductions in stream concentrations of an herbicide used in orchard areas were observed in 2012 as a result of recent collaborative efforts in the Valley. In addition, total insecticide applications have been reduced from 10,045 kg in 2007 to 2,745 kg in 2010 and are being maintained at these low levels.

2:30–2:45 PM

Ratio of Carbon to Nitrogen in Peach and Susceptibility to Peach Tree Short Life

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Peach Tree Short Life (PTSL) is a disease syndrome in the southeastern United States that often is characterized by tree death from bacterial canker (*Pseudomonas syringae* pv. *syringae*). This bacterium produces a syringomycin toxin that kills plant tissue. Gene expression of this toxin is influenced by tissue nitrogen content. Previous studies indicated that a high C/N ratio favored bacterial canker development in peach. Adjacent healthy and diseased pairs of trees with multiple replicates from six different cultivars on six PTSL sites in South Carolina were sampled in early April 2011 and 2012 (three orchards each year). Live, healthy cambial tissue was removed from scaffolds of both healthy and diseased trees (bacterial canker symptoms). Percentages of carbon and nitrogen in the tissue were analyzed. Nitrogen content of healthy cambium was significantly higher in diseased trees at four of the orchards. The C/N ratios were also significantly lower in diseased trees at these same four sites. These results did not confirm previous research. Timing of sampling, tissue type or cultural practices may be the reason for contrasting results. Additional data on rootstocks and time of sampling will be discussed.

2:45–3:00 PM

Impact of Nitrogen on Vegetative Growth of Mature Peach Trees in a Subtropical Climate

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The Florida peach industry has rebounded from devastating freezes in the 1980s with increasing production and acreage. As the main production area shifts into southern areas with a subtropical climate, fertilization regimes developed in temperate climates may not fulfill the nutritional demand of trees planted in these new production areas with extended vegetative growth periods after harvest. The objective of this research was to examine the effect of different nitrogen rates on peach tree growth in a subtropical climate to determine the optimal rate of nitrogen. Four rates of nitrogen (N) plus a control (N at 0 kg·ha⁻¹) were applied to six-year-old ‘TropicBeauty’ peaches budded onto ‘Flordaguard’ rootstock in Citra, FL and included: 45 kg·ha⁻¹, 90 kg·ha⁻¹, 179 kg·ha⁻¹, and 269 kg·ha⁻¹ annually during the 2011 and 2012 growing season. Vegetative growth

An asterisk (*) following a name indicates the presenting author.

measurements included trunk cross-sectional area (TCSA), vegetative and floral bud distribution on 1-year-old growth, pruning weights, total leaf nitrogen content (%), and chlorophyll content. The TCSA measurements revealed no differences, however; trees in treatments with 0, 45, and 90 kg·ha⁻¹ tended to be smaller than those receiving 179 and 269 kg·ha⁻¹ annually. Trees with 0 and 45 kg·ha⁻¹ produced lower tended to have lower pruning weights; however, there were no statistical differences after two years. Vegetative and floral buds were fewer in the low nitrogen rates (0 and 45 kg·ha⁻¹) with high numbers of blind nodes present in all treatments. Total leaf nitrogen (%) was lower in the 0 and 45 kg·ha⁻¹ treatments (3.7%) than the highest two N treatments (4.1%). These results indicate that although trees in the lowest N treatments contained seemingly adequate amounts of nitrogen, decreasing vegetative and floral buds over subsequent years may lead to smaller trees with reduced yield, while trees with higher rates of N produced more blind nodes, requiring more severe pruning to maintain productivity.

Specified Source(s) of Funding: Florida Department of Agriculture and Consumer Services

3:00–3:15 PM

Fruit Development Alters the Vegetative and Reproductive Shoot Growth in ‘Hass’ Avocado (*Persea americana*, Mill.)

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Avocado, specifically the Hass cultivar, is known for its alternate bearing tendency. This study focused on examining alternate bearing at the single shoot level, across seasons and considering vegetative and reproductive growth. Four-year old ‘Hass’ avocado trees grafted onto ‘Duke 7’ clonal rootstock in a commercial avocado grove in De Luz, CA, were selected by similar size and bloom intensity. Individual shoots (N = 260) were tagged and followed for 3 years (2010–12) after dividing the trees into two groups (N = 8 per treatment). Trees in the first group (“thinned”) had all inflorescences manually removed from the tree during the 2010 flowering period. The second group of trees served as a control and were allowed to flower and set fruit without intervention. There was a clear difference between the “thinned” and the control group where the former exhibited longer shoots and higher bloom intensities than the latter. Furthermore, we observed that there were very few shoots which set fruit in consecutive years (0.1%). This indicates that alternate bearing in ‘Hass’ avocado occurs at the shoot level rather than on a whole tree level. We also observed a similar pattern of reduction in shoot length and bloom intensity when shoots did not bear any fruit for two consecutive seasons

regardless of treatment. The significance of these results on alternate bearing patterns in ‘Hass’ avocado will be discussed.

3:15–3:30 PM

Cutting Type and Time-of-Year Affect Rooting Ability of Hardy Minnesota *Prunus*

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All species and cultivars within the genus *Prunus* are difficult to root. Thus, most cultivated accessions are grafted for propagule increase. The University of Minnesota *Prunus* germplasm and cultivar releases include a variety of ornamental and edible types that have received little research focus. Many accessions have never been evaluated for their ability to root, even though at least one sour cherry, *P. cerasus* ‘Northstar’, is not grafted and sold on its own rootstock. Two experiments were conducted to evaluate if cutting position, time of year, or auxin treatment were important for terminal and basal softwood-semi-hardwood rooting success of: I) *P. xcistena* (control); *P. armeniaca* ‘Westcot’, ‘Hardygold’; *P. cerasus* ‘Northstar’, ‘Meteor’; *P. domestica* ‘Superior’, *P. spp.* ‘Alderman’ treated with 1000 or 4000 ppm K-IBA for 10 seconds and II) *P. xcistena* (control) and *P. spp.* ‘Alderman’ treated with 80 ppm each of K-IBA and ICapA (Indole-3-caprioc acid) for 20 hr basal soak. Cuttings were taken biweekly (June 5 to September 11, 2012) and then monthly until Dec. 4, 2012. Cuttings were scored for callus formation, root development, and bud break (leaves, flowering). The highest frequency of rooting occurred in June and again in October–December for *P. xcistena* and July, September–October for *P. armeniaca* ‘Westcot’. All other cultivars had very low rooting. Yield potential of transplantable seedlings ranged from 1.14% (*P. spp.* ‘Alderman’) to 24.09% (*P. armeniaca* ‘Westcot’) and 40.23% (*P. xcistena*).

3:30–3:45 PM

Developmental Sensitivity of European Pear and Sweet Cherry Floral Buds to Sub-zero Temperatures from Late Dormancy through Petal Fall

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Late winter and early spring freeze events can have devastating impacts on tree fruit production. Our primary objective was to determine the critical temperatures resulting in 10%, 50%, and 90% reproductive bud mortality at distinct phenology stages of sweet cherry and European pear cultivars from late dormancy through anthesis. A secondary objective was to phenotype the variability in reproductive bud development throughout this period. Samples were collected from two sites, weekly, beginning in mid-January through petal fall on commercially important cultivars of sweet cherry ['Sweetheart', 'Skeena', 'Regina' and 'Bing' (standard)] and European pear ['Bosc', 'd'Anjou', 'Starkrimson', and 'Bartlett' (standard)]. All buds were frozen at 1 °C per hour. Ice nucleation temperatures of sweet cherry floral buds were detected by a high-throughput differential thermal analysis (DTA) system between dormancy and first swelling (earliest visible stage of bud development). Subsequent to bud swelling, DTA lost the capacity to accurately detect individual flower exotherms; therefore, bud hardness of advanced phenology stages was based on the visible presence or absence of oxidative browning following freezing. Ice nucleation events within dormant and transitioning pear buds were not detectable during freezing. We experimentally established that water migration from buds, presumably to extracellular ice, was the cause of this; hence, microscopy was used to assess pear flower bud hardness throughout the entire developmental period. Anthers and pistils of both cherry and pear flowers were rated separately. The relationship between temperature and bud survival was explained by a sigmoidal function. DTA and visual assessment data were well-aligned during late dormancy and bud swell. In fact, data suggest that DTA may be useful for detecting growth resumption and/or increased metabolism prior to visible changes in physical properties of reproductive cherry buds. Significant differences in hardness among cultivars were evident between late dormancy and Stage 3 of development; general hardness ranking in cherry was 'Regina' >> 'Skeena' > 'Sweetheart' ≥ 'Bing'; and, for pear 'Bosc' >> 'd'Anjou' > 'Bartlett' ≥ 'Starkrimson'. These genotypic effects were largely attributed to early developmental differences among cultivars, and were reduced or disappeared entirely with advancing bud development. Variability in bud stage was more pronounced in cherry than pear. Given the significant differences among bud stages for critical temperatures, combining a frequency distribution of bud stages with their respective critical temperatures provided a comprehensive analysis of freeze susceptibility and potential crop loss on an orchard scale.

3:45– 4:00 PM

Developing Autonomous Pruning for Specialty Crops

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Pruning of tree and vine crops is typically performed manually and accounts for the second largest labor costs, after harvesting. As well as the cost of labor, the availability of labor is a major concern. This project was initiated to address these concerns, and investigate whether advances in fields such as machine vision and robotics could be applied to developing autonomous pruners for grape and apple. This SCRI-funded project includes participants in the fields of pomology (Baugher, Hirst, Schupp), viticulture (Tarara), engineering (Park, Kak, Koselka, Wallach), economics (Seavert) and rural sociology (Glenna, Patel-Campillo). This multi-disciplinary team is focused on developing new technology, evaluating that technology, and determining the barriers to adoption. Previous work by our commercial partner, Vision Robotics Corp, has developed an autonomous pruner for grapevines that is currently being refined. It is undergoing field testing and should be commercially available by the end of the 4-year project. With apple, we have formulated a set of "rules" that describe optimal pruning and are currently evaluating those rules in terms of the physical attributes of the canopy structure. The engineering team is developing a 3D imaging decision system, and robot control technologies for automating dormant pruning operations. The socio-economic team will determine social and economic impacts of the proposed autonomous pruning system. Pruning of tree and vine crops is typically performed manually and accounts for the second largest labor costs, after harvesting. As well as the cost of labor, the availability of labor is a major concern. This project was initiated to address these concerns,

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Specified Source(s) of Funding: USDA-SCRI

Thursday, July 25, 2013 Springs Salon D/E

Propagation

Moderator: Donglin Zhang, donglin@uga.edu

2:45–3:00 PM

Impact of Location, Seasonality, and Iba Concentration on Rooting of *Prunus angustifolia*

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Interest in native plums has led to the initiation of a sand plum (*Prunus angustifolia* Marsh.) evaluation program in Oklahoma. Propagation by cuttings is being investigated as a method for generating clones of outstanding selections. However, recommendations for sand plum cuttings do not exist and recommendations for other *Prunus* spp. vary. The objective of this experiment was to determine which season and IBA concentration would produce the greatest total rooting percentage for *P. angustifolia*. Hardwood cuttings were collected in May, August, and October from three different clonal mots in Payne County, OK. Five reps. of 15 cuttings each were used. Cuttings were treated with Hortus IBA Water Soluble Salt treatments of 0, 100, 1000, 3000, and 7000 ppm using the quick dip method. Immediately after being dipped, the cuttings were stuck in a half vermiculite/half perlite media and placed under mist for 52 days. Rooting percent-

ages were recorded. Results indicated that rooted success varied by mot location. For two of the mots, total rooting significantly increased as IBA concentration increased. Within those two mots, cuttings taken in August showed a significantly ($P < 0.05$) higher rooting percentage (averaging 73%) than cuttings taken in May and October using 7000 ppm IBA. Results indicate that when taking cuttings for sand plums, results will be variable depending on location but higher IBA rates and taking cuttings during August is recommended for greater rooting success.

Specified Source(s) of Funding: ODAFF Specialty Crop Grant

3:00–3:15 PM

K-Iba Concentration Regulated Rooting Quality and Plant Vigor of *Prunus laurocerasus* L.

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Prunus laurocerasus L. is an evergreen species of Rosaceae, native to southwestern Asia and southeastern Europe. It is a widely cultivated ornamental plant in gardens and parks in temperate regions. A new type of branch sprout with 2–4 cm long and 0.5–1.5 cm broad leaves was collected and regenerated with the stem cuttings in November 2012. All cuttings were treated with K-IBA at 1000, 3000, and 8000 mg·L⁻¹. K-IBA concentrations had significant influence on rooting quality and after growth of *Prunus laurocerasus*. The rooting percentage was very high, ranging from 94.4% to 100% after two months. Although the rooting percentage did not show a great difference, the number of roots and root length were highly affected. As the K-IBA concentrations increased, the number of roots increased significantly from 6 to 11 to 17. However, root length had the opposite trend than that of root numbers. The longest root length, 21.9 cm, was obtained from cuttings treated with K-IBA at 1000 mg·L⁻¹. Cuttings treated with K-IBA 1000 mg·L⁻¹ had a mean root length of 6.2 cm, 4.8 and 1.9 cm for 3000 mg·L⁻¹ and 8000 mg·L⁻¹, respectively. Rooted cuttings were transplanted to one-gallon pots and placed in a heated greenhouse. The survival rate was recorded and dead cuttings were examined. The highest survival rate was 95.5% under K-IBA 1000 mg·L⁻¹ treatment, while those treated with K-IBA 3000 mg·L⁻¹ and 8000 mg·L⁻¹ was 78.8% and 50.0%, respectively. Higher K-IBA concentrations might increase the number of roots, but kill the rooted cuttings or reduce the plant vigor afterward. For the propagation of *Prunus laurocerasus*, stem cuttings treated with K-IBA 1000 mg·L⁻¹ are recommended.

An asterisk (*) following a name indicates the presenting author.

3:15–3:30 PM

Light Quality Affects Microshoot Growth of Apple Rootstocks: B.9 & G.30

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Tissue culture using shoot cultures is a procedure to rapidly increase plant numbers of newly released apple rootstocks, especially when they are in short supply. However, slow growing microshoots limit the commercial availability of desired apple rootstocks. Light quality can affect shoot elongation and shoot branching. The effects of red, white, and blue light on microshoot growth in B.9 and G.30 apple rootstocks were investigated. One-year-old greenhouse-grown shoots of both rootstocks were trimmed into 1.0–1.5 cm stem pieces with a single node and then were cultured in solid MS media without any hormone. After 38 days, the sprouts were transferred to new solid MS media with GA3 (0.5 mg/L), BA (1.0 mg/L), IBA (0.1 mg/L), and sugar (3%), and were then cultured under red, white, or blue light. After 42 days culturing, the number of shoots, length of the longest shoot, and the number of elongated shoots (>1.5 cm) were collected. Red light increased the number of new shoots, shoot length and the number of elongated shoots when compared with white or blue light, and there was no interaction with cultivar. The number of new shoots increased from 2 under blue light and 4 under white light to 7 under red light. Shoot length was 2.9 cm under red light compared to 1.2 cm under white light and 1.0 cm under blue light. The number of elongated shoots in both cultivars was also increased by red light, which increased from 1 under blue light and 2 under white light to 6 under red light. For the total number of shoots and the number of elongated shoots, there was no cultivar effect, but shoot length of G.30 was longer than that in B.9. Thus, using red light to culture microshoots will be recommended to improve apple rootstock microshoot growth. Moreover, survival and microbial contamination rate were also calculated and the results also presented that red light would be a better alternative to culture apple rootstock microshoots.

3:30–3:45 PM

Fine-root Dynamics of Apple (*Malus domestica* Borkh.) Rootstocks under Replant Condition

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Apple replant disease (ARD) is a soil-borne disease that affects young apple trees in many replanted orchards around the world. Symptoms of ARD are observed soon after planting and include, among others, stunted growth above ground, reduction in root biomass, and root tip necrosis. Due to the complex etiology and multiple causal agents of ARD, there is a limited understanding of the disease development on the fine-root system, as well as the dynamics that lead to effective plant defense or susceptibility of rootstocks in replant sites. The goal of this study is to identify morphological and physiological differences between susceptible and resistance/tolerant rootstocks and induced changes in the traits when grown in ARD soil. We hypothesized that rootstock resistance/tolerance to ARD is supported by higher root growth rate, higher turnover of tissues, and higher number of growing tips. In an outdoor nursery, seedlings of M.26 rootstock (previously shown to be susceptible to ARD) and clonal rootstock liners of CG.6210 (previously shown to perform well in replant sites) were grown in soil from an ARD site (FS) and in pasteurized soil (PS) from the same site for control. Above and below ground biomass was determined by harvesting a subset of plants per soil treatment and rootstock at 11, 17, and 23 weeks after planting. A subset of plants was used to track root dynamics during the growing season (13 weeks). Root observation windows were digitally photographed at 7-day intervals from shortly after planting to the final harvest. Rootstocks grown in PS grew significantly more than those in FS, but there were no differences in growth above ground between rootstocks. Total root biomass, first and second order roots, and second-to-first order root ratio were higher in CG6210 rootstocks than in M26 in both soil treatments. First order roots of M26 were larger in diameter and had higher N content than those of CG.6210 under FS and PS. Roots of M26 and CG.6210 were larger in diameter and had lower C content under PS than FS. Under FS, lifespan of M26 roots was significantly longer than those of CG.6210, and the mortality risk of M26 roots was 56% that of CG6210 roots. However, there were no differences on root lifespan or root mortality risk between rootstocks under PS. Differences in root production and lifespan might be linked to differences in resources allocation to production of defense compounds versus to plant growth.

Thursday, July 25, 2013

Desert Salon 1-2

Plant Nutrient and Horticultural Waste Management

Moderator: Aziz Baameur, azbaameur@ucdavis.edu

2:45–3:00 PM

Pepper N Uptake: Preliminary Field Study

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One of the challenging aspects of growing pepper is the lack of empirical information on nutrient uptake. To adequately manage the crop nutritional needs, growers rely on soil monitoring and crop and plant tissue analyses. This is especially true for nitrogen (N). However, as the regulatory environment gets tighter, there is an increasing need to better understand N uptake and partitioning in the plant. The main objective of this first year trial was to investigate the nutrient uptake by pepper crops. Eight fields were included representing bell and jalapeno peppers, in the central coast of California. The cooperating growers contributed their management practices and provided logistical support. We selected and replicated plots in each field. Plots consisted of five linear feet. Based on row configuration, the sample population comprised either 5 or 10 plants. Sampling consisted of collecting mature pepper pods, weighing and counting them, and then categorizing as marketable or reject. At the last harvest, we also harvested the above-ground plant part. Fruit and plant materials were separated, chopped, dried, and submitted for NPK analyses, to the University of California ANR laboratory. In addition, we composite soil samples from each plots at the 0–8 and 10–16 inch-depths and submitted them for NPK analyses. Plot production ranged between 24–40 tons/acre for jalapenos and 34–56 tons/acre for bells. Dry matter (DM) production was similar for both types of crops (2.6–2.7 tons/acre). Nitrogen content of above ground biomass varied between 224 and 240 pounds/acre for bells and jalapenos, respectively. Bell pepper and jalapeno fruit also took up about 270 pounds/acre of K and around 30–33 pounds/acre of phosphorus. In comparison with fertilizer applications, NP and K uptake was 72%, 48%, and 100% of these applied nutrients. Additional work is planned to further validate the data presented here.

Specified Source(s) of Funding: California Pepper Commission

3:00–3:15 PM

Soil Surfactant Increases Nutrient Use Efficiency and Yield of Tomato Grown in Sandy Soil

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Florida grows 33,600 acres tomatoes and the total yearly value is more than \$520 million; accounting for 65% of the value of the crop in the nation. Florida tomatoes are grown primarily in sandy soil, which has low water-holding capacity and high nutrient leaching due to its coarse-sized particles. A soil surfactant, however, is a surface-active substance with both hydrophilic (water-loving, polar) and lipophilic (fat-loving, apolar) properties like soaps and detergents. These amphiphilic properties can significantly improve soil quality, reduce water repellency, and increase the capacity for holding water and nutrients in sandy

soil. The objectives of this research were to: 1) evaluate the effect of a surfactant on nutrient use efficiency and 2) assess the yield enhancement of the surfactant on tomatoes grown in sandy soil. This research was conducted in a hyperthermic, uncoated Typic Quartzipsamments (USDA, 1979) sandy soil in UF/IFAS Plant Science Research and Education Unit, near Citra, FL, in Fall 2012. Prior to planting, fertilizers (lb/acre) were applied and incorporated into soil: 160 N (as urea), 83 P₂O₅ (as triple superphosphate), and 250 K₂O (as muriate of potash). There were two surfactant rates: 0 (control) and 30 (treatment) lb/acre (as Stockosorb® 660). Tomato (*Lycopersicon esculentum* Mill. var. 'Phoenix') seedlings were planted in 12.5 m² (135 ft²) plots with three replicates and irrigated with drip and plastic mulch. Nutrient use efficiency (lb/lb) was defined as tomato yield increment per pound of applied nutrients. The plant size of the treatment was 15% greater in both height and diameter than the control. Tomato yields of the control and treatment were 99,017 and 57,738 lb/acre, respectively. The marketable yield of the treatment was 84% greater than that of the control. Large, medium, and small tomatoes of the treatment were 192%, 102%, and 38% greater than those of the control. Nutrient use efficiencies of N, P, and K were 252, 485, and 162 and 123, 236, and 79 lb/lb for the treatment and control, respectively. These results indicate that soil surfactant significantly increases plant growth, yield, and nutrient use efficiency of the tested tomato cultivar.

3:15–3:30 PM

Biochar Increases the Ion Exchange Capacity of Potting Mix

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Biochar is organic matter that has been heated in little to no oxygen in a process called pyrolysis. Biochar's high surface area is covered with exchange sites that can hold and release the plant nutrient ions, potentially increasing fertilizer efficiency and decreasing leaching. Different amounts of biochar were incorporated into Sunshine mix planting media. The treatments included: 1) a control pot filled with media but without biochar or a plant; 2) a control pot without biochar but with a fibrous begonia plant; 3) 5%; 4) 10%; 5) 15%; 6) 20%; 7) 25%; 8) 30% biochar by volume incorporated into the substrate with a fibrous begonia plant; and 9) a 10% biochar by volume unmixed at the bottom of the pot without a plant. Leachates were collected weekly for 2 months, and the concentrations of ammonium, nitrate and ortho-phosphorus determined. The amount of nitrate, ammonia, and phosphate remaining in the media at the end of the season was measured. The biochar used in this study strongly sorbed both nitrate and ammonia, and a small but statistically significant amount of ortho-phosphate.

An asterisk (*) following a name indicates the presenting author.

Specified Source(s) of Funding: UC Riverside Department of Botany and Plant Sciences

3:30–3:45 PM

The Effect of Nutrient Ratios on Plant Height

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Height control is often achieved through the application of plant growth retardants (PGRs). However, environmental concerns surrounding the use of synthetic PGRs could potentially lead to restrictions on their use. Non-chemical methods, such as overhead irrigation with cold water and day and night temperature differential (DIF) treatments can be time consuming, labor intensive, and expensive. Some research suggests that plant height control may be achievable through modifications in plant nutrition. For instance, studies have suggested that limiting phosphorus supply limits plant height. Many growers also believe that nitrate (NO_3^-) nitrogen produces shorter plants than ammonium (NH_4^+) nitrogen. The primary objective of this study was to evaluate an alternative means of plant height control through adjustments in macronutrients like N, P and K. Ratios of NO_3^- : NH_4^+ , NO_3^- : H_2PO_4^- , NO_3^- : K^+ , K : H_2PO_4^- , NH_4^+ : H_2PO_4^- , and NH_4^+ : K^+ were tested at about 8 different levels, and approximately 50 hydroponic aerated nutrient solutions were compared to quantify their effects on plant height in sunflowers (*Helianthus annuus* L. ‘Sunrich Orange’), marigolds (*Tagetes erecta* L. ‘Vanilla’) and tomatoes (*Lycopersicon esculentum* L. ‘Roma’). All solutions were variations of a modified Hoagland’s solution, which functioned as a control. Solutions were first used at an electrical conductivity (EC) of ~ 1.0 mS/cm, which produced no significant differences in height and very few or inconsistent differences in plant biomass. Solutions were then evaluated at ECs of 0.5, 1.0, 2.0, and 4.0 mS/cm. Plant height and biomass were generally affected by varying EC levels but seldom by the ratios themselves at these different levels. Results from this study suggest that nutrient management, with the exception of EC modifications, may not be useful in plant height control.

Specified Source(s) of Funding: COHA, OMAFRA

3:45–4:00 PM

Quantifying the Impact of Macronutrients on Substrate pH

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While many factors that influence substrate pH have been quantitatively measured, the effect from fertilizers continues to be elusive. A multifactorial experiment was conducted to test macronutrient effects using the unique statistical method known as the central composite design. Five nutrients—nitrogen [ammonium (NH_4^+)] vs. nitrate (NO_3^-), phosphorus [as phosphate (PO_4^{3-})], potassium (K), calcium+magnesium (Ca+Mg), and sulfur (S)—were varied at five concentrations encompassing the proportionate range of these nutrients in commercial greenhouse fertilizers. Concentrations included N at 98 mg·L⁻¹ ppm where the ammonium:nitrate ratios were 0:100, 15:85, 40:60, 65:35, and 80:20; PO_4^{3-} as P_2O_5 at 10, 25, 50, 85, and 100% of N; K as K_2O at 35, 55, 100, 150, and 170% of N; calcium+magnesium (Ca+Mg) in a 3:1 ratio at 25, 35, 50, 65, and 75% of N; and sulfur (S) at 10, 17, 30, 43, and 50% of N. While a typical factorial experiment would have resulted in 55 = 3125 treatments, the central composite design reduced the number to 30 fertilizer treatments. Two replications of the same experiment were conducted where *Salvia farinacea* ‘Evolution White’ was grown in 15 cm-diameter pots (1.29 L) in a 3 peat : 1 perlite (v/v) substrate amended with non-residual powdered calcium carbonate to raise the substrate pH to approximately 5.6–5.8. Two harvests occurred for each experiment after three and six weeks of growth. Five reps. per harvest occurred in the first experiment and three reps. per harvest in the second experiment. From the data a model was generated that allowed the prediction of substrate pH over time. Significant effects in the model included the four main effects of N form, PO_4^{3-} , K, and Ca+Mg; nutrient x nutrient interactions of N form x K, N form x Ca+Mg, PO_4^{3-} x Ca+Mg, and Ca+Mg x S, and time x nutrient interactions with N form, PO_4^{3-} , K, and S. The model allows us to calculate that at 0, 2.8, and 5.6 mmol NH_4^+ ; 0.138, 0.69, and 1.38 mmol PO_4^{3-} ; and 0.728, 2.081, and 3.538 mmol K the calculated pH levels were at 45 days 6.01, 5.25, and 4.95; 5.07, 5.25, and 5.22; and 5.42, 5.27, and 5.18, respectively. Of all the nutrients used in the experiment, N form had the greatest impact on substrate pH; higher concentrations of NH_4^+ decreased substrate pH, while higher concentrations of NO_3^- increased substrate pH.

Specified Source(s) of Funding: Fred C. Gloeckner Foundation, Rockwell Farms, and USDA–ARS

4:00–4:15 PM

University Campus Composting Programs: Initiatives for the Future

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The purpose of this discussion is to examine two successful attempts at university-wide composting initiatives in the United States: Bobcat Blend at Texas State University in San Marcos, TX, and a composting program at the University of Hawaii at Manoa. Initially funded in 2006 through partnership with the Environmental Protection Agency (EPA), Bobcat Blend is one of the only student-operated composting programs in the nation and won awards from the Texas Commission on Environmental Quality (TCEQ) in both 2012 and 2013. Students manage education of students and staff, food waste management, compost creation and sales of compost to university faculty and local community gardens. The composting program at the University of Hawaii at Manoa was initially funded in 2012 by a University of Hawaii at Manoa Graduate Student Organization Greening Initiative Grant. The Graduate Student Organization of the University of Hawaii, Manoa campus created the Campus Greening program in order to move the campus toward more sustainable environmental practices. The grant was awarded to the student organization SOFT (Student Organic Farm Training) and provided stipends for the students involved. Similar to the Texas State University composting program, students at the University of Hawaii manage education of students and staff, food waste management, compost creation and applying compost to the agriculture research stations and farms on campus. This discussion will investigate the viability of similar endeavors across the country and allow for enhanced discussion of how similar programs can be initiated and learn from one another's successes.

Specified Source(s) of Funding: Campus greening fees

4:15–4:30 PM

Incorporating Wool-waste into Compost to Develop Alternative Compost Products

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Compost is used in many states as both a waste management alternative and a horticultural and agriculture-based resource. Wool has historically been used in garden beds and anecdotal records from gardeners from the 1940s suggest beneficial effects on growth of plants. Recent research found that wool or hair incorporated into the potted plant environment can improve the water-holding capacity of the soil as well as act as a slow-release fertilizer. Texas is the nation's leading wool producer. Waste and "tag" wool is readily available, inexpensive and considered low-quality because of weed seed contamination and stains from defecation. The purpose of this research was to test the feasibility of composting waste wool to determine proper proportions of material to develop a viable alternative compost product to market. Trial compost piles were constructed incorporating wool waste with proportions of various other feedstock ingredients including animal manures, university dining hall food waste, invasive river plants and horticultural production plant green waste, as well as tree-pruning waste and livestock bedding and straw to determine the best mixture of materials to create a product. Samples were sent to a certified compost quality testing lab and indicated that high quality composts were created. Results also found that wool fibers can be incorporated into piles and that best decomposition occurs by supplying greater than normal amounts of moisture and nitrogen. Additionally, results showed that the composting process was extended due to wool product being highly compacted upon receipt.

Snapshots



Sonny Ramaswamy, Director, USDA-NIFA (left) receives honorary ASHS membership from Paul Bosland



Student service project at Indio Senior Center



Socializing during a break in the activities

Hall of Fame inductees

J.C. Raulston
accepted on behalf
of the family by
John Dole



Exhibitor booths were busy



Charles E. Hess



Cutting-edge research was on display in the Poster Hall



Exotic fruit tasting sponsored by the American Pomological Society

Additional conference photos can be seen at
http://www.flickr.com/photos/ashs_hort/

A good time was had by all attendees



Poster Abstracts

Presented at the Annual Conference of the American Society for Horticultural Science

July 22–25, 2013, Palm Desert, California

Monday, July 22, 2013

12:15–1:00 PM

Bioenergy

(288) In Vitro Pollination and Pollen Germination of *Moringa oleifera* Lam. Growing under Sub-optimal Growing Conditions in Gauteng, South Africa

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Moringa oleifera Lam., a tree naturally grown in the tropics, is becoming increasingly popular as an industrial crop due to its multitude of useful attributes as water purifier, nutritional supplement, and biofuel. The tree originates from tropical areas (India) and tolerates sub-optimal growing conditions, but we are investigating the possibility of growing the crop in cooler climates with medium to low rainfall, such as the Gauteng Province. This study is therefore aimed at investigating the success of self- and cross-pollination of trees under the latter climatic conditions. Ten trees were randomly selected in an 8-year-old *Moringa oleifera* orchard at the Experimental Farm of the University of Pretoria (25°45'S, 28°16'E) at an altitude of 1372 m above sea level and an average annual rainfall of 674 mm. For in vitro pollen germination, pollen was collected from five individual flowers at three stages a) early anthesis, b) one day after anthesis, and c) two days after anthesis. The hang drop method was applied, allowing pollen to germinate. Three slides for each stage were prepared. Germinated and ungerminated pollen were counted on each slide in five different microscopic fields. For semi-vivo pollen germination, flowers starting with anthesis were emasculated and bagged. On the second day the flowers were collected and self- and cross-pollinated and pedicels inserted in a congealed 1% agar + 0.02% boric acid + 10% sugar substrate in plastic dishes. For each self- and cross-pollination treatment, there were five replications with five flowers each. Flowers were incubated under a 12 h photoperiod and 60 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PAR using two cool-white fluorescent tubes per shelf. Temperatures were maintained at 24 \pm 2 °C. After the second day flowers were fixed in Carnoy solution. The ovaries were softened, rinsed and stained. Squashed preparations were viewed under a confocal microscope. Fresh, 1-day-old, and 2-day-old pollen germinated equally well in vitro. There was no obvious difference in the number of ovules with penetrated pollen tubes between semi-vivo, self-, and cross-pollinated ovaries. A high percentage

ovules from both self- and cross-pollinated ovaries had branched pollen tubes at the entrance of the embryo sac.

(289) Comprehensive Functional Analyses of Expressed Sequence Tags (ESTs) in *Jatropha curcas* L.

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Jatropha (*Jatropha curcas* L.) is an economically important plant with great potential for biodiesel and jet fuel production because its seeds contain high quality oil. However, *jatropha* remains a wild plant since it has not yet undergone a systematic selection and breeding program. The availability of genetic and genomic information of *jatropha* is very limited. Genomic resources are important foundations for gene discovery and marker development, which can assist and accelerate *jatropha* breeding programs through genetic diversity analysis, marker-assistant selection, and other approaches. Expressed sequence tags (ESTs), providing informative transcript sequences, is a fast way for gene discovery and gene expression pattern analysis. To date, only a small portion of about 40,000 predicted genes have been identified. The objectives of this study were: 1) to study the *jatropha* transcriptome and the transcript sequence feature in depth by enriching the *jatropha* EST database utilizing next generation sequencing technology; 2) to identify the abundant transcripts of mature *jatropha* leaves; and 3) to discover the transcript sequence variance. The mRNA sample of mature *jatropha* leaves was sequenced using 454 Roche GS FLX platform. A total of 1,714,433 raw reads were generated. After trimming the adaptors and primers, the sequences were assembled into 38,716 contigs and 58,317 singletons using a combination of Newbler 2.8 and CAP3. The average length of contigs and singletons are 1,147 and 399 bases, respectively. A total of 96,677 unigenes were obtained after removing short sequences (< 20bp). About 73.5% of unigenes were annotated using blast tools (e-value \leq E-06). This unigene set will be compared to the nucleotide and amino acid sequences of *Arabidopsis thaliana*, cassava (*Manihot esculenta*) and castor oil plant (*Ricinus communis*) for similarity comparison. Some sequence features and allele variance will be identified. This unigene set will significantly enrich the current *jatropha* EST database by adding a large amount of new ESTs to Genbank. Together, this study will not only allow the identification of new unigenes in *jatropha*, but also provide additional marker resources to be used in breeding programs.

Specified Source(s) of Funding: Vecenergy, Inc.

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(290) Variability in Salt Tolerance of 10 Sorghum Genotypes

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Sorghum (*Sorghum bicolor* L. Moench) is one of most promising bioethanol crops because it is well adapted to semi-arid region where soil salinity is high and groundwater with high salinity is the major water source. Large variation in salt tolerance exists among sorghum genotypes. To provide additional information about such variation, the relative salt tolerance of 10 sorghum genotypes, 1790E, BTx643, Desert Maize, Macia, Schrock, Shallu, Tx2783, Tx430, Tx7078, and Wheatland was evaluated in a greenhouse study by irrigating plants with nutrient solution at electrical conductivity (EC) of 1.3 dS·m⁻¹ (control) or saline solution at EC of 5.0 or 10.0 dS·m⁻¹ for 30 days. Saline solution at EC of 5.0 and 10.0 dS·m⁻¹ had similar influences on shoot dry weight (DW) of all sorghum genotypes except for Tx2783. Compared to the control, the saline solution at EC of 5.0 and 10.0 dS·m⁻¹ reduced shoot DW by 38% and 47%, respectively; and increased the number of tillers by 112.8% and 116.0%. Foliar salt damage was observed on all salt-treated sorghum genotypes except for Shallu, which had the lowest shoot DW reduction and best visual score. In conclusion, Shallu was the most tolerant genotype, Desert Maize, BTx643, 1790E, Tx2783, Wheatland, Tx430, and Tx7078 had intermediate tolerance, and Macia and Schrock were the least tolerant genotypes.

Specified Source(s) of Funding: Texas A&M AgriLife Research Bioenergy Initiatives Program

(291) Evaluating Sweet Sorghum Germplasm for Maturity in Arizona

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Sweet sorghum (*Sorghum bicolor* L. Moench) is being evaluated as a potential feedstock for ethanol production in Arizona. Because it can be grown on poor soil and irrigated with reclaimed water, sweet sorghum production in the arid southwestern United States would not compete directly with food crops. Because of the long growing season, there is the possibility of two harvests of a short-season variety. One aim of this study was to determine if any available germplasm would fit in a double-crop model. This germplasm was also evaluated for earlier maturity and other desirable characteristics. In 2012, nine lines with variable maturities were planted on 8 May in a split-plot design with four replications. Plants were harvested by hand at physiological maturity (30 days after half the plants were observed to be flowering) and the weight of two 3.05-m sections of the middle two rows of the four-row plots was recorded. A subsample of 15 plants was weighed, stripped of leaves and panicles, weighed again, then pressed through a roller mill. Juice collected was weighed and then analyzed in the laboratory by High Performance Liquid Chromatography (HPLC) with a Refractive Index Detector for fructose, glucose, and sucrose. Theoretical biomass, juice, sugar, and ethanol yields per hectare were calculated for each variety and the data analyzed using JMP software. For the four calculated yield components (biomass, juice, sugar, and ethanol yields per hectare), Mer 74-4 and TX09055 (maturing at 178 and 162 days, respectively) were significantly higher than the short-season types that were harvested after 113 days in the field. In most cases, the longer the plants were in the field, the higher their yields. The predicted ethanol yield of the short-season lines was about half of that of Mer 74-4 and TX09055. This indicates that as planted, a second crop would bring the total for the short-season types up to approximately the same as the top performers. However, if planted at a tighter spacing than this study, there would be more biomass per area, which is one of the components contributing to ethanol yield. The growth habit is very tall and these varieties do not produce tillers, so another strategy to increase yields would be to breed for early maturity and tillering.

(292) Lesquerella Yield and Oil Quality Response to N Fertilizer Rate and Irrigation

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Water and nitrogen are the first and second limiting factors for crop production in the arid and semiarid Southwestern United States. We studied the response of lesquerella (*Lesquerella Fendleri* L.) to six nitrogen rates (0, 56, 1112, 168, 224, and 336 kg·ha⁻¹) and two irrigation levels (well-watered and water-stressed) at University of Arizona's Maricopa Agricultural Center in the 2011–12 and 2012–13 growing seasons. Lesquerella is a member of the mustard family and the oil in lesquerella seeds, as a component of engine oil at concentrations as low as 0.25%, has superior performance compared to many other vegetable oils in reducing wear and damage in fuel injected diesel engines. The hydroxylated oil in lesquerella is similar to castor oil but does not contain the deadly poison ricin. Therefore, lesquerella is a safer alternative to castor in the United States and can be handled both at the farm level and the oilseed processing level with industry standard equipment and technology. Nitrogen fertilizer and irrigation response was significant in both growing seasons. The optimal N rate for seed yield was 224 kg·ha⁻¹ of urea-N at both water levels. The highest lesquerella seed yield of about 2200 kg·ha⁻¹ despite very short plants (i.e., <25 cm). Recovery efficiency of N fertilizer ranged from 31% to 47% and was not affected by irrigation level. Recovery efficiency reached maximum at 168 kg·ha⁻¹ of urea-N. This study provides guidelines for lesquerella N and irrigation management for maximum yield and oil quality.

Specified Source(s) of Funding: Western SunGrant

Monday, July 22, 2013

12:15–1:00 PM

Floriculture

(001) Storage Time of Pine Wood Chip Aggregates Affects Phytotoxicity and Plant Growth

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Chemical composition of organic alternative substrates and substrate components may influence toxic and phytotoxic effects on plant growth during culture. In response to phytotoxicity reports in some substrates and substrate components, investigators have developed multiple evaluation procedures to predict a substrate's potential for affecting plant growth due to any phytotoxic effect. The use of fresh pine wood (as a substrate or substrate component) in horticultural crop production has increased in recent years and some data suggests that when used fresh and at high percentages, pine wood can decrease herbaceous plant growth

and inhibit seedling germination. Pine wood chips (PWC) are one such new component being evaluated as a replacement for perlite in greenhouse substrates. To screen for phytotoxicity, seedling germination tests and plant growth trials were conducted on fresh (pine trees freshly harvested) and aged (pine tree harvested, chipped and stored for 5 months) PWC. Both fresh and aged PWC were produced by chipping freshly harvested loblolly pine trees (*Pinus taeda*) and hammer milling the wood chips through a 6.35-mm screen. Fresh and aged PWC were both amended to peat moss at 20% and 30% ratios. An 80:20 peat:perlite control was also used in this study. Separate containers of each substrate were sown with five radish (*Raphanus sativus*) or cucumber (*Cucumis sativus* L.) seeds. At 14 d after sowing, germination percentage and germinated seedling dry weights were determined. Additional containers of each of the five substrates were planted with celosia (*Celosia plumosa*) or impatiens (*Impatiens walleriana*) plugs and grown for 4 weeks in a greenhouse. Radish germination was highest in both the 20% and 30% aged PWC compared to the fresh PWC or perlite seedlings. Radish dry weights were similar in perlite and aged PWC substrates and lowest in fresh PWC. Cucumber germination was similar in aged and fresh PWC at both percentages and lowest in the perlite control substrate, however dry weights of germinated seedlings was highest in the perlite control. In the growth trials, celosia plants grown in aged PWC at both rates had higher dry weights compared to plants grown in the fresh PWC substrates. Dry weights for impatiens were similar for the control and in both aged and fresh PWC substrates. These results indicate crop variability to fresh PWC phytotoxicity. Overall, the use of aged PWC seems to improve plant growth and therefore is recommended.

(003) Use of Plastic Trays to Reduce Irrigation Demand of Biocontainers

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Biocontainers have been successfully marketed as sustainable alternatives to petroleum-based containers in greenhouse production. Despite this appeal, past research has shown that biocontainers, especially those constructed from more porous plant materials (e.g., peat and wood fiber), tend to require more frequent watering than conventional plastic products. However, no research to date has investigated how the use of a plastic filling/carry tray (commonly used facilitate production using small diameter containers) influences water demand in biocontainer production. This project evaluated plant growth and water consumption for 10 different containers (a plastic control and nine biocontainer alternatives) used to grow a short-term greenhouse crop (*Vinca minor*) at three different greenhouse sites in Fayetteville, AR; Lexington, KY; and Crystal Springs, MS. Containers were either left exposed or surrounded by an excised filling/carry tray pocket for the duration of the 5-week study. Results indicate that both container type ($P < 0.0001$, all sites) and the absence/presence of a tray ($P < 0.0001$, AR; $P = 0.0093$, KY; $P = 0.0023$, MS) influence total water consumption. Trays generally reduced watering demand (up to 40% for straw pots); however, the benefit offered by the addition of a tray was not as significant for the more impervious containers made of plastic, bioplastic, and pressed rice hulls. In contrast with water use, growth responses (i.e., leaf area, dry shoot weight, and dry root weight) generally did not differ among the treatment combinations (with the exception of leaf area at the Arkansas site), indicating that water consumption was driven largely by the treatment combinations and was not confounded by differences in growth. We conclude that filling/carry trays can be an effective means of managing the overall sustainability of greenhouse production when using more porous biocontainers, especially if water use is a key concern. Additionally, past research may overestimate differences in watering demand in production systems where plastic filling/shuttle trays are used.

(004) Vesicular–Arbuscular Mycorrhizae and Trichoderma Application Influenced Growth and Development of Poinsettia

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Beneficial microorganisms, such as mycorrhizae and trichoderma, are known for their benefits to plant growth and development. Vesicular–arbuscular mycorrhizae (VAM) and trichoderma fungi have been attributed to improve plant uptake of macro and micronutrients and enhance water availability. The main objective of this study was to examine the application of VAM and a commercial product, RootShield™ containing *Trichoderma harzianum*, on the growth and development of poinsettias.

The study was conducted in the greenhouse in a completely randomized design with four treatments (Control, VAM, RootShield™, and VAM+RootShield™); two soil media (Sunshine Mix+vermiculite and Promix Bx Mycorise Pro+ vermiculite); and two fertilizer rates (recommended and 50% of the recommended rate of a slow release fertilizer), with four replications each. Poinsettia cuttings, 'Poi Cortez Burgundy', were obtained from Greenstreet Grower, Inc. Treatments were added at the time of transplanting. Plant height, root length, number of bracts, and shoot and root dry weight were determined. No significant variations were found between the two fertilizer rates. However, soil type and fertilizer rate influenced plant growth and development. There was a significant difference in root dry weight and root length among treatments and media type when fertilizer was applied at the recommended rate. Significant differences were also found in root dry weight, shoot dry weight, and shoot height among treatments and media types when fertilizer was applied at the 50% recommended rate. More studies will be conducted to assess the effects of these beneficial microorganisms on poinsettia's flower growth and development.

Specified Source(s) of Funding: Evans-Allen

(005) GA/ABA Ratio Affects Breaking Dormancy of Uncooled Herbaceous Peony

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Herbaceous peonies are common perennials that have been used as garden or medicinal plants throughout temperate regions of the world and have been grown commercially as cut flowers for many years. Because of its short flowering period from May to June, off-season culture is needed. In our previous research, peonies were forced under greenhouse conditions to hasten flowering after long exposure to low temperatures. The effects of gibberellins (GA) were also investigated to break the dormancy of peonies. All uncooled peonies that were treated with GA₃ sprouted, but failed to flower due to shoot blind and flower bud abortion. The objective of the present study was therefore to examine the effect of ABA biosynthesis inhibitor or additional GA treatments on uncooled peonies, so that in the future we will be able to force peony without causing blind or abortion. Uncooled plants received 0 (control), 100, or 500 mg·L⁻¹ (250 mL/plant) GA₃ as a soil drench, were drenched 100 mg·L⁻¹ GA₃ + 100 mg·L⁻¹ fluridone (FLU: ABA synthesis inhibitor), or sprayed with 10 mL of 100 mg·L⁻¹ GA₃ every 2 weeks following the drenching

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with 100 mg·L⁻¹ GA₃ in the glasshouse for forcing. Control plants failed to emerge for 5 months, so there was no shoot or flower. However, plants emerged almost 100% following the GA or FLU application. When uncooled plants were treated with GA or FLU, shoots emerged within 10 days. However, shoot blind appeared in 85% or 90% of those treated with GA₃ at 100 or 500 mg·L⁻¹, respectively. The drench application of GA showed shoot blind and flower bud abortion as in previous research. Shoot blind percentage decreased to 0% or 20% by GA₃+FLU or additional GA₃ spray treatments, respectively. Moreover, plants reached 80% or 50% anthesis without flower bud abortion with GA₃+FLU or additional GA₃ spray treatments, respectively. We assumed that treatments maintaining a high GA/ABA ratio decreased shoot blind or flower bud abortion in uncooled peony. However, chlorosis appeared on the leaves when treated with GA+FLU because FLU additionally blocks production of carotenoids.

Specified Source(s) of Funding: Korea Institute of Planning and Evaluation for Technology of Food, Agriculture, Forestry and Fisheries. Project No. 109096-5.

(006) Breeding by Interspecific Crosses and Its Bulb Production in *Lilium* spp.

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In this study, we surveyed the cross-compatibility between lily varieties and the growth, development, and flowering characteristics of the hybrid lily progenies, to collect foundational data for the breeding of interspecific hybrids of *Lilium*. Further, we aimed to select effective growth media conditions for embryo and ovule cultivation in order to develop hybrid progenies in the

interspecific hybrid lilies. *Lilium x fomolongi* Raizan No.2 variety was used as the seed parent. Oriental lily (O) variety Sorbonne; Asiatic lily (A) variety Brunello; and a *Longiflorum*-Asiatic (LA) hybrid lily, Royal Fantasy, were used as pollen parents. For each cross-combination, 30 plants were interspecifically crossed. The number of recovered progeny was highest for the FA hybrid, at 23, and 18 FLA hybrids and 11 FO hybrids were recovered. Seed production for the F x A cross was 76.6% and for the F x O cross was 46.6%, indicating a difference between the crosses. We performed the following experiment to increase the development of shoots in the in vitro culture of hybrid progeny. A MS medium was used as the base medium; cytokinins BA at a concentration of 2.0, 3.0, or 5.0 mg/L and TDZ at a concentration of 0.2, 0.3, or 0.5 mg/L were added to the in vitro cultures. For the FO progeny, the shoot development rate was highest with 2.0 mg/L BA, at 18%, and 3.0 mg/L and 5.0 mg/L BA resulted in a lower rate of 12%. The TDZ addition tended to yield identical or similar results to that of the control media. For the FA progeny, the addition of TDZ tended to lead to a higher shoot development rate and was superior with 0.3 mg/L treatment. However, the addition of BA to the media resulted in a shoot development rate between 14.3% and 15.7%, similar to that of the control.

(007) Evaluation of Bioplastic-coated Fiber Containers for Greenhouse Grown Plants

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Biocontainers made of coconut coir, paper, peat, wood, or other natural fibers are considered sustainable alternatives to containers made of petroleum-based plastics. Feedstocks for fiber containers are biorenewable and biodegradable, and therefore more ecofriendly than petroleum-based plastics, but growers' acceptance and use of fiber containers have been limited by their comparatively high cost, low strength and durability, and low water-use efficiency. We hypothesized that coating fiber containers with bioplastics would improve their strength, durability, effectiveness, and water-use efficiency during plant production. We dip-coated fiber containers (11.4 cm top dia.) of coir, paper, and wood with one of four bioplastics (polyamide,

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polylactic acid, polyurethane, or tung oil) and then compared the effectiveness of coated containers, uncoated containers made of the same three fiber types, uncoated peat-fiber containers, and injection-molded controls made of petroleum-based plastic. Ease of coating was assessed, along with the cost and strength of containers and their effectiveness and water-use efficiency during greenhouse production of marigold, petunia, salvia, pepper, and tomato. Subsequently, the establishment of transplants outdoors with containers removed, crushed, and installed near plant roots, and the degradation of container materials in soil were evaluated. Polyurethane was the least expensive bioplastic and was easy to apply as an ecofriendly, water-based dip coat. The other bioplastics required a hazardous and costly organic solvent. Coatings of polyamide, polylactic acid, and polyurethane increased container strength and durability, and improved water-use efficiency during plant production. Coated paper-fiber containers resisted compression better than petroleum-plastic controls. Greenhouse-grown plants in containers coated with polyamide, polylactic acid, or polyurethane were larger and rated healthier and of better quality than plants grown in uncoated or tung-oil coated fiber containers. Plants grown in paper- and coir-fiber containers coated with polyamide, polylactic acid, or polyurethane were similar in health, size, and quality to plants grown in petroleum-plastic controls. Coated fiber containers degraded more slowly than uncoated containers in soil, but the degradation of container pieces near roots did not affect the establishment or growth of transplants. Our results support the hypothesis that coating fiber containers with bioplastics can improve their effectiveness for crop production. Paper-fiber containers coated with polyurethane showed particular promise and were similar in cost and performance to containers made of petroleum-based plastic.

Monday, July 22, 2013

12:15–1:00 PM

Genetics and Germplasm

(339) Flow Cytometry and DNA Microsatellite Analysis Detect and Identify Triploid *Pyrus* Cultivars

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The U.S. Department of Agriculture (USDA), Agricultural Research Service (ARS), National Clonal Germplasm Repository (NCGR), Corvallis, OR, maintains an international collection of diverse pear (*Pyrus* L.) genetic resources. All *Pyrus* species are primarily diploid, with a base chromosome set of $x = 17$ ($2n = 2x = 34$), however, some cultivars are triploid ($2n = 3x = 41$) or tetraploid ($2n = 4x = 68$). Flow cytometry was performed on 725 genebank pear accessions to assess ploidy, and 91% were found to be diploid. Of the 62 triploid accessions, two were Asian (*Pyrus pyrifolia*) cultivars, 56 were European (*P. communis*) cultivars and four were interspecific hybrids. Simple sequence repeat (SSR) or microsatellite-based profiles were generated for 20 triploid accessions and reference pear cultivars at NCGR using a standard fingerprinting set of 12 SSR markers developed by the European Cooperative Programme for Plant Genetic Resources. The triploid accessions included pairs of same name cultivars (*P. communis* 'Batjarka' and 'Karamanlika') obtained from different sources, and a sample of *P. communis* 'Obican Vodenac' growing at the Appalachian Fruit Research Station (AFRS). SSR loci generated three alleles for each of the triploid accessions, thus confirming triploidy. Cultivars with the same name had the same fingerprints and are therefore duplicates. Cultivars Batjarka and Kajzerka were misidentified and Obican Vodenac from AFRS did not match that cultivar from NCGR. SSR fingerprints of 'Batjarka' and 'Kajzerka' matched those of two other genotypes: 'Erabasma' and 'Karamanlika', respectively. The presence of either one or two alleles at each of the 12 SSR loci for 'Obican Vodenac' from AFRS indicated that it was diploid and not true-to-name. The use of SSR markers for genetic fingerprinting confirmed triploidy in pear genebank accessions and resolved three cases of misidentification. The NCGR genebank provides propagation material for breeding and genetic research by on-line request through the USDA ARS Germplasm Resources Information Network (GRIN).

(340) Identification of Lettuce (*Lactuca sativa* L.) Cultivars using Newly Developed EST-SSR Markers

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Lettuce (*Lactuca sativa* L.) is a member of the Asteraceae and one of the most widely cultivated vegetables. Sixty-five lettuce

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cultivars have been registered at the Korea Seed & Variety Service for Plant Variety Protection. Molecular markers have many advantages for cultivar identification due to their independence from environmental influences. We developed novel expressed sequence tag (EST) derived simple sequence repeat (SSR) markers from the NCBI EST database and used them to analyze the genetic relationship of lettuce cultivars distributed in Korea. A total of 1,183 SSR primer pairs were developed from 81,330 lettuce ESTs. Out of the 1,183 primer pairs, a random set of 200 EST-SSR primers was selected for characterization with 52 cultivars. Sixteen primer pairs among 200 EST-SSR primers showed polymorphisms between cultivars and repetitive reproducibility on capillary electrophoresis system. Totally 65 polymorphic amplified fragments were obtained using 16 EST-SSR markers. Two to seven SSR alleles were detected for each locus with an average of 4.0 alleles per locus. Average polymorphism information content was 0.576, ranging from 0.142 to 0.754. Genetic distance of clusters ranged from 0.17 to 0.96 by unweighted pair-group method with arithmetical average based on Jaccard's distance coefficients. A total of 52 cultivars were discriminated by 16 EST-SSR marker genotypes. EST-SSRs developed will be useful for identifying lettuce cultivars and for future study, such as genetic diversity study of germplasms and genetic mapping and molecular breeding.

(341) The Verticillium Resistance 1 (*Vr1*) Gene from Cultivar La Brillante Determines Resistance in Different Lettuce Cultivars

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Verticillium wilt in lettuce (*Lactuca* spp.) is a threatening disease caused by the soilborne fungus *Verticillium dahliae*. In lettuce, two races of the pathogen are known (race 1 and 2). Resistance to race 1 is controlled by a single dominant gene named Verticillium resistance 1 (*Vr1*) located on linkage group 9 in 'La Brillante'. Several other lettuce cultivars also express resistance to race 1; however, no genetic studies have been conducted to determine if *Vr1* is responsible for the resistance in them. Approximately 300 F₂ plants from crosses between 'La Brillante' and 'Annapolis', 'Merlot', 'Little Gem', 'Pavane', and 'Eruption' were assessed for their resistance to race 1 *V. dahliae* isolate Ls16 in the greenhouse, and 238 F₂ plants of the cross 'La Brillante' x 'Merlot' in the field. The parents of each cross and the susceptible 'Salinas' were also included. Each test of Salinas or a parent cultivar consisted of four reps.;

five plants per rep. Each plant was assessed for root symptoms (vascular discoloration) and foliar wilting. Crown sections of each symptomatic F₂ plant were plated on semi-selective NP10 media to confirm that the symptoms were due to *V. dahliae*. The fungus was isolated from the positive plates, single-spored, and the race determined by PCR using race-specific primers. A plant with any degree of root discoloration or foliar wilting and from which *V. dahliae* was recovered was considered symptomatic for Verticillium wilt. 'Salinas' exhibited >50% incidence of symptomatic plants in greenhouse experiments and 80% in the field experiment, while no symptomatic plants were detected in the resistant parents in the greenhouse experiments or the field experiment. No symptomatic F₂ plants were detected in the greenhouse experiments from crosses of 'La Brillante' with 'Annapolis', 'Merlot', 'Little Gem', 'Pavane', or 'Eruption'. An insignificant percentage (0.8%) of F₂ plants were symptomatic in the field test. The F₂ families in these experiments either did not segregate or segregated in an unacceptable fit to a two independent dominant gene (15 non-symptomatic : 1 symptomatic) model. Resistance to *V. dahliae* race 1 in lettuce appears therefore to be controlled by *Vr1* or a closely linked gene in 'Annapolis', 'Merlot', 'Little Gem', 'Pavane', and 'Eruption'.

(342) Development of Novel Microsatellite Markers and Construction of a Microsatellite Database Containing 288 Radish (*Raphanus sativus* L.) Commercial Cultivars in Korea

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Radish (*Raphanus sativus* L.) belongs to the Brassicaceae family and is a close relative of *Brassica*. This species shows a wide morphological diversity and is an important vegetable in Korea. Microsatellite is one of the most suitable markers for cultivar identification as it has great discrimination power for cultivars with narrow genetic variation. Unfortunately, there are no reports on the use of microsatellite markers to characterize commercial radish cultivars in Korea. The microsatellite markers were developed using the biotin-streptavidin enrichment procedures. Seven-hundred-eight clones containing microsatellite sequences from GA/CT microsatellite enriched library were identified and 237 primer pairs designed and synthesized. The polymorphism level between these microsatellite primer pairs and 11 commercial radish cultivars was investigated. A set of 30 primer pairs showed high polymorphism on the basis of allele numbers. These markers were applied for constructing DNA profile data base of 288 commercial radish cultivars through automatic detection system. A total of 233 polymorphic amplified fragments were obtained

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by using 30 microsatellite markers. The number of alleles per locus ranged from 2 to 18 with an average of 7.77 alleles. The average polymorphism information content was 0.738 ranging from 0.491 to 0.906. The unweighted pair group method with arithmetic mean cluster analysis based on the Jaccard's similarity coefficient values was utilized to construct a dendrogram. Two-hundred-eighty-eight cultivars could be divided into eight major groups corresponding to varietal types. Almost all of the cultivars were discriminated by markers genotypes. This information may be useful to compare through genetic relationship analysis between existing cultivars and candidate cultivars in distinctness tests and protection of plant breeders' intellectual properties rights through cultivar identification.

(343) Genetic Structure in a Core Subset of *Pinus Massoniana* Lamb. Germplasm

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The genetic structure of a plant species gene pool has become increasingly important in plant association mapping research. Many advanced molecular techniques have been applied to assess the genetic diversity in a plant gene pool. Masson pine (*Pinus massoniana* Lamb.) is one of the most important native coniferous trees for timber plantation and resin production in southern China. A core subset of 121 Masson pine individuals, representing 33 populations from two gene pools, was planted at Guiyang National Orchard in Hunan province and were screened using 11 ISSR markers. The ISSR primers detected 258 polymorphic bands with frequencies ranging from 0.053 to 0.936 (mean 0.457). Population-specific ISSR variation (P) ranged from 68.46% to 94.23% (mean 81.04%) among 10 geo-

graphical distribution populations. The genetic differentiation among populations revealed different patterns of ISSR variation, of which 10.77% ISSR variation among 33 populations, 6.88% variation among 10 geographical distributions, 5.45% variation among different seed sources, and 2.46% ISSR variation in agronomic traits such as DBH. The above germplasm classification was further supported from principal component and neighbor-joining analyses. The most genetically distinct germplasm was identified with the individuals' dissimilarity that ranged from 0.322 to 0.426. A mini core subset of 50 genotypes from 33 populations representing 10 geographical distributions was thus developed for further structural inferences. The inferred optimal clusters provided the best possible structural description of the current Masson pine gene pool. This characterization effort could provide a set of baseline information for the future Masson pine research associated with gene mapping and marker-assisted breeding.

Specified Source(s) of Funding: Outstanding Youth Fund of Hunan Province Department of Education(09B112);National High-tech R&D Program of China (2011AA100203).

(344) Genetic Relationships of *Michelia* L. Species Revealed from ISSR Markers

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Michelia L. is a popular genus for urban landscapes and gardens. However, the genetic relationship among *Michelia* plants is unclear, which limits the further studies of its molecular phylogeny and ornamental breeding work. ISSR makers were applied to analyze genetic relationships among 25 *Michelia* taxa. Sixteen primers with the most polymorphic bands were selected for this study. A total of 239 useful markers between 250 to 2500 base pairs were generated. Among them, 87.9% of bands were polymorphic markers. The average number of markers for each taxon was 128.3. These polymorphic bands had frequencies ranging from 0.06 to 0.98. The genetic distance ranged from 0.28 between *M. foveolata* Merr. ex Dandy and its variety *M.*

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foveolata var. *cinerascens* Y.W. Law et Y.F. Wu to 0.47 between *M. chapensis* Dandy and *M. shiluensis* Chun et Y.F. Wu. Cluster analysis showed that *M. maudiae* Dunn was apparently an out-group to other species. *M. foveolata* var. *cinerascens* should be accepted as a legitimate variety, not lumped to its species. *M. platypetala* Handel-Mazzetti is a legitimate species and DNA ISSR markers did not support it as a variety. A new species, *Michelia nanyueshanensis* Y.J. Yang et X.L. Jin, was proposed and it should be much closer to *M. floribunda* Finet & Gagnepain genetically. These results indicated that ISSR makers should be powerful techniques for determining genetic relationships in *Michelia*, which is important for future genetic improvement, identification, conservation, and breeding of *Michelia*.

Monday, July 22, 2013 12:15–1:00 PM

Human Issues in Horticulture

(203) Determining the Effects of Mutual Interaction in Horticultural Activity on Acceptance of Children toward Children with Disabilities and Improvement of Language Capability for Children with Disabilities

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The impact of horticultural therapy regarding linguistic development of children with disabilities and the acceptance attitude of children without disabilities was examined in this research. For this research, 16 children aged either 6 or 7 participated from City I, Northern Jeonlla Province in South Korea. Eight children with disabilities (from the M center for children with disabilities) and eight children without disabilities (from a child care center) participated. The horticultural program was composed of a total of fifteen sessions. For 10 sessions, participants were engaged in outdoor gardening activities (preparing a kitchen garden, sowing, seedling, harvesting, etc.) while for five sessions they carried out activities indoors (planting, water cultivation, etc.) The sessions were specifically geared toward engendering a positive impact on children with disabilities through horticultural activities where their linguistic development could be stimulated by the acceptance of children without disabilities. During the session, pairs composed of a child with disabilities and a child without disabilities worked together in the horticultural activities. The acceptance of children without disabilities toward children with disabilities was examined using an “adjective scale-disability acceptance attitude test.” In addition, an acceptance language & expression language development scale was used before and after

each session to examine the improvements in language capacity of children with disabilities. In all areas of perception, activity, and acceptance, significant improvements took place based on the result of the research. Furthermore, there were meaningful improvements in acceptance and expressive language after the horticultural therapy program. In conclusion, the horticultural therapy program focused on interaction of children with and without disabilities through horticultural activities is effective in enhancing acceptance of children with disabilities by other children and improving language capability of children with disabilities.

(204) Hydroponics Program for Improving Work Adjustment Skills in Students with Mental Retardation

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The objective of this study was to determine the effects of a horticultural therapy (HT) program using hydroponics procedure for lettuce (*Lactuca sativa* L. ‘Asia Heuk Romaine’) for improving work adjustment skills in students with mental retardation. A total of 22 sessions in the HT program was developed based on the critical role transitional model and Korean special education curriculum for agriculture, especially hydroponics. Fourteen students (grades 1st to 2nd) with intellectual disabilities from a special education class in a high school located in Incheon, South Korea, participated in the HT program for 4 months (from September to Dec. 2011, twice a week, about 60 min per session). The McCarron assessment neuromuscular development, emotional behavioral checklist, interpersonal negotiation strategies, and KEPAD picture vocational interest tests were used by teachers and horticultural therapists before and after the HT program. The results showed that motor performance, emotional behavioral strategies, and interpersonal negotiation strategies were significantly improved after finishing the 4-month HT program. There was no significant difference for vocational interest before and after the HT program. Finally, the HT program using hydroponics would be applicable for the students with intellectual disabilities and it may improve work adjustment skills by improving the motor performance, emotional behavioral strategies, and interpersonal negotiation strategies.

(205) Determining Metabolic Costs of Gardening and Typical Physical Activities in Children

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The objectives of this study were to determine the exercise intensities and energy expenditures of two gardening activities—such as planting transplants and sowing seeds in a garden plot—and four typical physical activities—such as running, jump roping, walking, and passing a ball—in children aged 11 to 13 years. Eighteen children volunteered in this study at a high tunnel in Cheongju, Chungbuk, South Korea, and performed randomly selected activities. Each child did each activity for 10 minutes and had a 5-min rest time between the each activity. During the gardening and physical activities, the children wore a Cosmed K4b2, which is a portable calorimetric monitoring system to measure metabolic costs such as oxygen uptake and energy expenditure for each physical activity. The heart rate during the each activity was also measured by radiotelemetry (Polar T 31). The results showed that the two gardening and four physical activities performed by the children were moderate- to high-intensity physical activities ($5.4 \pm 0.7 - 9.1 \pm 1.4$ METs). The activities with highest intensity were running (9.1 ± 1.4 METs) and rope skipping (8.8 ± 1.1 METs). The activities with lowest intensity were walking (6.1 ± 0.9 METs), planting transplants (5.8 ± 1.1 METs), passing a ball (5.6 ± 1.1 METs), and sowing seeds (5.4 ± 0.7 METs). Running and rope skipping showed a higher intensity than the other activities ($P < 0.0001$) and sowing seeds was the least intense activity performed in this study ($P < 0.0001$). This study showed a potential that gardening can be a healthy physical activity for children.

Monday, July 22, 2013

12:15–1:00 PM

Plant Biotechnology

(314) Purple Citrus? Utilization of Myb-related Transcription Factor Genes for Anthocyanin Production

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Three myb-related transcription factor genes of the anthocyanin biosynthetic pathway, *VvmybA1* from *Vitis vinifera*, *Ruby* from *Citrus sinensis* and *PAP1* from *Arabidopsis thaliana* were introduced into *Citrus aurantifolia* ‘Mexican Lime’ under the control of the cauliflower mosaic virus 35S promoter. The 35S: *VvmybA1* construct had the highest expression levels with some regenerated citrus plants being completely purple. The 35S: *Ruby* plants expressed anthocyanin at a much lower level than that observed in the 35S: *VvmybA1* plants. We did not observe any anthocyanin production in any 35S: *PAP1* derived transgenic line. Transgenic citrus plants expressing the *VvmybA1* or the *Ruby* gene gave a range of phenotypes, from green to slightly or intensely purple plants. Expression levels could not be correlated to the copy number in selected transgenic lines. The intensely purple plants lacked vigor and grew slowly. Anthocyanin biosynthetic pathway gene transcripts were observed to be up regulated when analyzed by qRT-PCR. These myb-related transcription factor genes hold potential as a simple and non-destructive visual marker for citrus transformation when coupled with a tissue specific or inducible promoter. These genes can also be used as a component in a marker free transformation system.

(315) Marker Free Plants using Bxb1-Mediated Site-specific Recombination Driven by a Seed-specific Promoter

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An important tool for the production of GM crops is the selectable marker gene (SMG), which allows for the identification of a few transformed plants from among the bulk of non-transformed plants. The SMG, usually an antibiotic or herbicide-resistance gene, remains in the genome of GM crops. Several strategies have been employed in plant genetic transformation to remove SMGs, including site-specific recombination (SSR) systems. The mycobacteriophage Bxb1 SSR system has been used in plant transgenesis to excise SMGs. The objective of this research is to use Bxb1, a uni-directional SSR system, to excise the SMG and render it unable to reinsert into the genome of the tobacco plant. The Bxb1 recombinase is codon-optimized to express in plants and is driven by a tissue-specific seed promoter. The binary vector was designed to allow the SSR system to delete both the SMG and the recombinase-coding region from the genome of the tobacco plant. The vector was transformed into tobacco, and T0 putative transgenic plants were obtained. GUS-positive T0 lines were transferred to soil for setting T1

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seeds and used for excision analysis. Bxb1-mediated excision was preliminarily identified in T1 seeds, and T1 plants through junction PCR analysis. Sequencing has confirmed successful excision results.

Specified Source(s) of Funding: Northeastern State University Faculty Research Committee Grant P120000

(316) Clustering of Differentially Expressed Genes from Transcriptome of *Vitis flexuosa*

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Transcriptome analysis is one of powerful tools to select valuable genes and genetic information in grape breeding program. In the present study, transcriptome of flower (full blooming and 7 days before flowering), leaf, fruit (young green, and ripe fruit), and root from *Vitis flexuosa* was analyzed to select useful genes, to elucidate their function, and to compare their differential expression through assembly, selection of DEGs, clustering, and annotation (GO and KEGG) of data from sequencing short reads on Solexa platform. We have assessed the effect of sequence quality, various assembly parameters and assembly programs on the final assembly output. We assembled ~132 million high-quality trimmed reads using Velvet followed by Oases with optimal parameters into a non-redundant set of 188,058 transcripts (≥ 100 bp in length), representing about 41 Mb of unique transcriptome sequence. The average length of transcripts was 1,722 bp and N50 length of 2,182 bp with largest contig length of 12,228 bp. Among assembled transcripts, a total of 31,834 *V. flexuosa* transcripts were selected as unigenes/predicted proteins from sequenced *V. vinifera* or other plant genomes at the protein level. From them, 143 unique loci were selected specifically from *V. flexuosa* based on similarity with *V. vinifera* and other plant genomes. Functional categorization revealed the conservation of genes involved in various biological processes like primary metabolic process (33.3%), cellular metabolic process (32.3%), and cellular metabolic process (33.3%) in *V. flexuosa*. The *V. flexuosa* transcripts set generated here will provide a resource for gene discovery and development of functional molecular markers. In addition, the strategy for assembly of transcriptome data presented here will be helpful in other similar transcriptome studies.

Specified Source(s) of Funding: This work was supported by a grant from the Next-Generation BioGreen 21 program (No. PJ008213), Rural Development Administration, Republic of Korea

(317) Gene Regulation Analysis of Alpha-linolenic Acid Metabolism in Fatty Acid Development of *Camellia oleifera* Seeds

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In an effort to better understand the factors that control alpha-linolenic acid metabolism in *Camellia oleifera* seeds, we had constructed the transcriptome library and expression profile of developing *C. oleifera* seeds with the initial stage and the peak stage, and had annotated detailedly the non-redundant unigenes in the transcriptome library. Comprehensive analysis of alpha-linolenic acid metabolism was carried out according to KEGG database. There were 112 non-redundant gene unigenes, which involved 14 key enzyme genes related to alpha-linolenic acid metabolism of *C. oleifera* seeds. The result of expression profile analysis concluded that there were four types of gene expression differences in alpha-linolenic acid metabolism under different developmental stage of *C. oleifera* seeds. Three of 14 successfully expressed in peak stage but not in initial stage. Seven of 14 expressed regardless of developmental stages. Two of 14 expressed in early peak stage and two of 14 expressed in late peak stage. In conclusion, the alpha-linolenic acid metabolism regulational pathway in *C. oleifera* seeds was proposed, which revealed the regularity of the synthetic process of alpha-linolenic acid and the conversion process to other unsaturated fatty acid in developing *C. oleifera* seeds. The findings should provide the basic scientific support for further conventional and molecular-aided *C. oleifera* breeding.

Specified Source(s) of Funding: Scientific Research Fund of Hunan Provincial Science & Technology Department (2012NK3065)

(318) Characterization of Ferric Reductase Oxidase (FRO) Genes in *Populus tremula* L.

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Many plant species suffer from iron chlorosis, causing millions of dollars loss yearly. Meanwhile, iron is an essential nutrient

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for human beings and iron deficiency leads to the major human nutritional disorder of anemia, particularly in populations of children and women. Iron uptake and transport in plants are controlled by a group of genes mainly in Ferric Reductase Oxidase (FRO) and Iron-Regulated Transporter (IRT) families. Genes in the FRO family encode the plasma membrane-bound Fe (III)-chelate reductase that reduces insoluble Fe (III) to soluble Fe (II), making Fe available for plant absorption. The function of FRO in Fe metabolism in plants has been verified in many herbaceous species including *Arabidopsis*, rice, tobacco, and soybean. In this research, the activity of FRO was compared between an iron-deficiency tolerant (PtG) and an iron-deficiency susceptible (PtY) trees of *Populus tremula*. In PtY, FRO activity in both leaf and root tissues was higher than in PtG under iron-deficient conditions. When Fe (III)-EDTA was applied to PtY, FRO activity increased in root tissues, but decreased in leaf tissues. In PtG, the activity of FRO was not notably changed regardless of iron status. Expression of *PtFRO* genes cloned from *P. tremula* in response to iron deficiency in PtG and PtY was investigated using quantitative real-time PCR (qPCR). Primers for qPCR were designed based on three putative *FRO* genes annotated in the genome sequence of *Populus trichocarpa*. The putative amino acid analysis revealed that the three genes contain three signature domains of ferric chelate reductase gene (Ferric_reduct, FAD_binding_8, and NAD_binding_6 domains). The three genes were named as *PtFRO3*, *PtFRO4*, and *PtFRO7* according to the similarity to *FRO* genes in *Arabidopsis*. Sequence analysis showed that *PtFRO3*, *PtFRO4*, and *PtFRO7* are 96%–99% similar to the corresponding gene sequences in *P. trichocarpa*. Expression of *PtFRO3* gradually increased under iron deficiency in leaves and decreased after Fe was resupplied. In PtY, expression of *PtFRO4* and *PtFRO7* decreased under iron deficiency followed by a progressive increase. In PtG, expression of *PtFRO4* first increased then decreased, while expression of *PtFRO7* gradually increased under iron deficiency. Similar to *PtFRO3*, resupply of Fe also decreased the expression of both *PtFRO4* and *PtFRO7*. The research will help understand the role of *FRO* genes in iron metabolisms and address iron chlorosis in woody species.

(319) Expression of FER-like Iron Deficiency-induced Transcription Factor (FIT) in *Populus tremula* L.

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FER-like iron deficiency-induced transcription factor (FIT), an ortholog of *FER* (also known as bHLH29, FRU, or FIT1) regulates various iron deficiency inducible genes with known or putative functions in iron homeostasis. Research indicated that FIT interacts with the subgroup Ib of bHLH transcription

factor genes to control iron uptake and transport by regulating the expression of *FRO2* and *IRT1* genes that are key genes regulating ferric reduction and iron transport in plants. In this research, expression of *PtFIT* gene in *Populus tremula* 'Erecta' was determined in response to iron deficient using quantitative real-time PCR (qPCR). Primers for qPCR were designed based on the putative *PtFIT* gene sequence that was annotated according to the whole genome sequence of *Populus trichocarpa*. The putative amino acid sequence analysis suggested that *PtFIT* gene contains a bHLH domain that shows 91.4% similarity to *AtFIT* gene. Sequence analysis showed that *PtFIT* of *P. tremula* is identical to the *FIT* gene in *P. trichocarpa* and contains partial bHLH domain. *PtFIT* highly expressed in roots; however, its expression was rarely detected in leaves. Expression of *PtFIT* in leaves was inhibited by iron deficiency (no iron or presence of Fe (III)-EDTA) in the first 3 days and then gradually increased after 3 days of iron deficiency treatment. Expression of *PtFRO2* and *PtIRT1* will be determined to confirm that *PtFIT* is a regulator of *PtFRO2* and *PtIRT1* in *P. tremula*. The research will help interpret the mechanism of gene regulation in response to iron deficiency and address iron chlorosis in woody species.

(320) Cloning and Characterization of a Stearoyl–Acyl Carrier Protein Desaturase Gene from Tung Tree (*Vernicia fordii*)

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The stearoyl–acyl carrier protein desaturase (SAD), a key enzyme, determines the ratio of saturated to unsaturated fatty acids in higher plants. Using the methods of reverse transcriptase polymerase chain reaction (RT-PCR) and rapid amplification of cDNA ends (RACE), a full-length cDNA encoding SAD was obtained from developing seeds of Tung Tree (*Vernicia fordii*) that was named VfSAD and deposited under GenBank (Accession no. GU363502). The VfSAD contained an open reading frame of 1179 nucleotides encoding 392 amino acid residues. At the deduced amino acid level, the VfSAD showed 76% to 96% similarities with other reported SADs. The predicted isoelectric point (pI) and molecular weight (Mw) of VfSAD is 5.99, 45217.7 Da, respectively. The VfSAD is predicted to be a kind of hydrophilic and non-secreted proteins. The predicted VfSAD contained several functional domains including N-glycosylation sites, cAMP and cGMP dependent protein kinase phosphorylation sites, and a FA_desaturase_2 motif. Quantitative RT-PCR analysis revealed that the VfSAD was expressed at all of the stages of *V. fordii* seeds, but displayed an irregular expression profile. These results would provide a base for understanding the mechanism of fatty acid composition and modifying the fatty acid composition in *V. fordii*.

Specified Source(s) of Funding: This work was supported by the projects of state forestry research and public service industry (200904023), Hunan Provincial Natural Science Foundation of China (10JJ4022), Scientific Research Foundation of Central South University of Forestry & Technology

(321) Assessment of Genetic Diversity of *Commiphora wightii* (Guggal) Germplasm in Rajasthan using RAPD and ISSR Markers

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The aim of the present study is to evaluate genetic diversity within and among populations of *Commiphora wightii* (Guggal) in different regions of Rajasthan using RAPD and ISSR markers. An extensive survey was conducted to identify the plant gender in each population. All the plants from Mangaliyawas, Pushkar, and Ajmer were found to be hermaphrodite. Plant materials were

collected from different locations in Rajasthan namely Ajmer, Pushkar, Mangaliyawas, Jodhpur, Udaipur, and other locations where *C. wightii* grows in natural conditions. Genomic DNA was isolated from 3-g leaf tissues from all accessions with the modified CTAB method. The DNA was treated with RNase for eradication of RNA. The DNA concentration was estimated using the spectrophotometric method. Absorbance of the solution was measured at wavelengths 260 nm and 280 nm. The DNA was diluted to 30 ng/μL for RAPD analysis. Sixty 10-base primers were used for polymerase chain reaction for screening of genetic diversity to ascertain their potential of clear amplification in polymorphism and reproducibility. The RAPD and ISSR profiles were produced through PCR amplification and polymorphism was recorded among the population of *C. wightii* in Rajasthan. The results of the research will help in determination of gender in early stages of development and establishment of the relationship of genetic variability with geographical distribution in Rajasthan and also, offer genetic resource information for future meaningful implementation of conservation programs applicable for *C. wightii*.

(322) Screening for Avocado Resistance to Laurel Wilt using Shoot Cuttings

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Avocado (*Persea americana* Mill.) is a high-value specialty crop commercially grown in California and Florida. The Florida avocado industry contributes ~\$13 million to the economy, with ~6,800 production acres in Miami–Dade County. However, the avocado industry is newly threatened by the fungal disease laurel wilt (LW; *Raffaelea lauricola*) vectored by an Asian ambrosia beetle (*Xyleborus glabratus*), which has devastated native avocado relatives. Injections of trees with propiconazole slow infection, but are not practical for commercial avocado production. Vector management strategies have so far been unsuccessful. However, there are preliminary indications that some avocado genotypes from more freeze-tolerant Mexican (M) and Guatemalan (G) races are more LW-resistant than the West Indian (WI) material that is the foundation of South Florida production. Most effective assessment of LW resistance reportedly requires inoculation of trees > 25 mm in diameter. Screening germplasm using this method requires laborious development of clonally propagated trees or use of heterogeneous own-rooted seedlings; trees are being grown for such field assessments now. However, to facilitate higher throughput screening, use of cuttings for LW resistance screening is being assessed. In preliminary experiments, 20 cm cuttings were placed in test

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tubes with the lower third immersed in water, inoculated with the LW pathogen, and monitored for disease development and aspects of resistance response. Internal disease symptoms of affected avocado are indicated by reddish brown to bluish grey sapwood. Disease severity as indicated by sapwood discoloration was recorded from 0.4 up to 13.8 mm from the inoculation point. When tissue was plated onto the semi-selective media CSMA+, the pathogen was recovered from both inoculation point and apex of some cuttings. Lula cuttings started showing external symptoms 12 days post inoculation while Hass x Bacon showed no external symptoms over 6 weeks post infection. Lula is a cultivar with G x WI background recommended for Florida production and has been shown to be more susceptible to LW compared to Hass (G x M) and Bacon (G). The potential application of resistance screening using cuttings to the overall goal of developing excellent avocado selections for east-central Florida will be discussed.

(323) Tomato Genotype-specific Biomarkers under Salinity Stress

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Salinity stress is increasing becoming an important research domain. The development of improved salt tolerant crops is urgently needed to face limitation in water resources, salinity accumulation in irrigated soils, and agricultural expansion to marginal areas. In this study, the expression profiles were investigated for three advanced tomato lines (salinity susceptible genotype L46, salinity tolerant genotype L56, and salinity intermediate genotype L66) and one salinity tolerant genotype as reference (BL 1076). The generated data were analyzed in a way to pinpoint genotype-specific biomarkers. Genotype L56 revealed prominent over-expression of major unique gene cluster over other genotypes under salinity stress, which include AP2 erf domain-containing transcription factor (Pti5), NAC domain protein, calmodulin binding, and osmotin-like protein with 422.6, 59.7, 45.8, and 45.1 fold, respectively. The LesAffx.70722.1.S1 (type-a response regulator) was found to be expressed mainly in root and hypocotyl, while Les.4483.1.S1 (NAC domain protein) was found to be expressed mainly in cotyledon and fruit. Two tomato responsive genes were found to be unique based on phylogenetic analysis. The tomato genes encoding xyloglucan endotransglucosylase-hydrolase XTH3 and salt responsive protein 1 did not cluster with any formed clade of related plant homologs. The revealed salinity stress biomarkers can be either beneficial or damaging to the stressed plant. Beneficial biomarkers are desired as they are part of tolerance mechanism against the salinity stress. The damaging biomarkers are undesired as they accelerate plant senescence

and reduce growth. Both biomarkers can be implemented in the breeding program, where one can select for the beneficial over the damaging ones. Thereafter, the beneficial biomarkers can be combined in one line by crossing and further selection. *Specified Source(s) of Funding:* The National Plan for Science and Technology at King Saud University for this project (number 10-BIO970-02)

Monday, July 22, 2013

12:15–1:00 PM

Postharvest

(383) Use of Gamma Radiation as an Alternative Method for Mite Control in Postharvest Storage of Garlic Bulbs (*Allium sativum*) cv. Perla

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Rhizoglyphus echinopus is the most important mite species in

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garlic crop in Mexico and its effect during the postharvest storage of bulbs can generate total product loss. The procedures for control of this pest include applying acaricides compounds in planting and crop development, which can generate resistance and difficulties in the controlling of this pest. The application of low-dose gamma rays can be a clean alternative that could control the mite population in bulbs stored by sterilizing individuals, thus preventing its reproduction. The aim of this work was to study the effect of two doses of irradiation (150 and 300 Gy) in the mite population and in the overall quality of the bulbs. Two sets of 12 boxes of 'Perla' garlic bulbs produced and harvested at Aguascalientes, Mexico, were irradiated at 150 and 300 Gy in a commercial irradiator of Co₆₀ gamma rays (Benebion Co.) and a third group was the control group (0 Gy). The bulbs were stored at room temperature (RT) and 0 °C for 83 and 200 days. Every 15 days, different samples of bulbs were taken to analyze the bulb firmness, weight loss, sprouting index or IB (100* length sprout / clove length), and the count of adult mite population per bulb. After 83 days of storage at RT, the application of 300 Gy controlled the mite population (2–150 adult individuals per bulb) compared to non-irradiated bulbs that reached counts of 150–1300 adult individuals per bulb. The bulbs irradiated at 300 Gy maintained a better firmness both RT and at 0 °C. This treatment did not affect the internal quality of the cloves or its weight loss (4% to 6.5 %) and decreased the IB (33% at RT and 0 Gy and 27 % at 300 Gy). Storage at 0 °C for 200 days was a synergistic factor that helped control the incidence of this pest during postharvest storage (6 adult individual per bulb) in comparison with the control group (198 adult individual per bulb). The application of 300 Gy in 'Perla' garlic bulbs can be recommended for the control of this pest in stored bulbs. It is possible that other varieties of white garlic, such as as 'California Early' or 'California Late', could also use this treatment for pest control.

Specified Source(s) of Funding: Consejo de Ajo de Aguascalientes

(384) Effect of Nitric Oxide, Microperforated Packages, and Ionizing Radiation on Postharvest Quality of Mango (*Mangifera indica* L.) cv. Manila

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In Mexico, mango (*Mangifera indica* L. cv. 'Manila') is widely accepted either for fresh consumption or industrial use. Among varieties, it has the second place of the total national production with 19.8%. Although this variety possess similar or superior sensory qualities compared to the other exported mango varieties (such as 'Ataulfo', 'Kent', and 'Tommy Atkins'), 'Manila' has not yet reached foreign markets, because its metabolic activity is three times higher than the others, causing a rapid loss of firmness and weight. Furthermore, mango is quite susceptible to anthracnose, a disease that produces a high loss postharvest. The present work studies the application of nitric oxide (NO) and microperforated packages (MP) in order to inhibit fruit softening and weight loss, and the use of ionizing gamma radiation as a quarantine treatment at cool storage (13 °C) and the transference to ambient temperature for 4 days. About 832 mangos at maturity were separated in two groups, irradiated (0.3 kGy) and non-irradiated (control). Both groups were treated against anthracnose (hydrothermal treatment; 53 °C, 6 minutes). Half of irradiated and non-irradiated groups were submerged in 1 mM nitroprusside of sodium solution (a NO donor). Control group was treated with distilled water. Mangoes were stored at 13 °C for 22 days in carton boxes with and without MP. Analyses were made every 4 days, three replicates of three fruits per treatment were analyzed for visual quality, anthracnose damage, loss of weight, internal and external color, firmness, total soluble solids, and titratable acidity. The NO treatments did not influenced significantly any parameters. The use of MP reduced by half the loss of weight, 7.54% compared to 15.21% at 22 days of storage. Ionizing radiation was the best treatment, significantly delayed fruit softening the first 10 days and retarded color development in storage at 13 °C. The irradiated group presented 77.7% anthracnose free damaged fruits compared to 54.1% from the non-irradiated. Moreover, non-irradiated fruits had 22% damage in level moderate to severe compared to 1% for the irradiated ones. In conclusion, the use of MP reduce in 50% the loss of weight. Ionizing radiation treatment (0.3 kGy) of mango 'Manila' delayed fruit color and softening as well as maintained fruit quality and reduced the decay incidence.

(385) Storage Life and Eating Quality of 'Bartlett', 'Comice', 'Bosc', 'Forelle', and 'Anjou', But Not 'Starkrimson', Could Be Improved by Modified Atmosphere Packaging

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There is considerable interest in the use of modified atmosphere packaging (MAP) for maintaining pear (*Pyrus communis* L.) quality similar to controlled atmosphere storage without the extensive investment in infrastructure and instrumentation. The objectives of this research were to study respiration physiology of the major pear varieties ('Starkrimson', 'Bartlett', 'Bosc', 'Comice', 'Forelle', and 'Anjou') grown in U.S. Pacific Northwest and their responses to MAP during storage at -1.1 °C. Results indicate that varieties vary significantly in respiration rate, ethylene production rate, and internal CO₂ concentration at -1.1 or 20 °C after satisfying the chill requirement of each variety, which in turn affects MAP response. The storage life with marketable quality of fruit packed in standard perforated polyethylene liners were 3 months for 'Bartlett', 4–5 months for 'Comice', 'Bosc', and 'Forelle', and 5–6 months for 'Anjou'. The commercial MAP equilibrated with atmospheres of 10% to 16% O₂ + 3–6% CO₂, depending on variety, inhibited ethylene production, and respiration rates and extended storage life up to 4–5 months for 'Bartlett' and 6 months for 'Comice', 'Bosc', 'Forelle', and 6–7 months for 'Anjou' with maintenance of fruit flesh firmness and skin color without physiological disorders. After extended cold storage, MAP packaged fruit could be ripened to their characteristic texture and flavor. However, 'Starkrimson' developed internal browning (IB) after 2 months of storage in MAP with atmospheres of either 9.5% O₂ + 6.0% CO₂ or 18.0% O₂ + 2.5% CO₂. 'Starkrimson' was highly susceptible to CO₂ injury, possibly related to its high respiration rate and internal CO₂ concentration. In conclusion, the storage life of 'Bartlett', 'Bosc', 'Comice', 'Forelle', and 'Anjou' with high quality could be increased by up to 2 months when packed in MAP compared with fruit packed in standard perforated polyethylene liners.

Specified Source(s) of Funding: Columbia Gorge Fruit Growers Association

(386) Respiration and Quality Responses of 'Bing' Sweet Cherry to Different Atmospheres during Cold Storage and Shipping

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Most sweet cherries produced in the U.S. Pacific Northwest that are shipped to distant markets, are often in storage and transit for over 3 weeks. The objectives of this research were to study the effects of O₂ and CO₂ concentrations on respiration physiology and the efficacy of modified atmosphere packaging (MAP) on extending shelf life of sweet cherry.

Oxygen depletion and CO₂ formation of 'Bing' cherry fruit were measured using a closed system method. While respiration rate was inhibited linearly by reduced O₂ concentration from 21% to ~3% to 4% at 20 °C, at 0 °C it was affected very little from 21% to ~10% but significantly from ~10% to ~1%. Elevated concentration of CO₂ (0% to 16%) did not affect fruit respiration rate in the closed system at 20 or 0 °C. 'Bing' cherry fruit were packaged (~8 kg/box) in 5 different commercial MAP bags and a standard perforated polyethylene liner (as control) and stored at 0 °C for 6 weeks. MAP bags that equilibrated with atmospheres of 1.8% to 7.4% O₂ + 8.8% to 10.3% CO₂ reduced fruit respiration rate, maintained higher titratable acidity (TA) and flavor, and reduced stem browning incidence compared to control after 4 and 6 weeks of cold storage. In contrast, MAP bags that equilibrated with atmospheres of 9.9% to 13.0% O₂ + 7.3% to 12.9% CO₂ had little effect on inhibiting TA loss, maintaining flavor, and reducing stem browning during cold storage. Higher CO₂ concentration in MAP retarded anthocyanin accumulation and fruit skin color darkening. All five MAP bags maintained higher fruit firmness (FF) and reduced decay compared to control after 6 weeks of cold storage. In conclusion, the atmospheres of 1.8% to 13.0% O₂ + 7.3% to 12.9% CO₂ generated by the commercial MAP, controlled decay and maintained higher FF, but only the MAP with lower O₂ permeability (e.g., equilibrated with 1.8% to 7.4% O₂) could maintain flavor and stem quality of sweet cherry compared to the standard perforated liners.

Specified Source(s) of Funding: Oregon Sweet Cherry Commission

(387) Effects of Modified Atmosphere Packaging and Irradiation on the Quality of Blueberries under Simulated Commercial Transportation and Retail Conditions

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The phase-out of methyl bromide as a phytosanitary treatment for fresh fruit poses a challenge to the United States export commodity market. Irradiation has the potential to replace methyl bromide by controlling pests while maintaining fruit quality. Modified atmosphere packaging has been shown to enhance the shelf-life of various fruits, including blueberries. The goal of this study was to determine the effect of the combination of irradiation treatment and modified atmosphere packaging on the shelf-life, overall quality, and consumer acceptance of southern highbush blueberries under simulated shipment and retail display conditions. Blueberry varieties Star, Jewel, and Snowchaser in 6-oz clamshells, 12 clamshells in a tray, were packaged in nylon film designed to create modified atmosphere conditions and subjected to irradiation at a target dose of 400 Gy. The treatments included blueberries packaged in modified atmosphere film (MAP), treated with irradiation (I), combination of irradiation and modified atmosphere packaging (IMAP), and control. After treatment, blueberries were stored for 1, 8, and 21 days at 0 to 4 °C to simulate refrigerated air, ground,

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and sea transportation, respectively, followed by a 3-day retail display simulation at 20 °C. Quality factors such as titratable acidity (TA), °Brix, texture, weight loss, gas concentration, and percentage of damage were evaluated periodically. Blueberries were also evaluated by 80–100 untrained consumers for appearance, flavor, texture, and overall acceptability and texture appropriateness. The attributes most significantly affected by treatment were texture, weight loss, and damage. After 3 weeks of storage, all three treatments retained firmness as compared to the control. Weight loss and percentage of damage were lower in MAP and IMAP compared to control and irradiated samples across all three varieties. There were significant varietal differences in response to treatment. Texture, TA and °Brix were impacted for ‘Star’ and ‘Jewel’ but not ‘Snowchaser’. In ‘Jewel’, MAP and IMAP had significantly ($P < 0.05$) higher values for liking of appearance, flavor, texture as well as overall liking during the 3-week sea shipment simulation as compared to the untreated and irradiated blueberries. In ‘Star’, MAP also increased all sensory scores over time. In ‘Snowchaser’, however, average sensory scores for all three treatments were not significantly different. Overall, MAP and IMAP are suitable treatments in maintaining blueberry quality but it is important to test each variety for its tolerance to irradiation, modified atmosphere, and combination treatments.

(388) Effect of Preharvest Bagging and Postharvest 1-Methylcyclopropene (1-MCP) Treatment on the Fruit Quality Attributes in Cold Stored ‘Gamhong’ Apple

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This study was carried out to evaluate the effects of preharvest bagging and postharvest 1-methylcyclopropene (1-MCP) on

the fruit quality attributes in cold stored ‘Gamhong’ apple [*Malus sylvestris* (L.) Mill var. *domestica* (Borkh.) Mansf.]. Fruit with bagging and non-bagging were harvested at the experimental orchard of Apple Research Station, treated with 1 $\mu\text{L}\cdot\text{L}^{-1}$ 1-MCP for 20 h at 20 °C, and stored in air at 0 °C for 6 months. At harvest, preharvest bagging treatment reduced respiration rate and ethylene production, compared to non-bagging fruit. 1-MCP treatment reduced ethylene production in both bagging and non-bagging during cold storage. Ethylene production between bagging and non-bagging was not affected by 1-MCP treatment. Ethylene production tended to increase after 3 months storage in the control fruit with non-bagging. In contrast, respiration rate was not different between bagging and non-bagging during cold storage. Flesh firmness and titratable acidity (TA) in 1-MCP treated fruit were not changed over the cold storage while flesh firmness in control fruit was rapidly decreased irrespective of bagging treatment. Flesh firmness was likely to be effectively maintained in fruit with bagging than in fruit with non-bagging. Soluble solids concentration (SSC) at harvest was higher in fruit with non-bagging than in fruit with bagging and the response of SSC was not changed throughout the storage. Fruit weight loss was significantly decreased by 1-MCP treatment during storage. Overall, the results suggest that 1-MCP treatment would be highly effective on retarding the alteration of fruit quality attributes in ‘Gamhong’ apple, regardless of the preharvest bagging.

(389) An Objective Method to Measure the Peelability of Citrus Fruit

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Ease of peeling is an important trait to consider in the development of new citrus cultivars. To objectively measure this trait, we used a Texture Analyzer (Stable Micro Systems, model TA-XT2, Godalming, England) equipped with a TA-265A platform and pulley system, and attached the cable to a cut section of the fruit peel. The analyzer was set to measure tension. A cutting system was developed by bonding together two adjustable utility knives (Husky SP304-HD) so that the hook blades were 16 mm apart. The cutting depth of the blades was adjusted depending on peel thicknesses so that the blades cut mostly the peel. The fruit peel was cut into strips of varying length depending on the part of the fruit being evaluated. Early experiments evaluated strips of peel from the equator to the stem-end or blossom-end of the fruit, or around the equator of the fruit. No consistent differences were found between these three regions. Therefore, subsequent tests measured peelability around the fruit equator.

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For this, a continuous strip was cut around the equator, with cross cuts on opposite sides of the fruit, and up to 30 mm of the peel pulled away from the segments to allow attachment of the cable clamp. The fruit itself was held using an adjustable clamp taken from a Homeland Goods Orange Citrus Peeler that allowed the fruit to rotate as the peel was pulled. The Texture Analyzer was set to begin data collection after cable slack was taken up (100 g trigger force) and then tension force measured for the next 75 mm, or until the peel broke. A computer macro was used to report the length of peel before breakage (if it occurred), average tension force (strength of peel adherence to the segments), peak force, and area under the curve. The macro detected if and when the peel broke and automatically excluded data after peel breakage. Tests comparing grapefruit and orange found, as expected, that 'Valencia' oranges required greater force (both peak and average) for peel removal, and that the peel would break after shorter distances than the grapefruit. Additional tests with 'Marsh' grapefruit, 'Murcott' tangerines, and navel oranges found that colder (5 °C) fruit required greater force for peel removal and resulted in easier peel breakage than warmer (22 or 35 °C) fruit. In these tests, 'Murcott' tangerines peeled easiest, followed by navel oranges, and then 'Marsh' grapefruit.

Specified Source(s) of Funding: New Varieties Development & Management Corporation

(390) Controlled Atmosphere Storage Reduces Deterioration Rate of Pomegranate (*Punica granatum* L.) Fruit

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Pomegranate is a non-climacteric fruit consumed fresh as whole fruit or as arils and used for production of wine and syrup. Pomegranate production has been growing worldwide in response to increased popularity due to pomegranate health benefits. In the United States, the largest pomegranate production is in California. Pomegranate is a new crop in the

southeastern United States. The objectives were to determine the effects of controlled atmosphere storage on physical and chemical properties of pomegranate fruit of different cultivars grown under Georgia conditions. Pomegranate fruit from Ponder Farm (PF), Ty Ty, GA, in 2010 and 2011 and Alma Farm (AF), Alma, GA, in 2011 were stored in controlled atmosphere (CA) storage (5% CO₂ + 3% O₂; 5 °C, 90% to 95% RH) and regular air (RA) storage (5 °C, 90% to 95% RH) for 3 months. Pomegranate whole fruit and juice were evaluated for various physical and physiochemical attributes at end of storage. Skin shriveling, fruit cracking, husk scald, chilling injury, and cercospora decay severity were reduced in fruit under CA than in RA storage. Fruit husk color was better maintained and juice total soluble solids were higher in fruit under CA than in those under RA. Fruit quality deteriorated rapidly after fruit were removed from storage and kept at room temperature (20 °C, 50% RH) showing marked skin shriveling and hardening due to high rates of fruit water loss. Fruit shelf life at room temperature was less than 7 days. In conclusion, controlled atmosphere storage was more effective in maintaining the quality of pomegranate fruit compared to regular air storage.

Specified Source(s) of Funding: ISE-NIFA-USDA

(391) A Link between Water Quality and Bacterial Growth in Christmas Tree Stands with Postharvest Needle Abscission in Balsam Fir

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Postharvest needle loss in Christmas trees is a complex phenomenon regulated by genetic, environmental, management and postharvest factors affecting physiological processes. Typically, the initial water consumption of a freshly cut Christmas tree is 0.20 mL·g⁻¹ per day, but follows an exponential decline until a steady state of approximately 0.05 mL·g⁻¹ per day is reached. It is hypothesized that bacteria growing in standing water of Christmas tree stands inhibits water flux and, ultimately, contributes to poor needle retention. A total of 100 branches were collected and placed in water. Each week 10 branches were randomly selected and assessed for percentage of needle loss, water use, xylem pressure potential (XPP), and relative water content (RWC). In addition, the stand water was collected and analyzed for bacterial count and percentage of transmittance at 600 nm wavelength. In general, it was found that water use, RWC, XPP, and transmittance all decreased over time; and the percentage of needle loss and bacterial count increased over time. Bacterial counts were only able to be monitored over

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the first three weeks, which followed an exponential growth and a logarithmic transformation of this data had a significant ($P < 0.001$) linear negative relationship with transmittance ($R^2 = 86.0\%$). Over the duration of the experiment, transmittance had a significant ($P < 0.001$) positive linear relationship with water use ($R^2 = 62.5\%$) and XPP ($R^2 = 62.1\%$). None of the factors studied was directly related to percentage of needle loss, but that was likely due to the fact that no needle loss occurred in the first few weeks. A comparison of the number of days until needle loss commencement and the number of days for water use to reach the steady state of $0.05 \text{ mL}\cdot\text{g}^{-1}$ per day revealed a strong positive linear relationship ($R^2 = 87\%$). It is suggested that the overall water quality, as indicated by transmittance, is strongly linked to water use. A quick decline in daily water use, due either to poor water quality or other reasons, can promote needle abscission. There is evidence to suggest that bacterial growth in standing water may perhaps be a contributor to the poor water quality and needle retention, postharvest.

Specified Source(s) of Funding: ACOA, NSERC-CRD

Monday, July 22, 2013

12:15–1:00 PM

Propagation

(324) Use of Unrooted Grafted Vegetable Cuttings: II. Shipping Trials Report

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Among many challenges associated with introduction of vegetable grafting to U.S. propagation nurseries, the seasonal nature of vegetable plant propagation is crucial to address. U.S. vegetable production inherently has various cropping systems with different transplanting seasons, yet the limitations of perishable seedling transportation (refrigeration requirement, weight and volume of soil and trays) forces the propagators to only serve producers within limited distances ($< \sim 500$ miles radius). To be able to ship a grafted, healed plant, but with the roots and soil removed (unrooted grafted cuttings) would theoretically allow large numbers of plants to be packed into insulated shipping boxes. This could make feasible overnight, long distance shipping of large numbers of plants used by larger commercial growers, who would then root the cuttings and grow them on to transplant stage. Additionally, the shipping of unrooted grafted cuttings would overcome some quarantine issues and allow shipping to locations where soil importation is restricted. Together with our preceding growth-chamber based study to find the environmental factors affecting the quality and growth of unrooted grafted cuttings, we conducted shipping trials in winter season of 2012–13. We shipped healed, unrooted watermelon ('Tri-X-313' scion on 'Strongtosa' hybrid squash rootstock) grafted cuttings from

Tucson AZ to Columbus OH, and back again, using overnight air freight, resulting in approximately 48 hours in shipping conditions. Plants were packed in various orientations and the temperature inside the package was recorded using a self-logging thermometer. A small number of grafted cuttings were kept immobile in a dark chamber maintained at a constant temperature of 12°C as a control comparison. For the trials conducted on 27–29 Nov. and 11–13 Feb., plant temperature during the shipment was in a range of 9 to 28°C and 12.5 to 23°C , respectively. Upon receipt after 2-day shipping, the cuttings showed minor signs of chilling injury and/or physical deformation (bending) but all cuttings were successfully rooted in greenhouse. Compared with control cuttings stored at 12°C , all visual quality parameters were significantly reduced for the shipped plants. Differences in some, but not all visual quality parameters between control and shipped plants became insignificant after rooting and grow-out (a total of 12 days). However, control plants maintained greater fresh and dry weight even after rooting and grow-out. Further studies are needed to test shipments using various container designs (e.g., inserts to reduce the mechanical stress and insulation methods to reduce the temperature fluctuation) to minimize the impact of long-distance transportation.

(325) Artificial Seeds in Asiatic Lily

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Lily is a monocotyledonous species belonging to the Liliaceae, and one of the most important cut-flower species, mainly because of its large, attractive flowers. The Asiatic lilies are the hardiest of all the lily hybrids, they grow very well in USDA Zones 3 to 10, are easiest for the beginner to grow, and are the first to flower each season. In an effort to establish an Asiatic lily in vitro breeding system, we developed a highly efficient plant regeneration system for an elite Asiatic lily hybrid 'Jocelyn's Bouquet'. In vitro bulb scales were used as explants, and somatic embryos developed following embryonic cell induction and somatic embryo induction. Regenerated somatic embryos were matured on artificial seed strength medium after 40 days. The well-developed artificial seeds were directly transplanted to peat moss:perlite:vermiculite (1:1:1) soil and kept under moisture in a growth chamber for acclimatization, and a 100% survival rate was obtained after 25 days of acclimatization. Greenhouse acclimatization is now in progress.

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(326) Plant Regeneration and Somatic Embryogenesis in *Amaryllis*, *Hippeastrum* Hybrids, and *H. papilio*

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Five *Hippeastrum* hybrid genotypes, Christmas Gift (CG), Royal Velvet (RV), Lemon Sorbet (LS), Orange Sovereign (OS), Red Lion (RL), and one genotype of *H. papilio*, Papilio Butterfly (PB) were tested in tissue culture for micropropagation. Flower buds and the basal and upper parts of bulb scales were used as explants for in vitro culture. Organogenesis and somatic embryogenesis were observed with all six genotypes. Direct shoot regeneration was induced from the basal parts of bulb scales of all genotypes. Shoot regeneration was induced from the upper part of scales with five genotypes (CG, RV, OS, RV, and LS) and from the flower buds of three genotypes (OS, CG and LS). Therefore, basal and upper parts of bulb scales and flower buds are all ideal explants to regenerate shoots or somatic embryos for micropropagation. Calli were induced from all three explants and embryogenic calli were carefully selected for further somatic embryogenesis and shoot multiplication.

(327) Micropropagation of Four Species of Hellebore (*Helleborus*) and Their Commercialization

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Being one of the earliest spring flowering perennial plants in nature, *Helleborus* is attracting increasing interest and market in North America and Europe in recent years. There are more than 20 species in the genus *Helleborus*, among which *H. xballardiae* and *H. niger* dominate the market nowadays, with *H. xhybridus* cultivars in great demand and with the highest market values. The slow natural propagation limits the commercialization of an elite breeding line. Although tissue culture techniques are widely applied to propagate many horticultural plants, *Helleborus* is still considered as one of the most recalcitrant plants, especially the species *H. xhybridus*. In collaboration with Pine Knot Farms (<http://www.pineknotfarms.com/>), we have established an efficient tissue culture system for four species of *Helleborus*, *H. xhybridus*, *H. xballardiae*, *H. xnigercors*, and *H. niger*. In the high value *H. xhybridus*, we have collected 132 elite breeding lines, with 82 growing in vitro. The tissue culture response rate is 62.1% (82/132). Calli and shoot regeneration were induced on young leaf segments, meristems and flower buds. Somatic

embryogenesis was observed during subcultures and developed into plants. By modifying the medium composition and culture conditions, we have more than 20 genotypes of *H. xhybridus* in tissue culture, including various flower colors, double petal layers, and special color combinations. The *H. xballardiae*, *H. xnigercors* and *H. niger* are commercially micropropagated by Dan River Plants, LLC, using our tissue culture systems. Five genotypes of *H. xhybridus* are currently micropropagated for commercialization, with additional genotypes planned for large-scale production annually.

(328) Micropropagation of *Corymbia ptychocarpa*

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Corymbia ptychocarpa (F. Muell.) K.D. Hill & L.A.S. Johnson (swamp bloodwood), a member of Myrtaceae, is native to northwestern Australia. Swamp bloodwood was introduced into China for ornamental landscape use because of its unique leaves and beautiful terminal inflorescences. An efficient micropropagation protocol is needed for the mass propagation of swamp bloodwood. Disinfested shoot tips with one axillary bud (1–1.5 cm) were cultured on modified Murashige and Skoog (mMS) medium containing with 0.2, 0.3, 0.4, 0.5, or 0.6 mg·L⁻¹ 6-Benzylaminopurine (BAP) and 0.1 or 0.2 mg·L⁻¹ 1-Naphthaleneacetic acid (NAA). Thirty days after culture, the highest induction rate, 93.3%, was observed on the mMS medium plus 0.5 mg·L⁻¹ BAP and 0.1 mg·L⁻¹ NAA. The induced shoots were cultured on mMS medium supplemented with 1, 1.5, or 2 mg·L⁻¹ BAP and 0.1 or 0.2 mg·L⁻¹ NAA. A total of 5.2 shoots per explant were induced on mMS medium plus 1.5 mg·L⁻¹ BAP and 0.2 mg·L⁻¹ NAA. Shoots (~2 cm) were subcultured on 1/2 strength mMS medium containing 1.0, 1.5, or

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2.0 mg·L⁻¹ Indole-3-butyric acid (IBA) or 0.1 mg·L⁻¹ NAA to form roots. The highest induction rate, 96.3%, was observed on the 1/2 strength mMS medium with 1.5 mg·L⁻¹ IBA. The rooted plantlets were then acclimatized and transplanted into a mix of coconut chaff and red soil (3:1, v/v), and the final survival rate was 81.2%. This micropropagation procedure would be suitable for commercial production of swamp bloodwood.

(329) Micropropagation of the Relict Genus *Cercidiphyllum* (Cercidiphyllaceae)

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The genus *Cercidiphyllum* (Cercidiphyllaceae) is endemic to Japan and China, consisting of two dioecious tree species, common katsura (*C. japonicum* Sieb. & Zucc.) and the broad-leaved hiro-ha-katsura (*C. magnificum* Nakai). *Cercidiphyllum* grows 5 to 10 m in height and similar width in riparian forests, forest margins, and streams. Prized as specimen trees, all genotypes of the genus have potential for commercial nursery development. The micropropagation of woody ornamentals provide a stepping-stone to biotechnological approaches in plant improvement programs, aid in nursery production, and conservation efforts. To date, there exists no literature on the micropropagation of *C. magnificum*, *C. japonicum* (Weeping Group), and limited information on *C. japonicum*. This study focuses on many aspects of micropropagation, in respect to well represented genotypes within *Cercidiphyllum*. Factorials of nutrient salt and plant growth regulator concentrations were used for in vitro establishment, proliferation, and root initiation of *Cercidiphyllum*. Four nutrient salt formulations (MS, DKW, LP, or WPM) ranging from high to low salt formulations were studied to determine a suitable nutrient salt formulations for the establishment and proliferation of axillary explants. Factorial combinations of thidiazuron (TDZ) concentrations (0, 0.05, 0.10, 1.0 μM), 6-benzylaminopurine (BA) concentrations (0, 1.1, 2.2, 4.4 μM), indole-3-butyric acid (IBA) concentrations (0, 0.05 μM), and 1-naphthaleneacetic acid (NAA) concentrations (0, 0.05, 0.10, 1.0 μM) were used for micropropagation stages. Reduction of phenolic exudation of explants during the initiation phase may improve vigor and can be prevented by carbon source treatments. Nodal explants 2 cm in length were used to initiate cultures and maintained on various media with 0%, 0.1%, 0.3%, or 0.5% sucrose; correlating sucrose concentration with phenolic exudates. All micropropagation experiments included 0.07% agar and a pH 5.8. Explants were incubated approximately 30 cm beneath cool-white fluorescent lamps that provide a photon flux of approximately 40 μmol·m⁻²·s⁻¹ for a 16-h photoperiod at 25 ± 3 °C. Preliminary results indicate lower nutrient salt formulations (WPM, LP, and MS, respectively) combined with low concentrations of auxin (0.5 μM IBA) and moderate cytokinin levels (2.2 μM BA) performed better at

axillary shoot initiation and higher concentrations of cytokinin (4.4 μM BA) for proliferation. Further results show a reduced concentration of sucrose (0.1%) shortens initial bud-break time and increased shoot induction. However, explants lose vigor after 4 weeks compared to 0.3% sucrose and should thus be transferred immediately after initiation.

(330) Somatic Embryogenesis of *Symplocos paniculata*

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Symplocos paniculata (Thunb.) Miq. (sapphire berry) is a deciduous shrub with showy white flowers and blueberry-like fruits. The fruit oil is used both as an edible oil and in the biodiesel industry. Plant regeneration via somatic embryogenesis is needed to provide source tissue for genetic transformation. Disinfested mature zygotic embryos were cultured on Murashige and Skoog (MS), modified MS (mMS), or woody plant medium (WPM) containing with 0.15, 0.2, 0.25, or 0.3 mg·L⁻¹ 6-Benzylaminopurine (BAP) and 0.1 mg·L⁻¹ 1-Naphthaleneacetic acid (NAA). Both medium and BAP significantly affected the callus induction. Twenty days after culture, calluses were induced on 64.6%, 85.1%, and 32.4% of explants that cultured on MS, mMS, and WPM, respectively. As BAP concentration increased, the callus induction rate quadratically increased. The highest induction rate, 92.5%, was observed on mMS plus 0.2 mg·L⁻¹ BAP and 0.1 mg·L⁻¹ NAA. To induce somatic embryos, calluses were cultured on mMS containing 0.2 or 0.25 mg·L⁻¹ BAP and 0.1, 0.15, or 0.2 mg·L⁻¹ NAA. Thirty days after culture, somatic embryos formed on 72.4% of calluses that cultured on mMS plus 0.25 mg·L⁻¹ BAP and 0.15 mg·L⁻¹ NAA. Somatic embryos were subcultured in the dark on the 1/2 mMS without plant growth regulator. Ten days after culture, 65% of somatic embryos formed shoots, which were still under test to develop roots.

An asterisk (*) following a name indicates the presenting author.

(331) Micropropagation of *Lycium barbarum* through Single Nodal Explants and Seeds from Mature Plants

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Studies were conducted to develop protocols for in vitro regeneration of *Lycium barbarum*, also known as wolfberry or goji. Wolfberry, which has received rapidly growing attention because of its antioxidant and nutrient values, has been termed a superfruit. Cultures were established from 3-cm single nodal explants and seeds extracted from mature fruits. Cuttings and fruit were rinsed for 5 minutes in sterile distilled water plus Tween 20. Agitation in 10% Clorox for 30 minutes was followed by three rinses in sterile distilled water. Seeds were then removed from the fruit using aseptic technique. Explants were cultured on MS medium which was supplemented with each of five concentrations of cytokinins and auxins: 1) kinetin 2.0 mg/L plus IAA 2.0 mg/L; 2) kinetin 1.0 mg/L plus IAA 0.1 mg/L; 3) 2iP 30 mg/L plus IAA 0.3 mg/L; 4) BA 2.0 mg/L plus NAA 0.5 mg/L; and 5) BA 0.1 mg/L plus NAA 0.5 mg/L. There were 8 replications of each of the treatments. Explants were incubated in a 16-h light photoperiod from cool-white fluorescent lamps at 25 °C. For both the single nodal explants and seeds, all media variants gave efficient callus formation after 39 days. Shoot proliferation was achieved at 100% using the BA 2.0 mg/L plus 0.5 mg/L supplement. Thirty-five days later, root regeneration occurred at 100% after shoots were transferred to BA 0.1 mg/L plus NAA 0.5 mg/L. Results show that in vitro regeneration protocols can be used for clonal multiplication and possible genetic transformation studies.

Monday, July 22, 2013

12:15–1:00 PM

Vegetable Crops Management

(133) Light Source Effects on Hydroponically-grown Miniature ‘Little Gem’ Lettuce

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There is growing concern about food safety, environmental impact, and efficient energy usage in agricultural production systems. Producing lettuce under artificial lighting can be a solution addressing these concerns. Light-emitting diodes (LEDs) offer the advantage of a narrow light spectrum, low power consumption, and little heat production. Light emitting plasma offer high light intensity, sun-like full spectrum,

and long life. The objective of this study was to determine the effects of different light sources on the growth of miniature ‘Little Gem’ romaine lettuce in a noncirculating hydroponic system. Lettuce seedlings were started in Oasis cubes, which were transferred to net pots and put in 1.9-L containers containing a hydroponic nutrient solution. The solution was Hydro-Gardens’ Hobby Formula 10–8–22 hydroponic fertilizer with added magnesium sulfate (9.8% Mg). The lettuce was grown in a lab under different light treatments—red+blue+white LEDs, light emitting plasma (LEP), and high output T-5 fluorescent lights. The light level was 253.7 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ with an air temperature 20.9 °C. At the end of the study, the fluorescent lights resulted in significantly greater plant height than the LED and LEP treatments. There was no significant difference in plant height between the LED and LEP treatments. Percent partitioning of dry weight to roots was greater with the LEP treatment than the fluorescent lights treatment. There was no significant difference in percent partitioning of dry weight to roots between the LEP and the LED treatments and between the LED and the fluorescent lights treatments. There were no significant differences in shoot dry weight, root dry weight, total dry weight, and percent partitioning of dry weight to shoots among the treatments. In conclusion, LEDs and LEP may provide alternative lighting sources for miniature lettuce.

Specified Source(s) of Funding: Hatch

(134) Weed Control in Okra [*Abelmoschus esculentus* (L). Moench] in the U.S. Virgin Islands

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Okra [*Abelmoschus esculentus* (L). Moench] is a highly valued vegetable and grown for fresh market in the U.S. Virgin Islands. Weed competition is an important factor affecting vegetable production. A study was conducted to evaluate preemergence application of two herbicides Preen Plus (Trifluralin) and Scythe (pelargonic acid) on weed control in okra. Two cultivars of okra, ‘Clemsen Spineless’, and ‘Red Burgundy’, were grown in conventional management system at the Agricultural Experiment Station University of the Virgin Islands, Kingshill. The experimental design was complete randomized block and three replication (treated) and a control (weedy) for each cultivar. Preen Plus applied at a rate of (2 oz/10 sq ft, granular) a day prior to transplanting okra plants into the field and Scythe sprayed at the rate of 5% volume with water. No emergence of weeds was observed in treated plots within the first 2 to 3 weeks after application. Plants recovered from initial injury a few weeks after transplanting. Marketable yields were higher in ‘Clemsen Spineless’ (10,615 lb/acre) and ‘Red Burgundy’ (12,641 lb/acre) plots sprayed with Preen Plus in than in plots sprayed with Scythe where lower yield in ‘Clemsen Spineless’ (10,582 lb/acre) and ‘Red Burgundy’ (9,167 lb/acre) recorded.

An asterisk (*) following a name indicates the presenting author.

Significant difference in yield of ‘Clemons Spineless’ recorded in Preen Plus sprayed and non-treated plots (control). Results on marketable fruit weight, marketable yield, pod size, and weed composition are presented. Two herbicides controlled a range of broadleaf and grasses in okra field.

Specified Source(s) of Funding: WRI (USGS)

(135) Root-knot Nematode Damage to Low Desert Bell Pepper

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Nematodes have not been reported as a problem in bell pepper production in California. However, in the Coachella Valley in Riverside County, CA, bell pepper growers are suspecting nematodes of causing widespread damage. In this low desert region approximately 5,000 acres are cropped with bell pepper with an estimated gross crop value of \$90,000,000. The general consensus among Coachella Valley growers is that root-knot nematodes can result in major crop damage if not controlled, research data on damage thresholds and tolerance limits for desert growing conditions are not available. This research project assessed the damage potential of the nematodes to bell pepper in the Coachella Valley, characterized root-knot nematode populations occurring in bell pepper fields, and evaluated damage thresholds and tolerance limits of bell pepper for a locally occurring root-knot nematode population compared to the resistant varieties. Under field conditions, nematode infested bell pepper plants appeared to show typical nematode damage and heavy chlorosis of leaves. Soil samples from the grower’s fields confirmed obvious symptoms (root galling) and plant damage. Morphological analysis of perineal patterns and a differential host range test revealed that the problem was caused by *Meloidogyne incognita* (Southern root-knot nematode) race 3. In a greenhouse trial, the nematodes did not significantly affect total fruit yield (grams per plant) in the two resistant cultivars ‘Carolina Wonder’ and ‘Charleston Belle’, while that of the ‘MiniBells’ (variety grown by Coachella Valley growers) was severely affected. The yields from ‘MiniBells’ inoculated with nematodes were reduced by approximately 50% compared to the no-nematode control.

Specified Source(s) of Funding: California Pepper Commission

(136) A Sampling Network for Insect Pests of Potato in the Columbia Basin of Washington and “Potato Pest Alerts”

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An insect sampling network has been in operation in the Columbia Basin of Washington since 2009 to monitor important potato pest populations in the region and to report timely information about their location and size to the potato industry via weekly alerts. It functions as an early warning system that encourages growers to increase scouting in their own potato fields when pests are detected in nearby fields. The sampling network targets four key insects: aphids, beet leafhoppers, potato tuberworms, and potato psyllids. Each of these pests should be observed carefully and managed as needed to limit significant yield and quality losses that can result from the insects feeding, and in the case of aphids, leafhoppers, and psyllids from the plant pathogens they vector. As well as providing current information about the whereabouts of these insects, the sampling network contributes to a better understanding of how they migrate to potato fields, establish populations, transmit pathogens, and damage potato crops in the region. Each year, 35–40 potato fields are monitored weekly from April to October using sampling methods previously established for each of the targeted pests. Results are reported in “potato pest alerts” sent via email to 340 subscribers who are mostly farm owners and managers, crop consultants, and processing company representatives. Each alert is a summary of the week’s findings with pest management recommendations and hyperlinks connecting readers to the project website for additional information. The website includes maps showing insect counts across the region, graphs showing insect population trends, and guidelines about managing the pests. In addition to information about insects, the alerts often include updates regarding potato late blight and other diseases that are present in the region. Subscribers were asked to provide feedback about “potato pest alerts” in an online survey sent Feb. 2013 (response rate was 24%). It was found that 87% of subscribers have recommended or forwarded the alert emails to colleagues. Most subscribe to get the regional monitoring results (93%), and many also indicated that they like to get information about new pests and diseases (82%), to get late blight information (72%), to get pest management recommendations (50%), and to get guidance on insect scouting methods (49%). They responded that services such as the “potato pest alerts” and the “late blight hotline” are important (29%) or very important (67%) for minimizing pest outbreaks across the region.

Specified Source(s) of Funding: The Washington State Potato Commission

(137) Field Chili and Sweet Pepper Cultivar Evaluation in Central Missouri

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The demand for chili and sweet peppers has been steadily growing in central Missouri. Information on varieties for the region, however, is scarce. The objectives of this trial were to evaluate and select new pepper cultivars that perform well when grown in the Midwest and to supply farmers with variety recommendations. Based on the results of non-replicated initial trials in 2011, 58 chili pepper cultivars (10 big chilies, 27 jalapenos, 9 poblanos and 12 cayennes) and 11 sweet pepper cultivars (mostly bell peppers) were chosen for the replicated studies in 2012. Pepper seeds were sown in the greenhouse and were grown to transplants with 3–4 true leaves. They were then planted into raised beds covered with black plastic mulch at Lincoln University's Carver Farm in Jefferson City, MO. For each pepper type, a completely randomized block design with four replications per variety and four plants per replication was applied. Because of the large number of cultivars involved, harvesting was done on a limited basis during the season. Jalapeno and sweet peppers were harvested three times while big chili, poblano and cayenne peppers were harvested twice. For each cultivar, 10 randomly selected fruit were chosen and fruit characteristics were measured including fruit length, width and weight. The 2012 growing season was characterized by extreme heat and drought. As a result, most sweet peppers experienced some degree of blossom-end rot disorder. Cultivars that performed well overall were 'Flavorburst', 'Large Red Snack', and 'Carmen' for sweet peppers; 'Rayo', 'Jalafuego', and 'El Jefe' for jalapenos; 'Anaheim', 'Joe E. Parker', and 'Sahuaro' for big chilies; 'Huizache', 'Abedul', 'San Ardo', and 'Masivo' for poblanos; and 'Super Chili', 'Andy', 'Long Slim', and 'Red Devil' for cayennes.

Specified Source(s) of Funding: Lincoln University Cooperative Extension

(138) Watermelon Variety Evaluations in Central, Southeast, and Southwest Missouri

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In 2010, Missouri ranked ninth nationally in watermelon production. There were 3,200 acres of watermelons harvested with a total value of \$857,600. The seedless watermelon industry demands high-yielding varieties that demonstrate high °Brix values. The objective of this trial was to evaluate the most recent

seedless watermelon varieties and update variety recommendations. Twenty-four triploid watermelon varieties were chosen for this study, but due to limited seed availability not all varieties were planted in the three testing locations. Seeds were started in a greenhouse three weeks before transplanting in early May for the southwest and southeast regions of Missouri and late May for central Missouri. Seedlings were planted into raised beds covered with black plastic mulch at Lincoln University's Carver Farm in Jefferson City (central Missouri), the Southwest Research and Education Center of University of Missouri at Mount Vernon (southwestern Missouri), and a private farm near Malden (southeastern Missouri). Vines of the diploid varieties 'Accomplice', 'Gladiator' and 'Estrella' were used as pollenizers. The experiment was conducted as a completely randomized design at each site, with four replications per cultivar and four plants per replication. Harvests were conducted as fruit ripened at the Mt. Vernon site, 3–12 July 2012. Single-day harvests were conducted on 6 Aug. 2012, at the Jefferson City site, and on 17 July 2012, at the Malden site. Data collection consisted of yield and number of fruit/vine at all three sites. One fully ripe medium-sized fruit from each replication plot was selected to determine fruit characteristics including fruit diameter, fruit length, rind width and soluble solids concentration. Marketable yield ranged from 3.3 to 9.9 tons/acre, lower than typical yields due to extended periods of extreme heat and drought. Fruit weights were low in the southwest region (7.5–12.4 lb) where it was noted that plants seemed to lack vigor compared to previous years, whereas average fruit weights in the central region ranged from 8 to 15.5 lb. The red-fleshed varieties 'Sweet Delight', 'Palomar', 'Millionaire', and 'Crispy Red' as well as the yellow-fleshed variety 'Buttercup' performed well in terms of yield during the challenging growing season. When comparing fruit characteristics among sites, few differences were detected except that °Brix was higher overall at the central Missouri site with a mean of 12. These varieties should be tested again to determine if performance improves during a typical Missouri growing season.

Specified Source(s) of Funding: 1890 Lincoln University Cooperative Extension

(139) Multisite Evaluation of Pumpkin Cultivars in Missouri

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The 2012 pumpkin variety trials were conducted at three sites

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including Carver Farm of Lincoln University in Missouri (Jefferson City), Bradford Research and Extension Center of University of Missouri–Columbia (Columbia), and the David M. Barton Agriculture Research Center of Southeast Missouri State University (Cape Girardeau). At each site, eighteen pumpkin cultivars were evaluated for yield and fruit characteristics. The varieties selected were Gold Gem, Solid Gold, Bus Stop, Goose Bumps II, Knuckle Head, New England Cheddar, Red Warty Thing, Magician, Warlock, Magic Wand, Mrs. Wrinkles, Gladiator, Lumina, Charmed, Dependable, Harvest Time, Magical, and Pro Gold. At the Jefferson City and Columbia sites, transplants were raised in a greenhouse in May and transplanted into raised beds covered with black plastic in mid-June. Plant spacing was 2.5 ft within a row and nine feet between rows. A cover crop of buckwheat was broadcast between the rows prior to planting. Pumpkins were harvested once in late August. Data from Southeast Missouri State University was not available so results presented are based on data from the other two locations. There were no interactions between cultivars and locations for yield and average fruit weight. Pumpkins grown at the Bradford Center had significantly higher yield and larger fruit than those grown at Carver Farm, probably due to soil type. ‘Goose Bumps II’ yielded the highest (20.3 tons/acre) while ‘Lumina’ had the lowest yield (2.2 tons/acre). Varieties that yielded more than 10 tons/acre were Goose Bumps II, Warlock, New England Cheddar, Gladiator, Solid Gold, and Harvest Time. ‘Harvest Time’ produced the largest (heaviest) fruit (16.7 lb.), followed by ‘Gladiator’ (11.8 lb.) and ‘Warlock’ (11.2 lb.). ‘Lumina’ had the smallest (lightest) fruit, about 4.4 lb. There was an interaction between varieties and locations in terms of the number of fruit. Most varieties had a similar number of fruit at both sites, except ‘Goose Bumps II’, ‘Knuckle Head’, and ‘New England Cheddar’, which produced much more fruit at the Bradford location. At Carver Farm, ‘Goose Bumps II’, ‘Gladiator’, ‘Bus Stop’, and ‘Magician’ produced more than four fruit per block. At the Bradford Center, ‘Bus Stop’, ‘Goose Bumps II’, ‘Knuckle Head’, ‘New England Cheddar’, ‘Warlock’, ‘Magic Wand’, and ‘Charmed’ produced more than five fruit per block. Similar varieties will be tested again in 2013 and will be analyzed for variety recommendations.

Specified Source(s) of Funding: NIFA AFRI

(140) Growth and Yield Comparisons among Sweet Pepper Cultivars in South Korea

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This study was carried out to select sweet pepper varieties suitable for summer cropping among 12 varieties (red and yellow 6 varieties, respectively) cultivated in South Korea. We investigated their characteristics of growth and yield in Cheorwon, Gangwondo from March to Oct. 2012. The plant heights of tested varieties appeared to be 270~307 cm, and stem diameter appeared to be 15.7~18.8mm. The stem appeared to have nodes of 34~37 per plant. The averaged fruit weights of several varieties were more than 300g, especially ‘Nagano’ showed the highest, 312 g. On the other side, ‘Dandan’ showed the lowest, 221 g. In red-type Paprika, the ranges of pericarp thickness and soluble solid content revealed 6.0~7.3 mm and 8.3~9.0 °Brix. The storage life in M.A. packaging was evaluated to be 20 to 30 days. The contents of Vitamin C showed 130~213 mg/100 g. Of 6 varieties, ‘Davos’ and ‘Nagano’ showed the highest yields, 10.4 and 10.6 kg/m², respectively. In yellow-type Paprika, the ranges of pericarp thickness and soluble solid content revealed 6.3~7.1 mm and 7.7~8.4 °Brix. The storage life in M.A. packaging was evaluated to be 17 to 26 days. The contents of Vitamin C showed 139~216 mg/100 g. Of 6 varieties, ‘Yorit’ and ‘Yellow mountain’ showed the highest yields, 10.0 and 10.6 kg/m², respectively. On the base of yield, we selected ‘Davos’ and ‘Nagano’ of red-type varieties, and ‘Jorrit’ and ‘Yellow mountain’ in yellow-type varieties as suitable varieties for summer cropping in Gangwondo, South Korea.

Specified Source(s) of Funding: This study was supported by the region agriculture research activity project (number : PJ008833) funded by the Rural Development Administration, Korea

(141) Muskmelon Production in Southern New England

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As the demand for local food grows, and farmers increasingly rely on direct-to-consumer marketing, there is a renewed interest in crops that may be marginally adapted to a particular area. In southern New England melons (*Cucumis melo* L.) are one such crop. Melons do best with a mean temperature of 18 to 24 °C and low humidity; growing season temperatures in southern

An asterisk (*) following a name indicates the presenting author.

New England range from 13 to 23 °C and humidity is often high. Use of transplants and black plastic mulch have been shown to greatly improve melon production in areas such as New England where the period of high temperatures is shorter than optimum. Recent research at the University of Rhode Island has focused on determining whether yields, quality, and earliness can be further enhanced by use of tunnels for season extension, and on identification of the best hybrid varieties for our production region. Low tunnels of slitted or perforated plastic consistently resulted in higher yields and quality than either high tunnels or open field production. Five varieties were trialed in all three production systems in both years. ‘Athena’ and ‘Sarah’s Choice’ yielded the greatest weight of marketable fruit in the low tunnel production system. Twenty-seven varieties were trialed in the open field in 2011, and 33 in 2012. Years were analyzed separately due to significant interactions between year and variety. The varieties ‘Electra’, ‘Maverick’, and ‘Halona’ had the best combination of pest resistance and fruit quality in 2011; ‘Electra’ and ‘Maverick’ also did well in 2012 but were surpassed by ‘Sarah’s Choice’, ‘Sugar Cube’, and ‘Wrangler’. ‘Maverick’ yielded the most marketable fruit per plot in 2011 while ‘Halona’ yielded the most in 2012. Striped cucumber beetle (*Acalymma vittatum*) feeding on roots, crowns, and fruit impacted yield and quality in both years, with gummy stem blight causing additional damage in 2011.

Specified Source(s) of Funding: Rhode Island Agricultural Experiment Station

(142) Herbicide Activation with Drip Irrigation in Celery

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In nearly \$0.5 billion California fresh market celery herbicides have been commonly applied with or activated with overhead irrigation, causing significant runoff, which contains nutrient and pesticide contaminants. Drip-line irrigation is already being used as precise irrigation alternative, which made the testing of herbicide safety and efficacy in drip-only systems necessary. Goaltender (oxyfluorfen) at 0.25 a.i./acre and Chateau (flumioxazin) at 0.063 lb a.i./acre were applied 1 day prior to planting to either drip pre-irrigated and dry beds. The lack of crop injury and 83% to 87% weed control in both dry and drip pre-irrigated beds were similar to sprinkler activation of these herbicides conducted previously. Lorox (linuron) at 1.85 lb/acre and Caparol (prometryn) at 1.48 lb/acre applied 3 weeks after transplanting, were also evaluated in drip-only irrigated celery. Both herbicides provided >90% control of five broadleaf weeds without significant injury to the crop. These studies showed that drip line irrigation was effective in its activation of currently

available herbicides and flumioxazin that is scheduled to receive registration for celery in 2014.

(143) Influence of Exogenous Uniconazole Application on Grafted Tomato Transplant Production

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Limited research information is available on the practical application of plant growth regulators in vegetable grafting. Uniconazole, a gibberellin biosynthesis inhibitor, was reported to competitively inhibit abscisic acid (ABA) 8'-hydroxylase, a key enzyme regulating ABA catabolism in *Arabidopsis thaliana*. Exogenous application of uniconazole may result in accumulation of endogenous ABA, leading to stomatal closure. The objective of this study was to determine the impacts of uniconazole application on the efficiency of grafted tomato transplant production, especially without facilitation of a healing chamber. In the first fall study (Fall 1), 4-week-old tomato scion ('Florida 47') plants were sprayed with uniconazole at 0, 0.5, 1.0, and 1.5 mg/L at least 24 h prior to grafting, after which stomatal conductance was measured before grafting onto tomato rootstock, 'Maxifort'. Newly grafted plants with water treated scions were placed inside a healing chamber, while grafted plants with scions treated with uniconazole were healed outside the chamber in the greenhouse. Plants were either floated or misted daily during the healing period. Number of non-wilted plants was counted daily until 10 days after grafting, after which scion length, chlorophyll content, scion fresh and dry weight, and leaf area were measured on day 11. Plants were transplanted into 0.4-L plastic pots, and the growth parameters were determined after 3 weeks. In the second fall study (Fall 2), uniconazole concentrations of 0, 0.7, 1.4, and 2.1 mg/L were utilized. Uniconazole application reduced stomatal conductance prior to grafting, and delayed the onset of wilting in plants healed outside of the healing chamber. However, recovery from wilting and graft survival were not improved with uniconazole application. Scion length was reduced when 2.1 mg/L uniconazole was sprayed, which may be beneficial in helping grafted seedlings withstand wind damage following field transplanting. In Fall 1, application of 1.5 mg/L uniconazole resulted in higher plant chlorophyll content compared to the 1.0 mg/L uniconazole treatment. However, uniconazole application did not significantly affect chlorophyll content in the second fall study. In Fall 2, plants kept outside

An asterisk (*) following a name indicates the presenting author.

of the healing chamber with uniconazole application at 1.4 mg/L did not differ significantly from plants kept inside the chamber in terms of scion fresh and dry weight and leaf area. Post-transplant growth of grafted tomato seedlings was not significantly affected by uniconazole application. Application of uniconazole in combination with other plant growth regulators may yield synergistic effects that further improve grafted tomato transplant production efficiency.

Monday, July 22, 2013

12:15–1:00 PM

Viticulture and Small Fruits

(108) Mow-down and Tip Pruning Management of Primocane Blackberries in Coastal California

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Fresh market blackberry (*Rubus* spp.) production is increasing in California largely in response to growing market demand. Newer primocane fruiting cultivars (*Rubus* subgenus *Rubus* Watson) enable annual mowing and may permit better targeting of market windows. California coastal production areas surrounding Watsonville, Santa Maria, and Ventura are important centers for blackberry production running north to south, but these areas have different temperature regimes that affect how plants respond to timing of off-season mow-down and subsequent pruning. Varying mow-down and tip pruning treatments were imposed on 2-year-old PrimeArk 45® blackberry plantings in Watsonville (2011 season) and Santa Maria (2012 season) and varying tip pruning on establishment year plants in Ventura, CA (2012 season). Mow-down periods for Watsonville and Santa Maria were the first week in January, March, or May and tip pruning was done at 0.45, 1.5, 0.45, and 1.50 m, and no pruning. Tipping (to 0.60 m) in Ventura was done 23 Apr., 31 May, or 25 July. In Santa Maria, highest yield and the best timing of production resulted from January mowing whereas in the more northern Watsonville, harvest began 1 month later and highest yields were from March mown plants. The January and March mow-down plots were not markedly different at Watsonville however, and the response to

mow-down timing was similar with May mow date producing later with lower yields at both Watsonville and Santa Maria. At Watsonville and Santa Maria, 0.45 tipping height produced more fruit than the other treatments at all harvest times and harvest periods were similar among tipping treatments. At Ventura, the May tipping produced higher yields and earlier harvest than earlier or later dates. Ventura plants were in the establishment year however, so the results may also represent plant size effects. Results suggest that at more northern coastal sites, mowing may be delayed until March whereas in Santa Maria, January pruning is better. Responses to mowing time and tipping were different at the different locations and warmer temperatures at more southern locations likely advance the optimum mowing time, response to tipping, and fresh fruit production period.

Specified Source(s) of Funding: Hansen Trust

(109) Nutrient Dynamic in Rabbiteye Blueberry (*Vaccinium ashei* Reade)

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This work was done in Zacatlán, Puebla, Mexico, in a blueberry rabbiteye orchard in full production; the objectives were to know the nutrient dynamic during the different fruit development stages, to identify the critical stages of different elements, and to know the nutrient diagnostic of the plants. For this, samples of leaf and fruit in five different fruit development stages were collected: green fruit, change of color in fruit (green–pink), beginning of ripe (red–pink fruit), during maturation (blue–red fruit), and ripe (blue fruit). The concentrations of macronutrients and micronutrients were determined. The order of nutrient concentration in leaves was: N>Ca>K>Mg>P>Fe>Mn>B>Zn>Cu. The critical stages in the cultivation of fruit were at change of color in fruit (green–pink) and fruits at the beginning of ripe (red–pink fruit). The culture presented deficiency of N and K, and soil fertility was medium to low in K, Ca, Cu, Fe, and N available to plants. Concentration in the fruits of all evaluated elements except Cu, had a decrease with advancing fruit development. In the leaves the concentration of all elements showed two major peaks, one in the green fruit stage and another at the end of fruit development (ripe fruit). These results will allow to establish an appropriately fertilization program to obtain optimum yields.

Specified Source(s) of Funding: Universidad Autonoma Chapingo

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(110) Developing a Genotyping by Sequencing Protocol for Linkage Map Construction in Black Raspberry

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Since the early 1900s, the black raspberry (*Rubus occidentalis* L.) industry in the United States has steadily declined due to lack of adapted and disease resistant cultivars. Renewed interest in production and breeding new cultivars has been fueled by research into the use of black raspberry bioactive compounds as potential chemopreventive agents for certain cancers. We are building the genomic infrastructure for black raspberry by developing, and making available, genomic tools including molecular markers for construction of linkage and physical maps, and a draft genome assembly that will benefit both black and red raspberry U.S. breeding programs. A genotyping by sequencing (GBS) library was constructed for 92 progeny of one mapping population. The library fragment sizes ranged from 191–551 base pairs (bp) with enrichment for fragments of 191–276 bp. Single-end sequencing of 101 cycles of the 96-plex library on a single flowcell channel was performed on a Hi-Seq 2000 platform. Initial variant calling analysis through a custom data pipeline identified over 23,000 SNP/indel loci. Preliminary results indicate that GBS is an appropriate approach for SNP detection in this highly-homozygous species. Validation of these SNP followed by genetic linkage mapping coupled with anchored SSR loci will be used to improve the assembly of the draft genome, which is currently at 300 Mbp and 2,226 scaffolds. The construction of a densely populated genetic linkage map will be used for QTL mapping of economically important traits and for comparative genomic studies with other members of Rosaceae.

(111) Friend or Foe? Bacterial Nitrate and Iron Reduction in the Roots and Rhizosphere of *Vaccinium corymbosum* and *Vaccinium arboreum*

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The rhizosphere surrounding roots is a dynamic ecosystem where plants and microorganisms can be partners or competitors for nutrient acquisition. Microbial partners can enrich the rhizosphere, enhance plant nutrient uptake or form mutualistic associations with plants. Conversely, microbial competitors limit the amount of nutrients available for plant uptake by taking them up in the same form and concentration ranges as plants. *Vaccinium corymbosum* L. hybrids (VC) and *V. arboreum* Marsh. (VA) differ in their soil adaptation responses and their ability to take up nitrate and iron. To determine the bacterial communities' contribution to these differences in iron and nitrate uptake, we isolated and cultured bacterial colonies from the roots and rhizosphere of hydroponically grown clonal plants. Rooted cuttings of VA and VC were grown in a hydroponic system with a complete nutrient solution for 5 weeks. Representative root samples and nutrient solutions were then used to inoculate nutrient agar plates. All unique colony types were subcultured for enzymatic activity analysis. Seventy-two isolates were obtained, 23 from VA roots, 21 from VC roots, 17 from VA nutrient solution and 11 from VC nutrient solution. Ferric chelate reductase (FCR) activity and nitrate reductase (NR) activity assays were adapted for measuring the activity of these enzymes in bacterial suspensions. Bacteria exhibited extremely low FCR activity. FCR activity was significantly different from zero in only 20 of the isolates (13 from VA and 7 from VC), where it ranged between 0.29 and 3.81 nmol Fe²⁺ per million cells per hour. A ferrozine gel-based visual assay for FRC activity indicated minimal color change for bacterial suspensions compared with *Vaccinium* roots. NR activity was low as well, ranging between 0.007 and 0.905 nmol NO₂⁻ per million cells per hour. Direct comparison with root NR activity was not possible. These results indicate that bacterial communities in the rhizosphere of *Vaccinium* spp. are unlikely to enrich the rhizosphere with plant-available Fe²⁺ and NO₂⁻. Additionally, bacterial communities in the roots and rhizosphere are unlikely to be the source of the uptake differences between VA and VC.

Specified Source(s) of Funding: USDA-NIFA Specialty Crop Research Initiative Award No. 2009-51181-06021

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(112) *Vaccinium arboreum*: A Rootstock for Southern Highbush Blueberry?

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Commercial blueberry production typically requires soil amendments to increase organic matter and decrease pH, increasing production costs. Further, most fresh market blueberries are hand-harvested, since the multi-caned architecture makes mechanical harvesting difficult. Hand harvesting is costly and labor intensive, and the supply of labor is likely to decrease in the future. *V. arboreum* is a wild blueberry species native to the southeastern United States that tolerates soils with pH up to ~6.5 and low organic matter, and exhibits a tree-like growth habit with a single trunk. These characteristics could potentially be exploited in commercial blueberry production by using *V. arboreum* as a rootstock to increase soil adaptation and mechanical harvest ability. The objective of this study is to evaluate canopy growth, bloom period and fruit yield in grafted vs. own-rooted southern highbush blueberry under two soil management systems—non-amended soil and pine-bark amended soil. Two cultivars were evaluated in two experiments at different sites. At both sites, treatments were arranged in a 4 x 2 factorial (“genotype” x soil treatment), with “genotypes” comprising 1) own-rooted ‘Farthing’; 2) ‘Farthing’ grafted onto *V. arboreum*; 3) own-rooted ‘Meadowlark’; and 4) ‘Meadowlark’ grafted onto *V. arboreum*. Fruit yield the first season after planting was not different for ‘Farthing’, however, own-rooted ‘Meadowlark’ plants had greater fruit yield than ‘Meadowlark’ grafted plants, averaging 148.7 g and 78.5 g per plant, respectively. In both years and for both cultivars, own-rooted plants grown in pine-bark amended soil had the greatest canopy volume. ‘Farthing’ grafted plants, regardless of the soil system, had the smallest canopy volume. ‘Meadowlark’ grafted plants in both soil systems, and own-rooted plants in non-amended soil had similar canopy volumes, which were smaller than own-rooted plants in pine-bark. In 2012, bloom period was shorter for grafted ‘Farthing’ vs. own-rooted ‘Farthing’, but not different for ‘Meadowlark’. In 2013, ‘Farthing’ and ‘Meadowlark’ grafted plants had shorter bloom periods than own-rooted plants. Soil management systems also affected bloom period. ‘Meadowlark’ plants on non-amended soils had a shorter bloom period than plants on amended soils, while this effect was not observed for ‘Farthing’. Vegetative growth on own-rooted plants was always greater in amended compared with non-amended soils. However, vegetative growth of grafted plants was not affected by soil management systems.

(113) Fertigation with Micronized Sulfur Rapidly Reduces Soil pH in Highbush Blueberry

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Blueberry is adapted to low soil pH in the range of 4–5.5. At higher pH, soil is often modified with elemental sulfur (So) prior to planting. A 2-year study was conducted to determine the potential of applying micronized wettable elemental sulfur (So) by fertigation through the drip system to reduce soil pH in highbush blueberry (*Vaccinium corymbosum* L. ‘Duke’). The field was planted in Oct. 2010. The So was mixed with water and injected weekly for 2 months prior to planting and each fall after planting (2011 and 2012), at rates of 0, 50, 100, and 150 kg-ha⁻¹ per year, and was compared to the standard practice of incorporating granular So into the soil prior to planting (two applications of 800 kg-ha⁻¹ each). Sulfur fertigation quickly reduced soil pH (0–10 cm) within a month from 6.6 with no So to 5.8 with 100–150 kg-ha⁻¹. So, but the change was short-term and by December averaged 6.2 and 6.0, respectively. Conventional granular So, in comparison, averaged 6.4 on the first date and 6.1 on the second. In July the following year, soil pH ranged from 6.5 with no So to 6.1 with 150 kg-ha⁻¹ and averaged 6.0 with granular So. Soil pH remained relatively constant thereafter with So fertigation but continued to decline to levels as low as 4.7 with granular So. The treatments had no effect on winter pruning weight in year 1 or on total plant dry weight, yield, or average individual berry weight in year 2. Leaf P, K, Ca, Mg, S, and Mn concentrations, on the other hand, were lower with So fertigation than with granular So during the first year after planting, while leaf N, P, and S were lower with So fertigation the second year. The findings indicate that So fertigation can be used to reduce soil pH following planting in blueberry and therefore may be a useful practice and safer than acids to correct problems with high pH. However, it was less effective and more time consuming than applying granular So prior to planting.

Monday, July 22, 2013

12:15–1:00 PM

Waste Utilization in Horticulture**(293) Survival and Persistence of Non-pathogenic *Escherichia coli* and *Escherichia coli* O157:H7**

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Land application of raw animal manure to enhance soil productivity may pose a food safety risk from pathogenic microorganisms that survive and contact fresh produce. Two studies, conducted at the University of Maryland Eastern Shore, evaluated the survival and persistence of non-pathogenic *E. coli* (Ec) and attenuated *E. coli* O157:H7 (attO157) as influenced by the application of poultry litter (PL) or dairy manure (DM) on field plots in the Delmarva peninsula and in the greenhouse where two soil types, sandy loam (SL) and clay loam (CL), were used. Field plots were individually amended with or without PL or DM in late fall and received spray inoculum at either low 5×10^6 CFU/m², or high, 5×10^8 CFU/m², cell densities; inocula contained three rifampicin-resistant (RifR) strains of Ec and two RifR strains of attO157 grown in dairy manure extract. Greenhouse pots (8.89 cm), filled each with 350 g of SL or CL soil were amended with or without PL or dairy manure liquid (DML) and received either a low, 1.15×10^4 CFU/m², or high, 2.07×10^5 CFU/m², dose of a multi-strain inoculum. Soil samples were collected periodically over 150 days post-inoculation from the field and 56 days post-inoculation from the greenhouse. All samples were analyzed for viable *E. coli* by direct plating and/or mini-MPN. Greenhouse results show that by day 28 at high inoculum densities, Ec counts on DML in SL and CL soil declined to 2.94 and 3.01 log₁₀ CFU/g, respectively, and attO157 counts declined to 2.88 and 3.01 log₁₀ CFU/g, respectively. By day 56 at high inoculum densities, Ec and attO157 counts on PL in both soils declined to 3.32 and 2.62 log₁₀ CFU/g, respectively. In comparison, by day 30, Ec counts in high inoculum dosed PL and DM field plots declined to 4.6 and 2.43 log₁₀ CFU/g, respectively, and attO157 counts declined to 3.83 and 0.46 log₁₀ CFU/g, respectively. In both studies the survival of Ec and attO157 populations declined more rapidly in soil amended with DML and DM when compared to soil amended with PL. *E. coli* survived for longer durations in field plots compared to pots in the greenhouse. Manure type influenced the survival of *E. coli* in soil, and these findings should be considered when setting guidelines for produce safety relative to PL, DM and DML application to soil. Greenhouse studies may underestimate survival of Ec in manure-amended soils compared to field studies.

(294) Reducing Cadmium Phytoextractability by Coal Bottom Ash

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Coal bottom ash is generally considered to be a ferro-aluminosilicate mineral and has a higher pH. In acidic and cadmium (Cd) contaminated soil, the coal bottom ash can be a good amendment for increasing Cd immobilization and for decreasing Cd uptake of crop plants. In addition compost having very high indigenous negativity can contribute on increasing Cd holding capacity of soil and then on decreasing Cd uptake of plant. The objectives of this study are to evaluate the effect of coal bottom ash on Cd phytoextractability in a gold mine tailing affected soil. Bottom ash was applied at four levels of 0, 20, 40, and 80 Mg·ha⁻¹ and compost at 2 levels of 0 and 30 Mg·ha⁻¹. A radish cultivar (*Raphanus sativa* L.) was sown by hand in the experimental field on 27 Aug. 2005, and harvested on 29 Oct. 2005. Radish yield was increased slightly with increasing application of bottom ash. It was maximized at level of BA 40 Mg·ha⁻¹. Radish yield was more effectively increased by compost addition. Cd uptake by radish was significantly reduced with increasing application of bottom ash. Addition of bottom ash and compost more significantly decreased exchangeable Cd concentration than addition of bottom ash. The water soluble + exchangeable Cd fraction was significantly decreased with increasing application of bottom ash, but residual fraction was increased. Soil pH and negativity were highly increased by addition of bottom ash. Reducing Cd phytoavailability can be attributed primarily to immobilization of Cd by enhanced pH-induced increases in negative charge. Conclusively, bottom ash could be good amendment to reduce Cd phytoavailability and extractability in Cd contaminated arable soil.

Specified Source(s) of Funding: Korea Rural Development Administration

(295) Relationship of Soil Organic Matter and the Stability of Soil Carbon

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The formation and decomposition of soil organic carbon (SOC) is important due to the impact on atmospheric CO₂ concentration. The functions of SOC depend on both its quantity and stability of soil organic matter (SOM). The stability of SOM can be defined by how easily SOC can be mineralized to CO₂. Humic substances in soil can be regarded as stabilized SOM, i.e., low-quality resistant, hardly biodegradable SOM and not capable of producing CO₂. Various estimation techniques have been used to characterize SOM stability. In this study, total organic carbon (TOC) for humic substance extracted from soil, the fraction of hot-water extractable organic carbon (HWEOC), and the soil itself were analyzed and results were compared to determine the relationships among them. Results between SOM and SOC showed that both have strong linear relationships with the slope of 0.580 and high correlation over 0.99, which indicated that 58% of SOM is SOC. In the comparison between SOM and HWEOC, the values of HWEOC/SOM were lied in 5~6%, which means that that much of the percentage of SOM fraction can be extracted by hot water—about 8.6~10.3% of SOC might be labile fraction. Results on the HWEOC and humic substance showed relationship that HWEOC=0.536 OC in humic substance – 0.0042, with somewhat scattered data distribution, which has correlation coefficient of 0.6938.

Specified Source(s) of Funding: Korea Rural Development and Administration

Monday, July 22, 2013

1:00–1:45 PM

Computer Applications in Horticulture

(181) Use of Simulation Modeling Software in Support of Container Nursery Process Improvement in the Gulf South

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For many years, decision makers have been using process modeling tools to influence design and improvement of complex systems. Typically, these efforts are associated with environments such as manufacturing or transportation systems. Conditions found in these systems are well suited to simulation modeling due to their inherent complexity, variability, and inter-connectivity of system components. If we consider the components of a nursery production system, we see a close relationship to a typical manufacturing system characterized by multiple raw materials coming together with the aid of a labor component to form a finished product. This product must be transported, re-configured, inspected, and tracked multiple times during its life while at the nursery. To this end, many process design decisions

made by nursery managers, are then, no different than those made in a traditional manufacturing environment. Decisions to make process changes in order to achieve a positive result in either cycle time or throughput are historically made based on trial and error or expert judgment. An ability to model these changes and simulate their impact over time without actually making a physical change to the operation should, theoretically, result in better decisions. A discrete event simulation program was used to evaluate its effectiveness in predicting system performance resulting from various process changes to production conditions found at container nurseries in the Gulf South. The simulation tool used in this study was specifically designed for manufacturing environments, but has the flexibility to model virtually any process. For this study, a limited number of container nursery processes were investigated. Changes in process cycle time and throughput were determined after comparing various “what-if” scenarios run over many replications simulating days, weeks and months of time. Decisions including relocation of processes, changes in number of workers, changes in transport/movement parameters and additions/changes in equipment were evaluated to demonstrate the feasibility of using this modeling tool in a nursery environment. Continued use of this tool will be evaluated to determine the possibility of adding custom operating parameters to allow model use with minimal programming knowledge.

(182) eBooks: A New Platform for Extension Outreach

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Printed books are the traditional method of delivering topic-focused information to a broad audience. In this increasingly digital world, mobile devices are ubiquitous in the United States and create a portable, lightweight platform for personal libraries. E-readers, Kindle, and Nook, and tablets, serve as effective platforms for displaying e-book content. eBooks can be an effective resource in the Extension toolbox; facilitating delivery of verbiage and pictorial content, while video content integrated within an eBook can only be displayed on mobile devices using the Apple iOS platform. An added benefit of eBooks is that of extended, color rich, pictorial content that supplements and enhances information presentation, especially when aiding identification of pest or abiotic/biotic symptomology is one of the intended outcomes of the Extension information. Developing an eBook is an intensive process. Co-authors from Clemson University, the University of Tennessee, NC State University, University of Florida, University of Georgia, University of Kentucky, and Virginia Polytechnic Institute and State University, partnered together in 2012 to write and publish the eBook “IPM for Select Deciduous Trees in Southeastern US Nursery Production” using iBooks Author. The iBooks Author program was selected because it enabled inclusion of video content and because it simplified layout and organizational considerations for eBooks. Yet various quirks and efficiencies are innate to iBooks Author and should be examined before its use for authoring and publishing Extension-based information. These considerations include: platform requirements for inclusion of video content (e.g., Android, iOS, or RIM), template and layout preferences, chapter designations, the iTunes connect account, and multi-

author editing tools. Translating your concept into an eBook is a relatively simple process, but the time spent to develop your concept, write the content, edit copy within iBooks Author, select images, and coordinate multi-author books is extensive. eBooks and printed books have a similar audience base, both using the internet to access information, yet eBook readership is exclusive to those who possess an E-reader or tablet device. Therefore, consideration of alternative distribution mechanisms is also important to maximize resource availability to a wider audience. Thus, we also released individual files using the portable document format (pdf) for each book chapter, along with a limited number of printed book copies. To effectively reach our target audience of stakeholders with eReaders or tablets, consideration of technical savvy and mobile device preference is necessary.

Specified Source(s) of Funding: Southern Region IPM Enhancement Grant

(183) iPhone/iPad Apps for Extension

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Smartphones and tablets are increasingly being used to supplement or replace laptops and desktop computers. Horticulture-related apps for extension are becoming more available. These apps deal with such topics as food safety, geographic information systems, image enhancement, hydroponics, insect scouting, turfgrass management and weeds, plant growth regulator calculations, creating and scanning QR (quick response) codes, house plants, landscape design, plant and tree identification, whiteboard, agricultural retailers, crop protection product information, and industry trade publications. Finding apps can be done in several ways. Search for apps on a specified subject in the iTunes App Store. Do Internet searches for apps. Use apps, such as AppAdvice, Appsfire, apps: Free!, Free App Tracker, FREE AppZ, and Apps Gone Free, to find apps. To get apps, downloaded them to a smartphone or tablet, or to a computer and then transfer them to mobile devices. Apps can be downloaded from Apple’s App Store using the app called App Store. Or, use the Mac App Store on a Macintosh computer. For my extension work, I have used the app Zapd to create mobile websites. Mobile websites can also be created using Google Sites. e-Books are easily created with the app Book Creator. I have given extension talks on QR code generator apps to produce QR codes and using QR code reader apps. News aggregator apps and RSS Feed apps are used to help find articles, websites, and videos about cutting edge technological developments in horticulture, which are then distributed to clientele. In conclusions, apps for mobile devices provide horticulturists with useful tools for their work.

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Monday, July 22, 2013

1:00–1:45 PM

Environmental Stress Physiology

(225) Analysis of the Purslane (*Portulaca oleracea* L.) Transcriptome under Drought Stress

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Purslane (*Portulaca* spp.) is a xerophyte that can survive severe drought conditions and is found in many arid regions around the world. In addition to its extreme drought tolerance, some purslane accessions have displayed tolerance to high salinity, heavy metals, and other toxins in soil. Purslane shoots and leaves also contain an abundance of phytochemicals with well known human health benefits, including phytosterols, omega-3 fatty acids, and antioxidants, thus purslane consumption is gaining popularity. Limited genomic information is available for purslane, although information behind its novel adaptations to stress and biosynthesis of phytochemicals would prove extremely valuable. Therefore, this study was conducted as a first step in characterizing the purslane transcriptome in response to drought. Our previous studies characterized drought tolerance of 9 different purslane accessions during germination and seedling development. The accession Tokombiya showed exceptional drought tolerance and recovery and was thus selected for transcriptome analysis using 454-sequencing. Water was withheld from 20-day-old seedlings, while untreated control seedlings were regularly watered. After approximately 30 days without water, seedlings began to wilt and were subsequently collected for analysis every 2 days for two weeks. cDNAs derived from RNA extracted from entire seedlings were pooled into early (week 1) and late (week 2) responses and untreated control (weeks 1 and 2) and were analyzed using 454-sequencing. Approximately 8,000 contigs were assembled per library and compared to sequences in public databases; around 60% of contigs showed significant similarity to known proteins. Genes involved in stress responses constituted around 4% of the assigned genes in well-watered control seedlings and 5% in both early and late responses to drought. Interestingly, 70% of the stress related genes were related to heat or drought stress in all libraries. Several genes involved in pathways and processes of interest, including melatonin biosynthesis and arsenic transport, were identified and analyzed using qRT-PCR.

(226) High Temperature Inhibits the Expressions of Some Genes Involved in Anthocyanin Biosynthesis in Strawberry 'Sachinoka' Fruit

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We investigated the effect of high temperature on anthocyanin content of pot-grown strawberry plants. Recently, Japanese strawberry growers have problems about fruit quality because of global warming. We had reported that strawberry 'Sachinoka' fruit grown at high temperature conditions had decreased anthocyanin content, especially inside of the fruit (Ikeda et al. ASHS Conference 2011). In this research, we focused on the genes involved in anthocyanin biosynthesis in order to clarify the mechanisms to control it at high temperatures. To obtain the plant samples, the air temperature was set to either 30/15 °C (day/night, 14/10h) (high temperature regime) or 20/15 °C (control) in growth chamber. The mature fruits were divided into three parts [skin, flesh, and center (pith)]. Total RNA was extracted from divided fruits. After reverse transcription, target genes were amplified and analyzed using real-time PCR. We investigated three anthocyanin biosynthetic genes, MYB, anthocyanidin synthase (ANS), and UDP glucose-flavonoid 3-O-glucosyltransferase (UFGT). In skin, RNA levels of three genes were not different in both temperature regimes. Also, in center, RNA levels were not different. In flesh, RNA levels of MYB and UFGT in high temperature were lower than those in control—especially UFGT—decreased by 40%. But RNA levels of ANS were not different. As a result, Color degradation of flesh in high temperature may be caused by inhibition of the expressions of MYB and UFGT. We found that high temperature had negative effects on expressions of MYB and UFGT in flesh part of strawberry 'Sachinoka' fruit.

(227) Temperature Effects on Sweetpotato Growth and Development

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Sweetpotato [*Ipomoea batatas* L. (Lam.)] storage root initiation and subsequent growth are sensitive to temperature conditions. Little specific information is available on sweetpotato growth and physiological responses to wide range of temperature levels, both at early and late seasons. Two experiments were conducted to quantify the effects of temperature using

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the cultivar Beauregard. In experiment I, slips were transplanted in pots at five day/night temperatures of 20/12, 25/17, 30/22, 35/27 and 40/32 °C for 55 days. In experiment II, same temperature treatments except 20/12 °C were imposed after initiation of storage roots, 18 days after transplanting at 30/22 °C, for 74 days. In Experiment I, plants were harvested on regular intervals and growth and development including storage root formation were monitored. In both the experiments final destructive harvest was carried to record number of storage and non-storage roots, and total and plant-component dry weights. Gas exchange and other physiological measurements were recorded during the last three weeks of the experiments. Temperature did not affect total number of roots formed. However, the number of storage roots formed changed significantly, when treatments imposed at the beginning of planting. Storage root number increased linearly up to 20 °C and declined linearly with increasing temperature. The time to reach 50% of storage roots formed, and size and quality of the storage roots, however were significantly affected by temperature. Total biomass produced increased up to 30/22 and 35/27 °C and declined slightly at the 40/32 °C. Storage root biomass increased with increase in temperature up to 30/22 °C, and declined by 11% and 90% at 35/27 and 40/32 °C, respectively. When temperature treatments were imposed after the storage roots are formed, the number of total and storage roots produced was not affected by temperature, but the size and quality of storage roots were significantly affected. The optimum temperature for total biomass production was 30/22 °C and declined by 9% at 35/27 °C and 27% at 40/32 °C. The optimum temperature for storage root growth was 25/17 °C and declined linearly by 31 g per 1 °C increase in temperature. The data obtained and functional algorithms developed using these studies will be useful in assisting management decisions on field planting to optimize yield.

Specified Source(s) of Funding: USDA-AFRI, Specialty Crops Block Grant Project

(228) Physiological and Biochemical Evaluation of Freezing Tolerance in Three Asparagus Cultivars in Early Spring

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Asparagus cultivars grown in Southern Ontario must be winter-hardy, establishing dormancy in the fall before freezing, and maintaining dormancy during the freeze-thaw cycles of the spring. A field experiment was conducted at the Simcoe research station, Simcoe, ON, to assess freezing tolerance and associated physiological parameters in three cultivars, with varying adaptation to southern Ontario, during dormancy release in the spring. In 2012, crowns of three cultivars ['Guelph Millennium' (GM), 'Jersey Giant' (JG), and UC157] were harvested

at four harvest dates and assessed for LT₅₀ (the temperature at which 50% of crowns die), carbohydrates, proline, protein, and percentage of water content. As soil temperatures increased in the spring, GM maintained higher levels of freezing tolerance than JG and UC157. With a period of decreasing temperatures during the sampling period, JG appeared to reacclimate and UC157 did not respond. Freezing tolerance was associated with carbohydrates (reducing sugars and fructans), total protein and percentage of water content. Of the three cultivars tested, GM is best for maintaining freezing tolerance in the spring, and likely resists damage during freeze-thaw cycle, explaining, in part, its superior longevity compared to the other cultivars. A replicate experiment is in progress (Spring 2013).

Specified Source(s) of Funding: OMAFRA, the Ontario Asparagus Growers' Marketing Board, and the Agricultural Adaptation Council

(229) Changes in Cold Hardiness, Carbohydrate Content, and $\beta\beta$ -Amylase Gene Expression of *Prunus persica* during Cold Acclimation and Deacclimation

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The present study was performed to confirm differences in cold hardiness, carbohydrate content and $\beta\beta$ -amylase gene expression during cold acclimation and deacclimation in the shoots of four peach cultivars (cvs. Daewol, Aikawanakajima, Fukuyokabijin, and Kiraranokiwami). During cold acclimation, from September to Nov. 2011, cold hardiness of four cultivars determined by electrolyte leakage analysis dramatically increased. Maximum cold hardiness of four cultivars reached at the end of Dec. 2011; LT₅₀ values were -61.1, -58.9, -55.2, and -55.1 °C, respectively. During deacclimation, from the end of January to Apr. 2012, cold hardiness of four cultivars gradually decreased. The LT₅₀ values in April, suggesting that cold-acclimated hardiness was lost, were -7.3, -7.7, -8.0, and -7.7

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°C, respectively. According to LT_{50} values, the difference in cold hardiness between ‘Daewol’ and ‘Kiraranokiwami’ was the most obvious throughout the whole period. The seasonal changes of cold hardiness representing with LT_{50} values were closely related to those of total soluble sugars and sucrose in all the cultivars ($P \leq 0.001$). Glucose content in ‘Fukuyokabijin’ ($P \leq 0.001$) and fructose content in ‘Daewol’ ($P \leq 0.01$) and ‘Aikawanakajima’ ($P \leq 0.001$) were strongly related to cold hardiness. No correlation between cold hardiness and sorbitol content was shown in all the cultivars. Relative gene expression level of $\beta\beta$ -amylase, confirmed by a quantitative real-time RT-PCR, in four peach cultivars significantly increased during cold acclimation, showed a transient decrease in mid-winter, and decreased during deacclimation. Expression of $\beta\beta$ -amylase was highly correlated with cold hardiness in all the cultivars ($P \leq 0.01$).

Specified Source(s) of Funding: This work was carried out with the support of “Cooperative Research Program for Agricultural Science & Technology Development (Project No. 907129)” Rural Development Administration, Republic of Korea.

(230) The Effect of Deacclimation and Reacclimation on Cold Tolerance, Carbohydrate Levels, and $\beta\beta$ -Amylase Gene Expression in *Prunus persica*

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To boost our understanding of recent outbreak of freezing injury, distinct factors between relatively cold-tolerant ‘Daewol’ and cold-susceptible ‘Kiraranokiwami’ were confirmed by mimicking unseasonable changes of temperatures that occur in spring through repeated deacclimation and reacclimation treatments. Patterns of cold hardiness declined dramatically during the deacclimation and rose during the reacclimation in both cultivars. Our result indicated that ‘Daewol’ possessed higher capacity in response to repeated deacclimation and reac-

climation. Interestingly, in our study both cultivars indicated the distinguished patterns in the contents of different carbohydrates each other. ‘Daewol’ showed more sensitive changes in the carbohydrates in response to warm and low temperatures compared to ‘Kiraranokiwami’. ‘Daewol’ indicated almost similar repeated down- and up- patterns in the contents of soluble sugars in response to repeated deacclimation and reacclimation, whereas indicated repeated up- and down- patterns in the contents of starch. However, ‘Kiraranokiwami’ showed a consistent increase in the contents of soluble sugars and a consistent decrease in the contents of starch. Relative gene expression of $\beta\beta$ -amylase confirmed by the quantitative real-time RT-PCR during the deacclimation decreased significantly and increased sharply during the reacclimation in both cultivars. Relative expression of $\beta\beta$ -amylase gene in ‘Daewol’ decreased in approximately half during deacclimation compared to before treatment (BT), whereas during the reacclimation relative expression of $\beta\beta$ -amylase gene in ‘Daewol’ increased approximately 3- to 4-fold compared to BT. Relative expression of $\beta\beta$ -amylase gene in ‘Kiraranokiwami’ also showed pattern similar to that in ‘Daewol’. However, the levels of $\beta\beta$ -amylase gene expression in ‘Kiraranokiwami’ were much lower than in ‘Daewol’ in all the treatments.

Specified Source(s) of Funding: This work was carried out with the support of “Cooperative Research Program for Agricultural Science & Technology Development (Project No. 907129)” Rural Development Administration, Republic of Korea.

(231) Diurnal Root Zone Temperature Fluctuations Affect Strawberry Water Relations, Growth, and Fruit Quality

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Root zone temperature (RTZ) variation in soilless production of strawberries has the potential to cause changes in growth, nutrient uptake, gas exchange, stem water potential (SWP), and yield, particularly for strawberries in solution culture. Root systems of control plants were kept at 20 °C, while plants in other treatments were exposed to diurnal temperature swings of 5 °C (mild), 10 °C (moderate), or 15 °C (severe), each with a daily mean of 20 °C. After 12 weeks, maximum carboxylation rate, photosynthetic electron transport rate, maximum CO_2 assimilation rate, and fluorescence parameters (Fv/Fm) and were unaffected by temperature regime. Likewise, there was no effect on chlorophyll content, number of leaves, or fruit yield. There was little effect of RZT on predawn or midday

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SWP, but the severe treatment had substantially lower (–0.5 MPa) SWP compared to all other treatments at mid-morning, when RZT was ~5 °C and air vapor pressure deficit was at its daily maximum. Shoot concentrations of N, Mg, Fe, B, Zn were similar across treatments, but, in the moderate treatment, P, Ca, and Mn concentrations were lower. Shoot K concentration was significantly higher in the severe treatment. Fruit in the moderate and severe treatments were significantly smaller than in the mild treatment, which had the largest fruits. Fruit soluble sugar content was elevated slightly by RZT fluctuation. Leaf area and shoot dry weight of plants in the severe treatment were over 30% lower than controls. Root dry weight in the severe and moderate treatments was 30% less than in the mild treatment. The reduced shoot and root growth may be explained by the transient reduction in SWP when RZT was ~5 °C. The consequences of diurnal RZT fluctuations for strawberry production appear to be small if the minimum temperature is above 5 °C.

Specified Source(s) of Funding: California Strawberry Commission

(232) Establishment on the Application Times of Foliage Spray with CaCl₂ for Water Core Reduction in Apple

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The objective of this study was to clear up the application times of CaCl₂ solution for reduction of water core, one of the physiological fruit disorders found in ‘Hongro’ apples. Recently, abnormally high temperatures in summer have induced more water core in fruit. Therefore, we introduced foliage spray with CaCl₂ to improve physicochemical properties that can decrease water core incidence. We performed field experiments at nine orchards in Chungcheongbukdo from the end of June to July in 2012. We tested 6-year-old+ ‘Hongro’ trees at orchard elevations ranging from 126~306 m. The pH levels of soil ranged from 4.1~7.7 and Ca²⁺ soil content ranges were 0.9~9.5 (standard contents of Ca²⁺ are 5~6). The CaCl₂ solution diluted by 0.3% was sprayed one to five times on orchard foliage. Water core

incidences were indexed 0~9. The incidences of water core on the control orchards ranged 1.35~2.20 and those on CaCl₂ treated orchards ranged 0.95~1.75. Fruit weights between treatments in each orchard were not different. The CaCl₂ treated orchards had 1~5 times reduced water core by 28.6%, 13.0%, 19.2%, 35.5%, and 54.8%, respectively. In the highest orchard, the one-time treatment of CaCl₂ was effective, however in lower orchards four treatments were more significant for water core decrease. The results showed the possibility that foliage spray of CaCl₂ solution over four times reduces water core by improving the physicochemical properties in the trees.

Specified Source(s) of Funding: Cooperative research program for agriculture science and technology development (Project No. PJ008796042013) of Rural Development Administration, South Korea

(233) Identification and Characterization of the Causal Agent of Gummy Stem Blight from Melon in East China

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Melon (*Cucumis melo*) is one of the most important fruits for summer season in the world. With the dramatic increasing planting area of melon in protected facilities in China, gummy stem blight is now becoming the most serious disease in melon production. To understand the pathogen which causes this disease, morphological characteristics and rDNA internal transcribed spacer (ITS) sequences as well as their pathogenicity were analyzed. 43 isolates were identified from the sample stem collected from Jiangsu, Zhejiang, Anhui and Jiangxi Provinces of the East China. The mycelia from the PDA culture were white to dark gray on top and black on the bottom. After 2 days, the colonies on the PDA varied in diameter from 2.5 to 3 cm and extended to the edge of the petri dish. The rDNA-ITS sequences were amplified from 43 isolates and sequenced. Based on the blast search and alignment analysis, the pathogen of melon

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gummy stem blight was *Didymella bryoniae*. The similarity of these 43 isolates and other *D. bryoniae* from BLAST searches of GenBank was 100% or 99%. Phylogenetic analysis, based on rDNA ITS sequence, clearly distinguished *D. bryoniae* and *Didymella* spp. from the 10 other species studied. A pathogenicity test was conducted in a greenhouse on watermelon cvs. Sugar Baby, Sugarlee and Charleston Grey and melon cvs. Tongtian and Zhengzhu per isolate. Eighteen isolates showed highly pathogenic to both watermelons and melons. Together, according to the morphological characteristics and rDNA ITS sequence analysis as well as pathogenic test, we concluded that the pathogen of melon gummy stem blight in East China was *D. bryoniae*. Further studies are undertaking to distinguish the physiological races of *D. bryoniae* which have not been reported yet. This project was supported by National Industrial Technology System for Watermelon & Melon (CARS-NO.8).

Specified Source(s) of Funding: National Industrial Technology System for Watermelon & Melon (CARS-NO.8)

(234) Observation with a Laser and Optical Microscope for Emarginated Fruits Surface of Paprika (*Capsicum annuum* L.)

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Paprika (*Capsicum annuum* L.) production in Japan has recently experienced a huge incidence of emarginated fruit and decreased product quality. Aging spot fruits often suddenly occur when air temperature becomes higher, but its mechanism has not been researched. We demonstrated the differences of aging spot and non-aging spot fruit surfaces using a laser and optical microscope, and we discussed it. The fruit surfaces were observed with a laser microscope to confirm whether the fruit is really emarginated. After a fruit surface was sliced as thinly as possible, it was observed with an optical microscope to analyze the structure of the cell below the pericarp. The non-aging spot fruits had a flat surface and regularly-structured cells below the pericarp, however, aging spot fruits had emarginated surfaces and broken-structured cells below the pericarp and spoiled.

(235) Phenotypic Correlation between Yield Components and Responsive Genes under Salinity Stress for Tomato Lines

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Water salinity greatly affects growth and production of agricultural crops. Thus, yield enhancement under salinity conditions is a major goal of plant breeders. Six advanced tomato lines along with their original populations and two salinity tolerant lines were used to evaluate their response to salt stress using five water salinity levels of NaCl (0.5 control treatment, 2.4, 4.8, 7.2, and 9.6 dS·m⁻¹). The phenotypic correlation coefficients (r) were calculated for all possible pairs of the studied traits, over all the five salinity levels and the 14 genotypes at the two seasons. The results showed significant and desirable positive correlation between total yield and nine traits; plant height (0.83**), stem diameter (0.76**), leaf area (0.67**), average fruit weight (0.84**), average fruit number (0.95**), Ca⁺⁺ content (0.45*), K⁺ content (0.80*), fruit flesh thickness (0.88**) and WUE (0.99**). Significant negative correlations were detected between total yield trait and both Na⁺ content (−0.53*) and total soluble solids (−0.82). These results indicated the importance of these traits in yield improvement and in selection program. Based on the performance of the tomato genotypes at different salinity levels, four genotypes were selected to represent salt susceptible, moderately salt tolerant, salt tolerant, and reference salt tolerant. The phenotypic correlation coefficients values between the total yield trait and 50 genes for the selected tomato genotypes under high salinity level were determined. The results showed significant and desirable positive correlation between total yield trait and eight of the 50 genes; JAZ8, LesAffx.30832.1.S1 (0.97*), Polcalcini jun (Les.5056.1.S1_x_) (0.99**), Polcalcini jun (Les.5056.1.S1_a_) (0.98*), ER5 (Les.3766.1.S1_) (0.96*).

Specified Source(s) of Funding: The National Plan for Science and Technology at King Saud University for this project (number 10-BIO970-02).

Monday, July 22, 2013

1:00–1:45 PM

Floriculture

(009) The Effects of Tree Harvest Season and Storage Method on Plant Growth in a Pine Tree Substrate

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Recent interest in pine tree substrates (PTS) in horticultural crop production has generated many possibilities as well as unanswered questions about its use. While much research has been conducted on plant growth in PTS, wood manufacturing,

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wood toxicity, etc., there remains limited information available on plant growth during production as it relates to: 1) pine tree harvest date; 2) changes to manufactured PTS during storage; or 3) changes to harvested pine tree logs (before being manufactured into PTS) during storage. Therefore, this research was conducted to determine the influence of harvest season and the effects of storage time of PTS following manufacturing and the effect of log storage following harvest on plant growth in PTS. In Apr. 2007 and every 3 months through Oct. 2008, coarse pine chips produced from freshly harvested 15-year-old loblolly pine trees (*Pinus taeda* L.) were ground in a hammer mill fitted with a 2.38-mm screen. At each harvest date some of the manufactured PTS was stored in 1.5-m³ perforated plastic bags and some of the whole unchipped logs were stored outdoors with bark intact. Also at each harvest date, some of the PTS from a freshly harvested tree and a peat lite substrate (80:20 peat:perlite; PL) was used to grow 'Inca Gold' marigold (*Tagetes erecta*) in 1-L plastic pots to determine if harvest date affected growth in comparison to plant growth in PL. In July 2008 and Oct. 2008, PTS manufactured from freshly harvested pine trees and PTS that had been stored since each of the four previous harvest dates (July 2007, Oct. 2007, Jan. 2008, April 2008; 12, 9, 6, 3 months, respectively) and PTS prepared by grinding logs that had been stored since the four previous harvest dates were filled in to individual containers. Seedling marigolds were grown in these substrates to determine the effect of tree harvest season and storage time on plant growth. Results showed that PTS quality in terms of affecting plant growth is not affected by the season of year in which trees are harvested. Storage of manufactured PTS in bags and stored whole pine logs (before grinding) resulted in a drop in pH (6.1 to 3.5) after 12 months. A reduction in plant growth was observed in the 12 mo aged PTS when lime was not incorporated to increase substrate pH compared to PTS manufactured from freshly harvested trees which had an acceptable pH for marigolds.

(010) Development of New Integrated Biological Control Technique against Western Flower Thrips Infesting Chrysanthemum in Korea

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The western flower thrips (WFT), *Frankliniella occidentalis*, are known as a pests on leaves, buds, and petals of horticultural crops and flowering plants, including chrysanthemum. The WFT lays its eggs in plant tissue. After egg hatch, there are two larvae stages and two pupa stages that both occur in the soil. It makes so difficult to chemical control. New integrated biological control technique is being developed to improve biological control of WFT on chrysanthemums. Combinations of biological control agents could be made more cost-effective if used selectively on "trap plants" attractive to WFT. WFT was attracted to White and yellow than pink flower chrysanthemum. In olfactometer studies, of the four color patterns plants for WFT, compared to yellow flowers, white flowers were attractive to WFT adults. The toxicities of nine commercial pesticides (five insecticides and four fungicides) which have been used in the domestic market were evaluated to WFT at the recommended concentration. The tests were performed according to the standard test method of the IOBC/WPRS working group "Pesticides and Beneficial Organisms". Among nine pesticides tested with adults of *Orius laevigatus*, Machine oil 5.0%, Acetamiprid 28.9%, Clothianiclin 20.1%, Mancozeb 29.4%, Benomyl 17.5%, Defenoconazole 26.5%, Bitertanol 9.0% were very low toxicity except Methidathion 41.5% and Deltamethrin 53.7%, with eggs of *Orius laevigatus* were very low toxicity except Machine oil 97.2% as well. It may be suggested from these results that 7 pesticides could be incorporated into the integrated WFT management system with "trap plants" on chrysanthemum.

Specified Source(s) of Funding: Rural Development Administration

(011) Optimal Postharvest Handling Procedures of Eremurus 'Line Dance' and 'Tap Dance'

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Eremurus is a striking specialty cut flower with high commercial potential, but postharvest handling procedures need to be optimized for longest vase life. Cut stems of 'Line Dance' and 'Tap Dance' eremurus were evaluated for optimal harvest stage, harvest procedures, ethylene sensitivity and effects of anti-ethylene agents, and storage methods and duration. Also, the effects of commercial hydrators, hydrators along with holding preservatives, or continuous use of floral foam saturated with or without commercial preservatives were investigated. Stems of both cultivars harvested when no floret opened, had longer vase life than stems harvested with three or more flo-

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rets open at harvest. Harvest procedures, exogenous ethylene and anti-ethylene agents had no significant effect on *eremurus* longevity. Stems of both cultivars stored for one week had similar vase life as of unstored stems irrespective of storage methods. Storage longer than one week greatly shortened the vase life of both cultivars. Stems of 'Tap Dance' *eremurus* hydrated in tap water with silver thiosulfate or Floralife Hydraflor 100 for 4 hours had longer vase life than stems hydrated with just tap water, 1-methylcyclopropene (1-MCP), or Chrysal Professional 1, while stems of 'Line Dance' were unaffected by commercial hydrators. Use of both hydrator and holding preservatives did not result in significant differences in vase life for both cultivars, while pulsing with 5% or 10% sucrose supplemented with the antimicrobial agent, Kathon at $7 \text{ mg} \cdot \text{L}^{-1}$, for 24 hours extended vase life by 1.2 or 2.2 for 'Line Dance' and 1.4 or 1.9 days for 'Tap Dance' stems, respectively, compared with tap water. Stems of 'Line Dance' kept continuously in commercial preservatives had longest vase life compared with tap water and use of floral foam reduced vase life. However, stems of 'Tap Dance' kept continuously in floral foam saturated with tap water or just Floralife Clear Professional flower food had longest vase life.

(012) The Effect of Growth Regulator Addition on Bulb Cultivation in Interspecific Hybrid Lilies

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To obtain virus-free bulbs in hybrid lily progenies, scale propagation of apical meristem culture was performed in vitro for each cross combination. Meristems sized 0.5 mm or less were

isolated from bulblets and cultured in MS media containing 0.5 mg/L IAA and the following growth regulators: 2, 3, or 5 mg/L BA and 0.2, 0.3, or 0.5 mg/L TDZ. We observed that 0.2 mg/L TDZ was effective in increasing the number of shoots to 10.6, but shoot length trended toward decrease with the addition of growth regulators, regardless of type or concentration. Fresh weight was greater with 5.0 mg/L BA or 0.3 mg/L TDZ treatment. For the FO and FLA progeny, treatment with BA and TDZ led to similar effects on the number and length of shoots and fresh weight, according to the type and concentration of the growth regulator, although the degree of changes was different. To grow proliferate bulblets from seedlings obtained through apical meristem culture, each hybrid progeny bulblets was cultivated on MS medium with 5.0 mg/L BA and 0.5 mg/L NAA. Medium containing 5.0 mg/L BA and 0.5 mg/L NAA was effective for shoot growth in the FLA progeny.

Specified Source(s) of Funding: lily apical meristem culture bulb

(013) Harvest Time and Cold Storage Duration of *Lilium* Oriental Hybrid Bulbs Affects Their Morphological Characteristics and Sugar Contents

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Morphological characteristics and constituents in *Lilium* bulbs change depending on the harvest time and storage duration, and these changes affect bulb quality. This study was carried out to examine the impacts of different harvesting times and storage duration on the nose size and carbohydrate content of *Lilium* Oriental 'Siberia' and 'Sorbonne' bulbs. For the harvest time study, bulbs were harvested weekly from September to November in a field farm in Taean, Korea. For the cold storage duration study, bulbs were harvested late November in the farm and stored at 0 °C. Bulbs were measured for morphological characteristics and total sugar and free sugar contents. As a result, bulb weight increased as time passed up to mid-October and then decreased due to a reduction of moisture content in bulbs. Regardless of cultivar, nose size increased with delaying the harvest time. Total sugar and sucrose contents increased as time passed to early November due to continuous translocation and accumulation of photosynthate. In the relation of cold storage duration with bulb characteristics, nose size increased with extending cold storage in both cultivars. During the storage period, monosaccharides (fructose and glucose) decreased until the end of March and then increased, whereas, sucrose showed a reverse trend. Total sugar was maintained at a certain level

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during the cold storage. Changes in carbohydrates content are considered to be related to the activity of enzymes involving carbohydrate metabolism and to affect nose growth in lily bulbs. This study was partially published in *Flower Research Journal* in 2012.

Specified Source(s) of Funding: This work was carried out with the support of “Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ008238062011)”, Rural Development Administration, Republic of Korea.

(014) Evaluation of Two Different Irrigation and Fertilizer Applications on Dianthus ‘Telstar™ White’ and ‘Telstar™ Red’

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Fertilization and irrigation are important components of greenhouse container crop production. Application method of controlled release fertilizer by topdressing or incorporating as well as hand watering vs. drip irrigation can affect plant growth and visual quality. The objective of this study was to evaluate the effect of application method on plant quality of *Dianthus* ‘Telstar™ White’ and ‘Telstar™ Red’ grown in the greenhouse. Fertilizer treatments of either 0, 10, or 20 g of 16–9–12 (N–P–K) Osmocote® Plus were applied as a topdress application or were incorporated into the media, and tap water was then used during irrigations. Pots were drip or hand watered at a rate that allowed media saturation and some leaching. Seven weeks after planting, data was collected on plant height, width, fresh weight, number of flowers, and plant survival rates. For all fertilizer treatments except the control, higher values were seen for drip irrigated plants for height, width, and fresh weight. For the measured variables mentioned above, higher fertilizer treatments (20 g and 30 g) did not lead to significantly higher values except for the number of flowers under hand irrigation using topdressed fertilizer, and fresh weight using drip irrigation for either topdressed or incorporated fertilizer for either cultivar. For plant survival, the interactions of irrigation \times treatment ($P = 0.037$) and irrigation \times cultivar ($P = 0.013$) were significant. Plant survival was highest for both irrigation treatments using 10 g of fertilizer incorporated, however, for drip irrigation 20 g and 30 g of incorporated fertilizer were also not significantly different. ‘Telstar™ Red’ plants had significantly fewer plants (20%) survive under hand irrigation compared to drip irrigation or ‘Telstar™ White’ under either irrigation averaging 53% survival.

(015) Induction of Variation in the *Petunia Mlo* Gene for Resistance to Powdery Mildew

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To develop genetic resistance to powdery mildew in *Petunia hybrida*, the *mildew locus O gene (Mlo)* was identified and characterized. The genomic sequence of *petunia Mlo* was determined using *petunia* EST sequences with homology to tomato *SIM1.1*. A single copy of *PhMlo* was identified and its expression pattern in *petunia* was established by RT-PCR. Two approaches were taken to examine whether eliminating *PhMlo* expression can confer powdery mildew resistance. First, an EMS-mutagenized population of *P. hybrida* ‘Mitchell’ was developed after optimizing EMS exposure levels. High-resolution melting (HRM) analysis was used to screen DNA from M2 plants for *PhMlo* variation. Two SNPs were identified that resulted in the missense mutations S130L and G176E. The G176E substitution was predicted by Provean software analysis to be deleterious to *PhMlo* function. Plants with the S130L substitution may have originated from seed stock contamination. The second approach involves the reduction of *PhMlo* expression through RNA interference. A *PhMlo* RNAi construct was developed and is being introduced into *petunia* by *Agrobacterium*-mediated transformation.

(016) Field Performance of Transplants Grown using Light-emitting Diodes

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Transplants grown using light-emitting diodes (LEDs) were evaluated during subsequent field development to determine if monochromatic spectral light distributions may affect morphology, flower formation or yield. Sunflowers and snap beans were seeded in a greenhouse and allowed to develop under LEDs or natural light supplemented with high-pressure sodium irradiance. The snap beans were grown using LED panels with red (peak emission at 665 nm) supplemented with 20% blue LEDs (peak emission at 455 nm). In addition to red/blue LEDs, sunflowers were also grown under white LEDs (3700 K), or a combination of LEDs (multi-LEDs) using 50% red (660 nm), 10% orange-red (635 nm), 10% orange (600 nm), 10% white (3700 K) and 20% blue (450 nm). Photosynthetic photon flux (PPF, 400 to 700 nm) under the red/blue LEDs used for the snap beans was between 350 to 400 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at plant height. The PPF for the sunflower transplants was approximately 150 to 180 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. The day length was 16 h except a short day (8 h) was provided to one set of sunflowers in the greenhouse. Following germination, the seedlings were grown for 7 d under the various light sources. Preliminary results suggest the various types of LEDs support similar growth, morphology and development as natural greenhouse conditions, without significant carry-over effects on field performance. Two selections of sunflowers (‘ProCut Bicolor’, ‘Sunbright Supreme’) were evaluated. Days to flower from transplanting were 50 ± 1.6 d for ‘ProCut Bicolor’ independent of treatment. For ‘Sunbright Supreme’, transplants

An asterisk (*) following a name indicates the presenting author.

receiving short days during the propagation stage flowered 8 ± 2.3 d earlier than the 78 ± 1.3 d for the sunflowers under 16 daily h using LEDs or a greenhouse environment. Three French filet type green beans ('Concador', 'Stayton', 'Velour') and the traditional 'Provider' were included in the study. The transplants were planted in double rows on 60 cm wide raised beds covered with black plastic. Despite producing the least number of bean pods, the largest yield was recorded for 'Provider'. The weight of picked beans for one meter length of the raised bed was 8.85 ± 0.78 kg for 'Provider' followed by 'Stayton' (7.80 ± 0.76 kg), 'Velour' (5.42 ± 0.38 kg), and 'Concador' (4.18 ± 0.54 kg). Although the yield varied among cultivars, there was no significant difference between snap beans started under greenhouse conditions or the red/blue LEDs.

Monday, July 22, 2013

1:00–1:45 PM

Growth Chambers and Controlled Environments

(002) Growth and Antioxidants of Cherry Tomato Seedlings Grown under Monochromatic Light-emitting Diodes

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Individual light spectrum within visible light spectra plays an important role in plant growth and development. Light-emitting diodes (LEDs) of a short wavelength range can be used in closed-type transplants production systems as an artificial light source. This study aimed to determine the effects of monochromatic LED on growth and antioxidants of cherry tomato seedlings (*Lycopersicon esculentum* Mill. cv. 'Cuty'). Two-week-old cherry tomato seedlings germinated under normal growing conditions (24°C , fluorescent lamp + high pressure sodium lamp, a photosynthetic photon flux (PPF) of $112.9 \pm 5 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, 12 hours photoperiod) were transplanted in a growth chamber equipped with various monochromatic LEDs (blue LED, 456 nm; green LED, 518 nm; red LED, 654 nm; white LED, 456 nm + 558 nm) and fluorescent lamp (control) and cultivated at $27/18^\circ\text{C}$ (day/night) with a PPF of $205 \pm 5 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and 12 hours photoperiod for 4 weeks. The plant height, stem length, and internode length of tomato seedlings subjected to blue LED were the highest among treatments during whole growth stage. Blue LED induced about 1.5–2.2 times higher stem length than red and white LED. The fresh weights of shoots and roots in red and green LEDs were higher than the other treatments including control after 4 weeks of LED treatment. The chlorophyll

content (SPAD value) of blue LED was significantly lower than the other LED treatments. In contrast, blue LED stimulated the biosynthesis of antioxidants in the tomato seedlings. Antioxidant capacity of blue LED was 2.1 times higher than that of green LED. Thus, this study suggested that the manipulation of light quality using LEDs is a critical factor for growth and antioxidants of cherry tomato seedlings.

279) The Effects of Duty Ratio and Intensity of Pulsed LED Light on Growth and Photosynthetic Rate of Lettuce Grown in a Plant Factory System

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This study was carried out to examine the effect of duty ratio and intensity of pulsed LED light on growth and photosynthetic rate of lettuce (*Lactuca sativa* L. 'Cheongchima' and 'Jeokchima') grown in a plant factory system. The 21-day-old seedlings were grown for 4 weeks under the bar type LEDs (5 red:2 blue:1 white) with different LED pulse (on/off) of 400/0 (continuous), 300/100, 200/200, 133/266, and 100/300 μs by using oscilloscope during 16 h photoperiod. These indicated to duty ratio (DR, percentage of on time from one cycle) of 100%, 75%, 50%, 33, and 25%, respectively. Light intensities were two levels (high and low, HL and LL) at DR 100%, 75%, and 50%. Air temperature and relative humidity in the system were maintained at $20 \pm 2^\circ\text{C}$ and $70\% \pm 10\%$, respectively. Nutrient solution (initial pH 5.8 ± 0.2 , EC 1.2 $\text{dS}\cdot\text{m}^{-1}$, $20 \pm 2^\circ\text{C}$) was supplied by nutrient film technique (NFT) methods. After 2 weeks of treatment, fresh and dry weights per plant in 'Cheongchima' lettuce were no significant difference in DR 100% HL, 75% HL, 50% HL, and 33%. The number of leaves of 'Cheongchima' was no significant difference in DR 100% LL, 33% HL. Fresh and dry weights of 'Jeokchima' were no significant difference in DR 100% HL and 75% HL. The Hunter's "a" values were significant difference among treatments. After 4 weeks of treatment, fresh weight of 'Cheongchima' was no significant difference in DR 100% HL and LL, 75% HL, and 50% HL. The dry weight per plant of 'Cheongchima' was no significant difference in DR 100% HL and LL, 75% HL and LL, and 50% HL. These results will be utilized for energy saving in the plant factory system using LED as a light source.

An asterisk (*) following a name indicates the presenting author.

Specified Source(s) of Funding: Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ9070222011), Rural Development Administration, Republic of Korea.

(280) Growth of Lettuce Plants Exposed to Air Anion in a Plant Factory

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Air anion is known to be beneficial for plant growth because it may improve photosynthesis and respiration of plants. The objective of this study was to determine the effect of air anion on lettuce growth in a plant factory where environmental conditions for growth and development can be controlled. Red leaf lettuce (*Lactuca sativa* L. 'Jeokchima') seedlings grown under normal growth conditions (20 °C, fluorescent lamp, $150 \pm 3 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, 12 hours photoperiod) for 18 days were transplanted to NFT systems in a plant factory equipped with LEDs (Red:Blue = 78 : 22, $184 \pm 2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, 12-hour photoperiod). Three levels of air anion (low $1 \times 10^4 - 5 \times 10^4$, middle $7 \times 10^5 - 12 \times 10^5$, and high $15 \times 10^5 - 20 \times 10^5$ ION/cc) produced by high voltage air anion generators were applied to lettuce plants for 4 weeks. Lettuce plants exposed to air anion showed vigorous growth 2 and 4 weeks after the treatment. Both middle and high levels of air anion improved growth characteristics such as leaf area and the fresh weight of shoots and roots although there was no significant difference between air anion and control in leaf shape index, number of leaf, and chlorophyll content (SPAD value). As the concentration of air anion increased, leaf area gradually increased at 2 weeks after the onset of anion treatment. Middle level of air anion led to 54% and 45% higher shoot fresh weight than control 2 and 4 weeks after the treatment, respectively. In addition, root fresh weight significantly increased in middle and high levels of air anion at 4 weeks after the onset of anion treatment. In conclusion, this study suggested that the application of air anion in a plant factory has a positive effect on lettuce growth.

Specified Source(s) of Funding: The Agenda Research Development Program, Rural Development Administration, Republic of Korea (PJ 008473).

(281) Cucumber Seedlings Growth and Morphology under Supplemental Pulsed Lighting using Light-emitting Diodes

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Emerging high intensity light emitting diodes (LEDs) are currently been studied for their potential as a supplemental lighting technology in greenhouses. In addition to the long durability, low diode operational temperatures, and spectral selectivity, LEDs unique features include the capability to turn ON and OFF at a rapid frequency (pulsed lighting). Previous research under sole source artificial light conditions has demonstrated that the use of pulsed lighting with optimal frequency and duty ratio could save energy consumption by increasing plant growth, while others demonstrated that there were rather reduction in photosynthesis observed under pulsed lighting with certain combinations of duty ratio and frequencies. However, to our knowledge, pulsed lighting has not been studied as supplemental lighting in greenhouses. In this study, greenhouse cucumber (*Cucumis sativus* cv. Cumlaude) was grown until the second true leaf stage under red supplemental LED light (661 nm peak wavelength, FWHM: 15 nm) for 18 hours (2:00–20:00) with an average intensity of $60 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF. The treatments consisted of 1) no supplemental lighting (control), 2) continuous red-LED lighting, and (3) pulsed red-LED lighting at 50% duty ratio and 2500 Hz frequency. The solar PPF contribution for this experiment was $7.6 \pm 0.7 \text{ mol}\cdot\text{m}^{-2}$ per day. Plant height, hypocotyl length, epicotyl length, stem diameter, number of leaves, shoot fresh mass, shoot dry mass, leaf area, and chlorophyll concentration were evaluated. Supplemental lighting increased shoot dry mass (32%) and plant height (55%) compared to the control. No significant differences were observed in the growth parameters such as number of leaves, fresh mass, shoot dry mass, and leaf area between continuous lighting and pulsed lighting treatments. However plant height and hypocotyl length were 6.2% and 7.5% respectively, greater in the pulsed light treatments. This study showed that supplemental pulsed lighting at 2500 Hz and 50% duty ratio did not increase cucumber plant growth and did not increase seedling's plant height, which is undesirable for cucumber propagators. Optimal pulsed lighting could be species specific, and in order to potentially increase growth and save energy, researchers have to develop recipes on the ideal frequency and duty ratio for greenhouse crops.

(282) Blue Light-emitting Diode Treatments Act to Decrease Kale Leaf Tissue Zeaxanthin Concentrations and Non-photochemical Quenching, Thereby Demonstrating a Less Stressful Light Environment

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Previous research in our group demonstrated that narrow-band wavelengths from light-emitting diodes (LEDs) improved concentrations of mineral nutrients and health promoting glucosinolates and carotenoids in broccoli (*Brassica oleracea*) microgreens. The objectives of this study were to: 1) measure the impact of light quality on the concentrations of nutritionally important pigments in baby ‘Dwarf Siberian’ kale (*Brassica oleracea* cv. *Acephala* group); 2) measure the impacts on non-photochemical quenching (NPQ); and 3) correlate NPQ with kale xanthophyll cycle pigments. Non-photochemical quenching is a mechanism employed by plants to protect light-harvesting complexes from the adverse effects of high light intensity, and indicates plant stress. Therefore, we compared the LEDs with incandescent/fluorescent light to understand how the treatments differ from regular growth chamber light conditions. Seeds were sown in 10 cm pots in soilless media and upon emergence of the first true leaf were fertilized with 80 mg N/L solution of 20–20–20 soluble fertilizer (100 mL per pot). Furthermore, light treatments of: 1) fluorescent/incandescent light; 2) 5% blue (455–470 nm)/95% red (627–630 nm); and 3) 20% blue/80% red were applied in controlled growth chamber environments. The light intensity was set at 250 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for all light treatments with a 16-h photoperiod and air temperature of 24 °C. After 30 days under the light treatments, whole kale plants were assessed for NPQ with a pulse-amplitude modulated fluorimeter. Consequently, kale plants were harvested and shoot tissues were freeze dried and measured for chlorophyll and carotenoid pigments. Exposure to blue light LED treatments significantly increased shoot tissue violaxanthin, neoxanthin, zeaxanthin, lutein, total xanthophylls, chlorophyll a, chlorophyll b, and total chlorophyll when compared to the incandescent/fluorescent light treatment. Results also revealed a significant positive correlation among NPQ and leaf tissue zeaxanthin concentrations, which indicated LEDs provided a less stressful light environment.

Specified Source(s) of Funding: USDA SBRI; University of Tennessee, Institute of Agriculture

(283) Investigating the Incorporation of Microbial Probiotics in Hydroponic Lettuce Production in Ohio

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Soilless controlled environment vegetable production is designed to tailor growing environments and nutrient delivery to enhance both crop yield and quality. Typically crop nutrients are provided through a nutrient solution, which for leafy crop production is either flowing in channels or contained within ponds or deep water systems. To achieve accurate and consistent supply of plant nutrients, the majority of hydroponic nutrient solutions are formulated with inorganic fertilizers. This method of nutrient delivery is less reliant on the biological activity critical in nutrient cycles in soil systems. While much is known about crop nutrition in hydroponic production, the potential managed incorporation of microorganisms and their products is incompletely understood. Soilless production of vegetables stands to benefit from increased utilization of biological materials, if applied and managed correctly. Therefore, this work was carried out to evaluate the performance of a microbial product (BiOWiSHTM) in hydroponic lettuce production during Summer and Fall 2012 in Wooster, OH. Three commercial cultivars (‘Fidel’, ‘Multy’, and ‘Ferrari’) were grown using nutrient film technique (NFT) with solutions maintained at 1.8 mS/cm EC and 5.8 pH. Greenhouse aerial temperature, relative humidity, and solar radiation in addition to nutrient solution pH, EC, and temperature were continuously monitored. Seeds were germinated in rockwool cubes (2.5 x 2.5 x 3.8 cm), transplanted to NFT channels after 2 weeks, and harvested after about an additional 4 weeks. Shoot weight was measured on all plants and elemental composition was evaluated on a subset of plants. Experiments one (13 June–20 July) and two (22 Aug.–3 Oct.) compared a control solution with three experimental treatments incorporating BiOWiSHTM formulations at either 10.0 or 3.3 ppm. Significant cultivar differences were present in both experiments ($P \leq 0.0001$). ‘Fidel’ consistently yielded highest. In experiment one, completed under summer conditions, biomass was significantly different among the control and BiOWiSHTM treatments ($P = 0.0046$). BiOWiSHTM treatments one and two were both significantly higher than the control. Experiment two, conducted in the early fall, showed similar trends but differences were not significant between the control and BiOWiSHTM treatments ($P = 0.83$). These two experiments indicate opportunities for microbiological products to impact crop yield in leafy hydroponic systems in northern U.S. climates, but also indicates that environmental conditions and management will likely be important in incorporating biological or microbial products in soilless leafy crop production systems.

(284) Cold Acclimation Attributes among Three Asparagus Cultivars under Controlled Conditions

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Southern Ontario is one of the coldest asparagus production areas in the world. Cultivars must demonstrate adequate cold acclimation before the first killing frost and continue to demonstrate freezing-tolerance throughout the freeze-thaw cycles in the early spring. In the field, cultivar Guelph Millennium (GM) senesces in mid-October while fern of Jersey Giant (JG) and UC157 often remain green until a killing frost. Superior longevity of GM compared to the other cultivars could be related to proper cold acclimation in the fall and improved freezing tolerance. A seedling experiment was conducted in growth chambers to assess the effects of temperature and photoperiod on the induction of senescence, freezing tolerance, and biochemical parameters related to cold acclimation. Ten-week-old seedlings of the three cultivars were acclimated in a factorial combination of two temperatures (23 °C, 8 °C) and two photoperiods (16 hour, 8 hour) or acclimated followed by sub-freezing (3 °C/–3 °C, day/night). Low temperature acclimation induced the greatest loss of chlorophyll in GM compared to the other two cultivars. Median lethal temperature (LT₅₀), the temperature at which 50% of the population dies, decreased for all cultivars when acclimated at low temperature; GM showed the lowest LT₅₀ (highest freezing tolerance) followed by JG and UC157. After subsequent subfreezing acclimation GM maintained its LT₅₀, whereas values for the other two cultivars increased (decreased freezing tolerance). Biochemical analyses indicated low crown percentage water, and high concentrations of sucrose, raffinose and proline are associated with freezing tolerance. Results also suggest a seedling screen may be useful to select for freezing tolerant germplasm in a breeding program.

Specified Source(s) of Funding: Agricultural Adaptation Council NSERC CRSNG Asparagus Growers of Ontario

(285) Shading Rate in Greenhouse Affects Indoor Performance under Different Light Intensity in *Mentha citrata*

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To investigate the effect of shading rate in greenhouse and indoor light intensity on indoor performance of lemon mint

(*Mentha citrata* Ehrh.), plants were grown at different shading rates (0%, 50%, 75%, 95%) in greenhouse for 7 weeks and two indoor light intensities (9 and 50 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPFD) for 16 weeks. Stem elongation tended to increase with increasing shading rate. Plant height under low indoor PPFD was higher than that under high PPFD. Internode elongation was similar in all treatments. Chlorophyll content was higher under low PPFD than high PPFD, regardless of shading rate. And there was no significant difference in chlorophyll content after 23 weeks among shading rates under each indoor PPFDs. Hunter's a value of leaves grown under low PPFD was lower than that under high PPFD. Plants under low PPFD had similar values irrespective of shading rate in greenhouse. Whereas, Hunter's a value under high PPFD was highest at 95% shading. Leaf shape index was highest under low indoor PPFD after 50% shading and lowest under high PPFD after 95% shading. Runners were formed in all treatments and the length was ≈ 60 cm in whole treatments excepting 95% shading under low PPFD. Axillary shoots were formed in all treatments and number and length of axillary shoots were different among treatments. Fresh and dry weights of plant grown under high indoor PPFD were greater than those under low PPFD, irrespective of shading rate. In conclusion, introduction of lemon mint for green interior needs $\leq 50\%$ outdoor shading and high indoor light intensity.

Specified Source(s) of Funding: "Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ907184032011)", Rural Development Administration, Republic of Korea.

(286) The Effects of Several Light Sources on Growth and Development in *Petunia* and *Torenia*

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This study was carried out to investigate the indoor performance of two flowering bedding plants, *Petunia xhybrida* 'Double Wave' and *Torenia fournieri* 'Clown Blue', under different artificial light sources. Three tube-type (tube) fluorescent lamps (FL) and four LED bulbs were installed at small frame structures (W80 x D100 x H75 cm), and high pressure sodium lamp (HPS), metal halide lamp (MH), and mercury lamp (MC) were equipped in large frame structures (W80 x D100 x H145 cm). *Petunia* and

An asterisk (*) following a name indicates the presenting author.

torenia seedlings were transplanted into plastic pots filled with soilless mixture, acclimated for one week in a greenhouse, and then placed under the frame structures lighted by the artificial light sources for 10 weeks. Cultural conditions were comprised of 22 ± 2 °C, 25 ± 2 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF (exceptionally, MC treatment: about 17 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$), 16-h photoperiod. Plant height of petunia was respectively high under MH, HPS, and MC, and low under FL tube. Chlorophyll content was high under LED bulb and MH. Number of branches was about five, regardless of light source. Fresh weight was great under MH and LED bulb, and dry weight was most under MH. Flowering percentage was 100% under MH, the others were $\geq 50\%$, especially 0% under FL tube. Under MH, days to flowering were smallest and the cumulative number of open flowers was much more than the others. Plant height of torenia was highest under MH, that was a little effect of blue light. Chlorophyll content and fresh and dry weights were also high under MH. Flowering percentage was 100% regardless of all treatments. Days to flowering were 23 days under MH and LED bulb, faster than the other sources. Cumulative number of open flowers was ≈ 10 under LED bulb, MH, and FL tube. As a result, when these flowering bedding plants were introduced interior, proper light source for good performance was MH or LED instead of FL.

Specified Source(s) of Funding: “Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ907184032011)”, Rural Development Administration, Republic of Korea.

(287) The Effect of Low Light Intensity by Dust of Greenhouses on Tomato Productivity

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The light of the sun have influence on the plant growth and pest occurrence and also the productivity and quality of greenhouse crops is reduced according to the light condition in the greenhouse. The light saturation point of tomato is 70,000 lux and the production of tomatoes is directly related to solar radiation. In Korea, most tomato crop is produced in a greenhouse. In recently, shading damage on tomato cultivated main producing areas is increasing due to the civil engineering and construction dust. In this study, the dust of the construction site was performed to determine the impact of the growth and productivity of tomatoes cultivated greenhouse. The clay powder 0 g/㎡, 15 g/㎡, 25 g/㎡

diluted in water was attached to the cladding according to the shading rate of 0%, 30%, 45%. The cultivating of tomato was performed in two layer vinyl greenhouse, in order to prevent loss of dust by rain or wind. Tomato was planted in September and harvested from November. As a results, the dry weight of tomatoes decreased 15%, 23 % compared with non-treated due to the 30%, 40% reduction of sunlight and sugar content 0.4 to 0.6 °Brix low results are shown. The calculated reduction in the harvest of tomatoes due to the shading rate equation is $Y = 0.9248x - 0.5857$. As this appears to mean the lack of sunlight in winter, a technology is needed sunshine damage due to dust, such as development of a film not attached to dust and supplementary lighting technology.

Monday, July 22, 2013

1:00–1:45 PM

Local Food Systems

(059) Lead Uptake in Radish Cultivars Grown in Lead Contaminated Urban Soils

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Arable land is diminishing worldwide as desertification and urbanization restrict highly productive agricultural lands. Escalating cost and availability of fossil fuels has renewed concern for global resource conservation. Rising food costs, resource allocation, and food security have increased interest in local, sustainably produced food. Escalating concerns over the risk of food borne illness, such as *E. coli*, associated with larger agricultural operations has diminished consumer trust. In an effort to address these concerns, alternative commodities sources have become progressively important for consumers. Consumer Supported Agricultural (CSA) Farms, community gardens, and home gardens have renewed interest from consumers. Urban farms may inadvertently increase the total body burden of heavy metals through the ingestion of food products grown in contaminated soils. Lead ingestion, particularly by children, has been identified by the EPA, WHO, and FAO, as of significant health concern affecting cognitive development, as well as a plethora of associated health risks. The full complement of health impacts from lead ingestion remains incomplete. Many plants have been identified as hyper-accumulators of lead. *Brassica juncea* has been found to consistently absorb and ac-

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cumulate lead at rates above bulk soil levels. Little is known about the lead absorption differences among varieties within a species. *Raphanus sativa* (radish) is a commonly grown *Brassica* across multiple cultures and a known metal accumulator. We compared various varieties of *Raphanus* for their uptake of lead from contaminated soil collected from an urban garden. Significant varietal differences of lead uptake were measured in *R. sativa* ‘White Beauty’, ‘Rudolph’, ‘Cherry Bell’, ‘Purple Plum’, ‘French Breakfast’ and *B. juncea* as a comparison to a known hyper-accumulator.

(060) It’s a SNAP! Reaching New Farmers’ Market Patrons with Community Collaboration

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The University of Arkansas (UA) and the four-county Northwest Arkansas Farmers’ Market Alliance (NWAFFMA) collaborated on a USDA Farmers’ Market Promotion Program to increase awareness and participation of supplemental nutrition assistance programs (SNAP) recipients at farmers markets by expanding EBT capabilities of markets and providing educational and promotional materials to organizations that support these potential customers. A supporting grant from Walmart Foundation allowed the NWAFFMA markets to develop a “Local Foods Double Dollars” market match program where markets were able to match SNAP purchases dollar for dollar up to \$20/market visit. Prior to this project only three farmers’ markets out of 11 in Northwest Arkansas were equipped to accept SNAP funds. Six additional farmers markets’ were equipped with electronic benefits transfer (EBT) machines, scrip, and signage as a result of this project. A brochure and posters printed in English, Spanish and Marshallese, a website, a Facebook page, TV and newspaper ads, and radio ads in English and Spanish were developed to inform potential shoppers of market locations, and dates and hours of operations. Approximately 15,000 brochures and 150 posters were distributed to Head Start, DHS, food pantries, Extension offices, WIC offices, libraries, and community centers. SNAP customers were surveyed at two of the larger markets in 2012. Surveys results indicate that word of mouth was the most important method for SNAP recipients to learn that SNAP was accepted at the farmers’ markets. Survey results indicated that 65% of SNAP recipients shop at the farmers’ market 3 to 4 times per month and if SNAP was not accepted at the markets they would continue to shop there although less often and would spend less money. SNAP recipients infused approximately \$41,000 into the local economy with purchases of locally grown and raised products at farmers’ markets in 2011 to 2012.

(061) Permaculture Solutions for an Urban Community Garden

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Many organizations have tried to establish sustainable community gardens and failed. Permaculture is a design framework that promotes sustainability through the design of efficient, regenerative systems that save resources, time, and energy. An urban community garden was re-designed using permaculture with a focus on energy efficiency, water efficiency, perennials, compost, shade, and signage. Energy efficiency included converting many of the annual beds to perennials; establishing a crop rotation with one-half the garden in cover crops throughout the year; composting weeds on site; and reorganizing the garden to maximize efficiency. Water conservation included more and better access to water in the garden for irrigation as well as beauty. In addition the soil’s ability to capture and hold water was enhanced. Strategies included: capturing rain-water off the shed; mulching more often and more deeply and using living mulches on garden edges; creating wind breaks to reduce evaporation; and creating a beautiful water feature as a small emergency water resource for surrounding plantings. Perennial plantings were increased as one method for decreasing maintenance while keeping beauty, interest, and food production as well as adding shade and shelter. Fruit trees and berry bushes; living mulch perennial edging; perennial edible and pollinator plants; edible perennial arbor for shade; food forest floor plantings; and an herb spiral were all added. Compost and soil were used more efficiently by improving access to the compost bins and improving signage. More, smaller compost containers were installed for faster, more efficient production. Compost bins were placed more strategically. A separate compost pile was created for grasses and weeds to minimize weed seeds in the main compost system. Living mulches decrease the need for additional compost during the season. A perennial food forest floor plantings will build soil in an existing empty quadrant. Signage enhancements included artistic, educational, welcoming, and directive signs including more street signage to welcome neighbors and direct traffic through the garden. Shade involved increasing shaded gathering spaces; increasing vertical growing spaces to create microclimates; replacing existing ornamental trees with fruit and nut trees that also provide shade; adding seating and gathering spaces; creating a visual and educational model for organizing a garden to connect with nature. A before and after comparison of permaculture elements showed 42%

An asterisk (*) following a name indicates the presenting author.

prior to the redesign and 73% after. A similar comparison of permaculture systems found 10 before and 44 after.

(062) Community Building: Growing a Model Farm to School Program with Community Partnerships

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Fayetteville Public Schools (FPS), the University of Arkansas, Apple Seeds Inc. (a local non-profit focused on nutrition education), Feed Fayetteville (a local non-profit dedicated to alleviating hunger through local resources), and KUAF radio (the local NPR affiliate), collaborated to develop a successful Farm to School (F2S) model program in Fayetteville, AR. The program was funded through the Southern SARE Community Development Program. This initiative was implemented through the summer lunch program at FPS middle school which offers a free, summer noon-time meal program. Through this partnership a core group of growers was interested in participating in a F2S program and producing for the FPS. A student nutrition education program was implemented through signage and field trips to the participating local farms and to the Fayetteville farmers' market. Community awareness of farm to school was increased through a series of stories on KUAF's daily news magazine, Ozarks at Large. Obstacles and challenges to implementation and expansion have been identified from the perspective of each of the various partners. Information on establishing a farm to school program, recruiting growers, incorporating nutrition education, identifying community partners and their challenges were shared with area child nutrition directors and school administrators in regional workshop. Some key lessons learned included: the flexibility of the summer lunch menu allowed the cafeteria staff to easily add local produce into the menu; lunch buddies were organized so that food and farming enthusiasts could eat lunch with kids and talk to them about food production and nutrition; signage in the lunch area about local foods was helpful especially if

there was no regular classroom education on local foods; willing cafeteria staff was critical to success. As a result of this project and previous farm to school activities, FPS has expanded farm to school programming with a recently received USDA Farm to School grant.

Specified Source(s) of Funding: SARE

(063) Good Agricultural and Good Handling Practices: Compliance By Everyone?

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Recent contamination outbreaks in specialty crops have raised concerns about the safety of how these crops are grown, harvested, processed, stored, and shipped. To this end, there is an increased awareness by buyers and consumers of specialty crop products for independent verification and certification that growers and other fresh produce handlers are following Good Handling Practices (GHP) and Good Agricultural Practices (GAP) to improve food safety. The University of Arizona, Yuma County Cooperative Extension and the Arizona Department of Agriculture, Agricultural Consultation and Training (ACT) Program have collaborated to implement a USDA GHP/GAP Training Program for Arizona specialty crop producers. The in-class training program has been very successful in attracting interest with the total number of small farm participants equaling 488 since the program's inception in 2010. Research findings from GHP/GAP programming indicate that growers participating in workshops are gaining a greater understanding of good growing and handling practices. Yet, this knowledge is not necessarily leading to behavior change in the form of USDA GHP/GAP certification. Change is primarily occurring among growers when they are required by those buying their produce to provide evidence of on-farm food safety practices. To date, activities that Arizona small growers are most commonly pursuing are participating in GHP/GAP training, writing some form of a food safety plan, and making convenient on-farm food safety modifications. Growers are not specifically developing a culture of food safety by keeping records that food safety plans are being acted upon, documenting potential food safety risks, or requesting on-farm site visits. Given that only a marginal number of growers are applying for certification, evidence indicates that only a select number of buyers are currently mandating third party compliance from small producers. Growers reported that the primary reason they did not carry out any of these GAP behaviors is that they are not required to do so, indicating that the external expectations of produce buyers are currently the primary driver in generating grower behaviors. Time, money, and the technical complexity of requirements are also viewed as barriers to implementation. Within the totality of GAP standards, change may not appear to have much significance, but successes—even seemingly small ones—must not be overlooked. As comprehensive and recent as GAP standards

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are, time is needed to address the wide range of needs of fresh produce growers. Extension's programming must be sensitive to the different needs that diverse growers have.

Specified Source(s) of Funding: Arizona Specialty Crop Block Grant Program, #SCBGP-FB10-41

(064) Economics of Growing Microgreens for the Local Food Market

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The hardest aspect of growing fresh produce for the local food market is establishing appropriate selling prices. New crops are put into the production rotation based on customer recommendations and seed catalog promotions. Many fresh market growers do not take the time to consider, let alone calculate, the ultimate costs to produce these new crops. One crop that is getting a lot of attention from both the restaurant market and consumers are microgreens. A case study was performed with a local grower producing microgreens. Production costs and inputs were evaluated to calculate and establish selling prices. Input costs are approximately \$2.46/ft² and is fairly consistent across the microgreen varieties grown. Harvestable yield varies from 1.5 oz/ft² to more than 4 oz/ft² depending on variety. Market prices depend on variety and production management. Market prices range from \$2.00 to \$6.00 per ounce with a resulting margin ranging from 35% to 75%. Ultimate customer preferences for microgreen variety are based on the end use.

(066) Evaluation of the Consumption of Fruits and Vegetables and Socio-economic Status on a Native American Reservation in Kansas

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Relocation from their native lands made drastic changes to the cultures and traditions of Native Americans, which ultimately changed their dietary habits and physical activity, is the leading cause of the high prevalence of obesity and obesity related diseases among these populations. To promote a healthy lifestyle, the objective of this project is to increase fresh fruit and vegetable availability through gardening for an Indian tribe in northeast

Kansas, the Prairie Band Potawatomi Nation (PBPB) through determining the best vegetable cultivars for soils and climate of their reservation, mentoring, and culturally relevant gardening education. A pre-season workshop was held in Spring 2012 with 35 participants, to provide gardening advice. This paper reports the findings of the study conducted at the PBPB harvest feast in Nov. 2012. A written questionnaire was developed to survey the consumption of fruits and vegetables, gardening experience, health status, physical activity, and the socio-economic status of the tribe. Out of 100 surveys distributed, 95 were returned composed of 15 pre-season workshop participants (WP) and 80 non-workshop participants (NWP). The mean numbers of servings of fruits and vegetables consumed were 1.68 and 1.92, respectively. Nearly 50% met the recommendation for fruit consumption (2+ servings/day) and 22% for vegetable consumption (3+ servings/day), but only 19% met both levels together. This is far below the targets set by the Healthy People 2010 objectives and needs to be increased. A major portion of the WP group (60%) were experienced gardeners with at least 5 years of experience compared to only 19% in the NWP group. The proportion with no previous experience in gardening in the NWP group was 46% and the major reasons for not gardening were "no land" (55%) and "no knowledge" (12%). By encouraging these groups to garden at the community garden and to attend gardening workshops, gardening activity and fruit and vegetable consumption in the reservation could be increased. In the tribe, 30% of the respondents were below the poverty threshold, compared to 14.3% for the entire nation and 27% for the American Indians and Alaska Natives, nationwide. The percentage of retired people in the tribe (27%) was also higher compared to the rates for the State of Kansas and the nation. These indices stress the importance and the potential of engaging these groups of people into gardening activities in the reservation.

Specified Source(s) of Funding: Partial support for this project was provided by the USDA-NIFA Tribal Colleges Research Grants Program

Monday, July 22, 2013

1:00–1:45 PM

Nursery Crops

(039) Evaporative and Transpirational Loss from Three Nursery Container Types

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There is growing interest in the use of fabric containers for nursery-grown plants. Potential benefits of their use include

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reductions in circling or girdling roots, maintaining more favorable root zone temperatures and the potential to use recycled or biodegradable materials for the container. While there is little published work comparing evaporative and transpirational loss from plants grown in fabric and black plastic containers, it is believed that plants grown in fabric types have greater water use requirements until established. Our research focused on three container types, all #5 in size: black plastic (BP), Root Pouch® (RP), and Smart Pot® (SP). In a greenhouse study conducted from January to Mar. 2013, we examined evaporative loss from containers containing only substrate. One set of each fabric type was wrapped in plastic to examine if the container sidewall had an effect on evaporative loss. Containers were watered to field capacity and allowed to drain for 24 hours. They were weighed and volumetric water content was measured daily for 26 days. We found that non-plastic wrapped fabric containers lost water more rapidly than BP and plastic-wrapped fabric containers. A field study was also conducted to examine evaporative and transpirational loss when growing a common shrub in the same three containers. Bareroot plants were potted in April 2013, grown outdoors, and watered and fertilized until established. Plants were then watered to field capacity and allowed to drain for 24 hours to begin dry down. Daily weight and volumetric water content measurements were taken until plants reached permanent wilt. In a second field study, plants were watered to field capacity, allowed to drain for 24 hours, and then watered daily at 100% or 75% of ET. Plant growth index (GI) was calculated every three weeks during the study. Leachate was collected to determine plant water use efficiency.

Specified Source(s) of Funding: Colorado Nursery Research and Education Foundation, CSU Agricultural Experiment Station, CSU Department of Horticulture and Landscape Architecture

(040) Production of *Ligustrum japonicum* in Composted Algae

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Due to several environmental and economic factors, the use of the main physical components in common substrates utilized for growing horticultural crops—peat and bark—have either become of limited supply, costly to use, or both. This research looks at composted algae as an alternative substrate for growing the woody nursery crop *Ligustrum japonicum*. Plants were purchased as liners and stepped-up to 11.4-L containers over a 12-month period with the experiment continuing for another year. At 24 months after transplant, data on physical parameters were collected: growth index, SPAD, trunk diameter, and shearing biomass (to 20 cm from side of pot to 40 cm tall from substrate surface). Treatments consisted of three substrates: Taylor Creek

composted algae (TC-CA), Egret Marsh-CA (EM-CA), a peat-based substrate control (PB), and three controlled-release fertilizer (CRF) rates: 0%, 50%, and 100% of the label recommended rate (0, 50, or 100 CRF). The experiment was a completely randomized design with six replications per substrate x CRF combination. In the 0 CRF treatment, plants growing in TC-CA or EM-CA when compared to the PB control were significantly greener by as much as 10 SPAD units (52 PB and 62 EM-CA SPAD), had a larger trunk diameter by 8 cm (17 cm PB and 25 cm TC-CA), and a greater growth index by 27 cm (37 cm PB and 64 cm EM-CA). For all CRF rates, plants growing in either of the composted algae substrates when compared to the PB substrate had significantly greater biomass removed from shearing by an average of 57% (436 g FW for PB and 780 g FW for CA). This research demonstrates that composted algae is a suitable, if not superior, substrate for growing *Ligustrum japonicum* compared to the PB control substrate. Using composted algae, based on the 0 CRF treatment, may require fewer nutrient inputs to produce a marketable plant.

(041) Influence of Time on Measuring Container Fertility by the Pour-through Extraction

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Research was conducted to compare the traditional pour-through (PT) extraction procedure of waiting 2 hours following irrigation to that of waiting only thirty minutes following irrigation to make electrical conductivity (EC) and pH measurements. It is believed that the time following irrigation, if consistent throughout the soluble salts reading for a given crop, will represent the available nutrient levels. This has not been previously verified. Recommendations for the time from irrigation to sampling vary greatly. Thirty to 60 minutes has been recommended for greenhouse crops. Two hours and more is the standard delay following irrigation for woody species. *Lindera benzoin* (L.) Blume were potted into straight pine bark media in 7-gal containers and fertilized with medium recommendation for 7-gal containers of 214 g of Osmocote® Plus 15–9–12, 12–14 month. The plants were placed in Top Hat™ Stabilizer Baskets on a gravel bed. Irrigation was provided via a single Tavlit 4463 sprayer delivering 15 lph per container by cyclic irrigation three applications per day for 10 minutes each application. The two treatments (the 30-minute delay, and the 2-hour delay) were allocated to three rows (blocks) of containers in a randomized complete-block design. Each treatment within each block consisted of seven containers. SAS was used for statistical analysis. Pour-through

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extraction data was collected every 2 weeks from 26 Apr. 2013 to 24 Sept. 2013. The EC and pH readings for the 30-minute delay and 2-hour delay after irrigation were statistically the same. The pour-through results 30 minutes and 2 hours following irrigation enable a recommendation to shorten the delay between irrigation and the pour-through procedure.

Specified Source(s) of Funding: University of Kentucky Nursery/Landscape Fund

(042) Cyclic Irrigation Does Not Overcome Low Water Holding Capacity of *Juniperus virginiana*-based Substrates for Greenhouse Production of *Rudbeckia*

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Nursery and greenhouse studies evaluating wood-based alternative substrates have consistently cited poor physical properties, specifically low water holding capacity and high air space, as reasons for reduced growth in plants produced in a high percentage of wood materials. In the Great Plains region of the United States, Eastern redcedar (*Juniperus virginiana*; ERC), is a locally available, weedy tree species. Several studies have indicated that ERC is suitable as a substrate amendment, but not as a replacement for pine bark (PB). When ERC is used up to 40% (by vol.), plant growth is often similar to PB-based substrates, but when blended at volumes greater than 40%, reduced growth is evident. The objective of this study was to determine if cyclic irrigation (same volume of water distributed throughout the day as opposed to one irrigation event) can help overcome low water holding capacity and improve plant growth. Black-eyed susan (*Rudbeckia fulgida* 'Goldstrum') liners were planted into three substrate treatments: 1) 80% PB:20% sand; 2) 40% ERC:40% PB:20% sand; and 3) 80% ERC:20% sand (by volume) on 29 Feb. 2012. Container size was 1-gallon (3.8 L) and substrates were pre-plant incorporated with Osmocote 18N-5P-13K + micronutrients (3-4 month release, The Scotts Co., Maryville, OH). Plants were placed in a glass greenhouse maintained at 70 °F (21 °C). An automated irrigation controller was used to apply the following cyclic irrigation treatments: 1x per day (0800 HR), 2x (1100, 1500 HR), 3x (0900, 1200, 1500 HR), and 6x (0800, 1000, 1200, 1400, 1600, 1800 HR). Total volume of water applied was 350 mL per day. Plants were arranged in a randomized complete-block design with a 3 x 4 factorial (substrate by irrigation frequency)

with 6 reps. There were no interactions between substrate and irrigation for any data. Black-eyed susan had the greatest growth index and shoot dry weight when grown in 80% PB:20% sand, though plants grown in the PB:ERC mix were marketable. Plants grown in 80% ERC : 20% sand were smaller than plants in the other two treatments and increasing irrigation frequency in this substrate resulted in the smallest plants in the study. Among all substrate treatments, plants irrigated 6x had less shoot dry weight than those irrigated 1x and 2x per day. Cyclic irrigation did not overcome low water holding capacity in the 80% ERC:20% sand substrate treatment for black-eyed susan. However, plants grown in PB:ERC grew to a marketable size.

Specified Source(s) of Funding: Floriculture and Nursery Research Initiative

(043) Nutrient Uptake and Removal by Christmas Tree Harvest

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Writing nutrient management plans for Christmas tree production requires accurate values for nutrient removal and harvest records. To obtain such data, freshly cut trees were collected from several commercial plantations in New Jersey. A total of nine market-size trees consisted of three trees per each of Norway spruce (*Picea abies*), Canaan fir (*Abies balsamea* var. *phanerolepis*), and Douglas fir (*Pseudotsuga menziesii*). Minimum, maximum, and mean cut tree size measurements were as follows for height (m): 1.98, 2.69, and 2.33, respectively; basal diameter (m): 1.30, 2.72, and 1.66, respectively; volume (m³): 0.87, 4.88, and 1.83; area (m²): 1.28, 3.43, and 1.96; fresh weight (kg/tree): 5.23, 51.29, and 21.98, respectively. Mean tree moisture content at harvest was 53.89%. Three whole tree plants per species were cut into smaller pieces, oven-dried, and ground for determining dry weight, nutrient concentration, and nutrient removal per given area. Nutrient contents were calculated for whole trees and there were no significant difference in nutrient uptake values among species. Assuming a tree row spacing and within row spacing of 1.5 m x 1.5 m for a population of 4,302 trees per ha, a clear cut harvest would be projected to remove on average (kg/ha) 560 N, 60.87 P, 168 K, 243.51 Ca, 37.75 Mg, 28.25 S, 0.54 B, 3.39 Fe, 4.74 Mn, 0.11 Cu, and 2.79 Zn, 2.92 Al, 105.85 Cl, 0.02 Mo, and 1.44 Na. Nutrient removal estimates for wider row spacing can be recalculated based on the number of trees harvested from a unit land area. Cities that collect Christmas trees after the holiday and shred them for mulch may also find the nutrient content values

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useful.

(044) Comparison of Irrigation Scheduling Based on Daily Water Use or Plant Water Demand of Container-grown Woody Plants

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Nursery irrigation scheduling based on two methods were compared (1) daily water use (DWU) and (2) a recently proposed plant demand-based irrigation system that assumes that growth would not be compromised when basing the irrigation set point on the substrate water content where photosynthesis begins to decline due to water stress. *Buxus microphylla* 'Boxwood' 4-inch liners were potted into 1-gal containers with 85% pine bark : 15% peatmoss (vol:vol). Each irrigation zone was controlled by a 13DE04K solenoid valve (Rain Bird Corp.). Irrigation was applied through four overlapping Toro 570 Shrub Spray Sprinklers (The Toro Co., Riverside, CA) per irrigation zone. Emitters were mounted on 1.3-cm diameter risers at a height of 66 cm. DWU was calculated based on the average soil moisture readings of ECHO-5 probes (Decagon Devices, Pullman, WA) inserted into two containers per irrigation zone and irrigation was applied daily at 9 AM. The demand-based irrigation system was designed to apply irrigation to return the moisture to container capacity (0.53 cm³) after substrate moisture set point (0.28 cm³) has been reached. Acquisition and control were monitored using a data logger (CR 1000, Campbell Scientific, Logan, UT). Gas exchange and pH and electrical conductivity of leachate were monitored during the experiment. Plant biomass metrics were measured at the termination of the experiment. Plant water use efficiency (WUE) was estimated by dividing total dry weight at the time of harvest by total water volume applied (irrigation plus precipitation; liters per container). Plant physiological parameters such as leaf water potential, photosynthetic rate, transpiration rate and stomatal conductance were not different among plants in both the treatments. The average growth index and average plant dry weight at the end of study were not different among plants grown in DWU and demand-based irrigation treatments. Total irrigation water applied was greater (35%) for the DWU-based treatment than the on-demand irrigation treatment. Plants under on-demand treatment had greater WUE (31%) than plants in the DWU treatment. In general, the DWU treatments were irrigated when the volumetric water content was about 23% above the plant demand treatment's set point. The pH and electrical conductivity of leachate were similar between the treatments and were within the acceptable range. These results suggest that for woody plants with low water requirement, such as boxwood, irrigation based on plant physiological parameters

can significantly reduce water use compared to DWU based irrigation methods.

(045) Impact of Container Material on Substrate Heat Buildup in an Outdoor Nursery

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The current study was conducted at the University of Kentucky Horticulture Research Farm in Lexington in conjunction with locations at Mississippi, Michigan, Texas, and West Virginia under the USDA–SCRI program. *Buxus* x Green Velvet 'Boxwood' were planted in four types of #1 (~3.8L) containers (treatments): 1) polyethylene PF400-SM (control) (Nursery Supplies Inc., PA); and alternative containers 2) Western Pulp 7X7RD (Western Pulp Products Co., TX); 3) Keratin (Horticultural Research Institute, Washington, DC); and 4) Root Pouch™ (Root Pouch Inc., OR). This one-factor completely randomized design experiment was conducted in Kentucky, Texas, Mississippi, Michigan, and West Virginia from June to Oct. 2012. All plants were irrigated at 7 AM and 7 PM to replace 100% daily water use. Two thermocouples (Type T copper-constantan thermocouple wires; Omega Engineering, CT) in each plot measuring substrate temperature were placed in the container of central growing beds at one inch below the substrate surface at 1 inch away from container wall facing south and at the center of container. Data were recorded using a datalogger (CR1000; Campbell Scientific) programmed to scan every 30 s and determined maxima, minima, and averages hourly. Average substrate temperature showed around 6 °C to 9 °C increase in black plastic containers as compared to alternative containers at one inch away from container wall and an increase of about 2 °C to 4 °C at the center of container during August in Kentucky. Substrate temperature was exposed to critical temperature (>37.8°C) for more than 3 hours on 15 different days in black plastic containers and about 9 days in keratin containers and none was observed for wood pulp

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and fabric containers during the study in Kentucky. Substrate temperature was increased by about 16 °C (plastic), 14 °C (keratin), 10 °C (wood pulp), and 7 °C (root pouch) from sunrise to mid-afternoon and substrate started cooling down from late afternoon with root pouch and plastic cooling the fastest, followed by keratin and wood pulp containers. Other locations observed similar trend in thermodynamics among the containers. Plastic containers exposed plant roots to rapid changes in substrate temperature than alternative containers types causing decreased plant root dry weight at harvest compared to plants grown in wood pulp. Highest substrate temperature observed in plastic was attributed to its black, non-porous and thin container walls. Porous walls of wood pulp and root pouch containers improved heat exchange and also allowed increased evaporative cooling resulting in reduced heat buildup.

2010, 2011, and 2012, respectively. Although the area received supplemental irrigation in all 4 years, irrigation amounts were not measured until the 2012 growing season. Plants growing in the Minimal Water Zone received only about 4,542 mL of supplemental water the 2012 growing season. Seventy percent of the *Penstemon wilcoxii* planted in 2009 were still alive as of 16 Aug. 2012. One hundred percent of the *Allium altaicum*, *Globularia punctata*, and *Sanguisorba tenuifolia*; and 90% of the *Penstemon fruticosus* and *Salvia multicaulis* planted in 2010 were still alive as of 16 Aug. 2012. One hundred percent of the *Centaurea bella*, and 80% *Tetaneuris scaposa* (formerly *Hymenoxys scaposa*) planted in 2011 were still alive as of 16 Aug. 2012. These plant taxa that can survive with little or no supplemental irrigation should be considered for planting in semi-arid areas and especially in areas where supplemental irrigation may not exist.

Monday, July 22, 2013

1:00–1:45 PM

Ornamentals/Landscape and Turf

(022) Attractive Plants for Minimally Irrigated Landscapes in Colorado

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In a plant taxa evaluation program conducted in conjunction with Plant Select® (<http://plantsselect.org/>), almost 100 plant taxa have been evaluated over a 2- to 4-year growing period at Colorado State University's W.D. Holley Plant Environmental Research Center. The evaluation area was designed with two irrigation zones so that each taxa could be evaluated for its response to limited amounts of irrigation. So that meaningful information pertaining to plant growth and survival could be obtained for each taxa, 10 plants of each taxa were planted in each of the two irrigation zones. In order for a plant taxa to gain access into the Plant Select® program, it must meet specified criteria, including: ability to grow in a broad range of garden situations in the Central Rocky Mountain Region, possess resistance to pests, thrive when grown under low water conditions, provide a long season of beauty in the garden, be non-invasiveness, possess capability of being mass produced, possess longevity in containers, and be fairly easy to propagate using basic propagation techniques. Not all plant taxa that are in the evaluation program possess all the necessary requirements for acceptance into the Plant Select® program. However, several taxa exhibited remarkable ability to not only survive, but to thrive when receiving only 39.1, 31.2, 41.9, and 23.1 cm of precipitation annually for 2009,

Specified Source(s) of Funding: Plant Select® (plantsselect.org)

(023) Turf Fertilization Effects on Seasonal Nitrogen Levels of Autumn Blaze™ Maple and Kentucky Bluegrass in a Mixed Urban Landscape

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It is commonly assumed that trees growing in a lawn receive sufficient nitrogen (N) from lawn fertilization. However, few researchers have examined the effect of N lawn fertilization on N levels of trees growing in urban landscapes. In this study, we applied nitrogen at a rate of 0 or 293 kg N per hectare (0 or 6 pounds N per 1000 square feet) to separate medians containing Kentucky bluegrass (*Poa pratensis* L.; KBG) turf and monostands of 15-year-old Autumn Blaze™ maples (*Acer xfreemanii* 'Jeffersred'; ABM). The purpose of this study was to determine the relative amounts of N assimilated by KBG and ABM throughout the growing season following spring and summer N applications. Nitrogen was applied in April and June 2013 [sic] using a 35N-0P-8.3K fertilizer (28.35% urea nitrogen from polymer-coated urea) at a rate of 146 kg N per ha (3 lb N per 1000 sq ft) at each application. Grass clipping and tree leaf samples were collected bi-weekly (June–September), dried, ground, and analyzed for total N. Leaves were collected on a monthly basis from single branches and used (via the pipe stem model) to estimate total tree dry leaf weight.

An asterisk (*) following a name indicates the presenting author.

Specified Source(s) of Funding: Colorado State Agricultural Experiment Station, Rocky Mountain Regional Turfgrass Association

(024) Green Roofs from Locally-available Materials

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The primary purpose of green roofs is to reduce stormwater runoff. Studies have shown that an ideal media for extensive green roofs consists of 80% to 90% inorganic material combined with a maximum of 10% to 20% organic material, such as sphagnum peat moss. *Sedum* species tolerate the harsh growing conditions on rooftops better than most of plant species that have been studied. Green roofs are more common in metropolitan areas where ordinances and incentives have been implemented, whereas small municipalities and rural areas typically have fewer green roofs. Therefore, supplies of green roof materials are often more difficult to obtain without incurring huge shipping costs. To encourage building owners in rural areas and smaller municipalities to implement green roofs, locally available materials were trialed on a demonstration site for efficacy in a green roof system. Two media substrates were trialed: one using locally available trap rock [(hadite) 80%], sand (12.5%), peat moss (5%), and compost (2.5%); and the other using reclaimed lava rock (red) in place of the trap rock. Two species of sedum (*S. reflexum*, *S. spurium*) were planted after the bags and flats were in place on the roof. To further simplify the installation process, plants were installed on the roof in one of two containers: 1) specially-designed landscape fabric bags or 2) plastic flats such as those used for bedding plant production. Media substrates and containers were combined in four possible combinations. They were arranged in a completely randomized design on a rubber-membrane covered roof having a 2/12 pitch (16.67% slope). Plant growth was evaluated a year after plants were established on the roof, and at the end of the second growing season. Results indicated that plants grew better in lava rock based media as compared to trap rock. Plants also grew better in flats than landscape fabric bags. Whereas some treatments had a score of zero, indicating no plants had survived, others had scores as high as ten, on a scale of 1–10. In spite of severe drought and above-normal temperatures, plants looked better overall in September than they had in March.

(025) Effects of Pre-emergent Weed Control Products on Container-grown Herbaceous Ornamentals

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Although there are many preemergent herbicides currently marketed for use in large-scale production of agronomic crops, the use of these products on horticultural crops may be prohibited if the name of the crop does not appear on the product label. An objective of the IR-4 Project's Ornamental Horticulture Program (<http://ir4.rutgers.edu/ornamentals.html>) has been to determine the effects of selected pest control products on ornamental crops. For many years, researchers at Colorado State University have evaluated the effects of selected weed control products on container-grown ornamentals. During 2012, Biathlon 2.75G, Echelon 4SC, Freehand 1.75G, and Indaziflam G were evaluated at 1x, 2x, and 4x the label rate; Gallery 75DF was evaluated only at the 4x rate. Control containers received no herbicide product. *Delosperma nubigenum*, *Delosperma cooperi*, *Helianthus salicifolius* 'Low Down', *Petunia hybrida* 'Cascadias Blue Dream', *Sedum spurium* 'Dragon's Blood', and *S. spurium* 'Red Carpet' were the plant taxa used in the study. Each herbicide product was not evaluated on every plant taxa. Each plant taxa and herbicide product interaction constituted an experiment; each experiment was comprised of three blocks, and each block contained five replications of each treatment plus controls. Blocks were randomly arranged within the study area, and treatments were randomly arranged within each block. Plants were grown in an organic growing medium in number 1 black plastic containers, and irrigated daily. Herbicide products were applied two times during the 10-week evaluation period; the first application occurred a few days after plants were transplanted into the containers, and the second occurred 6 weeks later. Plants were measured at the beginning and end of the evaluation period. At the end of the evaluation period, plants were harvested, oven dried, and then weighed. Echelon 4SC at all three rates caused distorted and necrotic tips on young leaves and significantly reduced the size of *D. nubigenum*, at the 2x and 4x rates significantly reduced the size of *P. hybrida* 'Cascadias Blue Dream', and at the 4x rate significantly reduced the size of *S. spurium* 'Red Carpet'. Freehand 1.75G at the 4x rate caused chlorosis of young leaves and significantly reduced the size of *H. salicifolius* 'Low Down'. Gallery 75DF at the 4x rate significantly reduced the size of *D. nubigenum* and *S. spurium* 'Red Carpet'. Indaziflam G at the 4x rate caused chlorosis of young leaves of *D. cooperi* and *S. spurium* 'Dragon's Blood'.

Specified Source(s) of Funding: United States Department of Agriculture, IR-4 Project

(026) Green Roof Substrate Durability: Particle Size Distribution of Five Mature Mid-Atlantic Green Roofs

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Green roofs are gaining popularity as stormwater management tools in densely urban areas across the country. German standards have been adopted across North America; however, these are applied to materials prior to and at the time of installation with no guarantee of roof performance. The purpose of this study was to collect substrate samples from mature green roofs in the Mid-Atlantic region to compare current particle size to the widely adopted German FLL particle size distribution curve limits. Particle size distribution is pivotal to green roof performance because it dictates important characteristics such as substrate water holding capacity, air space, total porosity, and green roof live load. A secondary objective was to conduct freeze-thaw analyses on popular commercially available green roof substrates to determine their durability in the Mid-Atlantic region. Five mature green roofs (3–7 years old) were sampled in Maryland and 15 replicates per roof were dried prior to sieving. Analyses showed the substrates no longer met FLL standards for particle size distribution, with particle diameters much smaller than recommended. The authors hypothesized the cause to be weathering due to freeze/thaw cycles, so a laboratory experiment was conducted using traditional expanded mineral green roof substrates. After 30 freeze/thaw cycles, particle size distribution was determined and compared to initial distribution of samples from the same batch of material. Significant weathering was identified through loss of larger particles and an increase in small particles. Decreased particle size distribution will increase water holding capacity and decrease air space in the root zone that could lead to decreased stormwater mitigation potential or plant disease. In conclusion, performance-based standards for green roof materials should be developed based on rigorous scientific study to expand the green roof industry's knowledge and accountability of total system performance and reliability.

Specified Source(s) of Funding: Maryland Industrial Partnerships

(027) A Trial Study of 11 Kordes Rose Cultivars Grown under Low Maintenance Conditions

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The concept of using low maintenance landscape roses has become very popular, and cultivars that can handle general landscape maintenance conditions are being developed by rose breeders. Kordes was an early proponent of trialing their roses under no-spray conditions. A group of 11 Kordes rose cultivars were field grown under low maintenance conditions which was limited to fertilization, mulching and weed control. Drip irrigation was provided only for establishment. The roses were not deadheaded or pruned, nor were they sprayed. Data were collected monthly for 2 years beginning in Apr. 2009. Height and width were measured from which was derived volume. Blackspot infection was estimated using the Horsfall–Barratt scale. Visual quality ratings were determined for flower quantity and quality, foliage quantity and quality, and plant habit and vigor. The cultivars were Cerise Flower Circus, Cream Flower Circus, Coffee Fruitilia, Cosmos, Escimo, Fortuna Vigorosa, Lions Fairy Tale, Pink Flower Circus, Red Ribbons, Sunrise Vigorosa, and Sweet Vigorosa. The cultivars were genetically diverse and results were highly variable. The strongest growing roses were 'Lions Fairy Tale' and 'Escimo'. No clear differences among cultivars were seen for blackspot resistance and there was no strong correlation between blackspot resistance and any growth or quality measurement. 'Lions Fairy Tale', 'Escimo', and 'Cosmos' maintained vigor better through the seasons than the other cultivars. Over time, these three cultivars appear to have more potential than the other cultivars in a low maintenance environment of a subtropical climate, such as found in east central Mississippi.

Specified Source(s) of Funding: Mississippi Agricultural and Forestry Experiment Station

(028) National Ornamental Grass Trials 2013

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Many ornamental grasses require low water and fertilizer inputs and minimal maintenance, making them complementary plants in landscape settings. The National Ornamental Grass Trial, coordinated through the University of Minnesota, began in 2012. Collaborators are conducting trials on native cultivars of ornamental grasses evaluating landscape characteristics and sustainability features in varied growing conditions throughout the United States. Seventeen regional sites in 11 states including Vermont, North Carolina, Florida (4 sites), Minnesota, Pennsylvania, Ohio, Nebraska, Texas (5 sites), Colorado, and Oregon are evaluating 22 cultivars of *Panicum amarum*,

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Panicum virgatum, and *Schizachyrium scoparium*. Four plants of each cultivar were established in Summer 2012 at all collaborator sites. Data collection will include plant size, overall growth habit rating, floral impact, foliage color, fall color, self-seeding, winter survivability, and pest problems. Trial plants will be evaluated for the next 3 years, 2013–15. Based on the information obtained, it will be determined which cultivars are best suited for each of the research sites as well which have superior landscape features. This preliminary report will highlight some of the first year results at various locations across the United States. The trial collaborators will continue to post information on a national website (www.grasstrials.com) adding pertinent and timely information in order that growers, retailers and consumers may make more informed decisions when choosing grasses for sustainable landscape settings.

Specified Source(s) of Funding: National Ornamental Grass Trials

(029) Comparison of Volatile Flavor Compounds in Korean Native Chrysanthemum Leaves

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This study was conducted to compare the volatile flavor compounds in leaves of Korean native chrysanthemums. The volatile flavor compounds from 15 Korean native chrysanthemums were collected using a simultaneous steam distillation and extraction technique, and analyzed using gas chromatography/mass spectrometry with mass selective detector. The peak area results were obtained by SAS system and evaluated by principal component analysis and cluster analysis. A total of 45 volatile-flavor compounds distilled from chrysanthemum were identified as nineteen hydrocarbons, fifteen alcohols, two acids, one aldehyde, four ketones, and four esters by their function. There was difference in qualitative and quantitative composition among chrysanthemum species. The volatile flavor compounds such as camphor, borneol, phytol, α -pinene, camphene, 1.8-cineol, and germacrene-D were detected in all tested chrysanthemums. The tested chrysanthemums could

be classified into three distinct groups by the cluster analysis based on volatile flavor compounds. The first group included *C. zawadskii* ssp. *acutilobum*, *C. zawadskii* ssp. *acutilobum* var. *tenuisectum*, *C. zawadskii* ssp. *acutilobum* var. *alpinum*, *C. zawadskii* ssp. *lucidum*, and *C. zawadskii* ssp. *coreanum*. The second group included *C. zawadskii* ssp. *naktongense*, *C. zawadskii* ssp. *yezoense*, *C. zawadskii* ssp. *latilobum*, *C. zawadskii* ssp. *latilobum* var. *leiophyllum*, and *C. makinoi*. The third group included *C. indicum*, *C. indicum* var. *albescens*, *C. indicum* var. *acuta*, *C. boreale*, and *C. lineare*. The first group showed low contents of aldehydes and acids while the second group showed high amounts of in aldehydes and ketones. The third group showed higher hydrocarbons, alcohols, and acids, but lower aldehydes and ketones. This result suggested that chrysanthemum flavors can be used as key compounds for the classification of Korean native chrysanthemum.

Specified Source(s) of Funding: Rural Development Administration, Korea

Monday, July 22, 2013

1:00–1:45 PM

Produce Quality, Safety, and Health Properties

(067) The Track and Scat Fresh Produce Safety Handbook for Southwest, Arizona

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Produce is perceived to be healthy and nutritious due to documented health benefits derived from consumption. Moreover, consumers also demand quality produce that has minimal risk of foodborne pathogens. However, over the years the number of outbreaks arising from the consumption of fresh vegetables has increased exponentially. Vegetables commonly associated with outbreaks include leafy greens where sources of contamination can be variable and amplified due to open environment growing conditions. Microbial contaminations in fresh vegetables can occur at any stage of crop growth, harvest, or in transport to facilities; therefore the key to any effective food safety program is prevention of such contamination. Specifically in Arizona, vegetable growers, wholesalers, and food-service buyers want to ensure that their fresh vegetables are being grown free of harmful pathogens and bacteria. Yuma, AZ, is considered a major player in the United States supply of winter grown vegetables, including leafy greens. As a fertile valley surrounded in a desert environment, a specific challenge for growers is wildlife intrusion within production acreage. Wildlife, such as birds, rodents, pigs, and deer, can

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be vectors for transmitting fecal pathogens to produce fields without growers' knowledge of intrusion. The ultimate goal for vegetable producers is to maximize food safety for the public while minimizing negative impacts on wildlife populations and habitats. Working in collaboration with the Arizona Game and Fish Department, Arizona Leafy Green Marketing Agreement, Arizona Department of Agriculture, and the Western Growers Association, the University of Arizona Yuma County Cooperative Extension developed a scat and track field guidebook to help identify signs of wildlife and domestic animal intrusion within production areas. Development of the field guidebook and contents will be discussed.

(068) Phytosanitary Irradiation Maintains Grape Quality under Simulated Transportation and Distribution Conditions

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Table grapes are an important export crop, with California accounting for 98% of production within the United States and exporting more than 328,000 tons to over 60 different countries. Currently, the most widely used phytosanitary treatment for grapes is methyl bromide fumigation. Irradiation can serve as an alternative to methyl bromide and is gaining use all over the world as a phytosanitary treatment for various fruit due to its efficacy on insects and maintenance of fruit quality. The objective of this study was to monitor the effects of low-dose irradiation on the quality of 'Sugraone' and 'Crimson' seedless grapes treated at phytosanitary dose levels. Grapes were irradiated at 400 Gy and stored at temperatures and times, simulating transport to Asia by sea and to Australia by air. Texture was the primary attribute affected by irradiation for both varieties of grapes, causing a loss of firmness. With respect to other attributes such as color, berry shatter, weight loss, and SSC/TA, there were significant differences in varietal response. Sensory testing showed that consumers did not notice a difference in color, flavor, and texture on both days of sensory testing of 'Sugraone' or 'Crimson' berries, nor was there a preference in overall liking. Though analytical testing detected significant differences of some quality attributes, sensory testing revealed that consumers did not have a preference between treated and non-treated berries. Our results show that irradiation is an acceptable phytosanitary treatment for table grapes and presents a viable option for export to Asia and Australia. The differences among grape varieties point to the importance of evaluating each variety for its response to irradiation treatment.

(069) Antioxidant Potentials and Inhibitory Activity of Orange & Purple Color Sweetpotatoes (*Ipomoea batatas* L.) toward Rat Intestinal α -Glucosidase using p-Nitrophenyl- α -D-glucopyranoside (PNP-G) as a Substrate

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Antioxidant compounds in food play an important role as a health promoting factor. Scientific evidence suggests that antioxidants reduce the risk for chronic diseases including cancer and heart disease. The trolox equivalence antioxidant capacity (TEAC), 2, 2-diphenyl-1-picrylhydrazyl (DPPH), and Folin-Ciocalteu are just a few electron transfer antioxidant capacity assays widely used today. Polyphenols and other naturally occurring compounds has become the target of investigation for the treatment of non-insulin dependent diabetes in recent years. Specifically, naturally occurring compounds and plant extracts have been tested for inhibition of the enzyme α -glucosidase (AGH). The antioxidant and antidiabetic potentials of the orange and purple fleshed sweetpotato genotypes were examined. The anti-diabetic activities were tested for inhibitory activity using the enzyme α -glucosidase obtained from rat intestine using the substrate p-nitrophenyl- α -D-glucopyranoside (PNP-G). The antioxidant activity was investigated with three different screening methods: the 2,2'-azinobis (ABTS), DPPH, and oxygen radical absorbance capacity (ORAC). It was observed that the antioxidant activities of sweetpotato extracts in the hydrophilic fraction have a significant antioxidant effect using each method. The results showed a relationship between the total polyphenol content and antioxidant function in case of ABTS and ORAC. The hydrophilic ABTS values correlated significantly with the hydrophilic DPPH values and the hydrophilic ORAC values correlated reasonably well with the hydrophilic ABTS values. The hydrophilic DPPH values and hydrophilic ORAC values also showed a strong correlation. However, antioxidant activities with the lipophilic extracts were not significantly correlated. Among the methods examined, ABTS proved to be the best method for antioxidant determination in orange-fleshed sweetpotatoes followed by the ORAC method. The sweet potato extracts demonstrated similar activity in the ABTS, DPPH and the Folin assays. Further, previous studies have shown a relationship between color intensity and antioxidant activity. This relationship is seen here as well with the purple sweetpotatoes having higher total phenols and antioxidant activity than the lighter colored orange varieties. However, there is no direct relationship observed between antioxidant activity and AGH inhibition. The information of this research will facilitate the genetic and chemical breeding study for improvement of the

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desired quality of orange and purple fleshed sweetpotatoes, as well as other produces.

Specified Source(s) of Funding: USDA/CSREES

(070) Decontamination of Fruit Surfaces by Combining Treatment of Infrared Radiation Heating and Ultraviolet Irradiation

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The application of single and sequential treatments of infrared radiation (IR) heating and ultraviolet (UV) irradiation to surface decontamination was investigated in relation to extending the shelf life of fig and peach fruits. The inactivation effects of IR heating or UV irradiation, and their sequential treatments on fig fruit related yeast were also investigated. The sequential treatment of IR heating and UV irradiation was effective in the surface decontamination of both fruits. The fungal counts detected after sequential treatments were lower than those obtained after a single treatment or in control samples. The number of fig fruits damaged by the growth of mold and yeast was also reduced after 30 seconds IR heating followed by 30 seconds UV irradiation. The sequential treatment was found to be highly suitable for decontamination of fig fruit surface, since few unfavorable effects were observed with regard to the surface color, hardness score, and respiration of fruits during storage. Peach fruits treated with IR heating and UV irradiation for further duration resulted in the surface discoloration of yellowing and browning, respectively. Single treatment with IR heating or UV irradiation had little effect on the inactivation of fig-isolated *Rhodotorula mucilaginosa* cells. However, *R. mucilaginosa* cells were successfully inactivated by sequential treatment with IR and UV. The killing efficiencies appeared to be independent of the order in which IR heating and UV irradiation were applied to the samples. It was hypothesized that the DNA damage caused by UV irradiation and the inhibition of its repair might be enhanced by the thermal energy of IR heating to a sub-lethal level, since the temperature monitored

during IR heating was considerably lower than the lethal level of *R. mucilaginosa* cells.

(071) Characterization of Anti-proliferative and Antibacterial Properties of Sulforaphane Obtained from Radish Seeds

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Many isothiocyanates (ITCs), are a mainly hydrolysis product in glucosinolates (GSLs), have been demonstrated the noteworthy overcoming impact against the survival and proliferation of cancer cells and their modulation of apoptosis and cell cycle progression by numerous molecular basis studies (Zang et al., 2006), such as sulforaphane (SFA) isolated from broccoli seed and sprouts. By the way, sulforaphane (SFE), is a major ITCs in radish seed, have been reported the potency of biological activity, a little bit recently. On the other hands, while much researches were known that SFA in broccoli has the excellent anticancer effects such as induction of apoptosis and detoxification enzymes in vitro and in vivo (Fahey et al., 2002), SFE in radish was hardly the biological study in spite of their similar chemical structure in comparison with SFA. In the present study, I demonstrated the broadly biological activity of SFE against cancer cells, *Helicobacter pylori* and multi-drug resistance pathogens. In four cancer cells isolated from each four organisms were notably inhibited the proliferation treated with purified SFE (IC₅₀ = 10.0 – 23 µg/mL). I also characterized that SFE modulated an induction of apoptosis pathway against A549 cancer cell through the proteins expressions related with apoptosis pathway. In addition, the highly bacteriocidal potency (MIC₉₀ = 0.6 – 5.0 µg/mL) of SFE was exhibited against *H. pylori*, particularly antibiotic resistant strain (212 strain, MIC₉₀ = 0.6 µg/mL). MRSA (Methicillin-resistant *Staphylococcus aureus*), is known as super bacteria, also were inhibited by SFE (MIC₉₀ = 10–20 µg/mL), whereas the MIC₉₀ value of MSSA (Methicillin-susceptible staphylococcus aureus) by SFE had little significant. These results suggested that the antibiotic potency of SFE in radish seeds would be associated with the potency in a broad range of cancer cells and antibiotic resistant pathogens.

(072) Watermelon Juice Supports Recovery from Strenuous Exercise

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Strenuous exercise, such as marathons, induces inflammation and oxidative stress in humans. Addition of a carbohydrate (CHO) source to liquid intake during exercise helps prevent inflammation. Watermelon contains large amounts of free water as well as sugars, some electrolytes and vitamins, lycopene, and amino acids. Watermelon juice, consisting of the puree from the flesh, was tested against a popular carbohydrate beverage to determine ability to alleviate oxidative stress, inflammation, and arterial stiffness in older male athletes (48 ± 2 years). Subjects consumed watermelon or no watermelon for 2 weeks prior to a 75 km bicycling trial. During exercise, subjects consumed either watermelon (0.2 g CHO/kg weight) or 6% CHO drink every 15 minutes. The study was designed as a crossover, so drink intake was switched following the first exercise trial. Indirect effects on arterial stiffness were determined using augmentation index (radial artery waveforms) and brachial blood pressure. Both watermelon and CHO drink fully supported energy demands of exercise. Intake of watermelon increased total nitrate and antioxidant capacity but not other biomarkers. Post-exercise augmentation index was reduced in both groups, but less so in subjects receiving watermelon. Our results indicate that watermelon juice can be used as a carbohydrate source to offset exercise inflammation.

Specified Source(s) of Funding: National Watermelon Promotion Board

(073) Comparison of IgE Binding Capacity and Expression Analysis of Strawberry Allergen Fra a 1

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Oral allergy syndrome (OAS) is usually caused by an allergy to fresh fruits. It is an immunoglobulin E (IgE)-mediated immediate allergy localized in the oral mucosa, and the characteristics depend on the lability of the antigen (Kondo and Urisu, 2009). Consumption of strawberries (*Fragaria xananassa*) can cause OAS, primarily because of the presence of proteins, such as Fra a 1–4, which cross-react to the birch pollen allergen Bet v 1. To produce strawberries with low allergen content, the expression patterns of proteins with high IgE binding activity should be demonstrated. In this study, we compared the allergenicity of Fra a proteins, estimated their stress inducibility, and investigated their expression during fruit (receptacles and achenes) ripening. His-tagged proteins were purified and their reactivity to IgE from six birch pollen-allergic patients was analyzed by western blotting. Homology searches were carried out on EST libraries of *Fragaria vesca* produced under several stress conditions. Fruits of *F. xananassa* were harvested at seven different ripening stages. For salt-stress treatments, fruits were soaked in 150 mM NaCl for 1–24 h. Real-time PCR was carried out using primers to detect Fra a 1. The IgE binding capacity of Fra a 1 was higher than those of the other Fra a isoforms. In *F. vesca*, the expression of Fra v 1, which has the same sequence as Fra a 1, seemed to be higher than the other paralogs and was especially induced by salt stress. In *F. xananassa*, Fra a 1 expression in fruits was highest at the early stage of ripening and decreased to 1/70th this level as maturation progressed to the red-colored stage, but increased beginning 5 hours after salt-stress treatment, suggesting that fruit allergenicity can be increased by environmental stimuli. These results indicated that Fra a 1 plays an important role in determining the allergenicity of strawberry fruit, and its expression is affected by environmental conditions such as salt stress.

This work was supported by the Hyogo Alliance of Universities and Colleges for Innovation and by JSPS KAKENHI Grant Number 24658030.

(074) Varietal Differences in Transcript and Protein Levels of Strawberry Allergen Fra a 1

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Fruit allergies are serious health problems that limit quality of life. In patients with a fruit allergy, the symptoms are generally mild and mostly limited to the oral cavity, hence the term oral allergy syndrome. To minimize these allergies, a method for screening hypoallergenic genotypes in strawberry is essential. A major strawberry allergen is Fra a 1, an orthologous protein to the major birch pollen allergen Bet v 1. In this study, gene transcript and protein levels of Fra a 1 were compared among strawberry fruits (receptacles and achenes) of eleven different cultivars. Nine cultivars were purchased from local markets, one was harvested directly from a working farm, and one was sampled from an experimental farm. Each cultivar was screened and ranked by its relative gene expression ratio of Fra a 1 to EF1 α , the internal control. Protein accumulation was analyzed by immunoblot using guinea pig polyclonal antibody raised against His-tagged recombinant Fra a 1. The cultivars ‘Tochiotome’ and ‘Akihime’ were selected for further analysis because they showed significantly different expressions of Fra a 1. Fruits of these two cultivars were gathered from different areas to examine Fra a 1 expression in response to local environments. The Fra a 1 transcript levels differed among fruits grown in different areas. However, average expression levels of the two cultivars showed the same rank order. The two cultivars were also grown under the same conditions in a glass greenhouse to compare the accumulation of Fra a 1 in their fruits, and again, the cultivars had the same rank order of both Fra a 1 transcripts and protein levels. These findings suggest that the profile of Fra a 1 gene transcription is similar to that of the protein expression and might be used as a basic estimate of allergenic differences among cultivars by removing environmental effects.

This work was supported by Hyogo Alliance of Universities and Colleges for Innovation and by JSPS KAKENHI Grant Number 24658030.

Monday, July 22, 2013 1:00–1:45 PM

Public Horticulture

(206) Public Horticulture—Public Gardens: Is There a Career for You?

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The poster was prepared to advertise an experimental course on Public Horticulture and Public Gardens. In three sections (Public horticulture sites, Public Gardens, and Turf Management), images of sample landscapes were represented by photographs.

Public horticulture sites included such venues as Disney World, Sea World, shopping mall, an airport garden, college campus, Singapore’s Gardens by the Bay, and hotel grounds. Public gardens included the San Francisco Botanical Garden, Longwood Gardens, and Fairchild Gardens. Turf sites included baseball and football fields, parks, a golf course, and the sports fields at ESPN–Disney’s Wide World of Sports in Orlando, Florida. Examples of careers in these kinds of settings were listed.

(207) Southern Nevada’s Outdoor Education Center

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The Southern Area office of University of Nevada Cooperative Extension (UNCE) is located on 7 acres in Clark County, NV, the location of Las Vegas. Because this property was not large enough for commercial development, and its proximity to a highway made it undesirable for new homes, the U.S. Bureau of Land Management offered it to UNCE. The Outdoor Education Center (OEC) is composed of three acres dedicated to offering programs in the subject areas where southern Nevada Extension concentrates its efforts: Horticulture, Children and Families, and Nutrition. Many local residents have had little or no success in Mojave Desert gardening. To meet this need and the educational needs of commercial landscapers, horticulture faculty members (the authors) have created several outdoor classrooms on 1.5 acres. We developed an irrigation demonstration area, where the push of a button activates an irrigation display. Other “classrooms” are demonstration areas where students and members of the public learn about growing fruits, vegetables, and ornamentals in the challenging desert climate. Produce grown in the test vegetable and orchard areas is donated to local food pantries. In 2012, over 100 Master Gardener students and 150 commercial horticulture students used the center for hands-on training. The children’s garden is the site where we offer the Junior Master Gardener program. This is a model for schools interested in creating a school garden. Over 120 people attended Master Gardeners’ monthly tours for the public in 2012, but on any day, visitors can see underutilized palms and learn what kinds of raised beds are best for use under local conditions. The mulch display area shows how and when to use different mulches: organic, colored or metallic, and rock. The native wash, where volunteer plants are growing without irrigation, collects 450,000 gal of water per year in an area that receives 4.25 inches of rainfall annually. *Specified Source(s) of Funding*: Clark County, NV

(208) Visitation Survey for The Crosby Arboretum in Picayune, Mississippi

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In Fall 2012 a need was determined to survey residents of Mississippi and Louisiana regarding visitation of The Crosby Arboretum in Picayune, MS. Frequently residents of both states, and particularly in Pearl River County and the City of Picayune, respond that they have never heard of The Crosby Arboretum, have never been and/or have no idea what an Arboretum is. To better gauge how to reach the public and what the public perceptions are in order to make positive changes, particularly within the local Gulf Coast community, a survey instrument was designed to reach an audience with a brief online survey. Because of the Arboretum's close proximity to the state of Louisiana (about fifteen minutes) and New Orleans communities, Louisiana and Mississippi were both included in the target audience. The objective was to determine possible causes for reasons affecting visitation to The Crosby Arboretum by residents in Pearl River County, MS and nearby. Survey questions, directed at those 18 years of age and older from either state, included: 1) I have visited The Crosby Arboretum in Picayune, MS (select one); 2) I am currently classified as a (select all that apply); 3) my main reasons for visiting The Crosby Arboretum are (select all that apply); 4) the following are the reasons I do NOT visit more often or have never visited The Crosby Arboretum (select all that apply); and 5) I was already aware of the following information about The Crosby Arboretum before this survey (select all that apply). Methods used to reach a diverse target population included the Arboretum website, social media, email listservs, the local newspaper and radio station. To increase participation, a randomly selected winner from qualified entries of submitted email addresses was chosen to receive a 2014 Crosby Arboretum Family Membership. Challenges included lack of funding to subscribe to an online survey service level that would offer unlimited survey responses. Results will be used to improve the Arboretum message, image, accessibility, interaction with the local community, and to increase visitor attendance. In addition to helping the Arboretum staff gauge the best ways to reach the public, the results will help improve outreach since the Arboretum is owned and operated by the Mississippi State University Extension Service.

Specified Source(s) of Funding: Mississippi State University Coastal Research and Extension Center

(209) Distribution and Characteristics of Children's Gardens in the United States

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A survey was carried out to identify and characterize children's gardens as a component of public gardens in the United States. Based on the public gardens listed by six different organizations and six other public records, survey questionnaires were

sent out to those public gardens containing children's gardens, and data were collected from Oct. 2010 to Dec. 2012. The survey results revealed that 17.0% (163) of the 959 public gardens and arboreta located throughout the 50 states and District of Columbia in America contained children's gardens. In addition, a total of 16 public gardens (1.7%) were in the process of constructing children's gardens, with 56 of them (5.8%) planning to open new children's gardens by the end of June 2013. Of the public gardens and arboreta surveyed, about 57.1% of children's gardens are contained in botanical gardens. Among the public gardens operating children's gardens, about 53.4% and 21.9% have less than 1% and 1% to 2%, respectively, of their total ground area being used for children's gardens. Hence, children's gardens are relatively small with about 70% of the public gardens providing less than 2% of their ground areas used for children's garden. Of the four geographic regions (Northeast, Midwest, South, West) surveyed, the southern region had the largest number of children's gardens. Among the 50 states and District of Columbia, California had the largest number of children's gardens, while Wyoming, Georgia, and Montana were ranked as top three states having one children's garden per 3,733, 4,384, and 7,487 children (ages 1–12), respectively. The relationship between the growth in the number of children's gardens and trends in the gross domestic products (GDP) and real gross domestic products (real GDP) showed a positive correlation statistically. There was also a positive correlation between the number of children's gardens and the state's population density and number of children (ages 1–12). The largest number of respondents (38.5%) indicated "to provide environmental experience with plants and nature through the gardens as the main purpose of establishing children's gardens."

Monday, July 22, 2013

1:00–1:45 PM

Small Fruit Breeding

(351) Parthenocarpy in Rabbiteye Blueberry (*Vaccinium ashei*)

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Under greenhouse conditions, some rabbiteye blueberry cultivars set fruit that develops to maturity without pollination. Since self-fruitfulness (or lack of) is a critical issue for rabbiteye, we undertook a 3-year study of the propensity of 48 rabbiteye cultivars to set fruit under greenhouse conditions. We measured fruiting interval, fruit set, ripening interval, and fruit size, and also monitored temperature conditions during the study with the goal of not only documenting the performance of different cultivars, but also understanding as much as possible

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about the conditions leading to parthenocarpy. Several cultivars stood out as having distinct expressions of parthenocarpy. The cultivars, ‘Early May’, ‘Ira’, ‘Suwanee’, and ‘Owen’ had virtually no fruit-set without pollination. Several modern cultivars, ‘Pearl River’, ‘Bonita’, ‘Alapaha’, ‘Ochlockonee’, ‘Columbus’, ‘Powderblue’, and ‘Premier’ had variable set across years, but relatively large seedless fruit at maturity (10–12 mm). In contrast, ‘Chaucer’, a modern Florida cultivar, was unique in its exceptionally high fruit-set without pollination, but it produced relatively small fruit, averaging approximately 7 mm. To evaluate greenhouse data in relation to field performance, we compared parameters of field-grown fruit (size, weight, seed/pulp ratios) to determine if cultivars with stronger parthenocarpic tendencies under greenhouse conditions also exhibit a lesser need for pollination under field conditions to achieve fruit development.

(352) ‘Nocturne’ Blueberry: A Winter-hardy Hexaploid Hybrid with Ornamental Fruit and Superior Quality

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‘Nocturne’ is a winter-hardy, black-fruited, hexaploid blueberry selection with significant rabbiteye ancestry for use as a specialty market plant for homeowner, landscape, and ornamental use. ‘Nocturne’ is a cross of [*V. constablaei* x NJ 89-158-8 (hexaploid mixed species hybrid)] x ‘Premier’. *V. constablaei* is a very winter-hardy hexaploid species found at high altitudes in parts of the southeastern United States. The general characteristics of this selection are: an upright, slightly spreading, highbush-type plant with glossy green foliage, and vivid, red-orange, unripe fruit that ripens to large, dark, sweet, interesting-flavored fruit in late-midseason to late season. Evaluations have shown ‘Nocturne’ to have winter hardiness comparable to northern highbush blueberry cultivars, and it has cropped reliably under mid-atlantic conditions. This selection is an offshoot of a winter-hardy rabbiteye development program. The USDA–ARS is patenting and licensing this cultivar.

(353) Impact of Interspecific Hybridization on Anthocyanin Accumulation in Blueberry Species (*Vaccinium* spp.)

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Blueberry, a rich source of anthocyanins with important implications for human health chronic diseases, has become a major fruit commodity in the United States. This study was designed to assess the impact of genetic introgressions among blueberry species that were introduced through interspecific hybridization on anthocyanin concentration and profile. Blueberries of commercial cultivars, NC breeding selections/clones, and F_1 populations with varying ploidy levels and degrees of introgression from multiple species were used to address this question. The commercial cultivars included Arlen, Columbus, Ira, Legacy, O’Neal, Pamlico, Sampson, Lenoir, Legacy, Ozarkblue, Montgomery, Tifblue, and Yadkin. The breeding selections included NC 3961, NC4263, NC4385, and NC4900. The F_1 crosses included Arlen x Georgia Gem, NC1223 x Columbus, NC 4295 x Arlen, NC4297 x Ozarkblue, NC81-10-2 x Columbus, and NC4302 x Georgia Gem. Ripe fruits from blue berry genotypes, grown in Piedmont Research Station at Salisbury, NC, were evaluated for anthocyanin concentration and profile in two consecutive years (2010 and 2011). Total anthocyanin concentrations ranged from 160–464 mg/100 g fresh weight in the commercial cultivars while in NC selections were 173–408 mg/100 g fresh weight. For the F_1 crosses, population means for total anthocyanins ranged from 227–546 mg/100 g fresh weight. The highest genetic introgression impact on anthocyanin accumulation was observed in the NC1223 x Columbus cross, with wild *Virgatum* (*ashei*) background. Ploidy level and degree of introgression among blueberry species were observed to affect total and certain anthocyanins species. However, the expression of the interspecific introgressions in blueberry species was genetic background-dependent. The genotype stability for anthocyanin accumulation over 2 years is discussed.

(354) Estimating the Chilling Requirement of Southern Highbush Blueberry Breeding Selections

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Currently, the chilling requirements of southern highbush blueberry (*Vaccinium corymbosum* L. hybrids) selections within the University of Florida (UF) blueberry breeding program are not quantified prior to commercial release. Due to the primary selection location, many of the cultivars released from the program are estimated to need approximately 300 hours of chilling (0 to 7 °C) for normal growth and development; thus, these selections are not well-adapted to areas that receive less chilling, such as central and southern Florida. In low chill production areas, blueberry plants are often treated with the dormancy-breaking compound, hydrogen cyanamide, to overcome inadequate chilling and promote uniform budbreak. However, application rate and timing of this compound are cultivar specific and phytotoxicity can be a problem. Furthermore, this compound is not available for organic production. There is a need for cultivars with a lower chill requirement that do not require hydrogen cyanamide application, as well as cultivars that respond well to hydrogen cyanamide when their chilling requirement is not met. The purpose of this study was to estimate the chilling requirement of advanced selections in the UF blueberry breeding program with and without treatment with hydrogen cyanamide. Breeding selections were clonally propagated in 2009 and were planted in blocks at Citra and Windsor, FL, in 2010. Plants in Windsor were treated with hydrogen cyanamide in Dec. 2011, while plants in Citra were not. Three branches from each treatment at each location were collected at approximately 50 chill hour increments. Branches were then placed in a greenhouse and floral bud development was evaluated bi-weekly for 5 weeks. The floral bud chilling requirement of a genotype was estimated based on a comparison of the rate and total percentage floral bud break for each 50 chill-hour evaluation. Of the 25 genotypes evaluated, 13 had the same chill requirement estimate both with and without hydrogen cyanamide treatment. Of the 12 remaining genotypes, only four were estimated to have a lower chill requirement when treated with the dormancy breaking compound. For treatments both with and without hydrogen cyanamide, an estimate of 100 chill hours requirement was the most frequently assigned (12 and 13 genotypes, respectively) followed by 150 chill hours (5 and 6 genotypes, respectively.) This initial analysis suggested that the majority of the germplasm in the breeding program can successfully flower with a minimum of 150 chill hours and without hydrogen cyanamide application.

(355) Identification of Sparkleberry (*Vaccinium arboreum*) Genome Introgression with Microsatellite Markers Developed in Highbush Blueberry

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Sparkleberry (VA, *Vaccinium arboreum* Marsh.) is a wild blueberry species that has been used in southern highbush blueberry (SHB, *Vaccinium corymbosum* L. hybrids) breeding as a source of genetic traits for soil adaptation and amenability to mechanical harvest. One of the primary limitations for trait introgression from VA has been difference in ploidy level with cultivated SHB. However, chromosome duplication of several VA genotypes by colchicine treatment has allowed direct crosses with SHB, resulting in several thousand hybrid seedlings available for evaluation. Currently, hybrid seedlings are identified by several phenotypic characteristics. Identification of VA specific alleles from microsatellite markers that amplify in both species would provide a rapid method of positively identifying seedlings where VA genome introgression has occurred. Twelve unrelated tetraploid VA seedlings that comprise the majority of founding clones in the current VA introgression project were genotyped with a set of 13 microsatellite markers previously used to genotype SHB cultivars and advanced selections from the University of Florida blueberry breeding program. Twelve of the 13 markers (92%) consistently amplified microsatellite loci in VA; 11 markers amplified a single locus. When both SHB and VA were considered, the number of alleles per marker ranged from one to 17. Of those markers, the number of alleles per marker that were only found in VA ranged from zero to 13. Two of the 12 markers amplified only unique alleles in the limited set of VA genotypes assayed and when used in combination with an additional highly polymorphic marker allowed identification of VA introgression in early generations of crosses.

Specified Source(s) of Funding: USDA–NIFA Specialty Crop Research Initiative Award No. 2009-51181-06021

(356) A Standardized Phenotyping Protocol for Strawberry in Rosbreed

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In an effort to implement marker-assisted breeding in Rosaceae, many traits need to be characterized in diverse germplasm. The USDA–NIFA Specialty Crop Research Initiative-funded RosBREED project includes breeding programs of four Rosaceae crops, apple, peach, cherry, and strawberry. Among them, strawberry is the only perennial herbaceous species. Phenotyping strawberry for specific horticultural and commercial traits is an important process needed to identify genotypic marker(s) associated with specific traits. This process is the first step in translating genomic knowledge into enhanced breeding efficiency through marker-assisted breeding. Large-scale standardized phenotyping protocols have been set up for each crop. The standardized phenotyping protocol for strawberries, as agreed upon by the breeding teams in Oregon, Michigan, New Hampshire, California, and Florida, will be presented. The protocol includes four trait categories: phenology, plant characteristics, fruit characteristics, and fruit chemistry. Phenotyping the RosBREED strawberry of 947 individuals representing the breadth of relevant diversity used in breeding the domesticated strawberry, took place in 2011 and 2012. These data will be used to identify quantitative trait loci and marker trait associations

that can assist breeding programs in the future. The phenotypic data for widely used founder accessions that have contributed to current cultivars is available through the “Breeders Toolbox” at the Genome Database for Rosaceae (http://www.rosaceae.org/breeders_toolbox).

Specified Source(s) of Funding: “RosBREED: Enabling marker-assisted breeding in Rosaceae” is supported by the USDA–NIFA, Specialty Crop Research Initiative by a combination of federal and matching funds (grant number 2009-51181-05808).

Monday, July 22, 2013

1:00–1:45 PM

Vegetable Crops Management

(144) Development of an In Planta Monitoring System of Phosphorus Content in Tomato

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Tomato (*Lycopersicon esculentum*), is an important vegetable crop in the world for fresh and processing consumption. In order to increase fruit yield and improve fruit quality, and avoid injury from typhoons, torrential rain, pests, and disease, most farmers in Taiwan use greenhouse cultivation for growing tomato. Overfertilization and lack of leaching by rain in greenhouse cultivation often leads to increased cost and an accumulation of salt in the soil. Reasonable fertilization is one of important approach for solving the above problems. To achieve the purpose of reasonable fertilization, it is essential to measure the nutritional status in plants. However, the commonly used methods for analysis of soil and plant material to assess fertilizer requirement is time-consuming, requires expensive equipment, and high techniques. Furthermore, in the case of phosphorus, a high amount of phosphorus detected in the soil is usually unavailable for plants, resulting in deficiency. Phosphorus plays an important role in the initial growth and flowering stage of tomato, thus phosphorus deficiency will reduce the growth rate and final yield of tomato plants. To achieve the goals of reasonable fertilization, decreased cost of fertilizer, and protection of ecological environment, we developed an in planta method for the convenient and quick assay of phosphate (Pi) status in tomato.

Specified Source(s) of Funding: This work was supported by National Science Council of the Republic of China (Grant 100-2313-B-002 -058 -MY2).

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(145) Prediction of Radish Growth as Affected by Nitrogen Fertilization for Spring Production

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The average annual and winter ambient air temperatures in Korea have risen by 0.7 and 1.4 °C, respectively, during the last 30 years. Radish (*Raphanus sativus*), one of the most important cool-season crops, may well be used as a model to study the influence of climate change on plant growth, because it is more adversely affected by elevated temperatures than warm season crops. This study examined the influence of transplanting time, nitrogen fertilizer level, and climate parameters, including air temperature and growing degree days (GDD), on the performance of a radish cultivar (Mansahyungdong) to estimate crop growth during the spring growing season. The radish seeds were sown from 24 Apr. to 22 May 2012, at intervals of 14 days and cultivated with three levels of nitrogen fertilization. The data from plants sown on 24 Apr. and 8 May 2012, were used for the prediction of plant growth as affected by planting date and nitrogen fertilization for spring production. In our study, plant fresh weight was higher when the radish seeds were sown on 24 Apr. than on 8 and 22 May. The growth model was described as a logarithmic function using GDD according to the nitrogen fertilization levels: for 0.5N, root dry matter = $84.66 / \{1 + \exp[-(GDD - 790.7) / 122.3]\}$ ($r^2 = 0.92$), for 1.0 N, root dry matter = $100.6 / \{1 + \exp[-(x - 824.8) / 112.8]\}$ ($r^2 = 0.92$), and for 2.0 N, root dry matter = $117.7 / \{1 + \exp[-(GDD - 877.7) / 148.5]\}$ ($r^2 = 0.94$). Although the model slightly tended to overestimate dry mass per plant, the estimated and observed root dry matter and top dry matter data showed a reasonable good fit with 1.12 ($R^2 = 0.979$) and 1.05 ($R^2 = 0.991$), respectively. Results of this study suggest that the GDD values can be used as a good indicator in predicting the root growth of radish.

(146) The Effects of Air Temperature on Yield and Phytochemical Content of Red Ssamchoo and Red Leaf Lettuce Grown in a Plant Factory

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The consumption of leaf vegetables has been steadily increasing in Korea. Leafy vegetables are commonly used for “Ssam (vegetable wrap-up),” a popular way of eating fresh vegetables using fingers to wrap some cooked rice and seasoned condiments inside several layers of young vegetable leaves. Nutritional values and health benefits of leafy vegetables are well known. Studies on the growth and quality of major leaf vegetables like lettuce and bak-choi in the plant factory are available, but little work has been done on minor vegetables. This study was conducted to improve yield and quality of redssamchoo (*Brassica koreana* Lee var. red leaf) and red leaf lettuce (*Lactuca sativa* L.) grown in a plant factory where fluorescent lamps were used as an artificial light source. Seeds of redssamchoo and red leaf lettuce were sown in a peat-lite germination mix. Twenty-day-old seedlings with roots being washed were anchored on a Styrofoam board and were grown hydroponically for 25 days under fluorescent light. Plants were exposed to three different daytime temperatures (20, 25 and 30 °C) which were being monitored with a sensor at 30 cm above the plant level. In all treatments, light intensity was maintained at $200 \pm 30 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, day length was 12/12 hr, and relative humidity was 50% to 80%. Electrical conductivity (EC) and pH of nutrient solution were $1.6 \text{ dS}\cdot\text{m}^{-1}$ and 6.8–7.0, respectively, in all treatments. Increase in fresh weight was observed in redssamchoo at 30 °C, but red leaf lettuce was not significance. Photosynthetic capacity and vitamin C content of redssamchoo leaves were higher at 30 °C than other temperatures. In red leaf lettuce, photosynthetic capability was higher at 20 °C, while vitamin C content was higher at both 25 °C and 30 °C. Polyphenol and flavonoid content were higher at 20 °C in red ssmchoo and red leaf let-

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tuce. Hence, the optimum temperature appears to be 20 °C for phytochemical both redssamchoo and red leaf lettuce in the plant factory with fluorescent light.

(147) The Effects of Nitrogen Fertilization on Glucosinolate Concentration and Yield in 28 Cabbage Varieties

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Cabbage, *Brassica oleracea* var. *Capitata*, is a significant vegetable crop in North Carolina with approximately 5000 acres harvested annually and an estimated market value of 15 million dollars. This is partly driven by increased interest by consumers in the health and phytonutrient quality of this crop. Members of the Brassicaceae family produce glucosinolates, which have been shown to have anti-cancer properties. These compounds play a role in both flavor development and influence the crops insect susceptibility. The purpose of this study was to evaluate established varieties and elite breeding germplasm in the field, with an emphasis on the impact of nitrogen fertilization and growing season influence on both production and the concentration of glucosinolates present. Eleven commercially available cultivars and 17 elite selections from the North Carolina State University Plants for Human Health germplasm collection were planted at the Piedmont Research Station in Salisbury, NC, in a replicated field trial. The trial was conducted over two growing seasons, spring and fall, at the same location. Three nitrogen levels were imposed based on the recommended rate for cabbage in North Carolina. Heads were harvested by hand based on days to maturity and head firmness. Significant differences in yield across nitrogen treatment and genotype were observed. Top performing varieties included Checkmate, SVR5210207, SVR05291201, C28 x C519, and Platinum Dynasty. Differences among varieties exist within nitrogen treatments. Postharvest phytonutrient analysis was completed at the North Carolina Research Campus's Plants for Human Health Institute in Kannapolis, NC, using HPLC-MS. While total glucosinolate con-

centration decreased with increasing N, indole glucosinolates were affected most by N treatment.

(148) Tissue Elemental Content and Growth Response of Lettuce to Hydroponic Solution Concentration Varied with Cultivar

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The growth and tissue mineral elemental content of lettuce [*Lactuca sativa* L. 'Paris Island Cos' (PIC) and 'Black Seeded Simpson' (BSS)] in response to nutrient solution source and concentration were evaluated in a Nutrient Film Technique (NFT) hydroponic culture system. Thirteen-day-old seedlings were grown; and harvested 27 days after transfer into NFT hydroponic culture. Fertilizer sources for the two hydroponic solutions comprised of either 100%– or 50% Steiner's nutrient solution formulation, or a soluble fertilizer (15N–2.2P–12K) at 200 mg·L⁻¹ of N, plus micronutrients (CAMG). Mean nutrient solution pH was maintained between 6.0 and 6.7, while electrical conductivity (EC) ranged from 1.61 to 2.83. With the exception of copper (Cu), whole lettuce-head tissue analysis indicates no significant ($P = 0.05$) fertilizer x cultivar interaction for tissue elemental content, or growth parameters measured. Compared with 100% Steiner's and CAMG, average leaf count (LCNT) decreased at 50% Steiner's, in both BSS and PIC ($P \leq 0.002$). In addition, head fresh- and dry weight (HFW, HDW) of PIC were reduced at 50% Steiner's ($P \leq 0.001$), compared with the 100% level, despite increases in tissue content of nitrogen (N, 2.7-fold) and phosphorus (P, 13.4%). Similarly, 100% Steiner's significantly increased the HFW and HDW of PIC, compared with CAMG and 50% Steiner's ($P \leq 0.001$). With BSS, there were no differences in HFW, HW, macro- and micronutrient content among the nutrient solution sources and concentration. Except for copper (Cu), zinc (Zn) and aluminum (Al), which increased at 100% Steiner's ($P \leq 0.0001$) in PIC, tissue concentration of iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), and sodium (Na) were highest at 50% Steiner's. Reductions in tissue elemental content at 100% Steiner's may have resulted from the 43% increase in EC (2.83 mS/cm) over the 50% level (1.61 mS/cm). The higher EC at 100% Steiner's caused root tip death and root stunting in seedlings, and delayed plant establishment by about 2 weeks compared to the latter. With both BSS and PIC, plants grown with CAMG had higher P and potassium (K) content than both levels of Steiner's, and higher N than 100% Steiner's nutrient solution. Similarly, with micronutrients, tissue Fe, Mn, B, and Mo content were higher with CAMG than at 100%, but not 50% Steiner's ($P < 0.05$).

An asterisk (*) following a name indicates the presenting author.

Specified Source(s) of Funding: This work is supported by USDA-NIFA Grant No. MOX-HYDROPONICS-05. Lincoln University in Missouri.

(149) Nitrogen Use Efficiency in Processing Sweet Corn

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Sweet corn (*Zea mays* L.) is a major processing crop in the upper midwestern United States. Our objective was to update nitrogen recommendations using modern cultivars of sweet corn under multiple crop management strategies. We measured fresh kernel cut weight ($t \cdot ha^{-1}$) and percent usable ears for corn on the cob freezing (%COC) from May and June plantings in 2010–12 to determine yield and nitrogen use efficiency (NUE) responses among two sweet corn cultivars ('Magnum II' and 'GSS 1477'), 6 nitrogen fertilizer rates (0 to $225 \text{ kg} \cdot ha^{-1}$), and 3 planting densities (54, 62, or 69 thousand plants/ha). We define NUE as the ability to convert N fertilizer to harvested yield [kg yield (kg available N)]. Overall fresh kernel cut weight was higher in 'GSS 1477', but NUE fell more rapidly than in 'Magnum II' as N increased. The lowest planting density resulted in higher NUE than the highest planting density. Increased planting density reduced fresh kernel cut weight in 'Magnum II' but not in 'GSS 1477', and increased planting density reduced fresh kernel cut weight in every N treatment except $180 \text{ kg} \cdot ha^{-1}$. A linear increase in %COC in response to added N was observed in 'GSS 1477', but the response in 'Magnum II' was quadratic. Low N rates reduced %COC more at high planting density than at low planting density. Variation in the response to N and population density among the six planting seasons studied (2 plantings per year, 3 years) was substantial and might be explained by temperature and rainfall patterns observed after planting and during kernel development.

Specified Source(s) of Funding: Midwest Food Processors Association

(151) Effect of Grafting on Roma-type Tomato Production in Southwest Florida

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Roma-type tomato varieties with acceptable horticultural characteristics for Florida growers often do not have resistance to *Fusarium* crown rot (FCR), a soil disease affecting Southwestern

Florida. Grafting can protect plants against FCR, but the extra cost of grafted plants is perceived as an obstacle for adoption of this technique by growers. Therefore, the objective of the study was to evaluate the performance of grafted vs. non-grafted roma-type tomatoes in plant growth, yield, and postharvest quality. Scions 'Sunoma' and 'Mariana' were grafted on rootstock 'Maxifort' ('Maxifort'/'Sunoma' and 'Maxifort'/'Mariana') and compared to non-grafted 'Sunoma' and 'Mariana' in a randomized complete-block design with four replications. The trial was planted on 25 Sept. 2012, with 22 inches between plants and 6 ft between bed centers in Immokalee, FL. Plant growth data were collected at third harvest or 120 days after transplanting. Tomato fruit were harvested three times at the mature-green stage and graded into marketable size categories and unmarketable yield. A subsample of 20 breaker-stage fruit/plot was collected at first harvest and ripened to table ripeness. Postharvest evaluation included firmness, skin color, total soluble solids (TSS), and pH. Plant growth, yield and postharvest data were analyzed by analysis of variance (ANOVA) and mean separation by Duncan's multiple range tests. Although there was a history of the *Fusarium oxysporum* f.sp. *radicis-lycopersici* in the field, there was low FCR incidence in the trial (< 3%). Of the grafted tomato plants, 21% produced rootstock suckers, which were removed during the production season. There were no differences in total plant biomass; however, grafted plants were taller than non-grafted plants. The highest, large-size tomato yield was produced by non-grafted plants at first harvest. 'Sunoma' produced the greatest total marketable, first harvest yields, but was not different from Mariana and 'Maxifort'/'Sunoma'. There were no differences among the treatments for total season, large-size tomato yield, whereas 'Sunoma' and 'Maxifort'/'Sunoma' produced the highest total marketable fruit yields (all sizes and harvests combined) of 2,745 and 2,607 boxes/acres, respectively. 'Maxifort'/'Mariana' had the firmest fruit, while 'Sunoma' and 'Maxifort'/'Sunoma' produced the softest fruit. The best color was from 'Mariana' and the grafted treatments. The lowest TSS was found in 'Maxifort'/'Mariana' and there were no differences in pH among fruit from grafted and non-grafted plants. With no FCR pressure there were no clear advantages to using grafted plants in roma-type tomato production, although rootstock suckering might have affected fruit yields in this study.

Monday, July 22, 2013

4:00–6:00 PM

Undergraduate Poster Competition

Please plan to be present for the entire poster competition session.

(193) The Inheritance of Plant and Flower Traits in Rose

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A series of diploid rose crosses consisting of selected parents from some introgression populations involving Old Blush, Ducher and *Rosa wichurana* 'Basye Thornless' that were crossed with 2 roses (Red Fairy and Sweet Chariot) released from the program of Ralph Moore were planted in the field in College Station. About 350 seedlings from eight cross combinations were evaluated for growth type, flower size, color, and form and the presence of prickles on the petioles and stems. The inheritance of the flower form, color and the presence of stem prickles generally were inherited as single loci as previously reported although some crosses displayed a distortion in their segregation probably due to the interspecific background of these progenies. The flower diameter was inherited in a quantitative fashion.

(194) Phylloquinone (Vitamin K) Variation, QTL Identification, and the Correlation with Carotenoids in Broccoli (*Brassica oleracea* var. *italica*)

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Phylloquinone (vitamin K) is important for bone metabolism, blood coagulation, and contributes to the carboxylation of vitamin K dependent proteins. This fat soluble vitamin is also associated with decreased risk of age related chronic disorders and in the plant acts as a cofactor in Photosystem I. Little information is available concerning the genetic control of this compound in *Brassica* vegetables or in the related model crop, *Arabidopsis*. The purpose of the experiment was to quantify phylloquinone in the broccoli population in order to identify QTLs associated with variation. Florets from 125 F_{2,3} broccoli families derived from the cross 'VI-158 x Brocolette Neri E. Cespuoglio (BNC)' were

harvested in 2009 and 2010 in Salisbury, NC. Tissue extracts were analyzed for phylloquinone, carotenoids and tocopherols to evaluate variability among the families. Three-fold variation in phylloquinone concentration was observed in both years with significant genetic and environmental effects. Genotype x environment interaction was not significant. Moderate to high correlations were observed ($r=0.28$ to 0.53) with all carotenoids and α -tocopherol (except epoxy lutein). These correlations were all positive suggesting that breeding for enhanced lutein, β -carotene, α -tocopherol and phylloquinone can be accomplished in the same genetic background. Two significant QTLs were observed that impacted phylloquinone variability. A single QTL on chromosome 7 co-segregated with the major carotenoid QTL that impacts lutein and β -carotene while the second QTL is independent of carotenoids or tocopherol accumulation. The results suggest that phylloquinone concentrations in broccoli are moderated by a relatively small number of genes that can be used in developing broccoli with higher levels of vitamin K.

(195) Microshoot Proliferation of *Geranium magniflorum* 'La Veta Lace'

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Geranium magniflorum 'La Veta Lace' is an herbaceous perennial that grows within the USDA hardiness zones 4–8. La Veta Lace® *Geranium* was originally collected from the Drakensburg Mountains of South Africa and it is a fern leaf species that has small purple blooms. Currently there is no published micropropagation protocol for *G. magniflorum* 'La Veta Lace'. The objective of this study was to investigate the effects of nutrient salt formulations and different plant growth regulator concentrations on initiation and proliferation of microshoot culture of La Veta Lace® *Geranium*. A 2 x 3 factorial combination of 1-naphthaleneacetic acid (NAA) concentrations (0.54 and 2.68 μ M) and 6-benzylaminopurine (BA) concentrations (0.44, 2.22, and 4.44 μ M) were compared to determine which plant growth regulator combination(s) would stimulate the proliferation of the most viable microshoots. Also, two nutrient salt formulations (MS, 1/2 MS) ranging from high to low salt formulations were studied to determine a suitable range of nutrient medium formulation for microshoot proliferation. Shoot tip explants that were 5 mm in length were used to initiate cultures and were maintained on the various factorial medium treatments plus 30 g/L sucrose and 7 g/L agar at a pH of 5.8. Explants were incubated approximately 30 cm beneath cool-white fluorescent lamps that provide a photon flux of approximately 30 mmol·m⁻²·s⁻¹ for a 16-h photoperiod at 25 ± 3 °C. Nodal explants were transferred

An asterisk (*) following a name indicates the presenting author.

every 3 weeks for a total culture period of 6 weeks. At each transfer date, data were collected on microshoot number with a length greater than 2 mm. Developing microshoots were found to be adventitious, originating from callus produced from initial explants. Explants cultured on MS (high) nutrient salt formulation coupled with 0.54 μM NAA and 0.44 μM BA significantly produced the greatest number of microshoots per explant with an average of 12.3 shoots after 6 weeks of culturing. Further research needs to be conducted on developing a suitable rooting medium along with acclimatization protocols.

(196) Stem-water Potential Reading Variability in Olive (*Olea europaea*)

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In the face of growing water insecurity, California farmers have embraced irrigation management technologies which help ensure a greater “crop per drop.” Stem-water potential (ψ_{stem}) is a plant based irrigation management tool that measures water stress. Previous research has established numerous technician measurement protocols to minimize variability in almond, walnut and prune water stress readings; these protocols have been adopted in olive with only anecdotal evidence of their validity. The objective of this study is to explore variability in ψ_{stem} readings in olive (*Olea europaea* ‘Arbequina’ and ‘Manzanillo’). Potential variability arising from crop load, the presence of olive knot, the location of the sampled shoot on the tree, shoot samples containing fruit, a 2-minute post-excision interval before placement in the pressure chamber, the length of the stem protuberant from the pressure chamber, re-pressurizing a bagged shoot, and examining differences between technicians are all investigated. Readings are principally taken from several replicates on four to five trees in a single fully irrigated row. Data sets are analyzed using ANOVA as a single factor randomized block design (RBD – 1 factor), blocking by tree. In the overall analysis of all investigations, the variability tested was insignificant ($P > 0.05$). An exception to the overall findings occurred in two of three investigations regarding the location of the sampled shoot on the tree, as well as the first of nine trials comparing readings between two operators. These results suggest a robustness of ψ_{stem} readings, despite variance in tree physiology and operator technique. The exceptions noted are also consistent with literature finding bag placement and operator as potentially significant sources of variation.

Specified Source(s) of Funding: College of Agriculture, California State University, Chico University of California Cooperative Extension, Glenn County

(197) Persistence of Urea in a Coastal Plain Soil: An Incubation Study

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Urea-based nitrogen sources can possibly lead to nutrient pollution of various water bodies due to leaching and runoff, and also trigger the diatom *Pseudo-nitzschia* spp. to produce shellfish poisoning. This causes economic and human health concerns in the Chesapeake Bay and other coastal regions. Urea-based fertilizer use has increased in recent years because ammonium nitrate was banned after the Oklahoma bombing incident. Thus, farmers switched to commercial urea-based fertilizers as an economical alternative. When manures are used as a nitrogen source, studies have shown urea to exist in runoff several days after application. To prevent these occurrences, researchers need to learn more about how urea behaves and pathway movement through soils to water bodies. The objective of this study was to determine how urea in urea-based fertilizers and manures persists in soil after application. Four treatments were used: poultry litter, broiler manure, urea prill, and a control. Our hypothesis was that soils amended with poultry litter and broiler manure will have slower mineralization (hydrolysis) rates of urea, and a longer release of inorganic nitrogen than soils amended with commercial urea fertilizers. The latter process is thought to provide a more rapid mineralization rate of urea, but shorter release of inorganic nitrogen over time. This study will inform those concerned about the health of the Bay as to what agricultural practices may harm the Bay. It will also aid farmers in choosing which urea-based fertilizers pose the least risk of polluting the environment through runoff and leaching.

(198) Free Radical Scavenging Activities of ‘Marrs’ Sweet Oranges

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Antioxidants neutralize free radicals before they can damage cellular structures, including DNA, proteins, and membrane lipids. In humans, the consequences of low antioxidant levels include obesity, cardiovascular disease, and poor immune function, but consumption of fruits and vegetables can prevent certain chronic diseases. Recent studies showed that people who consumed more fruits and vegetables had reduced risks of cancer, stroke, and heart disease. Citrus fruits have long been valued as part of a nutritious and tasty diet and contain many antioxidants. For example, Vitamin C, an essential water-soluble nutrient, acts as an antioxidant by donating electrons to free radicals to form a stable end product. The present study examined the free radical scavenging activities of citrus fruit extracts using different *in vitro* methods. ‘Marrs’ sweet oranges were extracted with five different solvents in the Soxhlet apparatus; extracts were dried and used to determine antioxidant activities. Free radical diphenyl-1-picrylhydrazyl (DPPH) scavenging activity was measured for five extracts. Chloroform extract had the highest DPPH activity and methanol extracts had the lowest activity whereas in case of 2,2’-azino-bis (3-ethyl benzthiazoline-6-sulfonic acid) (ABTS) assay water extract had highest activity. Furthermore, antioxidant capacity was also determined using the phosphomolybdenum method. Antioxidant capacity of the extracts as equivalent to ascorbic acid ($\mu\text{mole/g}$ of the extract) was in the order of water > acetone acetate > methanol > chloroform. Indeed, extract made with water had the highest antioxidant capacity and hexane extract had the lowest capacity as measured by this assay. Further experiments are needed to gather more data on how antioxidants affect our daily lives.

(199) Changes of Anthocyanin and Carotenoid Concentration in Purple Color Paprika Fruit during Ripening

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We investigated the changes of anthocyanin and carotenoid concentration during course of purple-color paprika fruit (‘Rikata’ and ‘Tequila’) fruit ripening. It is known that the fruits of these varieties change the color in two stages. At the immature stage, the color shifts from green to purple, then it becomes red at fully ripe stage. However, the pigment content at different color fruit has not been investigated. Furthermore, the purple pigment composition is not identified. In this research, we analyzed anthocyanin and carotenoid contents at different fruit growing stages. Plants were grown hydroponically. Sample

portions (3 x 4 cm) were obtained from the middle part of the fruits at various stages. Then these were divided into fruit skin and flesh. Anthocyanin (nasunin, flavonoid, and cinnamic acid derivative) and carotenoid (lycopene, $\alpha\alpha$ -carotene, $\beta\beta$ -carotene, and capsanthin) contents were analyzed by HPLC. We also identified the main anthocyanin composition. In fruit skin, anthocyanin increased within several days after setting of fruit, then decreased with ripening. Fruit flesh contained low amounts of anthocyanin at all stages. We found the primary anthocyanin is nasunin at purple color stage of the fruits for both of varieties. Carotenoid content was low at green or purple color stage, and increased sharply during ripening in both fruit skin and flesh. These results indicate that anthocyanin content was large initially, but decreased gradually up to ripening. Carotenoid content increased with ripening.

(200) Waste Wool, Cocoa Hulls, and Clover as Organic Mulch Alternatives in Tomato Production

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Three organic mulch alternatives for organic tomato production (cv. WV63) were compared to a bare soil control. A complete randomized design of 16 plots measuring 2.4 x 2.4 m was established and each treatment was replicated 4 times for a total of 12 treatment plots and an additional four control plots. Treatments included an organic waste wool application to a depth of 5 cm, organic cocoa hulls also applied to a depth of 5 cm, and white clover living mulch. Control plots were left bare. Data were collected on surface and soil temperatures, yield (weight and number of fruit), growth characteristics (leaf area, height, and width), and weed suppression. Significant differences in yield were observed. The highest overall yield was observed in the cocoa hull plots followed by plots mulched with wool and the control plots. Plots with white clover living mulch yielded significantly lower than all treatments and the control. Extrapolated seasonal yields were 306, 279, 201, and 64 metric tons/ha for cocoa, wool, control, and living mulch, respectively. Yield during the first two harvests was significantly higher for wool than other treatments or the control. In addition the average weight of 147 g of harvested tomatoes in the wool treatment was significantly higher than the 129 g per fruit in the control and 132 g per fruit in the cocoa plots. No significant differences were observed in plant height or leaf area. Average peak surface temperatures were 53, 48, 43, and 33 °C, for cocoa hulls, wool, control, and living mulch, respectively. All treatments lowered subsurface

An asterisk (*) following a name indicates the presenting author.

temperature when compared to the control and ranged from 21.6 °C in the control plots to 20.7 °C in the living mulch plots. Weed suppression as measured by time to remove weeds was greatest in cocoa hull plots, followed by the clover, wool, and control treatments. Overall the cocoa hull treatment performed best in total yield and weed suppression. However, if cost, earliness, and/or fruit size are factored wool can be considered a viable alternative to cocoa hulls in organic tomato production.

(201) Secondary Shoot Proliferation in *Hosta* ‘Honeybells’ and the Isolation Plantlets Free of *Hosta Virus X*

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Hostas are the most popular herbaceous perennial garden plant in the United States and are susceptible to infection by *Hosta Virus X* (HVX). It impacts hostas causing streaking, mottling, puckering of the leaves, and misshapen growth, eventually resulting in death of the plant. Currently there are no reliable methods of producing virus free plants, but there is preliminary evidence that periodic off-season, secondary shoots can be free from HVX for a short duration. Such shoots can be excised at an early stage from the infected mother plant and HVX-free plants recovered. The objectives of this experiment are to better characterize the rate of HVX-free shoots from infected plants of ‘Honeybells’ and compare different cultural manipulations on off-season shoot production. Vernalized plants were used to initiate all experiments. Plants have been grown at 18 and 27 °C in growth chambers, while a second group of plants grown under greenhouse conditions (21 °C) were treated with BA, florel, Fascination® and a water control in order to induce more secondary, off-season shoot development. Emerging secondary shoots were individually potted and grown on. Leaf samples of such shoots were taken and tested for HVX with immunostrips. Rates of HVX-free plants across treatments will be reported.

(202) Commercial Food Grade Cinnamon Products Inhibit Mycelia Growth of Four Fungi In Vitro

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Fungal contamination in tissue culture applications can lead to the loss of valuable plant material, and current in-vitro fungicides can be costly. This experiment evaluates the fungicidal efficacy of food grade preparations of *Cinnamomum* spp. against four common plant parasitic fungi. Ground cinnamon and cinnamon oil purchased from a local supermarket were added to potato dextrose agar (PDA) with pH adjusted to 5.6 at nine concentrations (0, 0.52, 1.04, 2.09, 3.13, 4.18, 5.23, 10.46, and 20.92 g/L; and 0, 1, 2, 4, 6, 8, 10, 20, and 40 mL/L, respectively). Agar was poured into quadruplex 150 x 10 mm petri dishes. Fourteen-day-old cultures of *Rhizoctonia* spp., *Phytophthora* spp., *Colletotrichum* spp., and *Fusarium* spp. were used to inoculate media by placing a 4-mm plug of each species in one of the four quadrants. Cultures were placed in dark at 22 °C and observations were made after 3 and 7 days. There were significant differences in growth rate of cultures placed on ground cinnamon treatments after 3 days. Overall, the higher concentrations of ground cinnamon (5.23–20.92 g/L) had inhibited mycelia growth, while no significant difference was observed between the control and lower concentrations. The three highest concentrations of ground cinnamon, beginning with 5.23 g/L, showed a linear decrease of mycelia growth with no apparent mycelia growth observed on the highest concentration (20.92 g/L), after 3 days. The seventh day after inoculation, mycelia growth on control and lower concentrations of ground cinnamon filled their respective quadrant while higher concentrations of ground cinnamon (10.46 and 20.92 g/L) continued to have inhibited mycelia growth. Cinnamon oil treatments showed slight decreases in growth of *Rhizoctonia* spp., *Fusarium* spp., and *Colletotrichum* spp., at higher concentrations (20–40 mL/L) after 3 and 7 days; however, no apparent decreases of *Phytophthora* spp. growth were observed with any rate of cinnamon oil in this experiment. These results indicate that ground cinnamon may be an effective, low-cost fungicidal amendment to tissue culture media.

Tuesday, July 23, 2013

12:15–1:00 PM

Consumer/Commercial Horticulture and Master Gardeners

(210) Citizen Scientist Master Gardeners Conduct Landscape Plant Variety Trials

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In 2010, Master Gardeners in Maricopa County, AZ, volunteered to trial three recently introduced ornamental plant cultivars and

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maintain performance records of those cultivars. The records were shared with the wholesale grower that provided the plants. *Calliandra eriophylla* × *Calliandra californica* (Maricopa Red™), *C. californica* (Sarita™) and *Caesalpinia pulcherrima* (Phoenix Bird™) were distributed to 13 Master Gardener citizen scientists. Of those, six Master Gardeners never submitted reports. The remaining seven submitted monthly reports that included a current photo of each plant and a completed data sheet that documented plant height, canopy diameter; method, frequency, and duration of irrigation; pruning events; fertilization; flowering; and fruiting and environmental stress symptoms such as frost damage, salt burn, and heat stress. Master Gardeners were also asked to subjectively state if the plant appears healthy and attractive. By the end of 2012, only four volunteers were still submitting monthly reports, either due to plant mortality or because the volunteer moved away.

(211) Regional IPM Webinars Reach Large Extension Master Gardener Audiences

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Two webinars were held to teach Integrated Pest Management (IPM) Extension Educators and Extension Master Gardeners (EMG). With support from the North Central IPM Center, the webinars were promoted through EMG coordinators in the North Central region and online at the national eXtension webinar site where anyone could register for the presentations. Both 90-minute webinars were hosted with umnconnect at the University of Minnesota and included 15–20 minute content sections followed by questions using the chat feature online. Tomato IPM for Gardeners held on 11 Aug. 2012 used 129 online connections, with a minimum attendance of 547 from 5 states: (Illinois, Minnesota, Ohio, South Dakota, Wisconsin) with 57 host sites reporting more than 1 person in attendance, usually at Extension offices with EMG. Growing Healthy Shade Trees with IPM webinar, 20 Feb. 2013, involved 156 online connections, with 56 host sites signing in on the chat feature indicating 521 participants. Although 107 host sites in 18 states registered (Colorado 2; Georgia 1; Iowa 6; Illinois 12; Kansas 2; Maine 1; Maryland 6; Michigan 1; Minnesota 25; Nebraska

4; North Carolina 3; Ohio 18; Pennsylvania 3; South Dakota 12; Texas 1; Virginia 1; West Virginia 3; Wisconsin 4) with an estimated audience of 660, on the final evaluation host sites indicated 1,447 participants from 102 sites. The tomato webinar was free to anyone who registered on the online google.doc spread sheet, up to 200 internet connections. For the shade tree webinar, individuals were asked to register and pay \$10 through eXtension for having a webinar line to their home or a non-host site; 39 individuals registered as individuals. There was no charge for host sites who registered for shade tree webinar. Pre- and post-test surveys for the tomato IPM webinar showed participants self-ratings changed from high IPM knowledge levels: 3% pre-test rose to 18% post-test; medium: 54% pre-test rose to 70% post-test; and low: 43% pre-test dropped to 12% post-test. Shade tree webinar participants reported high IPM knowledge levels: 1% pre-test rose to 3% post-test; medium: 36% pre-test rose to 69% post-test; and low: 63% dropped to 29% post-test. Shade tree webinar participants indicated they learned a lot 64% (148/233); similar to the tomato webinar participants 70% (127/181). Webinar challenges include: participant's technical understanding; recording live webinar attendance; gathering accurate pre and post test information; interaction between participants and presenters; and local host site activities to improve the educational experience.

Specified Source(s) of Funding: North Central IPM Center

Tuesday, July 23, 2013

12:15–1:00 PM

Crop Physiology

(296) The Effects of Plant Hormones on Root Growth and *GmEXPB2* Expression in Soybean

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The root system of a plant performs many important functions including water uptake, nutrient acquisition and anchorage of plants to the ground. Understanding the regulation of root development is therefore of vital importance. Previously, we found that soybean β -expansin gene *GmEXPB2* functioned as an intrinsic component of root architectural changes to abiotic stress in soybean. Here we examined the effects of exogenous plant hormones on root growth and *GmEXPB2* expression to illustrate the relationship between root growth and plant cell wall extension. Three-day-old soybean seedlings were grown in hydroponic solutions containing 0, 0.05, 0.5, 1, or 5 μ M of auxin (IAA, IBA, or NAA), gibberellin (GA_3), abscisic acid

An asterisk (*) following a name indicates the presenting author.

(ABA) or cytokinin (6-BA) and evaluated after 4 days. The results showed that soybean root morphology was significantly altered by the treatment of different levels of auxins, GA₃, ABA or 6-BA. Higher concentrations of IAA, IBA, and NAA inhibited the growth of primary root and lateral roots, consequently leading to the decrease of the total root length. Low concentrations of IAA (0.05 μM and 0.5 μM), however, slightly increased the total root length which was associated with increased lateral root growth. Similarly, higher concentrations of GA₃, ABA, and 6-BA inhibited primary and lateral root growth, but increased root diameters with an exception for GA₃, which induced finer root growth. Higher concentrations of 6-BA caused the root tips to curve up. Meanwhile, the expression of *GmEXPB2* varied with different types of hormones. The transcription levels of *GmEXPB2* increased with higher concentrations of IAA and NAA, but increased first and then decreased by IBA. In contrast, the accumulation of *GmEXPB2* transcript was strongly associated with concentrations of 6-BA and ABA, while it was not associated with GA₃. Our results indicate the complexity of plant hormone regulations on root growth, which is closely associated with plant cell wall expansion. Nevertheless, their detailed relationships need to be further elucidated.

(297) Laurel Wilt Differentially Affects Xylem Sap Flow of Three Avocado Cultivars

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Laurel wilt, caused by the fungus *Raffaelea lauricola*, has decimated members of the Lauraceae family in the southeastern United States since the early 2000s. It was detected in a Florida commercial avocado orchard in 2012, and poses a grave threat to the avocado industry. Affected trees wilt and usually die due to plugging of the vascular system. Susceptibility to laurel wilt varies among avocado cultivars. We assessed the effects of laurel wilt on xylem sap flow in three avocado cultivars that differed in susceptibility. ‘Russell’, ‘Brogdon’ and ‘Marcus Pumpkin’ trees (clonal scions grafted on ‘Waldin’ seedling rootstocks) were treated with either 750 conidia of *R. lauricola* at four equidistant sites above the graft union (inoculated; four plants per cultivar) or water (non-inoculated; one plant per cultivar). Xylem sap flow in each tree was continuously monitored with a Dynagage sap flow system (Dynamax, Inc.) until all of the inoculated trees of ‘Russell’ (most susceptible) completely wilted. Trees were also rated daily for laurel wilt

development, based on an external synoptic scale where 1 = asymptomatic and 10 = entire canopy wilted or dead. At the end of the experiment, trees were harvested, rated internally for laurel wilt (percentage of sapwood symptomatic, where 1 = asymptomatic and 10 = 100%), and assayed for the pathogen. *R. lauricola* was recovered from all inoculated trees but not from the non-inoculated trees. Mean cumulative sap flow over 9 days prior to inoculation was significantly higher in ‘Russell’ than in the other cultivars. Based on external and internal disease ratings, ‘Russell’ was significantly more susceptible to laurel wilt than ‘Brogdon’ and ‘Marcus Pumpkin’, which were statistically similar. Beginning 1 week after inoculation, xylem sap flow for ‘Russell’ declined rapidly until plants died. Mean sap flow per week was not significantly different between the less susceptible ‘Brogdon’ and ‘Marcus Pumpkin’. The results indicate that susceptibility to laurel wilt in avocado is associated with the rate of sap flow. Cultivars with a relatively high rate of sap flow (e.g., ‘Russell’) may be more susceptible due to a corresponding higher rate of conidium transport. Additional cultivars with a wide range of sap flow rates should be tested to examine this hypothesis.

(298) Increasing Root Zone Ca⁺² Concentration Will Decrease Uptake and Transport of Na⁺ and Enhance Plant Growth of Pistacia Species Grown in Saline Soils

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As surface water supplies dwindle and become more saline in California, the pistachio industry faces the challenge of managing orchards on increasingly saline soils with less water. Currently, the only approach we have for managing and alleviating the effects of root zone salinity is leaching. Methods of managing soil salinity that do not require more water would have great horticultural value. Recent research with the pistachio species, *P. lentiscus*, demonstrated that increasing the root zone Ca⁺² levels mitigated the effects of root zone salinity by reducing Na⁺ uptake to the leaves during salinity stress. Additional research on *P. lentiscus* and olive, reported when osmotic stress was relieved by leaching with quality water (relief period), both photosynthesis and growth rate recovered faster when previously treated with high Ca⁺² compare to low Ca⁺² treatment. These studies motivated us to investigate the specific effects of increasing root zone Ca⁺² on Na⁺ uptake, transport and plant growth in ‘Kerman’ trees (California’s most common pistachio scion) budded on PGI, UCBI clonal, and UCBI seedling rootstocks grown in saline soils. Based on recent reports, we hypothesized increasing that the Ca⁺² concentration in saline root zones may decrease the uptake of Na⁺ to ‘Kerman’ scions grown on different pistachio rootstocks. Additionally, during the relief period photosynthetic performance and therefore growth rate would recover faster. Our objectives for this project are to 1) rank the differences in tree water status, gas exchange, and ion distribution among ‘Kerman’ scions’ grown on different rootstocks

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under saline conditions; 2) determine how Ca^{+2} treatments affect these parameters; and 3) determine if trees respond better to leaching if pretreated with Ca^{+2} . Every 2 weeks, photosynthesis and gas exchange characteristics, stomatal conductance (gs) and CO_2 net assimilation rate (Asat) will be measured using a Li-Cor 6400 under 100% solar irradiance measured by Li-i800 spectroradiometer. Tree water status will be measured on leaves sampled at predawn using a pressure bomb. Leaf osmotic potential (Ψ_{op}) will be measured on expressed sap of these frozen and thawed leaves with a freezing-point Osmomat 030 osmometer (Gonotec, Berlin, Germany) equipped with a 15- μL measuring cell. Leaf turgor potential (Ψ_p) will be calculated as the difference between (Ψ_w) and (Ψ_{op}). Ion distribution will be analyzed on leaves for Ca^{+2} , Na^+ , and K^+ at 2-week intervals by samples sent to the University of California analytical lab.

(299) Analysis of Cold Hardiness, Dehydrins, and Their Gene Expressions during Cold Acclimation and Deacclimation in Four Peach Cultivars (*Prunus persica*)

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Changes in cold hardiness, dehydrins and their gene expressions were monitored in the shoots of four peach cultivars ('Daewol', 'Aikawanakajima', 'Fukuyokabijin', and 'Kiranokiwami'). Cold hardiness of all the cultivars, determined by electrolyte leakage analysis, gradually increased during the autumn, reached a maximum in midwinter, and then decreased by April. The SDS-PAGE profiles of proteins from four cultivars were very similar during investigated period. Data indicate that a 60 kDa protein encoded by PpDhn1 (*Prunus persica* dehydrin) gene of four cultivars accumulated to high level during fall and winter (from Nov. 2011 to Jan. 2012) followed by a complete disappearance in spring (from March to Apr. 2012). A 30 kDa of polypeptide, assumed to be a dehydrin protein encoded by

PpDhn2 gene, did not display discernible changes. A 16 kDa of polypeptide characterized as a "bark-storage protein" also exhibited a similar seasonal pattern in all cultivars. Changes of dehydrin gene expressions by a quantitative real-time RT-PCR were performed to find out the relationship with cold hardiness. Expression patterns of *PpDhn1* and *PpDhn3* genes paralleled fluctuations in cold hardiness. The *PpDhn2* gene did not appear to be seasonally regulated.

Specified Source(s) of Funding: This work was carried out with the support of "Cooperative Research Program for Agricultural Science & Technology Development (Project No. 907129)" Rural Development Administration, Republic of Korea.

(300) Evaluating Physiological Efficiencies of Branching Structure in Low-intensity Tart Cherry and High-density Apple

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Branch angle, rotation, and probability of termination have been used to describe the set of all possible branching structures, which can then be evaluated for their weight bearing capacity and light interception (Nikals & Kerchner, 1984, Paleobiology). This model has been updated and adapted to determine the range of generalized branching structures that occur among orchard systems. Pruning experts recommend maintaining 30° to 60° angles at branching nodes to optimally balance vegetative and reproductive growth. Often ties or weights are used to set these angles within the primary support branches or scaffolds. Does this "optimal angle" occur without such human manipulation in secondary branches? Does the "optimal angle" hold with the increase of management intensity? What effects does this branching angle have on light capture and biomass? Using data from a low intensity tart cherry (*Prunus cerasus*, mahaleb) and a high-density apple (*Malus xdomestica*) at the Kaysville Experimental Orchard, Utah State University, I establish branching parameters to model the trees' branching architecture and test how tree growth changes with various human manipulations (i.e., pruning). The model developed from this exercise tests the consequences of various horticultural management strategies on tree fruit physiology in the context of established scaling theory in ecology. It appears that primary branches of low-intensity tart cherry maintain an average of 30° angles, while terminal branches, which are pruned less, maintain somewhat narrower angles. High-density apples appear to deviate strongly from the low-intensity cherry system and are managed primarily with nearly horizontal lateral branches. The model developed is instrumental in defining branching characteristics of tart cherry trees and will be used to develop high-density tart cherry systems using the high-density apple system as a template. These models are being developed using ecological scaling theory to incorporate plant physiological

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efficiencies along with the human induced forces inherent in horticulture.

Specified Source(s) of Funding: Utah State University Ecology Center

(301) Measuring Soil Water Potentials in Horticultural Substrates at Very Low Water Potentials

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The study of water availability in substrates involves knowing the permanent wilting percentage (PWP). This has been traditionally defined as water held at soil water potentials between -1.0 and -2.0 MPa, with -1.5 MPa as the norm. The PWP has been determined with pressure plate systems set at 1.5 MPa without plants. However, the PWP range has not been thoroughly explored for horticultural substrates. Soil water potential measurements can now be made directly on soil/root systems under various conditions. This study determined soil water potentials in substrates as plants dried to five levels of wilt. Hibiscus plants were grown in 3 peat:1 vermiculite:1 perlite substrate in 3.8-L pots for 10 weeks before inducing wilt. Plant containers were completely submerged, drained and weighed. Plants were then allowed to dry to one of five stages of wilt: 1) first sign of leaf flagging; 2) leaves and stems flagging near 45° angles to main stem; 3) leaves and stems fully flagged; 4) 24 hours after stage 3; and 5) 48 hours after stage 3. Each plant was allowed to reach wilt stage individually. At each stage, pots were weighed and soil samples were taken from each pot, sealed and soil water potentials determined. After sampling, each container was watered and level of plant recovery was noted. Because much water is generally lost from the pot surface during drying, half of all treatments had covers placed on the substrate surface and half were left bare. After saturation, stage 1 was reached in approximately 7 days; stage 2 in 8–15 days; stage 3 in 15–20 days. Plants with covered soil surfaces were delayed about 2 days in reaching each stage. Soil water potential varied among stages of wilt. Plants showed wilt symptoms between 0.4 and 7.68 MPa. All plants recovered from stages 1, 2, and 3, with all of them beyond 1.5 MPa. All plants recovered from wilt up to 2.5 MPa. However, some plants recovered from wilt at 4.0 MPa. Covering the soil surface altered the time to wilt, but did not affect the severity of wilt or affect plant recovery. This work showed a range of soil water potentials much wider than 1.0 to 2.0 MPa for Hibiscus. This direct method of measuring soil water potential may aid in

determining PWP more precisely in plants grown in horticultural substrates.

(302) The Effect of Artificial Pollination and Growth Regulator Applications on Olive Trees under Mexican Desert Conditions

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Olive production in Mexico is about 30,000 tons annually and major problems in this arid region are pollination and fruit set. A study was carried out to evaluate the response of the artificial pollination (AP) and growth regulator application on productivity in olive trees. The trial was conducted under desertic conditions at Caborca, Sonora, Mexico during 2007. In this experiment we used a 7-year-old ‘Manzanillo’ olive orchard with 200 trees/ha under a drip irrigation system. For the AP we used pollen from ‘Sevillano’ (two applications 3 and 5 Apr.) with total dose of 70 g/ha. Two applications (29 Mar. and 10 Apr.) of the growth regulator Bioforte were used. The results showed that the AP increased the olive yield and decreased the shotberry incidence without affecting olive quality. The yield obtained using artificial pollination was 2464 kg/ha vs. 1273 kg/ha in trees not pollinated. Bioforte did not affect yield or olive quality.

(303) Enlarged Olive Fruit on ‘Manzanita’ under Arid Conditions

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In recent years, ‘Manzanita’ olive buyers have rejected fruit that does not reach sizes of at least $9/16$ inches. For producers, however, achieving larger olives has been problematic for

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economic and other reasons. Therefore, the Mexico Government Research Center (INIFAP) evaluated the feasibility of using different treatments to increase olive fruit size. The study was conducted in the Caborca coast, from June to Aug. 2012 on one commercial plantation. Foliar treatments were: 1) Celebrity (organic amino acids more K); 2) Bayfolan (chelated multimineral major and minor elements); 3) Benetizado fertilizer (44–0–0) applied to the ground; 4) ammonium nitrate (33–0–0); 5) olive hand thinning (10 kg/tree); 6) branch thinning; 7) branch girdling; and 8) control (nothing). All treatments were applied twice—on June 4 and June 19—and harvested on August 6–7, 2012. Each treatment was replicated three times. The analysis indicated that olive size significantly increased with Bayfolan treatments, hand thinning, and girdling branches. The other treatments showed no effect on fruit size in reference to control. According to the cost–benefit analysis, treatment with Bayfolan proved to be the best option.

(304) Heat Determination of Growth in *Pistachia vera* Cultivars

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With the rise in interest in systems modelling, there is an opportunity for pistachio growers to take advantage of new technologies to enhance their production. Management decisions have been made in other industries by using phenology models as tools. For example, the pressure of the olive fly in olive production is only severe when the olive is 80 mm³ in size and, therefore, tracking fruit development in a phenology model has shown that spraying for the pest before the crop has accumulated 1200 heat units is unnecessary. Heat unit accumulation has been shown as a driver of fruit development, especially well documented in peach and applied to almond production. We propose to expand the use of heat unit accumulation by characterizing nut growth as a function of heat units. Simultaneously, we will document stage development of the pistachio nut using biomarkers for the individual stages. By tracking this process stage development as a product of heat unit accumulation, our research will be a tool in pest and disease control.

Specified Source(s) of Funding: California Pistachio Board

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Tung tree (*Vernicia fordii*) is an important woody-oil plant with long cultivation history in China. Its seed has 52% to 64% oil-yields content. Alpha-eleostearic acid, an unusual conjugated trienoic fatty acid (18:3D^{9cis,11trans,13trans}), accounts for 80% (w/w total fatty acids) in tung oil that imparts industrially useful drying qualities to the oil. It can be easily oxidized and forms a unique polymer after being exposed to air. Tung oil is also used as a high-quality raw material in biodiesel production. In order to protect the tung tree resources from disappearing, we have collected more than 200 genetic resources of *Vernicia fordii* from 16 provinces of China and conserved in 20 hm² land. We investigated the growth and developmental characteristics of these genetic resources as they began to bear fruit, including morphological characteristics (tree height, diameter at breast height, ground diameter, crown breadth, branch angle, under branch height, and yield), economic fruit traits (fruit size, weight, shape, seed yield, shelling percentage, and seed oil yield) and flower characteristics (color, inflorescence number, and female flower number). According to this work we find some fine genotypes, i.e., maximum number of female flowers per inflorescence (ZNL-F14, 19.5), the heaviest fruit (ZNL-F39, 97.65g), the highest yield (ZNL-F29, 33.59kg), highest seed yield (ZNL-F6, 44.17%), highest shelling percentage (ZNL-F32, 63.90%), highest seed oil yield (ZNL-F52, 65.32%), and maximum oil production per tree (ZNL-F17, 2152.31g). The fatty acid composition was also analyzed using gas chromatography. Some genotypes with beautiful flowers and good tree structure can be used for ornamental tung tree breeding. This work provides resources for cross breeding and selective breeding of tung tree, and provides a foundation for molecular biology research on tung tree.

Specified Source(s) of Funding: This work was supported by the projects of state forestry research and public service industry (200904023), Hunan Provincial Natural Science Foundation of China (10JJ4022), Scientific Research Foundation of Central South University of Forestry & Technology

Tuesday, July 23, 2013

12:15–1:00 PM

Genetics and Germplasm

(345) Collection and Evaluation of Tung Tree (*Vernicia fordii*) Germplasm Resources in China

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(346) The Open Source Seed Initiative

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The Open Source Seed Initiative (OSSI) has been developed over the past two years by a working group of plant breeders, farmers, non-profit agencies, seed advocates, and policy makers. OSSI is dedicated to maintaining fair and open access to plant genetic resources worldwide. OSSI supports innovative plant breeding that produces resilient and productive cultivars. Enabling the open exchange of germplasm, with no restrictions on further breeding, is crucial to this new agriculture. The OSSI will work toward achievement of: 1) a germplasm licensing framework with no breeding restrictions on the germplasm released through its auspices other than that derivatives must also be released with the same license; 2) a robust, vibrant, and well-supported public plant breeding sector producing germplasm and cultivars that can be equitably grown, sold, changed, and distributed; 3) a plurality of sources for farmers, gardeners, and breeders to obtain seed; 4) integration of the skills and capacities of farmers with those of plant scientists for enhancing and enlarging participatory plant breeding; and 5) respect for the rights and sovereignty of indigenous communities, and of farmers and farm communities, to generate solutions to obtaining and improving seed for food production. Three OSSI licenses have been drafted to enact the core principles described above, with a planned release date of these licenses in 2014. The objective of this presentation is to engage the broader horticultural community in a discussion of OSSI's proposed work.

(347) Collection of North American Plums (*Prunus* spp.) for Use as Germplasm and Genetic Resources

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North America is an important center of diversity for plum

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species. The North American plums grow in diverse climatic and geographic regions. High levels of variation for plant architecture, fruit size, flesh texture, flesh color, disease resistance, chilling requirement, and other traits, have been reported. The survival of several of these species is being negatively impacted by urban sprawl and agriculture. Similarly, climate change threatens their habitats. The objective of this research was to collect and identify plant specimens from the wild, create a herbarium and living collection that could be used to preserve the species and to clarify the phylogenetic relationships of the North American plums. The University of Florida Stone Fruit Breeding and Genetics Program in collaboration with the National Germplasm Repository and USDA-ARS (Project No. 5306-21000-018-00D) collected, identified and archived ~400 genotypes of approximately 30 taxa across the United States. Geographic coordinates, location descriptors, and plant characteristics were recorded for all these genotypes. Vouchers for each genotype were submitted and are available at the Florida Museum of Natural History, Gainesville, FL (<http://www.flmnh.ufl.edu/herbarium/>). Seed collected from the germplasm accessions were submitted to John E. Preece at the National Clonal Germplasm Repository for Fruit and Nut Crops, Davis, CA, for future use by the scientific community. These collections will allow us to preserve and conserve these species as important genetic resources of unique traits and information that could be used for breeding plum scions and rootstocks in the future. Additional information about this collection will be reported.

Specified Source(s) of Funding: National Germplasm Repository and USDA-ARS Project No. 5306-21000-018-00D.

(348) An Economical Molecular Tool for Genetic Identity Confirmation in Blueberry

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Cultivated blueberries (*Vaccinium* L. section *Cyanococcus*), originally derived from native North American species during the past century, have become a major global fruit crop. Significant production areas now can be found in North America, South America, Europe, China, Japan, Australia, and New

Zealand. The United States Department of Agriculture (USDA) National Clonal Germplasm Repository (NCGR) in Corvallis, OR, is responsible for preserving genetic diversity of this important genus and its crop wild relatives, and maintains a national collection of 1689 accessions representing 91 species from 39 countries. Trueness-to-type of the blueberry plants in this collection must be ensured for scientific, commercial and public needs. Use of an economical genetic fingerprinting set can assist in the reduction of clonal redundancy or elimination of inaccuracies for efficient conservation. The objective of this study was to develop an efficient and economical fingerprinting set that consists of reliable primer pairs that can be multiplexed in a single PCR reaction and differentiate genetic variants. Seventeen microsatellite, or simple sequence repeat (SSR) primer pairs, flanking core tandem repeats of three nucleotides were screened for polymorphism and ease of scoring in seven diverse blueberry cultivars. Five of these 17 primer pairs were selected to compose a single multiplex set and were evaluated in 287 blueberry plants preserved at the NCGR. The blueberries selected for evaluation were chosen based on the largest numbers of requests mostly from the scientific community. Two to four replicate plants with the same name were included in the study and represented a total of 126 accessions. Eight accessions represented by a single plant were also included. One of the individuals from a set of five accessions with the same name had a unique genetic profile. Six pairs of accessions that had different names had identical SSR-based fingerprints. Additional SSRs will determine if the identical fingerprints of differently named cultivars is the result of low discriminating power of the fingerprinting set or by plant misidentification.

(349) Characterization of Libyan Olive (*Olea Europaea* L.) Cultivars using Morphological Data

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Olive (*Olea europaea* L.) consumption and production are important socially and economically in Libya. Olive cultivars that are adapted to local conditions produce olives that have high oil quality and quantity. Many of the important Libyan olive cultivars were included in this research. One goal of our project was to determine the plasticity of morphological traits collected from olive cultivars that have been grown at diverse locations

An asterisk (*) following a name indicates the presenting author.

within Libya. Another goal was to identify a set of traits that are independent and stable regardless of the environmental growth conditions. This set of traits can then be used in subsequent analyses to correlate genetic and phenotypic characteristics of Libyan olives. We compared two different groups of olive: 45 local cultivars and 45 introduced cultivars of *Olea europaea sativa*. Morphological data were collected for quantitative traits such as fruit weight, volume, width and length as well as seed and leaf weight, width and length. Scanned images were analyzed to determine cross sectional area and perimeter for fruit, leaf, and seed samples. Qualitative data were also collected for fruit and seed shape, symmetry, surface characteristics using standardized descriptors. Large differences were observed for many of the morphological traits across the diverse cultivars. We plan to use these sets of data to develop methods to identify unique and desirable Libyan cultivars morphologically and to then use these data as part of our genetic analyses.

(350) ‘CaroTiger’: A New, Late-season Peach Cultivar for the Southeastern United States

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In June 2012, the late-season peach selection SC82035-13-48 was named and released as ‘CaroTiger’ by the South Carolina Agricultural Experiment Station at Clemson University. The original cross was made by D.W. Cain. It was selected by W.C. Newall, Jr., and long-term evaluation and release preparation was made by D.R. Layne. The pollen parent was MSU57202-002 and the female parent was ‘Parade’. ‘CaroTiger’ requires 800–850 hours chilling to overcome dormancy. It has a nonshowy bloom that appears about 4 days before ‘Redhaven’ in South Carolina. The fruit development period in Seneca, SC, is 152 days. It is commercially harvested a few days after ‘Flameprinc’e and a few days before ‘Parade’ in most years. It is a suitable replacement for either cultivar or a suitable companion to them in a late-season series. Fruit are globose with a fairly prominent suture and occasional slight suture bulge. When trees are properly thinned, the average fruit size exceeds 3 inches in diameter. At maturity, fruit has a very attractive yellow/orange background with nice red overcolor. It is not solid red. Flesh is melting with some red anthocyanin pigmentation near the pit. It is completely freestone. Fruit does not soften too rapidly and it is suitable for both local and distant marketing. Fruit has normal acidity, excellent eating quality, and from 11–15 °Brix at maturity. Virus-free scionwood is being multiplied at the Clean Plant Center for Fruit Trees (WSU-Prosser). Scionwood will be propagated through South Carolina Crop Improvement Association to licensed nurseries.

Specified Source(s) of Funding: Clemson University Agricultural Experiment Station

Tuesday, July 23, 2013

12:15–1:00 PM

Herbs, Spices, and Medicinal Plants

(168) Field Performance and Medicinal Constituents of *Echinacea purpurea* and *Echinacea angustifolia* Varieties Grown in Eastern Washington

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A field experiment was initiated in 2012 at the Amway Corporation certified organic farm in eastern Washington state. Commercially available varieties (6 of each species) of *Echinacea purpurea* (Purple Coneflower) and *Echinacea angustifolia* (Narrow-Leaf Coneflower) were evaluated in a RCB, strip-split block field design, with 3 replications. Year of harvest [age of the plants at harvest] were the main blocks, with replications sub-blocked within each year, and varieties randomized within years. Individual experimental units consisted of 4 rows spaced 39 cm apart and 3 m long. For *E. purpurea*, the center two rows were harvested for aerial tops at an early bud stage, and roots near the end of the growing season. *E. angustifolia* roots were also harvested near the end of the growing season. Fresh and dry weights of aerial parts and/or roots from each experimental unit were recorded, and sub-samples collected for analytical chemistry and elemental analysis. The project will run for 3 years, and this report focuses on the year 1 results.

(169) Mint in Mississippi Nitrogen Fertilizer Study

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Mint has shown a potential as an essential oil crop for the southeastern United States. ‘Native’ spearmint and ‘Arvensis II’ Japanese cornmint were grown in field studies conducted in 2011 and in 2012 at two locations in Mississippi: the North Mississippi Research and Extension Center at Verona and at Westside Farms, in Friars Point, MS. The treatments were the nitrogen rates of 150, 200, 250, and 300 lb N/acre at two locations. Dry weight, plant height, essential oil yield, and essential oil composition were analyzed. One half of the N (0–0–46) for each treatment was applied in early spring and the other half applied 7 days after the first harvest. Beds were formed with a standard 4-row bed-roller spaced 38 inches apart. Mint was transplanted (May 2011) in the field using a wagon wheel transplanter, with 1-ft in-row plant spacing. Irrigation was used at both locations. Harvesting was done at initial flowering, representative samples were weighed immediately and air dried 5–7 days. Dried mint samples (8.82 oz dried material), were steam distilled for 45 minutes for extraction of the essential oil. The average oil yield of ‘Arvensis II’ (52.4 lb/oil per acre) was significantly greater than ‘Native’ spearmint (39.6 lb/oil per acre) over both locations and harvest dates. Nitrogen rates had no effect on dry weight and plant height. Nitrogen had an effect on oil yields at Friars Point and on the concentration of carvone in ‘Native’ spearmint oil. ‘Arvensis II’ plants were taller (38.2 inches) than ‘Native’ spearmint plants (26.8 inches). The dry weight of the plants was greater at Verona (4,090 lb/acre) compared to Friars Point (2,910 lb/acre), and ‘Arvensis II’ provided greater dry weight (3,926 lb/acre) than ‘Native’ spearmint (3,020 lb/acre). The concentration of carvone in ‘Native’ spearmint oil was greater at Friars Point compared to Verona. The results suggest ‘Native’ spearmint and ‘Arvensis II’ Japanese cornmint can be viable crops for Mississippi and provide essential oil with desirable composition and yield.

(170) Comparison of Anthocyanin Contents in Amaranth Sprouts According to the Different Cultivation and Low-temperature Treatment

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This study was conducted to clarify the effects of culture condition and light or dark treatment to the anthocyanins of four edible amaranth cultivar’s sprouts. We germinated and grew the amaranth sprouts in four conditions: 1) hydroponic culture in growth chamber (23 °C); 2) soil culture in growth chamber (23 °C); 3) soil culture in greenhouse; and 4) grown in field. Anthocyanin content was the highest under greenhouse and field conditions, the lowest value was in soil culture in growth chamber. The effect of low temperature treatment on the anthocyanin content was investigated. Amaranth sprouts grown in the greenhouse were treated low temperature. The low temperatures were 8, 12, 16, and 20 °C. After 1 week, we investigated the fresh weight of sprouts and sampled for analysis of anthocyanin content. Anthocyanin content was the highest at 12 °C, followed by 16, 8, and 20 °C in that order. We investigated the changes of anthocyanin content when treated light and dark at 12 °C. The fresh weight, length, and width of sprouts were the highest in the control, but the anthocyanin content in sprouts was higher in the dark treatment than in the light treatment. Results show that amaranth sprouts grown to a low-temperature and dark treatment increased the anthocyanin content.

(171) Characterizing Biomass Accumulation and Nutrient Uptake In Situ over Time in Wisconsin Peppermint and Spearmint

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Mint is a perennial crop in Wisconsin, which historically survives at least 5 to 8 years per rotation. However, many Wisconsin mint oil producers are currently finding it difficult to keep a healthy stand for more than 3 years. This is especially true of Scotch spearmint. Although many factors contribute to this change, our research focus was to observe plant growth in a holistic manner since there is little understanding as to how the plant grows vegetatively and reproductively. Our experiment collected data on biomass accumulation and major nutrient uptake in above ground (stems and leaves combined) and below ground portions

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of the mint plant (stolons). Because stolons are characterized as the reproductive, overwintering portion of the plant, healthy and unhealthy stolons were separated for evaluation to determine potential overwintering effects and nutrient uptake. The experiment was performed on both mineral and muck soils, on peppermint and Scotch spearmint. Results included a clear shift in nutrient uptake over time between the vegetative and reproductive parts of the plant as compared between repeated procedures and soil types.

Specified Source(s) of Funding: Wisconsin Specialty Crop Block Grant

(172) Identification of Host Resistance to Basil Downy Mildew (*Peronospora belbahrii*)

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In addition to being the most widely cultivated and economically important basil species, sweet basil (*Ocimum basilicum* L.) is also the most susceptible to downy mildew (*Peronospora belbahrii*). Significant crop losses have been experienced annually since the first reports of this disease in Europe and more recently in the United States. Although chemical control is available, registered products remain limited and costly. Thus, there is a hastened need for identification of host resistance. Two commercial varieties, *Ocimum americanum* ‘Spice’ and *Ocimum citriodorum* ‘Sweet dani’, have been previously reported as potential sources of resistance to basil downy mildew in a 2009 field trial. A leaf inoculation assay was developed for detection of basil susceptibility to downy mildew in controlled environmental conditions. Three commercial varieties, representing three *Ocimum* spp., were screened at the cotyledon, first true leaf set, and second true leaf set growth stages. All plants were evaluated for the presence of sporangiophores on the abaxial leaf surface daily for 15 days. *O. basilicum* ‘DiGenova’ was completely susceptible at all growth stages, while *O. americanum* ‘Spice’ displayed no signs or symptoms at any growth stage. *O. citriodorum* ‘Sweet dani’ exhibited a decreased mean disease incidence (DI) with increasing growth stage. Breeding and genetic implications are discussed.

Specified Source(s) of Funding: USDA-SCRI grant #2011-51181-30646

(173) Source-demand Relations in Varieties of Basil in Two Protected Environments

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The objective of this study was to compare the growth potential and total biomass production on three varieties of basil (*Ocimum* sp.) under soilless culture and two protected environments. The experiment was set up in a greenhouse and a shade house located in Xalisco, Nayarit in western Mexico during Fall 2012–Winter 2013. Steiner solution was used at concentration level of 75%, using three commercial varieties of basil (‘Thai’, ‘Dolly’, and ‘Medinette’). A randomized complete-block experimental design with five replicates was used. Periodic samples of five plants per experimental unit were recorded: plant height, leaf number, leaf area, and above-ground dry biomass. The leaf area index and net assimilation rate were recorded. The results showed significant differences for plant height, leaf number, and leaf area as a result of the production environment. Net assimilation rate depends on the growth and yield biomass production.

Specified Source(s) of Funding: PROMEP/103.5/12/3399

(174) The Effect of Population Density in the Yield of Two Varieties of Roselle (*Hibiscus sabdariffa*) Grown in Nayarit, Mexico

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In Mexico, Roselle (*Hibiscus sabdariffa*) is a crop of increasing popularity for its medicinal properties. The objective was to determine the effect of population densities 8,000, 10,000, 13,333, and 20,000 plants/ha on yield (dry weight of calyces) of China and UAN-6 varieties. This research was carried out during the spring–summer season of 2012 at northern Nayarit, Mexico. ‘China’ is widely used in western Mexico and ‘UAN-6’ is an outstanding experimental variety from the Roselle breeding program at the Universidad Autónoma de Nayarit. To achieve the evaluated population densities,

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the spacing between plants was 50, 75, 100, or 125 cm and the distance between rows was 1 m in all treatments. The experimental design was a randomized complete block with five replications. For ‘China’, the highest yield (1,253 kg·ha⁻¹) was obtained at a population density of 20,000 plants/ha. For ‘UAN-6’, the highest yield was obtained with 13,000 plants/ha (1,759 kg·ha⁻¹).

Specified Source(s) of Funding: CONACYT-Mexico

Fruits)] had opportunity cost of between \$429 to \$1,717 and \$259 to \$1,034, respectively, each of which were less than the English version of the article. Although it presents an incomplete picture of the impact of the article, deriving the opportunity cost allows authors of online articles to see how readers value their time and the investment they are willing to make to read online information.

Specified Source(s) of Funding: USDA-NIFA-SCRI

Tuesday, July 23, 2013

12:15–1:00 PM

Marketing and Economics

(056) Estimating Value of e-Xtension Grape Community of Practice Spanish-translated Articles

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Many vineyard workers throughout the United States do not speak English as a first language. Information translated into Spanish can help many of those workers better understand concepts that relate directly to their job performance. In 2010, the eXtension Grape Community of Practice began the task of translating articles into Spanish to extend information to an underserved portion of their community of interest. To date, over 100 articles have been translated into Spanish. Google Analytics data revealed that in some cases, the Spanish versions receive more unique page views and have longer reading times than the English version. South American Spanish-speaking countries and others such as Mexico and Spain have been frequent readers of the online articles. Assessing impact of these interactions is difficult; however, using economic models such as estimated time allocation (investment) or opportunity cost could help assign a monetary value to each page view. The top three Spanish articles were paired with their English counterparts for analysis. Average household net-adjusted disposable income data was obtained from OECD.org to calculate the opportunity cost. We assumed in this case that the information was used for work and that hours worked were flexible, allowing for use of hourly wage as a model input. Leisure time, valued at 1/3 of work time, was also used as a comparison. This data coupled with “unique page views” and “time spent on page” from Google Analytics (Dec. 2010 to Mar. 2013) resulted in values being derived for all six articles. The top Spanish article [(Partes de la planta de uva: Brotes (Parts of the Grapevine: Shoots))] had an opportunity cost of between \$1332 to \$5,326, besting the English version (\$787 to \$3,149). The other two articles [(Injerto de las Plantas de Uva (Grafting Grape Vines); Partes de la Vid: Flores y Frutos (Parts of the Grapevine: Flowers and

(057) Economic Profitability of Growing Lettuce and Tomato in Western Washington under High Tunnel and Open Field Production Systems

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Lettuce and tomato are popular fresh market vegetable crops. In western Washington, there is interest in growing them in high tunnel production systems due to the region’s mild, marine climate. The objectives of this study were to contrast the economic potential of growing lettuce and tomato under high tunnel and open field production systems, and identify the main factors affecting profitability within each production system. Economic data for this study were collected by interviewing experienced lettuce and tomato growers in western Washington during focus group sessions. Costs of production varied by crop and production system, and findings indicated that it was five times more costly to grow lettuce and eight times more costly to grow tomato in a high tunnel than in the open field in western Washington. For lettuce, the labor cost per square foot of growing area was found to be 6 times greater in a high tunnel than in the open field; and for tomato, the labor costs were 10 times greater in a high tunnel than in the open field. Total labor cost comprised more than 50% of the total production costs of lettuce and tomato in both the high tunnel and open field systems. The percentage of total labor cost was similar in both the high tunnel and open field production for lettuce, but was higher in high tunnel tomato production than in the open field. Tunnel-grown lettuce and tomato had three and four times greater marketable yield compared to field-grown, respectively. Given the base crop yield and average price, it was 43% more profitable to grow lettuce in the open field than in the high tunnel, while in contrast, high tunnel-grown tomato was three times more profitable than open field tomato production.

Specified Source(s) of Funding: This study is funded by the NIFA Specialty Crops Research Initiative, USDA SCRI-SREP Grant Award No. 2009-02484

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Tuesday, July 23, 2013

12:15–1:00 PM

Ornamentals/Landscape and Turf

(030) Green Roofs: Water Recycling Effect on Water Quality and Soil Chemistry

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Green roofs can improve urban environments by reducing the amount of runoff and in some cases improve the quality of runoff leaving urban areas. Water quality and soil chemistry of four green roofs in Houston that harvest and recycle rainwater and irrigation runoff were investigated. The green roofs vary in age from 2.5 to 8 years. Continuous recycling of water is expected to decrease soil and water quality and in turn decrease plant productivity. Soil cores, irrigation samples, and runoff samples were collected and analyzed. Preliminary irrigation samples indicate that the sodium absorption ratios (SAR) are below 2 which are not concerning. Electrical conductivity is relatively high (450, 450 475, 300 $\mu\text{S}/\text{cm}$ respective of age) in the irrigation water compared to the soil (all below 200 $\mu\text{S}/\text{cm}$). Soil organic matter percentage was rather high for a green roof substrate ranging from 15% to 18%. Other nutrient concentrations in the soil do not appear to be high enough to become problematic. We will collect more data to accurately quantify the effects of the water recycling system on soil chemistry, water quality and plant physiology of the green roof system under a wide range of environmental conditions.

(032) Conversion of Tall Fescue to Seeded or Vegetatively Propagated Bermudagrass and Seashore Paspalum

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Increasing drought and landscape water use restrictions dictate water conservation strategies, such as switching from warm-season to cool-season turf species. Field studies were conducted in inland (Riverside) and coastal (Irvine) climates of southern California to investigate three methods (scalping, glyphosate application, no removal control) of converting an existing tall fescue (*Festuca arundinacea*) sward to either seed- or vegetatively-propagated warm-season turf. Cultivars established vegetatively by plugging included TifSport hybrid bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) and 'Sea Spray' seashore paspalum (*Paspalum vaginatum*). Cultivars established from seed were Princess 77 common bermudagrass (*Cynodon dactylon*) and 'Sea Spray'. Establishment of warm-season turfgrasses into live tall fescue (no removal control) was not effective as evidenced by only 1% groundcover in the seeded plots at the end of the study. Scalping was better but still ineffective as a conversion strategy, as none of the bermudagrasses or seashore paspalum reached 50% groundcover within 1 year after planting. All of the species reached a higher percentage of groundcover at the end of the study when glyphosate was applied to tall fescue before propagation compared to the other conversion strategies. 'Princess 77' and 'Sea Spray' established from seed, and 'TifSport' from plugs provided the best overall establishment with 97%, 93% and 85% groundcover, respectively when glyphosate was used prior to establishment. In comparison, 'Sea Spray' propagated from plugs reached only 55%. Quality of seeded cultivars matched or exceeded that of cultivars established vegetatively by plugging. Location did not have an effect on final establishment suggesting that bermudagrass and seashore paspalum can adapt well in different environments. Our results suggest that eradication of cool-season turf followed by establishment of warm-season turf from seed is the best and most cost effective turf conversion strategy.

(033) Does Propagation Method Impact Survival and Growth of Below Grade Planted Trees?

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Rooted cuttings from four clonal taxa ranging from those that

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grow in dry well drained soils, *Chilopsis linearis* (Cav.) R. Sweet ‘White Storm’, to those that tolerate wet soils, *Vitex agnus-castus* L. ‘LeCompte’, and with intermediate soil requirements, *Nerium oleander* L. (unnamed large white flowered clone) and *Lagerstroemia indica* L. x *Lagerstroemia fauriei* B. Kohne ‘Basham’s Party Pink’, and seedlings from each of these same clones were propagated and growth concurrently in a container nursery under the same production conditions. Factorial combinations of each taxa propagated as rooted cuttings and as seedlings were transplanted to a landscape site at four planting depths [7.6 cm (3 inches) above grade, at grade, 7.6 cm (3 inches) below grade, and 15.2 cm (6 inches) below grade] resulting in a 4 planting depth x 2 propagation methods x 4 species factorial in a randomized complete-block design with four blocks containing two plants of each treatment combination per block. An unexpected rapid drop from growing temperatures to 18 °F (–8.8 °C) in Winter 2010–11 permitted assessment of cold injury in response to the planting depth treatments. Propagation method interacted with planting depth and taxa where *Lagerstroemia* responses to cold damage were different among propagation method and planting depth, while *Vitex* and *Chilopsis* were not. Exposure to low temperature had only minimal effects on the canopy survival of *Lagerstroemia*, *Chilopsis*, and *Vitex*, whereas *Nerium* canopy tissue survival was substantially reduced for plants planted above grade. Planting at grade was the best treatment for most characteristics across species and propagation methods, but there were significant interactions involving both planting depth and propagation methods for some taxa. For instance, the arid climate *C. linearis* improved survival with planting above grade, but planting below grade reduced the cross-sectional trunk area of *C. linearis* regardless of propagation method. Growth indices of seedling propagated plants tended to be larger across species when planted at or above grade, but cutting propagated plants exhibited reduced reduction in growth relative to seedling trees compared to those planted at grade. When evaluating the impacts of suboptimal planting techniques, data from this study supports the importance of knowing if the plants are cutting or seedling produced if it is a species that is sensitive to this effect.

Specified Source(s) of Funding: Tree Research and Education Endowment Fund Texas A&M AgriLife Research

(034) Granular Fertilizer Formulations Affect Nutrient Uptake in Perennial Ryegrass Turf

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Phosphorus (P) is an essential element for plant establishment and growth, but its uptake might be impacted by the formu-

lation of fertilizer used. A greenhouse study was conducted during 2011 and 2012 in Riverside, CA, to test nutrient uptake between homogenous pellet and blended formulations of 16N–6P–8K derived from ammonium sulfate, monoammonium phosphate, and muriate of potash, respectively. Perennial ryegrass (*Lolium perenne* L.) ‘Grandslam’ was established in pots containing sand and irrigated with deionized water. Two weeks after seeding, turf received 24.5 kg·ha⁻¹ of N from potassium nitrate (13N–0P–37K). At 4 weeks after seeding, the turf received 98 kg·ha⁻¹ of N from either the pellet or blended formulations. An untreated control was also included to determine nutrient uptake contributed from KNO₃ only. Turf (shoots and roots) in pots was harvested weekly thereafter for 3 weeks, washed free of sand, dried, weighed, and analyzed for tissue nutrient content. Overall, tissue dry weight was not affected by fertilizer formulation. In the first experiment, turf fertilized with the pellet formulation contained higher P and K compared to the blend and the control at one week after application. When the experiment was repeated, significantly higher P was detected in turf fertilized with the pellet formulation at all three harvest dates. Potassium uptake was consistent with the first experiment. Our results suggest that uptake of P and, to a lesser extent, K in turf is increased by use of an homogenous pellet formulation compared to a blended form of the same fertilizer.

(035) Full Sun Landscape Trial of Caladiums in Southeastern Louisiana

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Caladiums are known for being shade tolerant and providing bright colors to the long summer season in the South. Many new varieties released by several breeding programs can tolerate full sun. However, Louisiana landscape professionals are reluctant to use caladiums in full sun because of a lack of information on their performance in southeastern Louisiana. Two trials were conducted at the Hammond Research Station in 2012 and 2013 with 55 selected varieties. The objectives were to evaluate emergence earliness, sun damage, and overall visual quality under full sun and in comparison to partial shade. Plants were grouped into fancy leaf or lance leaf groups, each having four sub-groups: red, white, pink, or multicolor. Top performing varieties were selected for each leaf type by leaf color class. Best-in-class varieties were also selected for partial shade. Changes in plant size, leaf size, number of leaves, and foliage color under full sun vs. shade were also documented

An asterisk (*) following a name indicates the presenting author.

and compared. Results were communicated with the industry. Growers and landscape professionals from southeastern Louisiana are using our recommendations to choose caladiums for their production or customers.

(036) Urban Tree Selection in a Changing Climate

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Current climate projections indicate that mean global temperatures will increase 1 to 2 °C by 2050 and an additional 1 to 3 °C by the end of the century. Trees in urban and community forests may be especially vulnerable to climate change since general warming will be exacerbated by urban heat island effects. The long-term goal of this project is to identify street tree cultivars that show a high potential to acclimate to potential climate change. We are conducting the project in two phases. In Phase 1, we conducted a greenhouse study to determine the relative ability of street tree cultivars to acclimate their physiological responses to changing temperature regimes. Trees (5- to 6-ft whips) of nine shade tree (*Acer rubrum* 'Frank Jr.', *Acer saccharum* 'JFS-Caddo2', *Acer truncatum* x *platanoides* 'Warrenred', *Carpinus betulus* 'Fastigiata', *Gleditsia triacanthos* 'Skycole', *Liriodendron tulipifera* 'JFS-Oz', *Pyrus calleryana* 'Glen's Form', *Quercus bicolor*, and *Ulmus propinqua* 'JFS-Bieberich') were grown in #10 (34 L) containers under three temperature regimes (ambient, ambient +5 °C, ambient +10 °C) in a greenhouse trial during Summer 2012. Following 2 months of temperature acclimation, we developed photosynthetic temperature response curves for each species or cultivar. Among the species and cultivars evaluated, *Q. bicolor* showed the greatest temperature acclimation and maintained relatively high net assimilation rates at elevated temperatures. In Phase 2 of the project, we planted larger (#25, 104 L) container-grown trees of the same species and cultivars on two sites with contrasting temperature profiles (urban heat island vs. park-like conditions) near downtown Detroit. Field sites were established in cooperation with the Greening of Detroit, a community based tree planting program. We will present initial results and long-term plans for the out-planting portion of the study.

Specified Source(s) of Funding: MSU Project GREEN, J. Frank Schmidt Family Charitable Foundation, Michigan Nursery and Landscape Association

(037) Early Germination Response of Lodgepole Pine Seeds to Imbibition with a Commercial Extract of *Ascophyllum nodosum*

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Increased stress resistance has been reported in various crops treated with *Ascophyllum nodosum* (L.) Le Jolis extract (ANE). Forest nurseries strive for vigorous and synchronous germination because it is key to producing uniform conifer seedling crops. Seeds of most conifer species require cool, moist stratification to break endodormancy before sowing, and stratification guidelines have been developed to optimize germination for each species. In conifer crops sown in greenhouses or outdoor compounds from early spring through early summer, controlling temperature and moisture during germination has always been crucial. Now, under a changing climate, hotter, drier weather is occurring during this period, resulting in heat and drought stress on germinants and reducing crop yields. We hypothesized that ANE would improve stress resistance in germinants, thus providing forest nurseries with a climate-change adaptation tool. We present only the initial phase of the study here. The objective of this trial was to determine if, and at what rate, ANE would improve germination response in lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.). The trial was conducted at Natural Resources Canada's National Tree Seed Centre using seed collected from two natural stands in, respectively, southern British Columbia and central Yukon Territory. Seed was stratified for 21 d at 3 °C. We placed absorbent, multi-layered, cellulose wadding in rectangular, transparent plastic germination boxes and wetted it with solution, which was commercial ANE in distilled water at the following rates, listed in increasing concentrations: 1:2000, 1:1500, 1:1000, and 1:500. Distilled water alone served as control. We placed 25 seed of each seedlot in a box before placing the closed boxes in a germination cabinet at 30:20 °C day:night temperature, 8-h photoperiod supplied by fluorescent tubes, and constant 85% relative humidity, in accordance with International Seed Testing Association rules. We checked boxes at the same time daily, recording the germination status of each seed, scoring a seed as germinated at radicle length ≥ 5 mm. Germination was not evident in control and treated seed on day 3. By day 4, germination percentage for control, 1:2000, 1:1500, 1:1000, and 1:500 was 30%, 24%, 28%, 52%, and 28%, respectively. Germination percentage for control, 1:2000, 1:1500, 1:1000, and 1:500 was 80%, 88%, 84%, 92%, and 68%, respectively, on day 5. By day 6, 96% of control seed and 92% to 96% of treated seed had germinated. There was no difference in germination percentage for control and treated seed on day 7.

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(038) Daily Fluctuations of Chlorophyll Efficiency of Dark-adapted Rhododendron and Kidney Beans

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Phytophthora ramorum is a major risk to interstate trade of nursery stock. Our work focuses on chemical oxidant chemistry as a disinfectant on nursery-grown rhododendron. Disinfection of the plant is crucial, but the impact on plant health and phytotoxic responses are also important. To determine plant stress responses to applied chemical oxidants, we are measuring chlorophyll activity (PSII quantum efficiency). However, to determine the most effective time of day for replicate measurements of chlorophyll activity, we designed this study to determine if daily circadian rhythm impacts chlorophyll activity as measured by Fv/Fm values in dark-adapted rhododendron and kidney bean plants. Data were collected using a LI-COR 6400 Leaf Chamber Fluorometer (LI-COR, Lincoln, NE). Chlorophyll activity for rhododendron foliage resulted in no measurable differences ($P < 0.05$) in Fv/Fm of 0.800 at 0700 hours to 0.785 at 1930 hours. Chlorophyll activity for kidney bean decreased linearly from Fv/Fm of 0.800 at 07300 hours to 0.780 at 1930 hours. These results indicate that the time of day does not significantly influence chlorophyll activity for dark adapted rhododendron and kidney bean plants.

Tuesday, July 23, 2013

12:15–1:00 PM

Plasticulture

(052) Adoption of Plastic Mulch and Drip Irrigation by Small Limited Resource Farmers in North Carolina

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Plastic mulch and drip irrigation can increase vegetable yields, reduce chemical input on weed control, and help limited resource farmers sustain their business. The Cooperative Extension Program at North Carolina A&T State University provides plasticulture program training for field staff and growers in the use of plastic mulch and drip irrigation. In addition, the equipment needed to apply these technologies is available for checkout at no cost to limited resource farmers in four regions of the state. By 2010, at least 105 farmers were involved in the program and more have been added since. In 2010, a multiple-format survey was conducted and 31 farmers responded. Results indicated that 20 participants had not used plastic mulch and 18 had not used drip irrigation prior to the program. All of them started to use plastic mulch and/or drip irrigation after receiving the training. Among them, 29 had fully participated in the program using plastic mulch as well as drip irrigation. One participant chose to use drip irrigation but not plastic mulch. Approximately 90% of respondents indicated that the provided plastic mulch and drip irrigation training saved them money and/or increased their farm income. Seventy-three percent of respondents reported at least \$1000 increased income and 46% reported at least \$5000 more income. Increased crop quality and yield was reported by 96.5% of participants. Crop yield increases ranged from 10% to 300%. All respondents reported that the quality of information they received through the training was excellent or very good. At least 83.5% of farmers made changes to their farms due to the information they received, which included adding new/different vegetable species or cultivars, improving water and fertilizer management, applying organic practices, using less labor and/or buying plastic mulch equipment. Additionally, this program has allowed farmers to take advantage of a cost-share program where farmers can purchase drip irrigation supplies and/or plastic mulch depending on their individual farm needs.

Specified Source(s) of Funding: North Carolina Agricultural and Technical State University Cooperative Extension Program

(053) Effect of Biodegradable Mulches on Environmental Data Collected from High Tunnel and Open Field Settings

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High tunnels are used to protect crops from severe weather events and extend the growing season while mulches are commonly used for weed control in specialty crop production. Our USDA-funded trans-disciplinary research project evaluated conventional plastic mulch, four biodegradable mulches (BioTelo, BioAgri, WeedGuard, and an experimental spunbond PLA), and a no-mulch control in high tunnel and open field production with tomato ('Celebrity') as the test crop. The study was conducted at three locations, Mid-South (Knoxville, TN), High Plains (Lubbock, TX), and Pacific Northwest (Mount Vernon, WA), for three growing seasons (2010, 2011, and 2012). Environmental data collection by mulch treatment included soil and air temperatures (5 cm depth, and top of crop canopy, respectively), relative humidity (RH), and photosynthetically active radiation (PAR). Data were collected using a Hobo U30-NRC weather station installed in the center of one high tunnel and one open field plot at each location. Results showed distinct environmental differences among the three locations. The average soil temperature at Mount Vernon was 10 to 12 °C lower than at Knoxville and Lubbock throughout the three growing seasons. Soil temperature in the high tunnel was 1 to 2 °C higher than in the open field for all three location to -3 °C higher than under paper mulch. At Lubbock, soil temperature under conventional plastic mulch was 3 to 6 °C higher than under spunbond PLA and the no-mulch treatment. The average RH at Lubbock was 40% lower than at the other two locations. RH in the open field was 2% to 5% higher than in the high tunnel at Knoxville and Mount Vernon, but at Lubbock RH did not differ between the high tunnel and open field. As expected, the monthly average PAR was 200–300 μE higher in the open field than in the high tunnels at all three locations. The greatest difference in PAR between the high tunnel and open field was at Lubbock, followed by Knoxville and Mount Vernon. These environmental data provide useful information for interpreting findings from concurrent studies on crop production (e.g., yield, disease incidence, and weed control) and degradation of different mulch treatments.

Specified Source(s) of Funding: USDA-SCRI

(054) Grafting Influences on Fruit Yield of Tomatoes Grown in a High Tunnel

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There has been a large increase in the use of high tunnels for vegetable production in the United States. While high tunnels offer well-defined benefits, growers have difficulty practicing crop rotation. This increases risks of soilborne disease. Past studies have shown that grafting tomatoes onto disease resistant rootstocks can protect plants from soil borne disease, and improve plant growth and yield. A 2-year study was conducted in research high tunnels at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ, to determine if grafting affected tomato yield and quality independent of disease pressure using a bag culture system. The trial compared four tomato cultivars (BHN589, Primo Red, Red Deuce, and Scarlet Red) grafted onto 'Multifort' rootstock in 2011 and 'Maxifort' rootstock in 2012 with ungrafted plants. Plant height and total yield was greater for all four cultivars from grafted plants than ungrafted plants in both years. There was a significant interaction between cultivar and grafting treatment for total yield in 2012 ($P = 0.0022$) but not in 2011 ($P = 0.1202$). Average fruit size was significantly increased by grafting in 2012 but not in 2011. Grafting tomato plants is a useful tool for high tunnel growers when unable to rotate crops subject to disease pressure, and for increased productivity in the absence of disease pressure.

(055) Leafy Vegetable and Herb Production and Costs in High Tunnels in the Arid Southwest

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Low cost high tunnels are unheated, structures built from PVC or metal pipe and polyethylene glazing or shade cloth. They provide protection from adverse weather conditions such as rain, snow, wind, and hail and buffer plants from temperatures below freezing. These tunnels are an alternative controlled environmental agriculture structure for growers interested in crop production but without the need for high initial capital investment in greenhouses which contain full automation of their production systems. Currently, there is much interest in small scale, local food production, but many beginning farmers are not aware of the costs of production, which include initial investments for infrastructure, supplies, and labor. The objective of this study

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is to document the cost of production of leafy vegetables and herbs in low cost high tunnels in the arid Southwest. Two high tunnels with the dimensions of 4.2 m by 12.8 m (14 x 42 ft) were constructed with raised beds at the University of Arizona Campus Agriculture Center in Tucson. Kale (*Brassica napus* var. *pabularia* cv. Red Russian), spinach (*Spinacia oleracea* cv. Bloomsdale), arugula (*Diplotaxis tenuifolia* cv. Sylvetta), and cilantro (*Coriandrum sativum* cv. Santo) were direct seeded in Dec. 2012 in replicated plots in the two high tunnels. Tunnel remained closed for passive heating from solar radiation during seed germination and crop establishment. Air and soil temperatures in the tunnels were recorded and minimum temperatures were -7°C and 4.5°C , respectively, while maximum air temperature briefly exceeded 38°C and soil temperatures reached 17°C . Mild injury on heat tolerant kale was detected, none of the other crops sustained freeze damage. Harvesting of mature leaves from each crop began 59 days after planting and was repeated when sufficient new leaf material was produced. Average harvested fresh and dry weight per square meter of production area for the different species were as follows: spinach 580 g and 55 g; kale 758 g and 72 g; arugula 442 g and 49 g; and cilantro 927 g and 118 g. Material costs and time for construction of the high tunnels, preparation of the raised beds, and sowing, maintaining and harvesting crops were documented to estimate construction and labor costs for this type of business. This information will assist beginning farmers in making sound financial decisions when investing in high tunnels.

Tuesday, July 23, 2013

12:15–1:00 PM

Pomology

(089) Apple Rootstock Response to Prohexadion Calcium and SPAD Readings in a Non-cropping Year

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Application of prohexadione calcium (PC) beginning shortly after petal fall can prevent excessive vegetative growth. Recommended application timing is 2.5 to 7.5 cm shoot length. There is little information about application at later stages. The study block consisted of 10th leaf 'Golden Delicious' trees grafted onto M.9 T337, M.26 EMLA, and G.16. Applications of PC were made on 30 May, 13 June, and 26 June at rates of 125 ppm and 188 ppm with a handgun to drip. At the time of first application average shoot growth was 21, 20, and 18 cm for M.26, M.9, and G.16, respectively. Two weeks after the first application shoot growth was significantly reduced for all rootstocks for both rates of PC compared to the control. Shoot growth by

rootstock was significantly lower for trees on G.16 than on M.9 or M.26. After the subsequent applications (13 May and 26 June) there was a significant rootstock x treatment interaction. G.16 trees receiving the 125 ppm treatment had significantly less growth than the control while those receiving the 188 ppm were not significantly different from the control. For the other two rootstocks the increase in growth was inversely related to the PC rate. Chlorophyll level as measured by SPAD meter was significantly lower for trees on G.16 rootstock. Rootstock also influenced total shoot growth at the end of the season.

Specified Source(s) of Funding: State Horticultural Association of Pennsylvania

(090) Changes of Cold Hardiness, Dehydrins, and Their Gene Expressions in Response to Deacclimation and Reacclimation in Peach (*Prunus persica*)

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Changes of cold hardiness were estimated in the shoots of two peach seedlings (*Prunus persica* cvs. Daewol and Kiraranokiwami) during repeated experimental deacclimation and reacclimation. In addition, changes of dehydrins by SDS-PAGE and their related gene expressions by a quantitative real-time RT-PCR were examined to find out the relationship with cold hardiness. During the first deacclimation, relative electrolyte leakage (REL) values of two cultivars increased more than each control, indicating that their cold hardiness declined. When deacclimated two cultivars were reacclimated first, REL values, indicating that their cold hardiness was regained, decreased. And then, REL values of two cultivars reexposed to warm temperature by the second deacclimation increased more than those of the first deacclimation, and 'Kiraranokiwami' was entirely deacclimated. After that, when 'Daewol' was reexposed to low temperature by the second reacclimation, REL values

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of 'Daewol' increased more than those of the first reacclimation. Finally, 'Daewol' was entirely deacclimated by the third deacclimation treatment. Changes of dehydrins and their gene expressions (*PpDhn1*, *PpDhn2*, and *PpDhn3*), also positively correlated with changes of cold hardiness throughout the experiments. Our results indicate that recent repeated warm spells may cause premature deacclimation in late winter and early spring, and 'Daewol' may be more flexible to freezing injury caused by unstable temperature conditions.

Specified Source(s) of Funding: This work was carried out with the support of "Cooperative Research Program for Agricultural Science & Technology Development (Project No. 907129)" Rural Development Administration, Republic of Korea.

(091) Quality of Bartlett Pears Subjected to Phytosanitary Irradiation Treatment Followed by Commercial Distribution and Simulated Retail Display

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California exports about 36,000 tons of Bartlett pears (*Pyrus communis* L.) each year. Methyl bromide is used as a phytosanitary treatment on pears, but with its imminent phase out, alternative treatments are being sought. Irradiation is used as a phytosanitary treatment for various tropical fruit but little is known about its effect on the quality of 'Bartlett' pears. The objective of this study was to determine the effect of X-ray irradiation on the physicochemical properties and sensory attributes of early and late harvest Bartlett pears. Following harvest, the size 135 pears were stored at 30 to 32 °F for approximately 2 weeks. The pears contained in 36-lb tight fill cartons were treated at a target dose of 0.4 kGy and stored at 39 to 41 °F for another 2 weeks. The pears were removed and stacked in layers to simulate retail market display and allowed to ripen at ambient temperature. During ripening, the pears were tested daily for respiration rate, ethylene production, firmness, titratable acidity, total soluble solids, color, visual damage, and weight loss. When the pears were at peak ripeness, acceptability testing was conducted with 100 consumers to determine their liking of appearance, flavor, texture, and overall liking of control and irradiated pears. There were significant differences in the responses of the early and late harvest pears to irradiation treatment. The early harvest pears showed little difference from the control for firmness, weight loss, and TSS. Ethylene production was lower for early and late harvest pears, and respiration rate was significantly higher ($P \leq 0.05$) in late harvest irradiated pears. Appearance of the pears was rated lower by consumers but there were little differences in rest of the attributes: texture, flavor, sweetness perception, and overall liking. However, consumers rated the late harvest irradiated pears 0.5–0.6 points lower than the irradiated pears for overall liking, appearance, texture, and flavor on a 9-point

hedonic scale. Consumers perceived the irradiated pears to be less sweet than the control, which correlated with total soluble solids of 12.1% for irradiated pears vs. 13.7% for the control ($P \leq 0.05$). The weight loss of irradiated pears was significantly greater ($P \leq 0.05$) than the control, but the difference was 0.05%. Our results show that there were significant differences between the early and late harvest pears in their responses to irradiation. Given that the late harvest pears were sensitive to irradiation, a lower irradiation dose level might be warranted for maintaining pear quality.

Specified Source(s) of Funding: USDA

(092) Differential Effects of Deficit Irrigation and Reflective Mulch Application on Two Clingstone Peach Cultivars

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The effect of deficit irrigation and reflective mulch on fruit quality of clingstone peach cultivars 'Lodel' and 'Fortuna', which ripen during the second half of July, was studied during 2007. Four treatments were applied for each cultivar: 1) control (C), irrigation applied at 160% of evapotranspiration (ETc); 2) deficit irrigation, irrigation at 75% of ETc in the last 3 weeks before harvest; 3) reflective mulch Extenday® underneath the tree canopy on the tree row applied three weeks before harvest; and 4) the combined treatment of reflective mulch and deficit irrigation. Quality was assessed with fruit harvested at commercial maturity from throughout the canopy of the experimental trees. The fruit quality parameters measured included: skin color; firmness, specific conductivity and percent dry mass in the flesh; and acidity, soluble solids content, and total phenolic content in fruit juice. In addition, solar radiation (UV and PAR) underneath the tree canopy was measured. The reflective mulch significantly increased reflected UV and PAR to the lower canopy of peach trees compared to the reflected light from the soil underneath the control trees. Deficit irrigation of 'Fortuna' peaches delayed ripening with overall reduction in fruit quality compared to control peaches. In the same cultivar, reflective mulch combined with excessive or deficit irrigation did not affect fruit quality compared to control, but had improved quality compared to fruit from deficit irrigated trees. In contrast, 'Lodel' peaches of deficit irrigated or reflective mulched trees and their combination treatment had better quality (or advanced maturity) compared to fruit from control trees.

(093) Morphological Characterization of Early Floral Development in Apple, Pear, and Cherry in the Midwestern United States

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A comprehensive evaluation of floral morphogenesis was undertaken in order to characterize the early floral development of apple, pear and cherry flower buds in Ohio. Changes in flower bud morphology were studied during a whole season using apple, pear and cherry cultivars of ‘Fuji’, ‘Bartlett’, and ‘Regina’, respectively, located in a commercial orchard in Berlin Heights, OH. Collection of samples was performed from 40 days after full bloom (DAFB) in all species with a sampling interval of 15 days during spring and summer and 30 days thereafter. Buds were dissected under a stereomicroscope, classified into different stages, prepared and imaged by a scanning electron microscope. In apples, significant broadening of the meristems occurred by 40 DAFB. Four to six lateral floral meristems per flower were consistently seen from 55 to 110 DAFB. Terminal floral meristem initiation took place around 110 DAFB. Up to 160 DAFB, terminal and lateral flowers had developed in most samples with the final sepal number (5) completed. Stamens slowly started to differentiate first in the terminal flower 155 DAFB, and by 230 DAFB most flower meristems had initiated all flower organs. Pears followed the same sequence of flower organ differentiation but with shorter periods of times between stages. A pronounced domed inflorescence meristem was observed 60 DAFB. Lateral flower meristems were rapidly initiated in the bract axils in 10 days after doming. Apex transformed into a terminal flower meristem from 85 to 100 DAFB. By 135 DAFB, the inflorescence is formed and flower organs in the flower meristems started to differentiate. No dominance phenomenon was found between flowers in cherry buds; all flowers developed simultaneously in each stage. At the first collection a prominent broadening of the apex was observed in 95% of the samples, marking the change from vegetative to a reproductive phase. Floral primordia started initially to differentiate from 50 to 75 DAFB and sepal were visible 30 days after this period. Following this stage, the development of petals, stamens, and carpel was evident in this order from 135 DAFB. Flowers enlarged and organs continued to form after 180 DAFB.

(094) Boron Phloem Mobility and Boron Levels in Leaves and Fruit Are Altered in Transgenic Apple Trees with Decreased Sorbitol Synthesis

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It was previously demonstrated in tobacco that introducing sorbitol synthesis even at a very low capacity enables the plants to transport boron in the phloem via the formation of sorbitol-boron-sorbitol complexes in the phloem, but the effect of reducing sorbitol synthesis in species where sorbitol is a major end product of photosynthesis and translocated form of carbohydrates remained unclear. In this study, we used transgenic apple trees with approximately one-half or two-thirds of the sorbitol biosynthetic capacity of the untransformed control to determine the effect of decreased sorbitol synthesis and transport on phloem mobility of boron and boron levels in leaves and fruit. Five-year-old trees of the two transgenic lines along with the untransformed control were grown in pots and provided with complete nutrient solution via fertigation. Compared with the untransformed control, the transgenic lines accumulated only 36% to 40% of the control boron levels in fruit, but about 2.8 times higher boron levels in leaves by fruit harvest. When 10B was applied to bourse shoot leaves in mid-season, more 10B was retained in the leaves and less 10B was translocated to the fruit on the same fruiting spur in the two transgenic lines than in the untransformed control by the end of a 12-day period. These results indicate that decreasing sorbitol synthesis (and its corresponding translocation in the phloem) reduces boron phloem mobility, leading to lower boron levels in fruit but higher boron levels in leaves of apple trees.

(095) Turning the Shaded Side of Apple Fruit to Sunlight Exposure Increases Flavonoids and Total Phenolics in Both the Original Shaded Peel and the Original Sun-exposed Peel of ‘Fortune’ and ‘Mutsu’

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The shaded peel of ‘Fortune’ (a red cultivar) and ‘Mutsu’ (a yellow/green cultivar) apple was exposed to full sun by turning fruit 180° at about 1 week before harvest to determine the expression of key genes involved in anthocyanin synthesis in response to sunlight exposure and their relationships with the levels of anthocyanins and other phenolics. For the unturned (control) fruit, the shaded peel had lower expression levels of *MdMYB10* (a transcriptional factor) and seven structural genes in anthocyanin biosynthesis (*MdPAL*, *MdCHS*, *MdCHI*, *MdF3H*, *MdDFR1*, *MdLDOX*, and *MdUFGT*), and lower levels of anthocyanins and flavonols than the sun-exposed peel in both cultivars. Exposure of the shaded peel to full sun caused marked up-regulation of the expression of *MYB10* and all seven structural genes, which peaked between 6 h and 30 h after fruit

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turning, consequently leading to higher levels of anthocyanins, flavonols, and total phenolics than in the shaded peel and even in the sun-exposed peel of control fruit. Interestingly, the levels of flavonols were higher in the shaded peel of turned fruit (the original sun-exposed peel) than in the sun-exposed peel of both control and turned fruit in both cultivars. These results indicate that sunlight exposure promotes the synthesis of anthocyanins and other phenolic compounds by up-regulating the expression of *MYB10* and the structural genes involved in anthocyanin biosynthesis. Turning shaded fruit peel to sun exposure increases not only the levels of anthocyanins, flavonols and total phenolics in the original shaded peel, but also the levels of flavonols and total phenolics in the original sun-exposed peel of both red and yellow/green apple cultivars.

Tuesday, July 23, 2013

12:15–1:00 PM

Postharvest

(392) Developmental-dependent Responses of Beit-Alpha Cucumber Fruit to Ethylene Are Associated with Re-Dox Homeostasis

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Continuous ethylene exposure induces severe watersoaking of beit-alpha cucumber fruit (*Cucumis sativus* L., cv. Manar). Our previous studies have shown that ethylene-induced watersoaking is a programmed cell death (PCD) associated with increases in reactive oxygen species (ROS). Responses of beit-alpha cucumber fruit to ethylene are developmentally dependent, occurring more rapidly in immature compared with mature fruit. The present study examined ethylene responses of the re-dox system in immature and mature beit-alpha cucumber fruit by evaluating ROS production, antioxidant capacity, and antioxidant enzymes. Immature (69.4 ± 0.8 g) and mature cucumber fruit (400.1 ± 5.5 g) were exposed to continuous air or $10 \mu\text{L}\cdot\text{L}^{-1}$ of ethylene for up to 8 d at 15°C . As anticipated, watersoaking in ethylene-treated immature fruit was observed at 6 d ($35.5 \pm 2.1\%$ of cross-sectional area), concomitant with decreased firmness and increased electrolyte leakage. Ethylene-treated mature fruit, however, exhibited significantly delayed and attenuated watersoaking ($18.8 \pm 1.1\%$ at 8 d) including suppressed changes in firmness and electrolyte leakage. ROS production (H_2O_2 -generating capacity) in ethylene-treated immature fruit increased significantly from 0.29 ± 0.02 to $2.23 \pm 0.22 \mu\text{mol}\cdot\text{mg}^{-1} \text{H}_2\text{O}_2$ protein/min by 4 d, prior to watersoaking

development, then decreased to $0.59 \pm 0.09 \mu\text{mol}\cdot\text{mg}^{-1} \text{H}_2\text{O}_2$ protein/min by 8 d, as watersoaking became more severe. ROS production in ethylene-treated mature fruit increased gradually through 8 d and reached 44% of the maximum value in ethylene-treated immature fruit. Ascorbate content and total antioxidant capacity (ORAC) were higher in mature fruit compared with immature fruit. ORAC in ethylene-treated immature fruit significantly increased concomitantly with enhanced ROS production through 4 d and maintained afterward. Ethylene-treated mature fruit exhibited a gradual increase in ORAC, comparable to the trend of ROS-generating capacity. Activities of superoxide dismutase (SOD) and ascorbate peroxidase (APX) decreased 60.9% and 54.9%, respectively, and activity of guaiacol peroxidase (GPX) increased about 15-fold in ethylene-treated immature fruit by 8 d. However, APX activity in ethylene-treated mature fruit remained high and unchanged through storage. Activities of SOD and GPX in ethylene-treated mature fruit exhibited trends similar to those of ethylene-treated immature fruit but were present at higher levels. These results suggest that enhanced antioxidant enzyme activities and antioxidant levels are associated with suppression of ROS production and watersoaking development in ethylene-treated mature cucumber fruit. We conclude that developmental increases in homeostatic re-dox responses explain the decline in expression of watersoaking responses in ethylene-treated cucumber fruit.

Specified Source(s) of Funding: USDA NIFA Award (SCRI) #2009-51181-05783 and Federal formula funds NE1036.

(393) Leucine Catabolism Affects Acetate Ester Production in Bananas (cv. Senorita)

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The aroma of fresh fruits is an important factor in determining quality and consumer satisfaction. Esters are the major compounds responsible for aroma in most ripened fruits. Isobutyl acetate and isoamyl acetate are the predominant esters, which are bio-synthesized by enzymatic combination of alcohols, derived from amino acids and acyl CoAs, catalyzed by alcohol acyltransferase in bananas. However, ripened 'Senorita' banana has a very poor banana-like aroma production compared to other banana types. In order to elucidate the low level of isoamyl acetate production in 'Senorita' bananas, effect of leucine catabolism on the ester production was investigated in 'Senorita' bananas. Concentration of isoamyl alcohol in 'Senorita' and 'Cavendish' bananas was determined by gas chromatography (GC). Senorita banana pulp was incubated with different precursor compounds; isoamyl alcohol (4 mM), isovaleraldehyde (5 mM), alpha-keto isocaproic acid (10 mM) or leucine (7, 14, 50 mM) separately.

An asterisk (*) following a name indicates the presenting author.

After incubation, formation of isoamyl acetate was determined by GC. The levels of amino acids (leucine, isoleucine, and valine) present in ‘Senorita’ and ‘Cavendish’ bananas were also identified and quantified by capillary electrophoresis. The results indicated that isoamyl alcohol concentration of ‘Senorita’ was lower than that of ‘Cavendish’, which has a rich banana-like aroma. Addition of any of the precursor compounds to the pulp, increased the production of isoamyl acetate. However, only a slight increase in ester production was detected by the addition of 50 mM leucine to the pulp, which was incubated for 5 h. When the pulp was incubated with lower concentration of leucine (7 mM) for 19h, isoamyl acetate production was higher than that of incubated for 5 h with 50 mM leucine. In both banana types, approximately similar amounts of amino acids were detected. In spite of the presence of adequate amount of amino acids in the pulp, the ester forming capacity was rather low in ‘Senorita’, most probably due to lack of isoamyl alcohol. The data obtained from this study indicate that the production of isoamyl acetate ester is considerably low in ripened ‘Senorita’, possibly due to limitations in the conversion of leucine to alpha-keto isocaproic acid by amino acid transaminase and then to isoamyl alcohol.

Specified Source(s) of Funding: Toyo College of Food Technology

(394) Assessing Superficial Scald Risk in ‘Granny Smith’ Apples during Controlled Atmosphere Storage using Biomarker-based Technology

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Assessing and monitoring superficial scald risk at the beginning of and during storage will help fruit producers better manage inventory. Current techniques and tools do not provide an accurate assessment of whether apples will develop this costly disorder. By screening 30,000 potential metabolite and gene expression biomarkers for those whose concentrations change in ways that indicate that scald risk is high. Candidates are validated using multiple storage and crop protectant conditions. We have found biomarkers that indicate that fruit has been exposed to conditions that are conducive to scald and thereby, are at a higher risk for developing it later in storage. Employing this system has allowed for the adjustment of controlled atmosphere storage conditions when scald risk was high, effectively improving the storage outcome in relation to scald incidence and severity. Our project continues to find and validate additional candidates for superficial scald as well as other economically significant apple disorders—soft/scald soggy breakdown, CO₂ peel injury, and firm flesh browning.

(395) Evidences from Individual Studies of Ethylene and 1-MCP Treatment Prove that Volatile Biosynthesis Is Regulated by Ethylene in Apple (cv. ‘Golden Delicious’)

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Ethylene plays an important role in regulating fruit ripening and senescence and directly influences the development of the eating quality of fresh apples, including appearance, color, texture, and flavor. To better understand the regulation of volatile biosynthesis during fruit ripening and to examine the influence of ethylene on expression of volatile biosynthesis genes in fruit, apples harvested at the pre-climacteric stage were allowed to

An asterisk (*) following a name indicates the presenting author.

ripen naturally; or ripening was either stimulated by treatment with $36 \mu\text{L}\cdot\text{L}^{-1}$ ethylene for 24 or inhibited with 1-MCP treatment ($1 \mu\text{L}\cdot\text{L}^{-1}$ for 24 h). Real-time qPCR was used to investigate gene expression in relation to volatile biosynthesis up to 21 days after ethylene treatment and up to 43 days after 1-MCP treatment. Twenty-two genes proposed to be involved in volatile biosynthesis in relation to branched amino acids and fatty acids biosynthesis and metabolisms were selected to monitor gene expression. Through statistical analysis, including ANOVA and principle component analysis (PCA), among the 22 volatile biosynthesis genes, 17 genes changed significantly. Genes encoding BCAT, ArAT and AADC, which may involve in the initial steps in the catabolism of amino acids into aroma volatiles, are up-regulated during ripening process and enhanced after ethylene treatment. Genes related to fatty acid synthesis (ACPs, MCAT, ACPD), the LOX pathway (LOX, HPL, ADH3), the pyruvate pathways (PDC2), β -oxidation (ACAS, CAT, APX, ECH, ACAD), and the final step of volatile ester biosynthesis (AATs) also showed similar increasing patterns during ripening and in response to ethylene treatment. AOS, ADH1, KAT, and BCAT2 decreased with ethylene treatment. Treatment with 1-MCP and ethylene generally produced opposite effects, which provides additional evidence that regulation of these genes is ethylene dependent. Analysis and identification of significant gene expression revealed that volatile biosynthesis, especially fatty acids biosynthesis and metabolism in apple fruit is associated with fruit ripening and responsive to ethylene treatment. The understanding of significant changes of these genes and their function may help to explore mechanisms that control apple fruit ripening and their response to exogenous ethylene during ripening and senescence.

(396) Postharvest Treatments to Maintain Quality and Control Diseases of Cut Flowers

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Main reasons for loss of ornamental value are: flower senescence, deterioration of petals due to microbial caused diseases, loss turgor of petals, stem and leaves by microbial diseases in stalk solution, intolerance of flowers to low temperature and poor postharvest handlings from production to distribution. This project is focusing on pre- and postharvest treatments such as 1-methylcyclopropene (1-MCP) to extend the shelf life of cut flowers. Vase life of four types of cut flowers was evaluated by measuring color, water uptake, chlorophyll fluorescence and other quality parameters. Both ethylene sensitivity and microbial contamination play important roles in determining the vase life of cut flowers. Treatment of 1-MCP significantly delayed the senescence of cut flowers, especially for carnation, rose and gerbera. Antimicrobial agents were also investigated and showed the potential to reduce the microbial population (bacteria, yeast and molds) in stalk solution and to extend the shelflife of the flowers. The optimal condition for application of microbial agents was established for optimal treatment regime for postharvest management of cut flowers. In order to gain molecular insight into flower senescence, quantitative proteomic studies on cut roses were also conducted and provided insight on molecular basis of flower senescence and effect of 1-MCP treatment. Among the 249 proteins identified and quantified. Five cluster can be created and significant up- and down regulated proteins were identified in response to senescence and 1-MCP treatment. Both applied and fundamental knowledge will be beneficial for industry operation and long term breeding program.

(397) Fishing for Biomarkers: A Multivariate Approach to Scrutinize the Combined Metabolome–Transcriptome Profiles on Our Quest toward Biomarkers for Postharvest Apple Disorders

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Timely assessment of the risk for postharvest apple disorders, such as superficial scald, will help fruit producers better manage and optimize their postharvest revenues. As the industry currently is not able to predict if and to what extent apple fruit will develop postharvest disorders, there is an urgent need for biomarker-based tools that can. By screening changes at the various omic-levels preceding, and in relation to the progressive disorder development, potential biomarkers can be identified. The main challenges are to find the proverbial needle in the haystack of candidates and to properly balance the contributions from the different sized omic-pools. We are applying a combined transcriptomics and metabolomics approach, monitoring over 30,000 genes and 600 metabolites as measured in apples stored under more or less stringent conditions triggering the disorders of interest to various extents. Multivariate analyses techniques have been applied to analyze the omic-datasets either in isolation, or together, to find the most relevant candidates. Using appropriate visualization techniques, changes in selected genes and metabolites were interpreted in their wider context. Starting by identifying genes and metabolites characteristic for the disorders studied, we moved toward differentiating among the effects of the various experimental factors. Beyond that, we focused on identifying markers that allow for segregation of treatments long before the disorders appear.

(398) Reversal of the Petal Senescence Process and Ethylene Responses in Carnations

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During senescence, carnation flowers show a typical response characterized by petal inrolling, and autocatalytic ethylene production. It has been generally thought that the senescence process in carnation flowers is irreversible once the tissues have entered the climacteric phase. While petal tissues have a lower sensitivity to ethylene in the preclimacteric phase, these tissues are converted to the climacteric phase at a critical point during flower development. The conversion of preclimacteric petals to climacteric phase also can be induced by exposure of the petals to exogenous ethylene. Here, we show that the senescence initiated by exogenous ethylene is a reversible process in carnation petals. We took a molecular approach to explore the genes involved in the conversion of the petals to climacteric phase. We also characterized the relationship between ethylene sensitivity and petal senescence by monitoring petal inrolling and recovery

patterns. Our results show that petals treated with ethylene for 12 h exhibited sustained inrolling, while the petals treated with ethylene for 10 h exhibited inrolling followed by recovery from inrolling. We will describe the expression levels of specific gene family members in ethylene signaling and ethylene biosynthesis that were altered at the transition point from preclimacteric to climacteric phases.

Specified Source(s) of Funding: AgroFresh, University of Wisconsin-Madison

(399) Storability and Phenolic Compounds Profile of Organically Grown Blackberries

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Fresh market blackberries grown organically in North Carolina were used to determine storage life and phenolic compounds profiles. ‘Natchez’, ‘Ouachita’, and ‘Navaho’ freshly harvested berries were sorted into shiny black (SB) and dull black (DB) ripeness stages and stored at a constant 1 °C for 15 days or at 1 °C for 13 days plus 2 days at 20 °C. Subjective ratings of leakage and decay incidence were lower and overall ratings were higher in SB fruit or berries stored constantly at 1 °C. Freeze dried fruit tissue was extracted with acidified methanol and analyzed using high performance liquid chromatography with photodiode array detector, Synergi 4 μ Hydro-RP 80A column (250 x 4.6 mm) and formic acid-methanol gradients. Cyanidin 3-glucoside was the predominant anthocyanin in blackberries, representing 87% to 96% of the total anthocyanin content, and tended to increase after storage. Other anthocyanins found were pelargonidin 3-glucoside, cyanidin 3-rutinoside, and cyanidin 3-xyloside. Cyanidin 3-xyloside content was the lowest in ‘Natchez’ (< 0.2%) compared to ‘Ouachita’ or ‘Navaho’ (4% to 7%). Gallic acid (7–25 mg/100 g DW in ‘Natchez’ and ‘Navaho’) and quercetin 3-galactose or quercetin-3-glucoside contents (6–42 mg/100 g DW in ‘Natchez’ and ‘Navaho’) were generally lower in ‘Ouachita’ (6–10 and 5–20 mg/100 g DW for gallic acid and quercetins, respectively), and vanillic acid content was the lowest in ‘Natchez’ (18–24 and 72–87 mg/100 g DW in ‘Natchez’ and ‘Ouachita’/‘Navaho’, respectively). Phenolic contents were generally higher in ‘Natchez’ and ‘Navaho’ than in ‘Ouachita’, and tended to increase during storage. Our results show that organically grown ‘Natchez’, ‘Ouachita’, and ‘Navaho’ blackberries had excellent storage life after 15 days at 1 °C, especially when they were at SB ripeness stage.

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Organically grown blackberry cultivars used in this study are a rich source of cyanidin 3-glucoside compared to other berries, and phenolic contents did not decrease significantly after storage. Among cultivars, phenolic profile of 'Natchez' was slightly different from that of 'Navaho' or 'Ouachita' in cyanidin 3-xyloside and vanillic acid, but all three cultivars predominate in cyanidin 3-glucoside.

Tuesday, July 23, 2013

12:15–1:00 PM

Root Growth and Rhizosphere Dynamics

(249) Determining Root Hydraulic Conductance of Container-grown Plants as an Assessment of Root Mass

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Measuring hydraulic conductance and resistance of plant roots has been an effective way to quantify root system development and productivity of field-grown trees. Root hydraulic properties can vary with species, drought, temperature, soils, etc. With advancing technologies, new devices have been developed to quantify root hydraulic properties with rapid-flow measurements. The hydraulic conductance flow meter (HCFM) is one such device that was developed to measure hydraulic properties of undisturbed root systems of woody plants in soils but never on herbaceous plants in containers. The objectives of this study were to determine if 1) the HCFM can measure root conductivities of herbaceous plants grown in containers and; 2) root conductivities can be correlated to root dry mass as a technique to assess undisturbed root system development of container-grown plants. Chrysanthemum 'Garden Alcalá Red' were grown in peat-based substrates amended with either 20% perlite or 20%, 30%, or 40% shredded pine wood (SW). SW was produced by hammer milling freshly shredded loblolly pine trees (*Pinus taeda*) through a 6.35 mm screen. Six containers were filled with each individual substrate and one chrysanthemum plug was planted into the center of each container. Plants were grown for 4 weeks before the HCFM was used to measure root conductance followed by the roots being washed for dry weight determinations. Hydraulic conductance of all plants in all substrates was effectively determined using the HCFM, illustrating the potential for this technique to be used on container-grown plants. For each substrate and plant replication, root conductance

was plotted against root dry weight. Chrysanthemums grown in all substrates exhibited a positive correlation between increasing root dry mass and increasing root conductance. Plants grown in the 30% SW substrate had the strongest correlation with a linear increase in root conductance and root dry weight. Plants in the other substrates exhibited non-linear relationships but were still positively correlated. These data indicate that measuring root conductivities of container-grown plants can be a possible tool in assessing root development, productivity and mass in horticultural crops. Assessing root conductance could be a new parameter in studying plant productivity and root vigor during crop production.

(250) Mini-Horhizotron: A Non-destructive Technique for Observing and Measuring Growth of Developing Root Systems during Production

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There are several techniques used to measure/assess plant root growth and development, however most current methods are destructive and may not accurately quantify root systems. Two common practices often used include subjective root ratings and root washing to determine root dry mass, both of which alter the natural position/architecture of root systems. Subjective ratings are highly variable and are only qualitative while root washing often loses large amounts of fine roots and root hairs. The mini-Horhizotron is a new non-destructive technique developed to study root growth of small plant material (e.g., seeds, liners and plugs) during crop production. The mini-Horhizotron is designed with three quadrants extending away from the center of the box, allowing for lateral root growth to occur. Shade panels cover the quadrants to exclude light from the root zone. Each of the three quadrants have two clear sides which allows visible measurements to be taken from a plant growing in the center. Measurements include root length, speed of root growth, presence and quantity of root hairs, and root architecture/branching. The objective of this study was to use the mini-Horhizotron to quantify root growth patterns and observe the effects of different substrates on root growth development of *Rudbeckia*. *Rudbeckia hirta* 'Becky Yellow' plugs were grown in peat-based substrates amended with either 20%, 30%, or 40% pine-wood-chip (PWC) aggregates. The PWC was produced by hammermilling freshly chipped loblolly pine trees (*Pinus taeda*) through a 6.35 mm screen. Three mini-Horhizotrons were filled with each individual substrate resulting in nine mini-Horhizotrons used. The three longest *Rudbeckia* roots were measured on each quadrant face

An asterisk (*) following a name indicates the presenting author.

for each substrate, every 4 days from 15 to 67 days after planting (DAP). From 15 to 39 DAP root growth of *Rudbeckia* was not different among the three substrates. At 43 DAP root length of *Rudbeckia* in 40% PWC substrate was longer compared to plants grown in 30 or 20% PWC substrates. At 51 DAP plants grown in both 30% and 40% PWC had longer root lengths compared to plants in the 20% PWC substrate. The general increase in root growth of *Rudbeckia* with increasing rates of PWC is likely attributed to the increase in air space of the substrates as the percent aggregate (PWC) increased.

(251) Rhizometer: A Technique for Observing and Measuring Root Growth and Their Influence on Substrate Physical Properties In Situ

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Root growth of greenhouse crops is both influenced by, and influences, the substrate in containers. Current methods of measuring root growth of crops during/after production do not include undisturbed assessment of whole root systems, root growth over time, or the influence of root growth on substrate physical properties. The Rhizometer is a new technique developed to observe root growth of small plant material (e.g. seeds and plugs) and also measure substrate physical properties and the effect of root growth (in situ) on those properties over time. Rhizometers were constructed from clear cylindrical plexiglass tubes (7.6 cm tall x 7.6 cm inside diameter) which allowed for visible observations of root systems. Rhizometers were purposefully constructed to fit the base plates of the North Carolina State University (NCSU) Porometer, a method of determining substrate physical properties including total porosity (TP), air space (AS), and container capacity (CC). The objective of this study was to use the Rhizometer apparatus to measure changes in substrate physical properties over time as influenced by two plant species with differing root fineness/structure. Rhizometers were filled with a moistened 60:20:20 (peat:perlite:vermiculite) substrate and tapped five times to achieve similar bulk densities prior to planting. *Rudbeckia hirta* 'Becky Yellow' was selected for its fine (small) roots and *Begonia xhybrida* 'Dragon Wing Red' was selected for its larger/tuberous roots. For each species, 40 Rhizometers were planted. Every 7 days after planting 10 Rhizometers of each species were harvested. Of those 10, five were used in the NCSU Porometer method, and the remaining five were washed for root dry weight determination (the substrate was rinsed from the root balls). The study was conducted for four weeks, resulting in a total of 80 Rhizometers used. *Begonia*

had a linear decrease in substrate TP, AS and CC over 4 weeks. There was a linear increase in root dry weight (mass) observed during that time. Substrates containing *Rudbeckia* plants had a linear increase in root dry weight over time; however, there was no change in TP, AS or CC as a result of the fine nature of the root system. These data show how substrate physical properties in a container can be influenced differently depending on the crop being grown.

(252) Root Traits of Twelve Pecan Accessions of Varying Origin

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Fine root morphology is strongly affected by genotype, environment, and the interaction between genotype and environment. In surveys of herbaceous plants it has been shown that plants from competitive resource rich habitats generally produce fine roots with greater length per unit root dry mass (specific root length, SRL). Few studies have explored a similar relationship between habitat of origin and root traits within ecotypes of a woody species. We explored differences in a range of seedling fine root traits such as mean and median fine root diameter, diameter distribution, and SRL for 12 pecan (*Carya illinoensis*) accessions of origins that are widely divergent in environmental characteristics but grown under standard conditions in a common location. Preliminary analysis showed that fine roots of these accessions had a mean SRL that range from 37 to 58 m·g⁻¹. The two most southern accessions (87MX1-2.2 and 87MX5-1.7) exhibited the lowest SRL, while 'Moore', 'Riverside', 'Giles', and 'Elliot' exhibited the highest SRL. With the exception of 'Riverside', which originates from a site with intermediate precipitation (710 mm per year), accessions with the highest SRL originated from sites that receive 1000 mm or precipitation per year. Our data suggest that there is a link between root traits and environment, which we will explore further using principal components analysis where we will include longitude, latitude, precipitation, elevation, mean annual temperature, and soil type at origin.

(253) Assessing Root Characteristics of Cucurbit Rootstocks using a Simple Germination Test

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Vegetable grafting has many benefits including disease resistance, stress tolerance, and vigorous growth. The most commonly used rootstocks in melon (*Cucumis melo*) production are interspecific hybrid squash rootstocks, which have Fusarium wilt resistance and vigorous root systems. Different rootstocks may vary greatly in their influence on growth vigor of grafted melon plants. In this study, a simple germination test was conducted to compare the initial growth of the root system among the different rootstocks that may be used for grafted melon production. 'Athena' muskmelon was used as the scion control, and seven commercial cucurbit rootstocks were evaluated, including 'Strong Tosa', 'Shintosa Camel', 'Carnivor', 'Kazako', 'No.1', '53009', and 'Dinero'. Seeds were germinated in an incubator at 27 °C for 3 days, until their emergence. Root growth was assessed daily between germination and full emergence of the cotyledons. Total root length, total root surface area, total root volume, and average root diameter were determined using a root scanner. However, at day 1, only root length was measured, since the root systems were too small for root scanner measurements. At day 1, 'Athena' scion and 'No.1' rootstock had significantly greater root length than the other rootstocks. Most rootstocks tested did not demonstrate more rapid increase in total root length compared to the 'Athena' scion; however, 'No.1' at day 2 and 'No.1' and 'Carnivor' at day 3 had greater root length than 'Athena'. In contrast, 'Shintosa Camel' showed consistently the smallest root length during the germination test. For total root surface area, at day 2, 'No.1' and 'Carnivor' had significantly higher values than 'Athena' and by day 3, '53009' also had significantly higher root surface area than 'Athena'. Except for 'Dinero' and 'Shintosa Camel', five out of the seven rootstocks evaluated showed significantly higher root volume than 'Athena'. 'Dinero' showed similar average root diameters as 'Athena' at day 2 and day 3, whereas all other rootstocks demonstrated larger root diameters than 'Athena'. Overall, the 'No.1' rootstock showed the most vigorous root system in this germination test. Although this study will not reflect the growth and yield performance of grafted 'Athena' in field production, assessing root characteristics using germinated seeds may be a promising tool in the future for initial screening of rootstocks with vigorous root systems.

(254) Axenic Culture Growth Optimization of Adventitious Root Promoting Endophyte, *Piriformospora indica*

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Biological solutions to common production problems are welcomed by growers and consumers as our society continues to raise its expectations for sustainability and reduced chemical inputs. A relatively new mycorrhizal-like fungi, *Piriformospora indica*, has shown promise to improve adventitious root formation, nutrient uptake, and disease resistance of various plant species. One benefit of *P. indica* over other currently produced mycorrhizal products is the characteristic of being able to pro-

duce the fungi in pure culture without a plant host. This aspect proposes the ease and feasibility of becoming a commercially produced product. The objectives of this study were to determine: 1) the effect of temperature, light, and sugar concentration on radial mycelial growth in potato dextrose agar (PDA); and 2) the effect of shaker speed (RPM), sugar concentration, and temperature on mycelial mass and chlamydospore production in potato dextrose broth (PDB). In PDA experiments, temperatures between 5 °C and 40 °C at 5° intervals were tested. The temperature producing the fastest radial growth was 25 °C. PDA concentrations of 12 g/L, 24 g/L, and 48 g/L were evaluated. There was no significant difference between the growth rates for 12 g/L and 24 g/L, however, at 48 g/L growth was retarded. Light had significant effects on mycelial growth. Full spectrum light retarded growth as opposed to *P. indica* grown in the dark. During liquid culture experiments, the optimal spore production speed was 150 RPM. At 0 and 100 RPM few spores developed. The *P. indica* was tested to see if sugar concentration had an effect on growth while shaken at 150 RPM. Again, 48 g/L retarded growth and there was no significant difference between the growth rates for 12 g/L and 24 g/L. Finally *P. indica* was grown at 20 °C, 25 °C and 30 °C, at 150 RPM, and in 24 g/L PDB concentration. Significant mycelial mass and chlamydospores count occurred at 24 g/L PDB.

Tuesday, July 23, 2013

12:15–1:00 PM

Vegetable Crops Management

(152) Black Oat Cover Crop Management in Watermelon Production Systems

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Black oats (*Avena strigosa* Schreb.) were sown as a cover crop near Weslaco, TX (lat. 26°N), in Fall 2010. The cover crop was allowed to senesce naturally and planted to watermelons in both the Spring and in Fall 2011. Spring-planted watermelons transplanted into mowed black oats (either bedded or non-bedded) suffered retarded early season development in vine and root weight, reduced root:shoot ratio, delayed fruit maturation, reduced yield, and average fruit weight compared to bedded watermelons transplanted on beds with or without black plastic. Fall-planted watermelons transplanted into completely senescent black oats performed differently. Early season growth of bedded melons was delayed in the conventionally planted beds compared to strip-tilled and chisel-planted watermelons which had higher leaf SPAD values, more leaves per plant, greater vine length, more blooms, and greater tendril attachment to oat residue compared to conventionally bedded plants. Marketable season yield, marketable number, average weight (Chisel only), and soluble solids were higher in fruit from the conservation tillage systems. Water replacement (70% vs. 90% ETo) had no

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effect on marketable yield attributes or late season leaf stomatal resistance, but the higher replacement rate increased seasonal soil water profile content at 25, 50, and 0–100 cm depths.

(153) Effect of Deficit Irrigation on Pigment Content, Photosynthesis, Growth, and Yield of Cabbage

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Water is an increasingly scarce resource in the northwestern U.S. agricultural region. Deficit irrigation strategy, a practice that deliberately allow crops to sustain some degree of water deficit with no or marginal yield loss, has the potential to increase water use efficiency and save water. Field experiments were conducted in the Wintergarden of Texas to investigate the responses of leaf pigments, gas exchange, plant growth, and yield of cabbage (*Brassica oleracea* L. cv. Pennant) to deficit irrigation. Each fall, cabbage was seeded and thinned in the field at 0.90 m between rows with two lines per row and 0.30 m between plants. Irrigation was applied with subsurface drip at 100%, 75% and 50% of evapotranspiration (ETc) in the first season and 100% and 70% of ETc in the second season. Although chlorophyll index were marginally and temporally increased under deficit irrigation, the pigment (chlorophyll a, b, a+b, and carotenoids) contents were not affected by deficit irrigation based on either leaf area or dry weight. Deficit irrigation at 50% ETc reduced leaf area per plant, and during late development it marginally reduced leaf fresh weight and increased leaf relative water content and specific leaf area. The plant height and width were temporarily reduced while the photosynthetic rate and transpiration decreased under 50% ETc irrigation. Deficit irrigation reduced both head size (height and width) and fresh weight, resulting in decreases in marketable and total yield. However, the difference in head dry weight among the three irrigation rates was not significant, suggesting most of the increases in yield under 100% ETc irrigation are just water content. These results suggest that deficit irrigation (75% ETc) could save water though moderate decreases in yield and head size is expected.

(154) Biofumigant Performance of Four Brassica Crops in an Irrigated Chile Pepper Rotation System

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Biofumigants are biologically active cover crops that can be used as an alternative to chemical fumigation for agricultural soil management and pathogen control. When incorporated as a green manure, biofumigants have the potential to increase soil organic matter and alter soil pH. Both of these changes are desirable in southwestern United States soils. Biofumigants also contain naturally occurring biocidal compounds, called isothiocyanates (derived from glucosinolates), that can suppress soilborne pathogens. In the present study, a field project was conducted over 2 years to evaluate the biofumigant performance of three *Brassica juncea* cultivars ('Caliente 61', 'Caliente 199', 'Pacific Gold') and one broccoli cultivar (*Brassica oleracea* var. *botrytis* 'Arcadia'). *Brassica* crops were seeded in the fall, flail mowed and incorporated into the soil in the winter. Green chile pepper 'AZ-20' (*Capsicum annuum*) was direct seeded in the spring into drip irrigated plots. Biofumigant performance was evaluated based on soil changes including organic matter, pH, E.C., biomass production, and glucosinolate concentrations in Brassica crop tissues. Chile pepper crop yield and stand establishment in biofumigant plots were also measured and evaluated. In both years, all mustard treatments produced significantly higher biomass than broccoli, but were not significantly different from one another. In year one (2011), biofumigant plots produced an average of 104.6 metric t·ha⁻¹ of fresh biomass. Biofumigant biomass in year two was less than year one (49.6 metric t·ha⁻¹ of fresh weight) due to delayed planting. In 2011, after incorporation of the biofumigants and before seeding the chile pepper, soil organic matter showed a temporary increase of more than 24% ('Pacific Gold') to 9% (mean of all other treatments). After incorporation, the pH of the three mustard treatment plots was significantly lower ('Caliente 61', pH 7.54; 'Caliente 199', pH 7.5; 'Pacific Gold', pH 7.5) than the pH of the control (bare soil, pH 7.7). 'Caliente 199' and 'Pacific Gold' treatments had significantly higher glucosinolate levels than all other treatments. Chile pepper plants growing in the 'Caliente 199' and 'Pacific Gold' treatment plots produced significantly higher red pod yield than the other two biofumigant treatments and the control. Biofumigants have potential to improve the characteristics of southwestern soils. These effects may be cumulative and have a greater positive impact on chile pepper growth and yield in the second season.

Specified Source(s) of Funding: New Mexico Chile Association, NMSU Ag Experiment Station

(155) Modeling Environmental Parameters Affecting Processing Pea Yield in Minnesota

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Green peas (*Pisum sativum* L.) are a major processing crop in southern Minnesota. The University of Minnesota Southern Research and Outreach Center (SROC), located centrally in this pea processing region, has performed pea variety trials and has records of average yield from these trials dating to 2004. From 2004 to 2012, a total of 385 tenderometer-adjusted yield averages, planting dates, and harvest dates from 2 to 3 plantings per year of commercial varieties and advanced selections from vegetable breeding companies are available. The effects of multiple weather parameters (observed at the SROC) on pea yield was modeled using these data. Six environmental parameters explained 46% of the variation in yield, irrespective of plant genetics: average wind speed ($\text{m}\cdot\text{s}^{-1}$) 17 to 21 days before harvest (AWS), time to accumulate half of the total heat units (HU) and precipitation (cm) from planting to harvest (percentage of days to harvest), average soil temperature ($^{\circ}\text{C}$) for 1 week after planting, average air temperature ($^{\circ}\text{C}$) for 1 week before harvest, and season-long photothermal ratio ($\text{MJ m}^2/\text{C}$). A linear decrease in yield as AWS increased was the most substantial relationship ($R^2=0.29$), suggesting that poor pollination or damage to flowers occurred under windy conditions. A simplified model could be used by processors to partially estimate yield prior to harvest. Using only AWS, day of the year at planting (1 Jan. = 1), and estimated HU to maturity for each variety (available from breeding companies or past observations), 33% of the variation in observed yield was accounted for. The simplified model supports earlier planting for selections with low HU requirements, which is standard practice in the processing industry.

(156) Cover Crops and Tillage Systems: Three Years of Impacts on Soil Characteristics and Sweetpotato Yield in North Mississippi

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Sweetpotato is a high value, high input crop, with an estimated production value of over 500 million dollars in 2012 (USDA, National Agricultural Statistics Service). Sweetpotato fields are generally left bare after mechanical harvest, allowing for soil erosion. In 2009, studies of cover crops and conservational tillage systems were begun at Mississippi State University's Pontotoc Branch Experiment Station (Pontotoc, MS). Each cover crop species was planted individually in 2010, while some species were mixed for 2011 and 2012 based on 2010 data. Due to poor plant stand in the no-till planting, yield was very low in 2010. Total marketable yield ranged from 99 to 133 bu/acre for crimson clover and wheat, respectively. Changes in

soil characteristics were not observed in 2010, possibly due to previous long term no-till soybean and corn rotations. In 2011, modifications including a sub-soiling shank were made to a mechanical transplanter to facilitate planting into the stale bed and stand was improved significantly. Nitrate nitrogen ranged from 27 to 128 ppm for fallow and crimson clover treatments, respectively. Total sweetpotato marketable yield for stale bed planting on hairy vetch and wheat ranged from 308 to 553 bu/acre, respectively. In 2012, soil organic matter tended to be higher with the stale seedbed when cover crops were compared with their conventional tillage counterparts. There were no differences in total marketable yield in 2012 when compared to the conventional tillage plots. In 2011 and 2012, sweetpotato yields were comparable between stale beds and conventional tillage. Therefore, with modifications to currently used machinery, stale bed production in connection with winter cover crops can have positive impact on sweetpotato production by reducing erosion and allowing earlier planting.

Specified Source(s) of Funding: SSARE

(157) Cover Crops in Conventional Tillage System: Three Years of Impacts on Soil Characteristics and Sweetpotato Yield in North Mississippi

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Mississippi production of sweetpotato has increased from 13,000 acres, in 2000 to 24,000 acres, in 2012. Sweetpotato fields are generally left bare after mechanical harvest, allowing soil erosion and overwintering sites for insect and rodent pests in culled roots. In 2009, studies of cover crops were begun at Mississippi State University's Pontotoc Branch Experiment Station (Pontotoc, MS) and a grower field in Chickasaw County, MS. Cover crops included brassica, legume, and grass species. At the Pontotoc location each species was planted individually in 2010, while some species were mixed for 2011 and 2012 based on 2010 data. In all years and locations cover crops were destroyed by mowing then disk incorporated prior to bed formation. Interactions with year and treatment were observed in soil organic matter at the Pontotoc site ranging from 1.2% to 2.0% for rape and fallow treatments, respectively. Soil nitrate nitrogen levels varied among treatments in all years. Nitrate nitrogen ranged from 5 to 91 ppm for the Daikon radish and the mustard treatments, respectively. Total marketable sweetpotato yield ranged from 214 to 741 bu/acre for fallow and Dwarf Essex rape cover crops, respectively. In all years, sweetpotato yields were comparable between cover crops and fallow treatments at the Pontotoc location. In 2010,

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the grower location was limited to brassica cover crops in order to determine their effect on natural reniform nematode levels, however, nematode populations were too low to be meaningful. In 2011 and 2012, legume and grass species were added to complement the trial at the Pontotoc location. In 2010, at the Chickasaw location organic matter was low ranging from 1% to 1.3% for fallow and Daikon radish, respectively. Total marketable yield for all three treatments ranged from 613 to 707 bu/acre for Daikon radish and fallow, respectively. In 2011 and 2012, organic matter ranged from 1.85% to 2.08% for Daikon radish and ryegrass, respectively. Total marketable yield was influenced by year. The fallow treatment ranged from 609 to 421 bu/acre in 2011 and 2012 respectively. It appears that certain cover crops and mixtures can be beneficial for sweetpotato plantings in North Mississippi.

Specified Source(s) of Funding: SSARE

(158) Living Mulch Cover Crops on Small Parcels for Urban and Small-scale Applications

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One of the production aspects that most distinguishes small-scale and urban farmers from their rural counterparts is extremely limited land availability in urban and peri-urban areas. Soil quality is critical to any farming operation but poses a special challenge to small-scale growers who commonly use intensive production systems. Given limited ability to effectively rotate crops or use typical soil building techniques, growers have identified maintaining and building soil quality as one of the primary challenges of extremely small acreage production. A multitude of studies have established the ability of cover crops to reduce erosion, build soil organic matter, improve water filtration, and provide weed control. Non-conventional tillage systems, including living mulches and strip tillage, offer alternatives that allow growers to gain the benefit of cover crops while simultaneously producing crops for food and income. To investigate alternative production systems that allow small-acreage growers to integrate cover cropping techniques into their production systems while maintaining cash crop production, a cover crop trial was designed with the goal of identifying effective living mulch systems applicable to small scale organic vegetable production. Four cover crops (buckwheat, field peas, crimson clover, and medium red clover) and a control of no cover were planted in early spring. Covers were mowed in early June immediately prior to planting vegetables (snap beans, bell pepper, and broccoli) directly into living mulch. Mulches were mowed throughout the season and biomass samples of weeds and living mulches were collected. In addition to vegetable yield, biomass of weeds and living mulches, mulch height, weed species, and labor/management time were

recorded. Drought conditions in 2012 likely impacted cover crop mulch and weed growth with implications for vegetable crop yield. The study will be repeated in 2013.

Specified Source(s) of Funding: United States Department of Agriculture, National Institute of Food and Agriculture USDA Award 2011-68004-30044

(159) Comparing Minirhizotron and Soil Core Methods for Measuring Root Growth of Melons under Deficit Irrigation

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Water stress alters biomass allocation strategies of crop plants, resulting in changes in root growth patterns in time and space. Understanding these changes will assist in screening cultivars for drought tolerance traits in melons. This study was conducted to investigate the effect of deficit irrigation (50% vs. 100% crop evapotranspiration, ET_c) on root growth of three melon (*Cucumis melo* L.) cultivars ('Mission' and 'Da Vinci', reticulatus type and Super Nectar, inodorus type). Root length intensity (RL; mm·cm⁻²) was measured using the minirhizotron method 6 times at bi-weekly intervals during 2012 growing season, and at final harvest with the soil core method. Minirhizotron data showed that RL increased significantly up to 70 days after planting (DAP), with no significant differences among 70, 84, 98, and 112 DAP. Both minirhizotron and soil core methods showed similar root growth trends at final harvest, concluding that deficit irrigation significantly enhanced root growth in 'Mission', but had no effect in 'Super Nectar'. However, the two methods differed in 'Da Vinci', which showed 17% higher root growth under deficit irrigation with minirhizotron; whereas, soil core method showed no significant effect of deficit irrigation on root growth. As in previous studies, the minirhizotron method underestimated root growth in the upper soil layer (10–30 cm) as compared to the soil core method. Conversely, the minirhizotron estimates were higher than the soil core method at deeper soil layers (50–70 cm). Further, spearman's correlation coefficient, showed poor association ($r = 0.1043$) between minirhizotron and soil core root growth estimates. These results indicate disagreements between the two methods for root growth measurements. This

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disparity may be due to the poor soil-tube interface contact in the upper soil layers in the minirhizotron method. However, better estimates under deeper layers indicate that minirhizotron is a more suitable method for root growth measurement under deficit irrigation.

Specified Source(s) of Funding: TDA-SCBP

Tuesday, July 23, 2013

1:00–1:45 PM

Citrus Crops

(103) The Effects of Huanglongbing and Foliar Nutritional Treatments on Orange Flavor

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The citrus disease, Huanglongbing (HLB) has been demonstrated to impart off-flavor to orange fruit and juice. This is more prevalent in fruit that are symptomatic for the disease (small, green and lopsided). Growers in Florida are resorting to foliar nutritional spray programs for management of HLB disease, in lieu of removing symptomatic trees, to maintain

tree health and yield. The impact of these programs on HLB-infected fruit flavor and aroma is unknown. This study looked at the effects of 3 different foliar nutritional spray treatments applied to healthy and HLB-infected trees for effects on flavor chemical composition and sensory quality of the fruit, and compared them with the fruit treated with a conventional spray program. Three types of fruit samples were selected: healthy fruit from non-infected trees (healthy), asymptomatic fruit from HLB-infected trees (HLBa), and symptomatic fruit from HLB infected trees (HLBs). Two varieties (Hamlin and Valencia) were investigated over multiple harvest dates and several seasons. Differences in general between healthy and HLB fruit juice were greater for HLBs fruit, for ‘Hamlin’ variety, and earlier in the season. Sensory differences in taste and sometimes smell between nutritionally-treated HLB fruit and healthy controls were greater in the first few years than the last years, with descriptors including more bitter, grapefruit like, sour, astringent, and metallic. The sugar/acid ratio was generally lower in HLB fruit and content of bitter limonoids higher, regardless of the nutritional treatment. However, differences were minimal or not significant for ‘Hamlin’ in Jan. 2012, ‘Valencia’ in Apr. 2011, and ‘Valencia’ in Apr. 2012, with descriptors sometimes including more sweet and more flavorful for HLB fruit juice. More seasons of study are warranted to determine if foliar nutritional treatments have any positive effect on flavor, but finding healthy trees for comparison is becoming more difficult.

Specified Source(s) of Funding: Florida Department of Agriculture and Consumer Services (FDACS)

(104) Evaluating the Effects of Controlled Release Fertilizer Application Rate and Watering Regime on Photosynthesis and Growth of Potted Grapefruit Foliage

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Few previous studies have focused on the effects that horticultural practices have on the vegetative growth of young, non-bearing grapefruit trees. The results of this study describe the interacting effects of the amount of controlled release fertilizer applied and watering regime on the photosynthetic metabolism and growth of foliage in potted grapefruit (*Citrus paradisi* Macf. cv. Ray Ruby). Individual plants were assigned to one of three amounts of a dry, controlled release fertilizer [no fertilizer added (NF), low fertilizer volume (LF, 15 mL), or high fertilizer volume (HF, 30 mL)] and to one of two watering regimes [high water volume input (HW, 1,200 mL/week) or low water volume input (LW, 600 mL/week)]. There were no significant differences in mean, instantaneous leaf net photosynthetic rate

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among treatments. However, treatments LFLW and HFLW had significantly larger mean values of instantaneous, leaf water-use efficiency (WUE), relative to the NFHW treatment. All of the other treatments had intermediate mean values of WUE, compared to the LFLW and HFLW and NFHW treatments. For the LW watering regime, regardless of the amount of fertilizer applied, values of leaf WUE were related linearly to the total leaf dry weight, number of leaves produced, stem length, and stem diameter. For the HW watering regime, regardless of the amount of fertilizer applied, values of leaf WUE were related linearly only to total leaf dry weight and number of leaves produced. In conclusion, watering regime had a greater influence on leaf WUE than did the amount of fertilizer applied. Increasing values of leaf WUE were related to greater leaf dry weight, number of leaves produced, stem length, and stem diameter in potted grapefruit plants subjected to a restricted watering schedule.

(105) Seasonal Production of Phloem Tissue in HLB-affected Citrus Trees

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Citrus trees affected by Huanglongbing (HLB or citrus greening) exhibit a progressive degeneration of the phloem tissue that culminates phloem collapse. The physical collapse of the phloem conduits obstructs photoassimilate transport to heterotrophic tissues ultimately resulting in tree death. However, despite the apparent collapse of phloem elements in HLB affected trees, new vegetative growth continues to develop for several additional seasons. In fact, HLB-affected branches with evident HLB symptoms and seemingly obstructed phloem are capable of maintaining fruit production for some time, albeit progressively smaller fruit sizes and crop yields. We therefore, hypothesize the existence of temporary or ancillary (albeit less efficient) route for photoassimilate transport that can sustain some level of growth. We examined samples of petioles, new flush stem tissue, mature stems, and fruit pedicels after termination of the 2012 summer flush. In petioles and mature stems, a distinct ring of new and apparent functional phloem was evident inside a circle of collapsed protophloem cells. In fruit pedicels, a larger functional layer of phloem cells was present. These exhibited a more gradual transition between functional and damaged phloem elements. In new vegetative growth, vascular tissue showed no evidence of damage, the only signs of HLB presence was the abundance of starch on cortex parenchyma. Our observations demonstrate the seasonal production of healthy phloem which provides for temporary passage of photoassimilates capable of sustaining limited growth and development.

(106) Microsprinkler Location in Citrus

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Typical placement of microsprinklers in citrus orchards is between trees in the tree row. In this experiment sprinklers were placed under the tree canopies as well as in the typical between tree location. Placement under the canopies provides for application of irrigation water where a greater percentage of the root system is typically located, offers the potential for reduced evaporative loss of applied water, and reduces the amount of applied water outside the tree canopy as a source of moisture for weed seed germination and growth. Yield and fruit quality measurements were made with the 2012 and 2013 crops. Measurements of tree water status were made in Summer 2011 and 2012.

(107) Results of Providing Weekly Data on Citrus Tree Cold Acclimation to Florida Growers

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The Polk County UF/IFAS Cooperative Extension Service provides citrus growers with citrus tree cold acclimation information during the winter. This information is used by growers to make informed decisions on the use of microsprinkler irrigation for citrus tree cold protection. Information on cold acclimation is generated in the lab using a process that measures electrolyte leakage from damaged frozen leaves. Leaf leakage is measured at progressively colder test temperatures to determine the critical temperature at which 50% of leaf cells are damaged. Field observations have held out the validity of using this 50% benchmark methodology as a threshold for citrus leaf damage. Beginning in 2005 eight central Florida grove locations per year have been used for the collection of weekly leaf samples from 15 Nov. to 15 Mar. of each year. Five leaves from the same six trees each year at each location are collected to determine the weekly citrus leaf freezing point temperatures. Data collected demonstrate the dynamic nature of citrus tree acclimation during the winter and between individual years. Critical citrus leaf freezing temperatures ranged from -8.30°C to -2.7°C depending on the year. Results of annual grower surveys indicate that there has been over the past 7 years a significant percent reduction in the amount of irrigation water that has been pumped for citrus tree cold protection in central Florida. Grower's average estimated savings over the 7-year period ranged from no savings to over 50% depending on the year. The mean average water savings for the seven year period was 19.28% when growers considered the critical citrus

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leaf freezing temperature data in making cold protection decisions. This demonstrates that savings in water and pumping costs can be realized by the use of relevant research information that has been appropriately transferred to growers. However, recent field observations indicate that HLB (huanglongbing or citrus greening disease) has a significant negative effect on citrus tree cold acclimation. In the future, this apparent difference will need to be quantified in future citrus leaf freezing temperature determinations as the incidence of HLB increases in Florida.

Tuesday, July 23, 2013

1:00–1:45 PM

Nursery Crops

(046) Plant Growth Regulators Increase Branching of *Hydrangea paniculata* ‘Limelight’ and ‘Jane’ (Little Lime™)

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Pruning is commonly performed during production to produce symmetrical, compact plants that are pleasing to the consumer’s eye. Pruning can also allow for closer spacing and reduce breakage during production and shipping. To achieve desired branch architecture and crop uniformity, nursery growers typically hand prune or, less commonly, apply plant growth regulators. However, hand pruning is expensive and is not always effective, and efficacy of plant growth regulators can depend on cultural practices, environmental conditions, irrigation, cultivar and rate. Therefore, the objectives of these experiments were to evaluate *Hydrangea paniculata* ‘Limelight’ and ‘Jane’ (Little Lime™) hardy hydrangea in response to single foliar applications of three plant growth regulators (PGRs) at two rates: dikegulac sodium (Augeo®) at 800 or 1600 ppm, benzyladenine (Configure®) at 300 or 600 ppm or ethephon (Florel®) at 500 or 1000 ppm. There were two additional treatments: a hand-pruned control leaving three nodes and an unpruned water control (untreated) applied the same day as PGRs. Plants were potted in 3-gal containers with 85% pine bark:15% peat, topdressed with Harrells 19–1.7–6.6 (N–P–K), 5–6 month control release fertilizer (64 g per container). Vegetative growth, floral attributes, plant quality and phytotoxicity were assessed. Experiments were conducted using a completely randomized design with 12 (Limelight) and 10 (Little Lime) single pot replications. Limelight and Little Lime had similar branching response to dikegulac sodium. For example, Limelight treated with dikegulac sodium (800 and 1600 ppm) had 74.4 (279%) and 76.7 (287%) more branches than hand-pruned (26.7) plants and 75.7 (298%) and 78 (307%) more branches than untreated (25.4) plants. Moreover, Little Lime treated with dikegulac sodium (800 and 1600 ppm) had 35.8 (163%) and 27.4 (125%) more branches than hand-pruned (21.9) plants and 44.7 (344%) and 36.3 (279%) more branches than untreated (13.0) plants. Hand pruning Limelight decreased

flower number compared to untreated and PGR treated plants, with the exception of plants treated with 1600 ppm dikegulac sodium, which had flower numbers not different from hand-pruned and untreated plants; whereas, hand pruning Little Lime resulted in fewer flowers than all other treatments. Initial bleaching and interveinal chlorosis was observed on new growth of both cultivars; however, 6 weeks after treatment neither cultivar had ratings different from the untreated. These results suggest dikegulac sodium (800 and 1600 ppm) may be a viable option to achieve more branching and crop uniformity without reducing flower number of Limelight or Little Lime.

Specified Source(s) of Funding: IR-4

(047) The Effect of Selected Herbicides on Growth of *Aucuba* and Flowering of *Scaevola*

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Liners of *Aucuba japonica* ‘Variegata’ and *Scaevola aemula* ‘Scala Blue’ were potted in 12-L and 4-L pots, respectively in June. Within 7 days of potting, *Aucuba* plants were treated with 3 rates each of sulfentrazone (F6875), isoxaben (Gallery), dimethenamid-p (Tower), indaziflam, oxyfluorfen + prodiamine (Biathlon), pendimethalin + dimethenamid-p (Freehand), or trifluralin + isoxaben (Snapshot). Also within 7 days of potting, *Scaevola* plants were treated with 3 rates each of Tower and Freehand. An untreated control was included for both species. Plants were grown under container nursery conditions using a randomized complete-block design with *Aucuba* under 30% saran and *Scaevola* under full sun. Treatments were repeated 6 weeks after the first treatments were applied. At 1, 2, and 4 weeks after each application, phytotoxicity was rated for each plant. Stunting symptoms were noted on *Aucuba* plants, which were rated at 4 weeks after the first application and at 1, 2, and 4 weeks after the second application. An effect on flowering was observed on *Scaevola*, which was rated at 1, 2, and 4 weeks after the second application. Plant heights and widths were measured at the beginning of the study and at the end of the evaluation period so that changes in plant growth could be calculated. For *Aucuba*, F6875 and Gallery treatment resulted in significantly more phytotoxicity and stunting than control plants after both applications. With Gallery, phyto and stunting symptoms decrease over time after the first application. Growth over the course of the experiment was less than the control for all rates of F6875, but this held only for height of plants treated with the highest rate of Gallery. For *Scaevola*, there was no effect of any of the treatments on growth. However, flowering was reduced by all treatments when compared to the control at 2 weeks after the second application. By 4 weeks after the second application, flowering on treated plants had completely recovered.

Specified Source(s) of Funding: The IR4 Project

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(048) Use of Biocontainers in Pot-in-Pot Nursery Production System

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Biocontainers are being considered as more environmentally sustainable alternatives to plastic containers. However, the use of biocontainers may have unforeseen challenges including increased water use and poor durability in long-term nursery production settings. The objective of this research was to investigate the suitability of using biocontainers in a pot-in-pot (PNP) nursery production system. This study was conducted in Mississippi, Texas, Kentucky, and Michigan. Two types of 7-gal fiber containers, Kord Fiber Grow and Western Pulp, and a 7-gal standard plastic container were used in this study as inner pots (production pots). A plastic container was used as the in-ground socket pot. Birch (*Betula nigra*) bare root liners were planted in mid-June 2011 into the production pots filled with pine bark and peat (85:15, v/v). At the end of the first growing season, there was no significant difference in plant growth index and daily water use among the three container types in all four locations. Visual inspection of the biocontainers showed that the side walls and the bottom of the containers were intact. At the end of the second growing season, there was still no significant difference in plant growth index and daily water use among the three container types. However, the visual inspection of the biocontainers showed some degrees of degradation, especially the bottoms of the pots. The results suggested that the biocontainers we tested might be suitable for short-term rather than long-term PNP production.

(049) The Use of Topflor G in Knockout Rose Container Production

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Knock Out rose is a popular landscape shrub rose and a major nursery crop in the southeastern United States. It needs several pruning during production to have dense foliage and abundant flower buds. Growers are interested in using plant growth regulators to reduce pruning, improve plant quality, or manage crop scheduling. Topflor G (flurprimidol) is the first granular “Type II” growth retardant that has shown size reduction effects in some crops. Experiments were conducted in 2012 on Knock Out roses at a local nursery in Louisiana. Four groups of plants: 1) Knock Out Red transplanted from 4-inch liners; 2) Double Knock Out Red transplanted from 4-inch liners; or 3) from quart liners; and 4) Double Knock Out Pink transplanted from 4-inch liners were potted into 3-gallon pots and treated with Topflor G at 0, 7, 14, and 28 g/pot at 4 weeks after potting. Growth and number of flowers were recorded at 2, 4, and 6 WAT. Significant interactions were found between group and sample date, but not between group and PGR rate. Analyses for each group indicated that, PGR treatment effects were not significant for Knock Out Red. For Double Knock Out Red, all rates reduced plant height compared with the untreated, but had no effects on plant width. Percentage of growth reduction was smaller for the group of Double Red transplanted from quart liners than those from 4-inch liners. Results suggest that vigorously grown variety such as Double Red responses better than weaker varieties, and effects are more significant when plants were young at the time of treatment. However, large variation in treatment effects were observed within individual rates; and the participating nursery manager expressed concerns about this inconsistency. Further research is needed to identify key factors affecting plant response and application methods to improve uniformity.

(050) Transplant Establishment of Container-grown Plants Produced in Eastern Redcedar Substrate

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In the Great Plains region of the United States, Eastern redcedar (*Juniperus virginiana*; ERC), an aggressive tree species, has been identified as a possible alternative to pine bark (PB) for nursery substrates. The objective of this study was to evaluate plant growth of eight species produced in an ERC- or PB-based substrate, both in production and after field planting. In June 2011, three substrate mixes consisting of: 1) 80% PB : 20% sand; 2) 80% ERC : 20% sand; and 3) 40% PB : 40% ERC : 20% sand were pre-plant incorporated with controlled-release fertilizer containing micronutrients. Dwarf maiden grass (*Miscanthus sinensis* ‘Little Kitten’), Knockout rose (*Rosa* ‘Radtkopink’), holly (*Ilex glabra* ‘Compacta’), and Allee lacebark elm (*Ulmus parvifolia* ‘Emer II’) were planted in trade 11.36 L containers. Sedum (*Sedum telphium* ‘Autumn Joy’), hosta (*Hosta* ‘Sum and Substance’) and daylily (*Hemerocallis* ‘Charles Johnston’) were grown in trade 3.81-L containers. Growth index (GI), caliper (lacebark elm only), foliar SPAD, pH and EC levels were measured during the production phase. In October 2011 plants were field planted. Plants were harvested 336 days after field planting (DAFP). Shoots and roots were separated for dry weight data. At the end of the production phase, no significant differences were observed for substrate pH and EC. Knockout rose had no significant difference in plant GI among the substrates. Maiden grass and holly plants grown in PB had greater GI than plants grown in ERC. Sedum and lacebark elm had greater GI in the PB : ERC mix. Knockout rose and holly grown in ERC had greater leaf greenness (SPAD). Substrate blend did not influence SPAD measurements of lacebark elm and blanket flower. Lacebark elm had greater caliper in PB : ERC mix. At 336 DAFP, the substrate did not influence GI, SPAD, and dry weights (shoot and root) of knockout rose, maiden grass, daylily, sedum, and lacebark elm. Holly and hosta grown in PB had greater GI and shoot dry weight, whereas root dry weight and SPAD were unaffected. Overall, container-grown plants produced in ERC were slightly smaller than plants grown in PB, however, these differences were overcome in one growing season in the field for most species.

Specified Source(s) of Funding: Floriculture and Nursery Research Initiative

(051) Increased Chlorophyll Efficiency of Dark-adapted Camellia Foliage when Treated with Chlorine Dioxide or Hydrogen Peroxide and Blended with an Ionic Surfactant

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Phytophthora ramorum is a major risk to interstate trade of nursery stock. Our work focuses on chemical oxidant chemistry as a disinfectant on nursery grown *Rhododendron* species. Disinfection of the plant is crucial, but the impact on plant health and phytotoxic responses are also important. To determine plant stress responses to applied chemical oxidants, we are measuring chlorophyll activity (PSII quantum efficiency) as measured by Fv/Fm values in dark-adapted camellia plants. Data were collected using a Li-Cor 6400 Leaf Chamber Fluorometer (LI-COR, Lincoln, NE) to evaluate the potential phytotoxicity of Camellia to ClO₂ and H₂O₂ at various concentrations, with or without the surfactant sarcosinate, and consecutive sprays. Chlorophyll activity (Fv/Fm) of dark adapted camellia foliage was greater when ClO₂ and H₂O₂ were applied with the surfactant sarcosinate to camellia foliage. Chlorophyll activity decreased with increasing concentrations of ClO₂ increased when sarcosinate was not present. No differences between ClO₂ and H₂O₂ solutions at the similar concentrations were observed. Visual injury of the camellia foliage increased with each subsequent spray application; however, foliar injury did not exceed a marketable threshold for most treatments, until after four or five consecutive spray applications of ClO₂ at 400 mg·L⁻¹, with or without surfactant.

Tuesday, July 23, 2013

1:00–1:45 PM

Organic Horticulture

(075) First Year Primocane Yield Data of Advanced Thorny and Thornless Primocane-fruited Blackberry Selections at Kentucky State University

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Primocane fruited blackberries are attractive to Kentucky growers because they can be grown organically and are able to produce a niche-market crop from late summer until frost.

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Therefore, locally produced fruit from primocane fruiting blackberry selections can be harvested from July until usually October, providing fruit for sale at farmers' markets, community supported agriculture, and organic markets. In June 2011, a blackberry variety trial was established at Kentucky State University (KSU). Plants of the commercially available primocane-fruiting cultivar 'Prime-Ark 45®' (thorny erect, primocane-fruiting) and the Arkansas Primocane-fruiting (APF) selections of thorny or thornless (T) advanced selections (APF-153 T, APF-156 T, APF-158, APF-172 T, APF-185 T, APF-190 T, and APF-205 T) from the UARK blackberry breeding program, were planted at the KSU Research and Demonstration Farm, in Frankfort, KY. Plants were arranged in a randomized complete-block design, with 4 blocks, including 5 plants of each cultivar per block (total of 20 plants of each cultivar) in a 10-ft plot. Spacing was 2 ft between each plant, and 5 ft between groups of 5 plants. Rows were spaced 14 ft apart. This trial was planted on the certified organic land and managed with organic practices following the National Organic Program standards. Weed control was achieved by placing a 6–8 inch deep layer of straw around plants, adding straw when necessary and hand weeding. Plants were irrigated weekly with t-tape laid in the rows. Primocane fruit production began in late July or early August for most selections. APF-158 had the highest yield at 2559 lb/acre. However, all other selections had yields that were much lower, ranging for 62–575 lb/acre. APF-185 T had the largest average berry size at 4.6 g, while Prime-Ark 45® had the smallest berry at 3.0 g. The extremely high temperatures during June–September (over half the days had daily highs of 85 °F or higher), likely negatively impacted both yield and berry size on all selections. Year to year yield and fruit quality characteristics will need to be further evaluated and none of these advanced selections have yet been released for commercial production.

Specified Source(s) of Funding: Evans-Allen

(076) The Presence of Genetic Modification in USDA Organic Certified Corn and Soy Food Products

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A federal law mandated the protocol for food to be USDA Organic in 1990. Organically certified foods command higher prices than conventionally produced food. The use of genetically modified organisms (GMOs) is an excluded method in certified organic production systems. We purchased food labeled as USDA Certified Organic, Non-GMO Project verified, or both, containing the most common GM crops, corn and soybeans from online sources as well as brick-and-mortar grocers in Kentucky and Tennessee. It is widely accepted that the presence of a viral 35S CaMV promoter and a bacterial NOS terminator sequence in a crop genome is evidence of genetic modification. DNA was extracted from whole and processed foods and garden seed. These sequences were detected by PCR reactions and visualized by gel electrophoresis, alongside positive and negative standards. Our results indicate the presence of genetic modification in some of these foods.

Specified Source(s) of Funding: WKU Leichhardt Professorship Endowment

(078) Identification of Phytohormones Present in Vermicompost Tea and Their Effect on Growth and Yield of Tomato

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Vermicompost teas (VCT) are documented to increase plant growth and yield. However, the underlying mechanisms for these results remain obscure. Radioimmunoassay (RIA) was used to identify and quantify phytohormones present in commercially prepared "growth-promoting" VCT. Isopentenyladenine (IPA) and indole-3-acetic acid (IAA) were detected in different batches of VCT, along with a low amount of abscisic acid (ABA). Comparison of effects of VCT applied at the recommended rate with IPA and 6-benzyladenine applied at an amount equivalent to that supplied in the VCT treatment provided evidence that IPA increased *Solanum lycopersicum* vegetative biomass in the initial growth phase, but as the experiment progressed, results indicated that VCT improved the number of leaves, dry weight, and root length significantly over other treatments. The VCT also improved fruit number and fruit size significantly over control and other treatments. The results provided the first evidence that plant hormones are present in VCT, consistent with the growth promoting capacity of VCT. Two experiments provided evidence that different batches of VCT contained different amounts of phytohormones, including some growth

An asterisk (*) following a name indicates the presenting author.

promoting and growth inhibiting phytohormones, likely other hormones not analyzed, and other essential metabolites that had a greater beneficial effect on tomato plant growth and yield than equal amounts of isopentenyladenine. The study confirmed that phytohormones present in VCT play an important role, but there are other factors in VCT that contribute to increasing plant growth and yield. Although, VCT can be a good organic amendment, it is difficult to standardize the composition of VCT to ensure its quality due to the many variables involved in its production.

(079) Location, Cropping System, and Genetic Background Influence Carrot Performance, Including Top Height and Flavor, in the CIOA (Carrot Improvement for Organic Agriculture) Project

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U.S. organic farmers surveyed listed improved seedling germination and *Alternaria* leaf blight resistance as top breeding

priorities for field production of organic carrots. Nematode resistance is also very important for growers. Flavor was deemed the most important consumer trait to improve in carrots, and nutrition the most important product quality variable for consumers. To address these needs, field trials of 34 diverse carrots varying in top size, disease and pest resistance, root shape and color, flavor, and nutritional value were evaluated by the Carrot Improvement for Organic Agriculture (CIOA) Project on both organic and conventional farms in California, Indiana, Washington, and Wisconsin. Wide ranges of seedling growth rates and canopy sizes were observed in this diverse carrot germplasm that includes not only orange carrots, but also novel purple, yellow, and red storage root colors. Top height varied two-fold among entries at a given location, and fresh carrot flavor (sweetness and harsh, turpentiney flavor) varied widely among the genetic stocks evaluated across the locations and production systems. Relative top height ranking among genetic stocks was consistent with no system-by-variety interaction detected for this trait. Relative ranking of flavor scores was also relatively consistent across locations. Soil assays comparing the organic and conventional trials at each site indicated significant differences among locations, and between organic vs. conventional paired trials in all four locations, including labile organic matter pools, and bacterial, fungal and archaeal community composition. To evaluate root-knot nematode resistance, select material was planted in a trial on nematode infested ground at the University of California South Coast Research & Extension Center. Leaf blight resistance was evaluated in trials at the University of Wisconsin Hancock Experiment Station. Nematode and *Alternaria* leaf blight resistance trials demonstrated a wide range of variation among genetic stocks. Other diseases observed in some of the trials were bacterial blight, *Cercospora* leaf spot, and powdery mildew. A brochure was prepared and distributed, and a web site was developed through eOrganic (<http://eorganic.info/carrotimprovement>) to inform growers, the carrot industry, researchers, and consumers about the project, including trial results. The CIOA Project reached approximately 60 farmers in 2012 with education on organic breeding and variety trials. This project has a diverse advisory panel, and is creating a model for farmer-researcher participation in breeding, seed production and evaluation programs for organic systems.

Specified Source(s) of Funding: United States Department of Agriculture, National Institute of Food and Agriculture Award no. 2011-51300-30903 of the OREI (Organic Agric. Res. & Ext. Initiative)

(080) The Optimal Time to Establish Late-summer Cover Crops in the Great Lakes Region

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For organic growers, planting a cover crop after vegetable harvests is an important tool for weed management and soil building. In the Great Lakes region, there is often not sufficient time for a second vegetable, but there is enough growing season left for weeds to become a serious problem. Cover crops are only effective at producing these results if they are sown at the right time of the season. We identified the optimal planting date range for sudangrass and mustards, developing a degree-day model that allows growers to estimate the best time in their location. In order for the model to be applicable across the region, we did sequential plantings in two states: Michigan and New York. Sudangrass required a minimum of 700 growing degree days with a 50 °F base temperature (DD_{50}) before frost to suppress weeds and produce meaningful biomass and suppress weeds. 'Idagold' and 'Tilney' mustard required 1700 to 2200 DD_{32} before a hard frost to produce sufficient biomass. The biomass increased sharply with DD within that range, so a few days delay in planting can substantially reduce the cover crop value. The crucifer-planting window is approximately 2 weeks long, occurring in early-mid August in the cooler parts of the region, and late August in the warmer parts. When mustards were sown earlier ($> 2200 DD_{32}$) they produced no more biomass, but they did produce seeds. Those seeds create a high risk for volunteer mustard, that is a difficult weed problem. Tests of other crucifer cover crops (albeit not on organic ground) show that the response of cover-crop radish, brown mustard, forage rapeseed, forage turnip, and winter canola have exactly the same optimal planting window. All have a tendency to bolt and go to seed in the fall sown later than ideal, and a tendency to overwinter and go to seed in spring if sown too soon.

(081) A New Economic Assessment Tool for Organic Apple Producers

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Although conventional apple production in the United States is not increasing, and is decreasing in some states and regions,

organic fruit production has increased significantly in the last decade. Organic orchards in the Pacific Northwest have been proven to be both economic and sustainable, however, there is limited experience and published research on organic apple orchard production in the southern region. Preliminary work through surveys of stake-holders in the southern region indicated great opportunities exist for markets of both fresh and processed fruits within the region, but also indicated there are significant challenges. These challenges include assessments of lack of information available on the economic impacts of different organic production practices and the potential returns available from organic production. In this poster, we describe the development of an interactive organic apple production economic assessment tool. The tool is both easy to use and highly customizable. It can be used for two economic purposes. First producers can use the tool to estimate enterprise production budgets. The produce can choose to: 1) use default cost values built into the tool; 2) enter costs from their farm; or 3) combine both. Anytime producers modify an activity, the budgets automatically calculate total cost per year, a break even analysis for yield and price and a sensitivity analysis for total cost. Second, producers can use it to evaluate cost, returns and break even points for X different production management systems (x ground cover, x fertilization treatments). With a click of a button producers are given tabular and graphical information that highlights estimated costs, returns and break even values for these many options. This tool is useful because it allows producers to estimate operating costs, fixed costs, total costs and expected total returns by modifying an important production practice, cost or return value. Allowing comparisons among different practices would assist apple producers to make better investment decisions.

Specified Source(s) of Funding: USDA IOP

Tuesday, July 23, 2013

1:00–1:45 PM

Propagation

(332) The Effect of Nitrogen Application on Bud Take, Scion Growth, and the Level of Endogenous Cytokinins in Shoots of Trifoliolate Orange Rootstocks

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Experiments were conducted at the University of Florida Citrus Research and Education Center, to study the effect of nitrogen application on bud take and scion growth, and on the biosynthesis and translocation of endogenous free cytokinins in shoots of trifoliolate orange rootstocks. Liner trees of citrus rootstock 'Swingle' citrumelo (*Citrus paradisi* x *Poncirus trifoliata*) were grown in washed quartz sand under growth chamber conditions (28 °C day/21 °C night temperatures, 14 hours daylight). In the

An asterisk (*) following a name indicates the presenting author.

first experiment, the bud wood ('Valencia' sweet orange) and liner trees were subjected to two treatments consisting of no N application and 150 mL of 200 mg·L⁻¹ N solution per tree per week for 12 weeks before budding. Budding was performed to get four total treatment combinations as follows: N sufficient budded on N sufficient (N⁺/N⁺), N deficient on N sufficient (N⁻/N⁺), N sufficient on N deficient (N⁺/N⁻) and N deficient on N deficient (N⁻/N⁻). The nitrogen application treatments were continued post-budding. In the second experiment, the trees were subjected to two treatments: to one set 150 mL of 200 mg·L⁻¹ N solution was applied daily for 8 days, while no N was applied to the second set. Trees were destructively harvested for 5 consecutive days from each treatment for xylem sap extraction. After 5 days, the trees under both treatments were further subdivided into two categories: half of trees from N⁺ were moved to N⁻ and half remained in N⁺, and vice versa, resulting in four categories: N⁺ to N⁺, N⁺ trees moved to N⁻, N⁻ to N⁻ and N⁻ trees moved to N⁺. The extracted xylem sap was analyzed for cytokinin content. The results show that N deprivation decreased leaf chlorophyll content by 26%, while N application increased it by 28.6% in respective treatments. The whole plant nitrogen content (% dry weight) was also significantly higher in N⁺ trees. As a result, the N sufficient trees also had significantly higher net photosynthetic rate than the N deprived trees. The bud survival rate, bud break, and scion growth all were positively influenced by N application. The N sufficient trees had higher endogenous cytokinin levels before budding, at the time of budding and at unwrapping, but not 6 weeks after unwrapping when the scions were growing. The second experiment showed no significant changes in endogenous cytokinin levels with N application over 5 days.

Specified Source(s) of Funding: FNGLA

(333) The Effect of Auxin on Vegetative Propagation of *Idesia polycarpa* Maxim

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Idesia polycarpa is a deciduous ornamental tree with 10–20 cm panicles of yellow-green flowers in spring and summer turning to orange-red berries in fall and winter. There is no recent documentation of vegetative propagation protocols for *I. polycarpa*. The objective of this study was to evaluate the effectiveness of different harvest dates and auxin concentration combinations on rooting of shoot tip cuttings. In 2009, cuttings were collected at nine dates between June and August. At each collection date, five replications of five softwood cuttings were treated with three K-IBA auxin concentrations of 0, 5000, and 10000 mg·L⁻¹ giving a total of 25 cuttings per treatment. Increases in K-IBA up to 10000 mg·L⁻¹ resulted in higher rooting percentages for most collection dates, though rooting percentage did not exceed

32% for any given treatment combination. Additionally, rooting percentages did not differ among cutting dates. In 2010, a second study with four replications of five cuttings was conducted with two cutting collection dates (June and September), and three K-IBA auxin concentrations of 0, 10000, and 20000 mg·L⁻¹. The two cutting collection dates corresponded to two shoot tip cutting types, softwood (June) and semi-hardwood (September). For softwood cuttings, the application of auxin improved rooting success versus the control from 0% to 60% and 75% for 10000 and 20000 mg·L⁻¹, respectively. Rooting of semi-hardwood cuttings was improved to 40% and 45%. There was no statistical difference between the two high concentrations for both cutting types. For all rooted cuttings, softwood cuttings showed a greater root length (4.83 cm, length of longest root) compared to semi-hardwood cuttings (1.82 cm). These data indicate the necessity of supplemental auxin in rooting *I. polycarpa* cuttings and that softwood cuttings are preferable versus semi-hardwood cuttings.

Specified Source(s) of Funding: Longwood Gardens

(334) Clonal Propagation of Stem Cuttings of *Spigelia Marilandica*, *S. Gentianoides* var. *alabamensis*, and *S. Marilandica* x *S. gentianoides* var. *alabamensis* F₂ and F₃ Hybrids

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New clonally propagated ornamental cultivars must display high levels of rooting success in order to be commercially viable. *Spigelia marilandica* (L.) and *S. gentianoides* Chapm. ex A. DC. var. *alabamensis* K. Gould are species endemic to the southeastern United States that show potential for development of cultivars for landscape use. The objectives of this study were to determine whether cutting date, indole-3-butyric acid (IBA) level, and genotype impacted rooting percentage, root number, and root length in *Spigelia*. Stem cuttings were obtained from five genotypes of *S. marilandica* (SM), one genotype of *S. gentianoides* var. *alabamensis* (SGA), three genotypes of SM x SGA F₂ hybrids, and two genotypes of SM x SGA F₃ hybrids. IBA level significantly affected rooting percentage and root number, but not root length of the genotypes. The SM x SGA F₂ and F₃ hybrids successfully rooted through all months evaluated, while SM and SGA genotypes exhibited a decline in rooting in cuttings taken in September. Results suggest that SM and SGA may be successfully propagated by treating stem cuttings taken in May, June, July, or August with 0.3% IBA. Cuttings of SM x SGA hybrids can be taken through September. These protocols provide a basis for rapid propagation of *Spigelia* and may provide a foundation for other species and hybrids within the genus.

An asterisk (*) following a name indicates the presenting author.

(335) Micropropagation of *Ostrya virginiana* (Mill.) K. Koch

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Ostrya virginiana (Mill.) K. Koch (American Hophornbeam) is a member of Betulaceae and is primarily found in the eastern United States. It grows in USDA hardiness zones 3–9. American hophornbeam is an underutilized ornamental landscape tree, which resulted from commercial clonal propagation limitations and its slower growth. American hophornbeam has desirable ornamental features including exfoliating bark and unique fruit clusters that resemble fruit of hops. Currently, American Hophornbeam is seed propagated, with no clonal propagation reported within the species. Lacking clonal propagation has limited superior selections from being made and utilized with this species. The objective of this study was to develop a micro-propagation protocol by evaluating nutrient salt formulations and plant growth regulator concentrations for establishment, shoot proliferation, and root initiation in vitro. Factorial combinations of thidiazuron (TDZ) concentrations (0, 0.05, or 0.10 μM) in conjunction with 6-benzylaminopurine (BA) concentrations (0, 2, 4 μM) and indole-3-butyric acid (IBA) concentrations (0, 0.5, 0.10 μM) were compared to determine which plant growth regulator combination(s) would stimulate the proliferation of the most viable axillary shoots. In combination, five nutrient salt formulations (MS, DKW, LP, or WPM) ranging from high to low salt formulations were studied to determine a suitable nutrient salt formulation for axillary shoot proliferation. Nodal explants that were 2 cm in length were used to initiate cultures and were maintained on the various medium treatments plus 3.0% sucrose and 0.7% agar at a pH of 5.8. Explants were incubated approximately 30 cm beneath cool-white fluorescent lamps that provide a photon flux of approximately $40 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for a 16-h photoperiod at $25 \pm 3 \text{ }^\circ\text{C}$. Initial results indicate that high nutrient salt formulations, combined with high cytokinins performed better at axillary shoot initiation. Poor shoot elongation was observed and further research needs to be performed to address this issue.

(336) In Vitro Germination of *Ostrya virginiana* (Mill.) K. Koch using Gibberellic Acid as a Substitute for Overcoming Seed Dormancy

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Ostrya virginiana (Mill.) K. Koch (American hophornbeam) is a member of Betulaceae and is primarily found in the eastern

United States, usually as an understory tree. It grows in USDA hardiness zones 3–9. American hophornbeam is commercially propagated only through seed, with no clonal propagation methods reported within the species. Currently, American hophornbeam seed requires 60 days of warm stratification followed by 120–140 days of cold stratification. The purpose of this study was to determine if seed dormancy could be overcome in vitro using gibberellic acid (GA_3). Seed was collected from the accession lines located at the North Dakota State University Horticulture Research Farm during late fall. A 6×2 factorial experiment was used with GA_3 concentrations at 0, 0.5, 1.0, 2.0, 2.5, or 5 μM . The second factor was light vs. dark. MS basal medium was used supplemented with 3.0% sucrose and 0.8% agar. Seed grown in light was incubated approximately 30 cm beneath cool white fluorescent lamps that provide a photon flux of approximately $40 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for a 16-h photoperiod at $25 \pm 3 \text{ }^\circ\text{C}$. Seed grown in the dark was incubated at $25 \pm 3 \text{ }^\circ\text{C}$. Seed was left in the treatment medium for 7 weeks, at which time they were evaluated for germination. Seed was considered germinated if the radicle or hypocotyl emerging from the seed coat was $\geq 5\text{mm}$. Initial results indicate the presence of GA_3 under no light conditions is needed for germination of American hophornbeam seed. As the concentration of GA_3 increases, so do germination rates. Further research needs to be conducted ex vitro on non-stratified seed of *O. virginiana* to determine if gibberellic acid could be utilized by commercial seed propagators to significantly reduce the long stratification period.

(337) Development of Cutting Propagation Techniques of *Deutzia amurensis*

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Deutzia amurensis is an important ornamental shrub with

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important medicinal and economic value. In this study, a five-factor (types of cuttings, types and concentrations of rooting hormones, treatment duration, and types of rooting media) and four-level orthogonal experiment was conducted using softwood cuttings and hardwood cuttings of *Deutzia amurensis*. The results indicated that the 2-year-old hardwood cuttings treated with NAA at 500 mg·L⁻¹ solution for 90 seconds and rooted in perlite produced the better rooting percentage of 60.5% and had better survival rate at 89.5%. The treatments were significant and the highest survival rate was 47.4% higher than that of the control. The four-year-old hardwood cuttings produced the lowest survival rate at 82.1%. The rooting percentage decreased with increasing age of hardwood cuttings, i.e., 2-year-old cuttings had the highest rooting percentage (60.5%), followed by 3-year-old cuttings (39.6%), and 4-year-old cuttings (13.8%). The rooting percentage and survival rate of softwood cuttings on *Deutzia amurensis* were higher than those of hardwood cuttings. The softwood cuttings treated with GGR of 1000 mg·L⁻¹ solution for 90 seconds and rooted in vermiculite produced the highest rooting percentage and the highest survival rate. The highest rooting percentage, 98.3%, was 1.36 times higher than that of the control. The highest survival rate, 95.8%, was 42.4% higher than that of the control. In addition, the survival rate and the rooting percentage of the softwood cuttings did not decrease with hormone treatment duration and concentrations reached 90 seconds and 1000 mg·L⁻¹. *Deutzia amurensis* should be regenerated using softwood cuttings during busy growing season. Alternatively, 2-year-old hardwood cuttings with hormone treatment could be rooted for commercial production.

Specified Source(s) of Funding: Special Foundation for Forestry Scientific Research in the Public Interest (200904024)

(338) Rootstock Age Affects Grafting Ability and Rootstock Re-rooting of Grafted Watermelon Transplants

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Regrowth from the rootstock of a grafted watermelon competes with the scion for nutrients and sunlight, and could cause yield loss and scion abortion. Control of regrowth is costly and labor-intensive. Fatty alcohol treatment of the meristem is a useful technology that prevents rootstock regrowth, thus reducing overall transplant costs. During a three-week period after treatment, rootstock carbohydrates increase while plant growth is prevented. This increase could provide needed energy to improve graft healing of the scion and encourage rootstock re-rooting. A greenhouse grafting experiment was conducted to determine the effect of rootstock age after fatty alcohol treatment on graft healing and re-rooting. Bottle Gourd (*Lagenaria siceraria* ‘Macis’) and Interspecific Hybrid Squash (*Cucurbita*

maxima × *C. moschata* ‘Carnivor’) rootstock seed were sown in subsequent weekly plantings to achieve rootstock ages of 1, 7, 14, and 21 days after fatty alcohol application. All rootstocks were grafted using Tri-X 313 scion. The age of the scion was the same for all rootstock types, and the grafting was done on the same day using the one-cotyledon grafting method. Two weeks after grafting, the percentage of healed grafts, scion fresh and dry weights, percent rooting, root length density (RLD), surface area (SA), and number of forks were measured. Significant effects of scion and rooting characteristics were observed over changes in rootstock age after fatty alcohol treatment.

Specified Source(s) of Funding: Development of Grafting Technology to Improve Sustainability and Competitiveness of the U.S. Fruiting Vegetable Industry project - USDA SCRI PROJECT NO. 2011-51181-30963

Tuesday, July 23, 2013

1:00–1:45 PM

Seed and Stand Establishment

(245) Evaluation of Seed Treatments for Sweet Corn at Sixteen Locations in the United States

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The Seed Treatment Committee of the International Sweet Corn Development Association (ISCD) organizes a multi-location seed treatment trial every year. Researchers at locations across the U.S. evaluate the selected treatments for their effect on seedling stand establishment and vigor. Eighteen seed treatments and a nontreated control were evaluated in 2012 using a single seed lot of the sweet corn hybrid, Super Sweet Jubilee (*sh2*) (warm germination 84%, cold germination 70%). The seed treatments included mixtures of conventional, experimental, or organic fungicides, and many included seed enhancements and insecticides. The treatments were sponsored by five seed treatment companies. Additionally, two standard seed treatment mixtures and an organic treatment were selected by the committee. Sixteen sets of treated seed were sent to cooperating researchers at locations in seven states (FL, ID, IL, MN, NY, WA, and WI). Experimental design was a randomized complete-block with four replications. Planting dates ranged from February to September. Stand counts and vigor assessments were recorded at the 5–6 leaf stage. Data from each location were subjected to ANOVA and means were separated using the Fisher’s Protected Least Significant Difference ($P = 0.05$). Data from each location were then combined in a summary across locations, and analyzed with ANOVA and a comparison of the combined treatment means. The nontreated control and Treatment 12 (Organic Quick Roots) resulted in the smallest stand counts when averaged across locations, 47% and 49% respectively. It should be noted, however, that Treatment 12 did not include a fungicide, but was an organic seed enhancement product. Treatment 19 (Organic Champ Formula 2) also resulted in significantly smaller stand counts compared to the other seed

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treatments, only 54% when average across locations. However, Treatment 19 resulted in a significantly larger stand count compared to the nontreated control in the summary across locations. The other seed treatments resulted in mean stand counts ranging from 68% to 75% when averaged across locations. Overall, these treatments performed comparably to the two standard seed treatment mixtures in the trial. The treatment resulting in the largest stand count when averaged across locations was Treatment 17 (Metlock, Sebring, Rizolex, AP2, Signet, Captan, and Nipsit Inside) with a significantly larger stand count compared to all other treatments, except for Treatment 3 (Captan, Thiram, Dividend Extreme, Apron, Vitavax) and Treatment 10 (Maxim Quattro, Apron, Avicta Duo). A complete list of treatments, stand count results, and vigor results will be presented.

(246) The Use of a Photoselective Film during Lettuce Seed Production for Improving Germinability

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Previous studies suggested that modifying red to far red (R:FR) ratio of maternal environment during lettuce seed development represents a practical alternative to reduce thermoinhibition (reduction of germination at high temperatures) and photoblasticity (light requirement for germination) in seeds. The objective of this work was to evaluate the effect on seed quality of using a photoselective polyethylene film (PPF) during lettuce seed production. Seed of three lettuce cultivars ('Tango', 'Pyramid Cos', and 'Gallega de Invierno') was produced 1.44 m² cages representing one of these treatments: i) control, covered with conventional polyethylene film; b) PPF, covered with a PPF (Solatrol®, bpi.visqueen Horticultural Products); and c) PPF+FL, covered with the same PPF plus permanent fluorescent light. Inside the cages, the R:FR ratio during the day averaged 1.0 for the control and 1.5 for the PPF and PPF+FL treatments. Additionally, during the night the PPF+FL treatment has a R:FR ratio of 3.2. Photosynthetically active radiation varied among days and time hours, but was similar for the three treatments. Plants of each cultivar were cultivated in pots filled with a soilless media, watered daily and fertilized once per week. At bolting, three plants per cultivar were randomly assigned to a cage of one of the treatments. There were 6 replications (cages) per treatment in a completely randomized design. Seed harvest was performed manually. Seed germination was evaluated at 20, 25 and 30 °C in light and darkness. At 20 °C and 25 °C (light), seed from all cultivars germinated near 100% and there were no significant difference among treatments. However, at 20 °C (dark), seed from 'Tango' presented a significant reduction in germination (5.4%), problem that was alleviated by PPF and PPF+FL treatments (41.9 and 67.5% germination, respectively).

At 25 °C (dark), seed from all cultivars presented a significant reduction in germination (lower than 3% for control treatments), but photoblasticity was reduced in seed from PPF (10% to 21% germination) and PPF+FL (18% to 31% germination) treatments. At 30 °C (light) only 'Tango' seed had germination over 95%, with no difference among treatments; in 'Gallega', seed from PPF and PPF+FL treatments germinated around 50%, while the control did 29%. 'Pyramid Cos' germination at 30 °C (dark) was between 4.7% (control) and 13.7% (PPF+FL), but differences were not significant. At 30 °C (dark), seed from all cultivars and treatments germinated no more than 5%; the only exception was seed from the PPF+FL treatment in 'Tango', where germination was 24.3%.

Specified Source(s) of Funding: Project financed by Fondecyt # 11100122, from Conicyt, Chile.

(247) Delayed Seeding of Muskmelon (*Cucumis melo*) following Spring Brassica Cover Crop Incorporation Improves Seedling Emergence

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The benefits associated with cover cropping stand to enhance vegetable production through a variety of well-documented mechanisms. Although cover crops (CCs) have been shown to improve nutrient cycling, reduce soil erosion, and decrease certain soil borne diseases, some CCs have been shown to reduce emergence and stand establishment of both direct seeded and transplanted cash crops following their incorporation. *Brassica* family CCs have shown a particular tendency to reduce emergence due to the production of glucosinolate hydrolysis products following incorporation. It is hypothesized that these inhibitory effects are reduced over time following CC incorporation. The goals of this project were to (i) identify safe plant-back periods for sensitive crops after CC incorporation and (ii) evaluate the impact of planting date on muskmelon yields and quality. Experimental field plots were established at the Southwest Michigan Research and Extension Center (SWMREC) in Benton Harbor, MI. Six CCs were seeded at standard rates and included: oilseed radish (*Raphanus sativus* 'Defender'), Oriental mustard (*Brassica juncea* 'Forge' and 'Pacific Gold'), yellow mustard (*Sinapis alba* 'Ida Gold'), oat (*Avena sativa* 'Excel'), and a no cover control. Oat was used as a non-*Brassica* control. Following incorporation, *C. melo* cv. 'Athena' was seeded at 5-day intervals beginning with day 0 (immediately following incorporation) and ending with day 30. Crop emergence was recorded in each plot 15 days after seeding; muskmelon yields and fruit quality data were collected and evaluated by analysis of variance (ANOVA) and means separated using Tukey's multiple comparison test ($P \leq 05$). The results of the time series analysis indicate that the optimal plant back period may be between 10 and 15 days after incorporation (DAI) depending on the CC. There did not seem to be a clear difference between

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the inhibitory effects among *Brassica* and non-*Brassica* CCs suggesting that the observed inhibition might be less related to *Brassica* allelochemicals than originally thought. Marketable melon yields were greatest for the 5 DAI planting and declined (along with fruit quality) the longer planting was delayed. These results indicate that while a longer waiting period is desired to maximize crop emergence following CC incorporation, muskmelon yields can be compromised when the growing season is narrow as it is in the upper Midwest.

Specified Source(s) of Funding: The Ceres Trust

(248) Bioassay of *Pythium* and *Rhizoctonia* in a Peat-based Substrate Amended with Pine Wood Chip Aggregates

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Substrates used for the production of horticultural crops vary in their occurrence and severity of root rot diseases. A bioassay of two common soil-borne pathogens was conducted on peat-based substrates amended with either 20% perlite or 20% pine wood chips (PWC) to determine disease severity. The PWC were produced by chipping freshly harvested loblolly pine trees (*Pinus taeda*) and hammer milling through a 6.35-mm screen. *Pythium ultimum* and *Rhizoctonia solani* were cultured and inoculated separately via pulverized rice grains into both substrates. *Pythium* was inoculated at the rate of 0.1 g/L substrate and *Rhizoctonia* was inoculated at the rate of 0.05 g/L substrate. Uninoculated controls of each substrate were also evaluated. Containers (1.3 L) were filled with each substrate and 10 cucumber (*Cucumis sativus* ‘Straight Eight’) seeds were evenly spaced and direct sown in the containers at a depth of 1 cm. Disease severity was assessed on each seedling 17 days after planting using the following scale: 1) healthy vigorous seeding; 2) seedling emerged but stunted; 3) seedling emerged and diseased; and 4) seedling dead or did not germinate. Ratings of all seedlings were then averaged within each treatment. Disease severity ratings were similar in uninoculated controls of both perlite (1.13) and PWC (1.08) amended substrates, which indicate no increased disease occurrence/introduction from the fresh PWC component. Disease severity rating of *Pythium* was highest in the perlite amended substrate (3.05) compared to the PWC amended substrate (1.20). The PWC rating (1.20) was similar to the uninoculated controls. Disease severity rating of *Rhizoctonia* was highest in perlite amended substrates (2.94) compared to the PWC amended substrate (2.58) demonstrating slight disease suppressiveness.

Results indicate potential suppressiveness of both *Pythium* and *Rhizoctonia* in greenhouse substrates amended with PWC but further screenings with floriculture crops is needed. Future investigations are also needed to assess how disease occurrence may change with varying rates of PWC aggregates.

Tuesday, July 23, 2013

1:00–1:45 PM

Vegetable Breeding

(364) Evaluation of Lettuce Germplasm for Response to Bacterial Leaf Spot

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A new method was developed for evaluation of lettuce germplasm for response to *Xanthomonas campestris* pv. *vitiensis*, the pathogen of bacterial leaf spot disease of lettuce. This method has the characteristics of 1) allowing a large number of lettuce plants to be tested at a time in a small space, 2) maintaining high humidity that is favorable for disease establishment and development, 3) using one application of inoculum that eliminates the potential confounding effects caused by multiple inoculations used in other methods, and 4) saving time because the testing is completed in a short period of time (6–7 weeks). Sixty nine germplasm lines and ten commercial cultivars representing crisphead, romaine, and butterhead lettuce were evaluated using this method. There were no lines exhibiting resistance stronger than ‘Little Gem’, the resistant control, however, several lines did not differ significantly from ‘Little Gem’ for disease severity. All commercial cultivars were susceptible or moderately susceptible to *X. c. vitiensis*. In this study, ‘Little Gem’ was only moderately resistant. Our study demonstrated that high resistance to bacterial leaf spot is rare in lettuce. Screening additional germplasm for high resistance is under the way in our laboratory.

(365) Genetic Study of the Banded Cucumber Beetle Resistance in Romaine Lettuce Cultivar Valmaine

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The romaine lettuce cultivar Valmaine has resistance to banded cucumber beetle (*Diabrotica balteata*), serpentine leafminer (*Liriomyza trifolii*), *Trichoplusia ni*, and *Spodoptera exigua*,

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which makes it a highly valuable germplasm for development of new resistant cultivars and for genetic studies of the multi-insect resistance. A lettuce population was developed for analysis of inheritance of the banded cucumber beetle resistance by crossing ‘Valmaine’ with ‘Okeechobee’. The F_1 progeny performed similarly as ‘Valmaine’ in response to foliar feeding of the beetle. Of 97 F_2 plants evaluated for response to foliar feeding of beetles, 69 were resistant and 28 were susceptible. The chi-square (χ^2) test for the 3 resistance : 1 susceptibility ratio was 0.77 with a P value of 0.38. In partial F_3 families segregating for the beetle resistance, a total of 90 plants exhibited resistance and a total of 23 plants were susceptible. The chi-square (χ^2) test for the 3 resistance : 1 susceptibility ratio was 1.30 ($P=0.25$). The results indicate that a single dominant gene is responsible for the banded cucumber beetle resistance in ‘Valmaine’. Due to the nature of single gene inheritance, this banded cucumber beetle resistance should be readily transferable into adapted cultivars. A genetic mapping study is underway to identify molecular markers for use in marker-assisted selection.

(366) Measuring Selection Progress in Onion Germplasm after One Selection Cycle for Reduced Iris Yellow Spot Symptom Expression

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Onion thrips and *Iris yellow spot virus* (IYSV) cause huge adverse qualitative and quantitative losses to onion bulb and seed production throughout the world. An increased resistance to several insecticides by onion thrips along with elevated costs of pesticide sprays restricts onion grower’s options to effectively control thrips population and IYSV. Due to the absence of resistant cultivars to thrips and IYSV; the objective of this study was to find if any progress was made in onion germplasm for thrips and IYSV resistance after selection was performed. Plants with fewer Iris yellow spot (IYS) disease symptoms were selected in Summer 2009 and self-pollinated in the following year to produce seed. In Oct. 2011, IYSV-infected bulbs were placed on the first and last bed of the study and at the front and back borders to obtain maximum exposure of thrips and IYSV to the test plots. In addition, to act as disease spreader rows, IYSV-susceptible cultivar, NuMex Dulce, was sown in Autumn 2011 after every two rows of the test plots. The original and selected onion germplasm were evaluated in 2012. Data were collected on number of onion thrips per plant from 10 plants per plot at three times 4 weeks apart, starting at 17 weeks after sowing. Plants were rated for IYS severity based on a rating scale of 0–4 at three intervals, starting at 17 weeks after sowing and 4 weeks apart. To confirm the presence of IYSV in plants through ELISA, leaf samples from 10 plants in each plot were collected. NMSU 10-807 had a significantly fewer number of thrips from

its original material of NMSU 07-53-1 and susceptible check Vaquero at week 25 after sowing. NMSU 10-785, NMSU 10-799, and NMSU 10-813 all had a significantly lower disease severity from its original materials, NMSU 07-32-2, NMSU 07-52-1, and NMSU 07-53-1, respectively, along with from the susceptible checks, ‘Rumba’ and ‘Vaquero’ at 21 weeks after sowing. NMSU 10-785 had a lower disease incidence from its original material, NMSU 07-32-2, and the susceptible check, ‘Rumba’ at week 17 after sowing. No significant differences among different entries were observed for thrips count, IYS disease severity and incidence at two out of three intervals after data evaluation. On the whole, some progress was observed in some of the improved populations for better resistance for thrips and IYS after one selection cycle.

Specified Source(s) of Funding: This research was funded by the USDA-CSREES Specialty Crop Research Initiative, grant award 2008-51180-04875, the New Mexico Agricultural Experiment Station, and the New Mexico Dry Onion Commission.

(367) Screening of Cucumber Plant Introduction Accessions for Resistance to *Phytophthora capsici*

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Fruit rot in cucumber (*Cucumis sativus* L.) caused by *Phytophthora capsici* is a major concern in cucumber growing areas in the country. To screen for resistance to *P. capsici*, the cucumber plant introduction (PI) collection from North Central Regional Plant Introduction Station, Ames, IA (1,025 PIs), was grown in a non-replicated trial at the Horticulture Teaching and Research Center, MSU. Approximately half of the accessions were tested in 2011 and the remainder in 2012. The detached fruit method by Gevens et al. (2006) was used to screen the PI accessions but with some modifications. To increase the ability to screen larger number of fruits and to avoid manifestation of resistance due to age-related resistance (ARR), young fruits (approximately 4 dpp) were evaluated and zoospore suspension, instead of agar plugs, was used as inoculum. Five to ten fruits of each PI accession were surface sterilized and inoculated with 30ul zoospore suspension with a concentration of 1×10^5 zoospores/mL. Symptom development on each fruit was monitored daily for five days after inoculation. The disease rating used was in a scale of 1–9 with 1 as no symptoms and 9 for tissue collapse. Disease development in response to *P. capsici* infection showed variation in symptoms across the PIs, and examples include: no symptom, water soaking, water soaking with necrosis, exten-

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sive water soaking with necrosis, mycelial growth or both with necrosis and mycelial growth, tissue collapse with or without mycelial growth. Three trends of disease development were observed among the PIs. Fruits were either highly susceptible, exhibited delayed symptoms, or showed potential resistance to *P. capsici* after 5 days post inoculation (dpi). The majority of the PIs tested exhibited high susceptibility to the pathogen. The mean rating for the population was 7.1. The susceptible commercial variety Vlaspiik had a mean rating of 8.0. In our initial screen through the collection, a small number of accessions including several from India and Turkey showed delayed symptom development compared to the rest of the PIs tested. These PIs are now being retested. One accession from Turkey (PI175693) has consistently showed reduced susceptibility to the pathogen after two seasons of screening of young fruits collected from the field and one in the greenhouse with a mean of 3.58 at 5dpi, showing localized necrosis at the point of inoculation. Based on this initial screening, there are possible sources of resistance to *P. capsici* for future cucumber breeding programs.

Specified Source(s) of Funding: USDA–SCRI, Pickle Seed Research Fund

(368) Selection Progress for Reduced Iris Yellow Spot Symptom Expression in Onion

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Onion thrips and *Iris yellow spot virus* (IYSV) are two major pests of onions worldwide for which host plant resistance is absent. In Summer 2009, plants with fewer Iris yellow spot (IYS) disease symptoms were selected from plant introduction accessions and the resulting progeny were evaluated in Summer 2012. These selected lines were compared with their respective original population and ‘Rumba’ to see if any progress had been made for reduced thrips number and IYS symptom expression. In order to ensure that every plant in the field screening had the potential to be infected with IYSV, the experiment was design with the spread of thrips and IYSV in mind. In Oct. 2011, border rows were planted with thrips-containing onion bulbs selected from the previous year’s IYSV study. Spreader rows were sown at the same time with a known IYS susceptible cultivar. Plants of the test entries were transplanted in Mar. 2012. As bulbs of the border rows flowered, thrips and IYSV moved to the plants of the spreader rows. When those plants matured, thrips moved to the test plants and moved the virus from the periphery of the field to the interior. The number of thrips per plant was determined from 10 plants/plot at 9, 12, and 15 weeks after transplanting (WAT). Since thrips exhibit feeding differences based upon leaf color and epicuticular wax amounts, plants were rated for leaf color and waxiness at 9 WAT. At 12, 14, 16, and 18 WAT, plants were rated on a scale of 0 to 4 for disease severity, where

0 indicated no symptoms and 4 represented more than 50% of leaf tissue was necrotic. NMSU 10-575-1, which possessed waxy, bluish green leaves, exhibited significantly fewer thrips at 15 weeks when compared to its original population. NMSU 10-577-1 and NMSU 10-582-1 did not exhibit any reduction in thrips number, but showed significant less IYS severity when compared to their original populations. NMSU 10-575-1 and NMSU 10-577-1 exhibited less severe symptoms when compared to ‘Rumba’. The results from this evaluation suggest that the progress can be made toward the development of cultivars with reduced IYS symptoms.

Specified Source(s) of Funding: This research was funded by the USDA-CSREES Specialty Crop Research Initiative, grant award 2008-51180-04875, the New Mexico Agricultural Experiment Station, and the New Mexico Dry Onion Commission.

(369) Participatory Evaluation of Broccoli Varieties Grown under Organic Conditions in Western North Carolina

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In 2012 we initiated a participatory broccoli (*Brassica oleracea*) variety screening to identify varieties best adapted to the climate and organic farming systems of western North Carolina. The study was established in the Organic Research Unit on the Mountain Research Station in Waynesville, NC. Practices and products used were in accordance with the USDA National Organic Program. Seven organic farmers selected 19 standard heading type varieties and nine unusual varieties (romanesco, rapini, and sprouting types) to be included in the trial. They also selected 16 traits to be evaluated for the wholesale and retail markets. Transplants were set into raised beds with white-on-black plastic mulch with drip-irrigation. Research staff rated the broccoli throughout the season. At a summer workshop in the middle of the harvest season, 50 growers used a small group consensus process to rate the test plots for quality and market acceptability. A blind taste test was also conducted. It was a stressful growing season because of high heat conditions early in the season and extensive rains that resulted in flooding in the test area. In this first year, a number of the varieties tested produced higher yields, more marketable heads, and better tasting broccoli than did the standard variety Packman. The Oregon State University (OSU) West Coast and East Coast participatory populations and ‘Arcadia’ performed the best on head color. None of the varieties had a pronounced dome shaped head. The varieties Bay Meadows, Gypsy, and Belstar all performed in the top five for both head uniformity and head smoothness, indicating they were the most heat tolerant of the varieties studied. Growers rated the OSU East Coast Population as their favorite. Scientists rated ‘Bay

An asterisk (*) following a name indicates the presenting author.

Meadows' as having the best quality. In general, growers rated the varieties as more marketable than the researchers did. In taste tests, the varieties Belstar, Batavia, Bay Meadows, and the OSU West Coast participatory population all were more likely to be purchased than Packman based on flavor. 'Green Goliath' yielded the greatest. Despite having close to the lowest yield, the OSU East Coast participatory population had the most side-shoots. Across all traits 'Bay Meadows', 'Batavia', 'Belstar', the OSU West Coast and East Coast participatory populations outranked 'Packman', in that order. Out of the unusual varieties, Tipoff romenescos, Atlantis, and Purple Peacock were the best performing varieties. This study is a complimentary study to the Developing an Eastern Broccoli Industry project.

Specified Source(s) of Funding: Organic Farming Research Foundation

(370) QTL Mapping for Quinone Reductase Activity in Broccoli with Hepa1c1c7 Cell Lines

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Floret tissue from 125 F_{2,3} broccoli families derived from the cross 'VI-158 x Brocolette Neri E. Cespuoglio (BNC)' was harvested in 2009. Tissue was freeze-dried and stored in the dark at -80 until use. Distilled water was added to floret tissue (50 mg/mL) and auto-hydrolyzed for 24 hours in room tempera-

ture. Murine hepatoma cell lines (Hepa1c1c7, American Type Culture Collection) were used to measure quinone reductase (QR) activity. Broccoli extracts were incubated with Hepa1c1c7 cell in 96 wells plate and then, after 24 hour incubation, QR activity measured. Triplicates of QR induction ratios were generated for each of 2 field replicates for a total of six QR data/line. The average of these scores were used to generate a phenotypic QR activity score for each line. A recently generated, highly saturated SNP based map of this population was used to identify 4 significant QTL associated with QR activity. The most significant of these QTLs co-segregate with a major QTL for glucoraphanin variability in the population and maps to the GSL-ELONG locus on chromosome 2. The relationship between QR activity and other potential health promoting compounds in broccoli is further illustrated through the use of partial least square regression (PLS-R) model utilizing phytochemicals. Glucoraphanin, sulfur, gluconapin, and aliphatic glucosinolate were the most important variables to construct PLS-R model to predict QR activity. The results demonstrate the efficacy of utilizing plant populations segregating for multiple phytochemicals and nutrients for identifying factors that contribute to health related bioactivity.

(371) Differential Response of Taro (*Colocasia esculenta*) Cultivars to Taro Leaf Blight

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Taro (*Colocasia esculenta*) is a non-graminaceous monocot consumed primarily for its starchy corm. It is a major staple crop in the Pacific, and is grown widely in the Caribbean, Africa, and Asia. A major disease that threatens the sustainability of taro is Taro Leaf Blight (TLB) caused by the oomycete pathogen *Phytophthora colocasiae*. Two methods were used to determine TLB resistance within the taro germplasm: a) field evaluation at five months after planting based on naturally-occurring epidemics of TLB; and b) excised leaf assay that challenges leaf disks with zoospores of *P. colocasiae*. Using both methods, resistance to TLB has been found within the taro germplasm. We hand-pollinated two taro cultivars that appeared to be TLB-resistant based on the field assay. Then, we challenged 76 of the resulting progeny using the excised leaf assay with zoospores of two strains of TLB that were isolated from the Island of Hawaii. Interestingly, individual progeny responded differentially to two strains of *P. colocasiae* (HPA1 and HPE1), with some resistant to both strains, some resistant to strain HPA1 only, some resistant to strain HPE1 only, and some susceptible to both strains. Correlation between TLB resistance to each strain

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was positive and significant ($P = 0.001$); however there was no significant correlation between normalized TLB resistance in either excised leaf assay and that based on field evaluation of these same progeny. Further studies are being conducted to determine whether: 1) additional strains of *P. colocasiae* are present at the site where the field evaluation was conducted; 2) numbers of zoospores differ between the laboratory assay and the field; or 3) there are other critical factors involved in field-based TLB resistance (e.g., orientation of leaf blades) that are not assayed under laboratory conditions.

Specified Source(s) of Funding: USDA Tropical Subtropical Agricultural Research (T-STAR) program

(372) Managing Downy Mildew of Spinach: A Genomics-based Approach

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Spinach is an economically important vegetable crop in the United States that has undergone dramatic industry changes in recent years and is valued at over \$250 million annually. Spinach downy mildew disease, caused by the oomycete pathogen *Peronospora farinosa* f. sp. *spinaciae* (Pfs), continues to be a major production constraint for commercial spinach (*Spinacia oleracea*) worldwide. A total of 14 races of Pfs have been reported and a number of deviating isolates also have been described. Recently, an NIFA/SCRI grant was funded to develop: 1) a better understanding of the genetic and molecular basis of downy mildew resistance; 2) a more comprehensive understanding of the genetic diversity and global movement of races of the pathogen; 3) a real-time PCR based test to detect Pfs on seed; and 4) establish a comprehensive deployment of effective management strategies. Several isolates of Pfs have been partially sequenced, as have several parents being used in the development of mapping populations. In addition, PCR based real-time primers have been developed which are both highly specific for Pfs as well as highly sensitive in detecting the pathogen on seed. Genotyp-

ing of a worldwide collection of Pfs is currently underway. In addition, efforts continue to develop markers linked to the six Pfs resistance loci, RPF1-RPF6.

(373) A Promising Breeding Strategy for Improving Tuber Quality in Chipping Potatoes

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Tuber internal quality is a major limiting factor for the U.S. potato industry. Breeding efforts have produced varieties with improved processing traits such as ‘Atlantic’ but this variety lacks of desirable internal quality. In-season fertilization with calcium is known to result in an increase in tuber calcium, improved internal quality, and lower incidence of tuber internal defects, bruise susceptibility, and reduced storage rot. Significant genetic variation was found for tuber calcium content among the major U.S. potato cultivars, and ‘Superior’ has been the highest calcium accumulator among the chipping varieties. Our studies aimed to investigate the genetic potential for improving internal quality of ‘Atlantic’ type by increasing tuber calcium content. Therefore, reciprocal populations were generated by crossing ‘Atlantic’ and ‘Superior’ in order to study the genetics of tuber quality traits and select varieties with chipping quality similar to ‘Atlantic’ and improved internal quality similar to ‘Superior’. From the evaluation of over 300 clones, significant genetic variation for tuber calcium, chip quality and internal quality was found for both reciprocal populations. One of the reciprocal populations, ‘Atlantic’ x ‘Superior’, was SNP-genotyped by the SolCAP project. Combining the phenotypic and genotypic data, a tetraploid linkage map was developed and quantitative trait loci (QTL) for tuber calcium, yield, specific gravity, internal defects such as hollow heart, and pitted scab were identified. We also found a relationship between improved tuber quality and tuber calcium concentration. In addition, we have identified promising cultivars with good chipping quality, enhanced tuber internal quality, and tolerance to scab.

Specified Source(s) of Funding: USDA–NIFA and Hatch grant

(374) Productivity and Quality of New Onion Varieties Bolting Resistant in Northeast Sonora, Mexico

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Onion production is an appropriate alternative for northeast Sonora, Mexico (Magdalena River). However, seed varieties are needed that are adapted to the temperature conditions of this region and also have a high potential for quality and yield. The objective of this experiment was to evaluate yield and quality of nine white onion varieties. The evaluation was carried out in Magdalena of Kino, Sonora (Magdalena, River) in Winter 2009–10. The evaluated varieties were: Azteca, Kristal, White Grano, Carta Blanca, Cirrus, Early Suprime, Nube, Virgin, and Stratus. The date sowing was 6 Oct. 2009, and the date seedling transplant establishment was on 19 Dec. 2009. We used a plant density of 339,600 plants/ha in furrows with four rows using drip irrigation system. In this trial, we used a completely randomized design with four replications. The measured variables were yield, bulb weight, bulb diameter, and bolting. The harvest period harvest was 10–17 May. The results indicated that the bolting was low in all varieties with a variation of 0.0% for the varieties ‘Carta Blanca’ and ‘Virgin’ to 0.76% for ‘Suprime Early’. The highest yield were obtained from the varieties ‘Kristal’, ‘Early Suprime’, ‘Cirrus’ and ‘Carta Blanca’ with yields of 93.0, 92.5, 91.6 and 86.4 t·ha⁻¹, respectively, while lower yields were for ‘Nube’ and ‘Virgin’ with 70.9 and 50.9 t·ha⁻¹. The Stratus variety (control) presented a yield of 71.4 t·ha⁻¹. The highest bulb weights were obtained from ‘Cirrus’, ‘Kristal’, and ‘Carta Blanca’ with 289, 268, and 262 g, respectively, while the largest bulb diameter corresponded to ‘Cirrus’, ‘Kristal’, and ‘Carta Blanca’ with 8.6, 8.5, and 8.5 cm, respectively.

(375) Evaluation of Segregating Tomato Lines for Salinity Tolerance

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Salinity is a major abiotic stress affecting plant growth and productivity during all developmental stages. Responses of fourteen tomato genotypes to salinity was investigated using five water salinity levels of NaCl (0.5 control treatment, 2.4, 4.8, 7.2, and 9.6 dS·m⁻¹) through drip irrigation system. Based on the performance of the tomato genotypes at different salinity levels, L46, L66, and L56 genotypes were selected to represent salinity susceptible, moderately salinity tolerant and salinity tolerant genotype, respectively. The salt-tolerant breeding line BL 1076, was also selected as a reference for salinity tolerance.

Development of the genetic populations (parents, F₁s and F₂s) were produced. The data of the first generation hybrids under both reference and high salinity levels reflected pronounced hybrid vigor on the general performance of some vegetative growth traits, fruit number and total yield. In all families, the F₁ hybrids showed significant superiority in fruits’ number and total yield over their respective higher parents. This general trend, apparently, indicated that the inheritance of these traits involved complete- to over- dominance for high over low number of fruits and total yield per plant. The comparisons between the two successive generations, the F₁ vs. F₂ within each family, reflected an obvious inbreeding depression on the general performances of the these traits. In all cases, the F₂’s were significantly lower in number of produced fruits and total yield than those of their respective F₁ parents. Primers for qPCR were engineered to be on two consecutive exons spanning an intron. The qPCR fold increases were detected for all selected probe for the salinity tolerant L56 under salinity stress compared to the reference similar to gene expression data. However, some genes showed higher fold increase in expression than in qPCR, e.g. four time increase for the Les.4483.1.S1. Similar trends were also revealed for the salinity intermediate L66 under salinity stress compared to the reference.

Specified Source(s) of Funding: The National Plan for Science and Technology at King Saud University for this project (number 10-BIO970-02)

Tuesday, July 23, 2013

1:00–1:45 PM

Viticulture and Small Fruits

(114) Patterns of Variation for Sugar and Organic Acid Composition during Berry Ripening in Cold Climate Wine Grape Cultivars

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The physical and chemical composition of wine grape berries at harvest is a key factor that determines the fruit quality characteristics, and ultimately, the quality of the wine produced. As berries ripen, their chemical composition changes with regards to sugars, organic acids, and phenolics etc. Knowledge of the developmental profiles of these compounds is important for determining optimal harvest times in making quality wines. While these profiles have been well characterized for *Vitis vinifera* cultivars, little is known about the changes of chemical composition in cold-hardy wine grape cultivars. These cold-hardy hybrid cultivars, which combine the excellent fruit quality of Eurasian species (*V. vinifera*) and the cold tolerance of American species (*V. riparia*, *V. labrusca*, *V. rupestris*, etc.) allow them to be grown in cold climate regions that experience harsh winter conditions. In this study, we report the changes observed in soluble solids (°Brix), titratable acidity (TA), and pH for 11 wine grape cultivars grown in Chaska, MN, that

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were sampled approximately every 10 days from August to October during the 2010, 2011, and 2012 growing seasons. Concentrations of sugars and acids were measured to predict optimum maturity for these cultivars. We are also determining profiles for organic acids in grape juice using ultra performance liquid chromatography (UPLC). This will enable us to track concentration changes for two predominant acids (tartaric and malic acids) during the berry ripening process. Understanding the varying proportions of these acid components in juice will help guide growers toward optimal harvest times for the intended wine style.

Specified Source(s) of Funding: USDA-SCRI, Project #2011-51181-30850

(115) Understanding the Causes of Flower Necrosis in Grapevines

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A series of experiments was carried out in 'Pinot noir' grapevines to better understand why flower necrosis occurs. Previous research investigating late bunch stem necrosis indicated that an abnormal accumulation of the polyamine, putrescine, was the causal agent leading to necrosis. We tested if putrescine was also responsible for causing flower necrosis by feeding single flower node cuttings various metabolites, or by applying metabolites via a needle-delivery method to developing clusters in the field. Both approaches showed that high levels of putrescine in the rachis can cause flower necrosis in 'Pinot noir' and induce pedicel abscission in the field. The concentration of putrescine that induced flower necrosis was similar to the concentration previously shown to induce late bunch stem necrosis. However, further work comparing healthy and necrotic clusters from 'Pinot noir' grapevines grown in sand-culture (with a history of flower necrosis) showed that flower necrosis was not due to the accumulation of putrescine. These findings combined with other observations led to the hypothesis that flower necrosis may also be caused by an imbalance in the root to shoot ratio of vines, presumably related to whole vine carbohydrate stores and the number of competing sinks at flowering. We tested this hypothesis by manipulating shoot number in the sand culture vines and other vines with no prior history of necrosis. In both cases, flower necrosis was reduced by increasing shoot number per vine while vine nitrogen status was not altered. These results show that putrescine can cause flower necrosis in some cases, but at least one other mechanism (presently unknown) also causes flower necrosis in grapevines that appears to be related to above and below ground vine balance. Vineyard blocks with

a history of flower necrosis could be managed by increasing shoot number per vine.

(116) Chlorine Dioxide Sachets for the Control of Postharvest Decay of 'Crimson Seedless' Table Grapes

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Table grapes are of increasing importance in the world. Gray mold (*Botrytis cinerea*) is the main postharvest decay problem of table grapes and limits their shelf-life. Sulfur dioxide (SO₂) is traditionally used as an antimicrobial postharvest, in packages or storage rooms. Concerns about harm to human health from SO₂ encourage evaluation of alternatives. Chlorine dioxide (ClO₂) has proven effective to control microorganisms on produce. Our objectives were to assess the ability of ClO₂ to control rot and influence quality. ClO₂ gas was generated inside packages from sachets (2.5 by 4 cm, containing 0.1, 0.2, or 0.3 g Curoxin™; Worrell Water Technologies, VA). SO₂ was generated from sachets (4.5 by 6 cm, containing 0.3 g sodium metabisulfite; OSKU S.A., Chile). Our first experiment evaluated decay control, while the second evaluated berry quality. Experiment 1—plastic clamshells with 500 g of 'Crimson Seedless' berries (6 g/berry) were used. Grapes were inoculated by injection of conidia 0.5 cm deep into berries. One inoculated berry was placed in the center of each clamshell with nothing (control) or one sachet (SO₂, 0.1, 0.2, or 0.3 g ClO₂). Clamshells were placed inside an expanded polystyrene box with a plastic liner and stored for: 1) one month at 0 °C; or 2) one month at 0 °C + 1 week at 10 °C. After 1 month, decay incidence in clamshells (control or with SO₂, 0.1, 0.2, and 0.3 g ClO₂ sachets) was 22.8%, 4.8%, 3.4%, 1.7%, or 0.8%, respectively. After 1 month + 1 week, incidence in control, or SO₂, 0.1, 0.2, and 0.3 g ClO₂ sachets was 38.3%, 5.4%, 8.2%, 5.5%, or 4.1%, respectively. Natural incidence was similarly reduced. Some rachis injury was observed, particularly with 0.3 g ClO₂. SO₂ retarded aerial mycelia growth on inoculated berries. ClO₂ retarded it after 1 month, but not after 1 month + 1 week. Experiment 2—grapes were prepared as before, without inoculation, with nothing (control) or a sachet (SO₂, 0.1 or 0.3 g ClO₂), and stored for: 1) 1 week at 0 °C, 2) 1 month at 0 °C, or 3) 1 month at 0 °C + 1 week at 10 °C. Within each period, color (LCh), rachis appearance, shatter, soluble solids, pH, acid content, firmness, and berry size did not differ significantly. Berry appearance, particularly controls, declined during storage. Unlike experiment one, ClO₂ (0.3 g) caused no

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rachis injury. ClO_2 effectively controlled decay with minimal harm to grapes.

(117) The Influence of Post-veraison Foliar Potassium Applications on Table Grape Berry Quality

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Sugar concentration and skin color (for pigmented table grape cultivars) are primary indicators of maturity and important for marketing purposes. Treatments that accelerate sugar and pigment development enable earlier harvest. Early harvest not only improves marketing, it reduces risks of losses from bird feeding or insect and pathogen damage because the residence time of the grapes in vineyards is reduced. In addition to accelerating maturity, increasing sugar content and improving color could also enable a larger crop to mature on the vines. Potassium is the primary soluble salt to affect xylem and phloem flows. Particularly important for sugar transport, potassium from the roots and vine are primarily transported into fruit after veraison, and it exceeds what the root system can deliver, even from well water soil with abundant potassium. Our objective was to apply a potassium spray to the berries so their content would exceed that delivered naturally to the fruit, and determine if this altered the grapes compared to those with “natural” potassium content. Previous experiments indicated that potassium applications increased soluble solids. Among the potassium sources evaluated, potassium metalosate, a common fertilizer, was effective and approved for application to grapes. In 2010, cultivars located at California State University, Fresno, were used; two blue-black cultivars, ‘Autumn Royal’ and ‘Summer Royal’; and two red cultivars, ‘Scarlet Royal’ and ‘Sweet Scarlet’. Potassium metalosate or water (control) was applied to five replicate plots of five vines each arranged in a randomized complete-block design. Two cluster-directed applications were made, each containing 1.3 g/L of potassium or water alone, beginning at veraison and three weeks later. Samples of 50 berries were collected from each plot at four weekly periods after the first application until harvest at commercial maturity. Berry firmness, size, color, soluble solids, and concentrations of fructose and glucose were measured. Potassium significantly increased soluble solids, berry firmness, and color intensity; however, it significantly decreased

berry size. Soluble solids of ‘Autumn Royal’, ‘Summer Royal’, ‘Scarlet Royal’, and ‘Sweet Scarlet’ increased at harvest to 20.3%TSS, 20.0%TSS, 21.8%TSS, and 19.3%TSS, after potassium treatment, from 15.5%TSS, 18.2%TSS, 18.1%TSS, and 16.7%TSS, respectively, among the controls. It significantly increased fructose and glucose in berries, compared to controls. Fructose/glucose ratios from veraison onset to harvest time increased from about 0.65 to 0.90, independent of potassium treatment. Potassium application influence on fructose/glucose ratios varied, the only significant increase was to ‘Autumn Royal’, from 0.90 to 0.91 at harvest.

(118) The Evaluation of Different Cultural Practices on Scarlet Royal Table Grapes to Determine Postharvest Quality

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Scarlet Royal is a newer red seedless table grape variety developed by USDA–ARS, which ripens mid- to late August. As a late season variety, Scarlet Royal is subject to rain, which increases its susceptibility of Botrytis bunch rot. In addition, the variety lacks a thick epicuticular wax and seems to be susceptible to berry crack and rot infections where the berries touch. This problem is also evident and even enhanced in the cold storage environment where the grapes become unattractive for shipping and marketing. Table grape growers in the San Joaquin Valley use plastic covers that are mounted on top of the grapevine trellis system later in the season to protect the grapes from rain. These covers however, induce higher humidity in the grapevine canopy that also contributes toward rot infections. The aim of this project is to evaluate Scarlet Royal under different combinations of cultural practices to mitigate rotting problems due to rain and to maintain optimal postharvest quality under plastic covered grapevines. The cultural practices applied included bunch thinning and removal of bunch shoulders, GA (Gibberelic Acid) and GA + CPPU (Forchlorfenuron) treatments. The experimental layout consisted of four treatments with six replicates each. Clear plastic was used to cover all the vines in the trial before harvest for rain protection. Postharvest quality did not show any significant differences due to the absence of rain during the 2012 growing season. Berry size showed significant differences for the GA + CPPU treated clusters where the berry diameter and berry length were greater than the untreated control bunches. No significant differences were found in juice values, berry size, berry color, or postharvest defects when manual bunch thinning was compared to no bunch thinning. For Botrytis infections, the control and GA treatments with no manual thinning had a higher percentage of infection. Post-storage evaluations showed that GA applications with no thinning had lower titratable acid levels and no significant differences in juice pH levels. Regarding quality parameters, loose berry percentage was significant for

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the GA + CPPU treatment. Berry color presented no differences in lightness, chroma, or hue when the different treatments were compared. This study was only conducted for one season but will continue for two additional seasons. This study is dependent on late season rainfall in the San Joaquin Valley.

Specified Source(s) of Funding: California Table Grape Commission

(119) Impact of Yield Management Practices on Vine Growth and Fruit Composition of Oregon Pinot Noir

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Premium wine grape production requires yield management practices to achieve quality. The majority of Oregon producers (89%) conduct crop thinning to reduce yields, and it is typically conducted from fruit set to lag phase. With rising production costs, growers are questioning current crop thinning practices. Research was conducted in two Pinot noir vineyards, one in the north Willamette Valley and another in the warmer region of southern Oregon's Illinois Valley, during 2011 and 2012. The study evaluated crop thinning at three levels (0%, 40%, and 60% crop reduction) and four time points (pre-bloom, fruit set, lag phase, and véraison). Intensity of crop thinning had a greater impact on basic ripeness (SS, pH, and TA) and on total anthocyanin concentration than timing. Crop thinning by ~40% each year resulted in an increase in anthocyanins in the northern vineyard. Timing, not intensity, had an impact on anthocyanins in the southern vineyard during year 1 with 12% higher anthocyanin at véraison compared to thinning at pre-bloom and fruit set. Crop thinning by 60% did not further increase maturity nor result in higher anthocyanin, phenolic or tannin concentration compared to 40% thinning at either vineyard. The yeast assimilable nitrogen (YAN) concentration was influenced by intensity and timing of crop thinning for only the southern vineyard. The YAN was 41% higher in the pre-bloom thinned fruit (186 mg/L) compared to later time points (132 mg/L) in year 1. In year 2, early season thinned fruit was 51% higher in YAN than in the unthinned treatment, and thinning ~60% increased YAN by 49 mg/L. Despite differences in YAN, there was no difference in leaf blade or petiole N measured at véraison in either vineyard. Increasing crop level did not have major impacts on vine vegetative growth. No differences were found for whole vine leaf area or dormant pruning weights for the northern vineyard. The southern vineyard had fewer laterals and lower pruning weight following year 2 for unthinned vines. Differences in vine growth and fruit composition observed in

the two vineyards is likely due to differences in climate and vine balance, as the southern site had a wider range of Ravaz Index (1.7 to 9.6) compared to the northern site (0.4 to 3.0). Despite different crop levels between years and location, crop thinning more than 40% of the crop in either vineyard did not enhance fruit composition for parameters measured.

Specified Source(s) of Funding: Northwest Center for Small Fruits Research and the Oregon Wine Board

Tuesday, July 23, 2013

1:00–1:45 PM

Weed Control and Pest Management

(214) Biology and Biocontrol of Lewis Spider Mite (*Eotetranychus lewisi*) in Strawberries

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Lewis spider mite, *Eotetranychus lewisi* (Acari: Tetranychidae), is a new emerging pest in California strawberries. The predatory mite *Phytoseiulus persimilis* (Acari: Phytoseiidae), typically used for biocontrol of the twospotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae), provided growers little to no control of Lewis spider mite. We evaluated the efficacy of four commonly used phytoseiid predatory mites: *P. persimilis*, *Neoseiulus californicus*, *N. fallacis*, and *Amblyseius andersoni*. We also investigated the interactions between the twospotted spider mite and Lewis spider mite and in relation to phytoseiid efficiency given the potential for indirect effects of biocontrol. When Lewis spider mite and twospotted spider mite are present on the same leaf, twospotted spider mite populations began displacing Lewis spider mite. *P. persimilis* did not feed on Lewis spider mite, but the other three predatory mites consumed this spider mite and lowered their populations from 40 to near zero in 14 days. When both Lewis spider mite and twospotted spider mite are present on the same leaf, *N. fallacis* and *A. andersoni* fed on both types of mites equally. *N. californicus* showed preference toward Lewis spider mite and allowed twospotted spider mite populations to increase from 20 to 180 in 14 day period. The reproduction rate of Lewis spider mite and twospotted spider mite on three popular strawberry varieties (Ventana, Benicia, and San Andreas) were also evaluated. Lewis spider mite reproduced best on Ventana and Benicia, while twospotted spider mite reproduced equally on all three varieties.

An asterisk (*) following a name indicates the presenting author.

(215) The Newly Sporadic and Major Insect Pests of Orchard Crops in Gyeonggi Province in South Korea

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This study was conducted to survey the sporadic and major insect pests of orchard crops in Gyeonggi province in south Korea. The occurrence and rapid range expansion of *L. delicatula* has recently been reported in south Korea. In vineyards, the grapes are damaged by *L. delicatula*, which sucks the stems and secretes nectar, causing sooty mold. The commercial value of grapes is lowered. The hatchability of eggs laid last year was influenced by the extremely low temperature (especially -20°C and under) in over-wintering season. *M. pruinosa* is mainly present in Austria, France, Italy, and Switzerland—in the Nearctic ecozone and in Neotropical ecozone. The first outbreak of *M. pruinosa* was reported in 2009 in south Korea. The major orchard crops that have a concern for damage are apple, pear, and grape. *M. pruinosa* females insert eggs into cracks in the corky bark of trees and shrubs. The eggs overwinter and hatch in the subsequent spring, nymphs aggregate on twigs and under leaves sucking phloem from their host plants. The first outbreak of *Ricania* sp. was reported in 2010 in south Korea. This outbreak damaged many kinds of fruit trees, such as *Cornus*, Persimmon, and Chestnut. *Ricania* sp. host plants included 51 species (32 xylophytes, and 19 herbaceous plants).

(216) Hydrilla IPM RAMP—Starting a Statewide Extension Project

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Hydrilla is an invasive aquatic weed, and millions of dollars are spent each year managing it in the southern US. Thanks to a new 4-year grant from the USDA National Institute of Food and Agriculture, University of Florida/IFAS research and extension faculty, FAMU faculty, and an ARMY Corps researcher are studying new chemical and biological control methods as part of an overall hydrilla integrated pest management (IPM) plan and transferring the information to stakeholders. The goal is to increase stakeholder awareness of research-based information regarding the hydrilla miner and other sustainable strategies for managing hydrilla. Materials have been developed to help resource managers understand how new strategies for managing hydrilla fit into a hydrilla IPM plan. A perception survey was distributed throughout Florida to determine the most effective information distribution method. The information distribution platform includes field tours and demonstrations, educational publications and exhibits, promotional items, project websites, and presentations at professional and stakeholder meetings. SurveyMonkey was used to determine hydrilla stakeholder perceptions and preferred information delivery methods. 541 stakeholders completed the survey. Responses indicated that the internet, boat launch signage, Florida Fish and Wildlife Conservation Commission, and Extension Offices in Florida were the preferred outlets for stakeholders to receive information about Hydrilla IPM. Extension faculty developed 10,000 Hydrilla IPM RAMP 1-yd Vinyl Fishing Rulers, 70,000 6-in Rulers/Bookmarks, and 17,000 web cards for distribution to Extension offices and collaborators. A web portal was developed and 6,694 hits were recorded in 2011. New tactics such as the hydrilla miner will be incorporated into Hydrilla IPM programs throughout Florida. The information obtained through this perception survey will have enabled Extension faculty to most effectively target their educational programming efforts.

Specified Source(s) of Funding: UF/IFAS, St. Lucie County, FL & USDA National Institute of Food and Agriculture

(217) Improving Pest Control Options through Split Application of Insecticides using Spike Wheel Liquid Injection Technology

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Spike wheel liquid injection systems were developed in the late 1980's as a method for applying fertilizer post emergence with minimal root damage and soil disturbance. The system can also be used to apply soil applied pesticides to mature plants since it

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can be used without damaging plant roots or causing crop injury. Recently, the authors conducted a 1-year study to determine if the useful life of the insecticide Coragen could be extended by making a second, split application 26 days after seeding (DAS). At 35 DAS, the results showed that as compared to the conventional treatment where the full rate of the insecticide was applied at sowing, use of the system increased insecticide concentration levels in lettuce plants from 10 part per million (ppm) to over 600 ppm. Additional study is needed to validate these results. The objectives of this research are to repeat the previous study to obtain additional data to 1) confirm that the useful life of the insecticide Coragen can be extended by making a second, post emergence application with the spike wheel system 25 DAS and 2) obtain a better understanding of the fate of the insecticide in the plant tissue over time. Appropriate field trials will be conducted to achieve the stated objectives. If this research shows that use of spike wheel injection systems increases the useful life of highly immobile, systemic insecticides, it will significantly increase the options growers have for managing yield limiting pests.

(218) Development of Native Natural Predator *Chrysoperla nipponensis* (Okamoto) for the Control of Mealy Bugs, *Pseudaulacaspis cockerelli* (Cooley), at Five Flavor Berry, *Schisandra chinensis* Baill Orchard in Korea

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The mealy bug, *Pseudaulacaspis cockerelli* (Cooley) is one of the hardest pests to control. Its body is covered with white waxy threads, which often make a chemical pest control useless. The development of new effective native predators against the mealy bugs is of great interest. We found that the lacewing had a potent control efficacy against mealy bugs. The identified DNA sequences indicate that this lacewing species is *Chrysoperla nipponensis* (Okamoto). It's the same results of morphological classification and unrecorded species in Korea. *C. nipponensis* go through complete metamorphosis and the developmental time of larva takes 16.8 days ($25 \pm 2^\circ\text{C}$, $75\% \pm 5\%$, 16L:8D). These larva are particularly effective at controlling mealy bugs

and can consume 668.7 mealy bugs in their larvae stages. The functional response of the *C. nipponensis* feeding on six different densities of the mealy bug was studied under laboratory conditions at $25 \pm 2^\circ\text{C}$, $75 \pm 5\%$, 16L:8D. The rate of increase gradually lessened, resembling a Holling's type III functional response. Daily predation amount of 2nd larva consumed 4.7 *Pseudococcus comstocki* (Kuwana), 13.3 *Myzus persicae* (Sulzer), 0.9 *Bemisia tabaci* (Gonnadius) ($25 \pm 2^\circ\text{C}$, $75 \pm 5\%$, 16L:8D). A treatment of *C. nipponensis* was applied to five flavor berry, *Schisandra chinensis* Baill fields infested by *P. cockerelli*. The treatment of biological control agents significantly decreased the fruit damage, which was comparable to the chemical insecticide treatment.

Specified Source(s) of Funding: Rural Development Administration

(219) Studies on Biological Control of Yellow Tea Thrips; *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) on Five Flavor Berry Orchards; *Schisandra chinensis* Baill, using *Amblyseius swirskii* Athias-Henriot (Acari: Phyto

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Five flavor berry; *Schisandra chinensis* Baill is used in traditional Chinese medicine, it is believed to astringe lung and nourish the kidneys, restrain the essence and stop diarrhea-astringent kidneys, calm the spirit by tonification of heart and kidney, Generate body fluids and alleviate thirst. The development of biological control against the major pest on five flavor berry is of great interest. Yellow tea thrip; *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) is anthophilous pests of many crops worldwide including five flavor berry. In this work, a treatment of *Amblyseius swirskii* Athias-Henriot was applied to two types of five flavor berry fields infested by *S. dorsalis*. Even though our tests found significant differences between the two culturing method, the treatment of biological control agents decreased or a little increased the fruit damage, which was comparable to the chemical insecticide treatment. In the sod culture experiment, thrip population was significantly low and increased at a lower

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rate than in the nonwoven type mulching. The use of *A. swirskii* as IPM program and sod culture reduced pesticide usage.

Specified Source(s) of Funding: Rural Development Administration

(220) Bark Beetle Flight in Relation to Lodgepole Pine Host Chemistry: Another Case for Coevolution?

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Mountain pine beetle (MPB) has devastated western North American forests from New Mexico to northern Canada over the past decade. Each year, female MPB initiate a new colonization by flying to a suitable host tree from late July to early August. The brief flight period occurs after the threat of spring freezing temperatures have subsided and yet early enough to provide suitable temperatures for oviposition. Water stress has been indicated as a factor that also influences beetle flight and host selection. Here we propose a third factor, host chemistry, for determining the timing of beetle flight. Previous research has shown that the host chemistry for lodgepole pine differs with altitude, temperature, humidity, and precipitation. Our research demonstrates the relationship between changes in the host chemistry across the growing season and at different plot densities and the MPB flight period. During the summers of 2008 and 2009, 24 healthy green trees were selected within 4 different density forest plots within the Colorado State Forest Park, Jackson County, CO. Bi-weekly, foliage was collected and terpene chemistry was analyzed by headspace solid phase microextraction and gas chromatography mass spectrometry. Of the 72 host compounds we tracked, alpha-pinene, myrcene, and 3-carene are known to attract MPB. Others are known deterrents (e.g., limonene) that have been shown to correspond with beetle flight. We show that MPB flight behavior corresponds with seasonal changes in host chemistry. Differences in host chemistry across a forest plot density gradient are also discussed. Alpha-pinene is shown to have the highest quantities in June and decrease by late July. The alpha-pinene pattern repeats regardless of plot density. Limonene and myrcene had the highest quantities in the lowest density plot, decreasing as plot density increased. In July, 3-carene quantities were the highest and then dropped by late July. Beta-pinene stayed relatively consistent

across the season and across a gradient in plot density. An unknown compound, close in molecular weight to limonene, was found mostly in uncolonized trees. It had the highest quantities in the 2nd densest plot with no distinguishable seasonal pattern in quantity shifts. Our findings have implications for managing seasonal plot density characteristics as determined by shifts in host chemistry.

(221) Biological Control of White Mold of Snap Bean with Low Rate Contans Applications

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The goals of this project were to 1) determine whether Contans (*Coniothyrium minitans*, Cm) applications to flailed diseased crop residues left on the soil surface generate a “biocontrol epidemic” under western Oregon conditions and 2) evaluate efficacy of low rate (1–1.5 lb/acre) at-bloom and after harvest Contans applications on white mold (*Sclerotinia sclerotiorum*/Ss) sclerotial survival in western Oregon. Exp. 1. A commercial fall cauliflower crop infested with white mold was flailed in November 2007; Contans (2 lb/acre) was applied to the decomposing residues. Sterile sclerotia were placed in bags on 4 dates then removed and evaluated for viability and Cm colonization. Exp. 2. Eight snap bean fields were planted, inoculated with Ss and flailed at maturity, Sclerotia were collected, bagged and replaced in each field. Contans (1.5 lb/acre) was applied to four of the fields. Bags were removed on 6 dates over 2 years and evaluated for viability and Cm colonization. Exp. 3. Four treatments were applied at bloom to 2 bean fields (one with and one without a history of Contans): 1) water, 2) 1 lb/acre Contans, 2) Contans/low rate Topsin, and 4) high rate Topsin. White mold sclerotia were collected at harvest and evaluated for Cm colonization. Results: Low rate Contans applications created an ongoing “biocontrol epidemic” in the field in western OR environmental conditions. Sclerotia died more rapidly in Cm+ fields than in Cm- fields. At bean planting in the second summer after fall Contans application there were still sufficient sclerotia in the Cm+ fields to generate white mold development. However, it is likely that by the following June, sclerotial populations in the Cm+ fields would be near zero. Sclerotia that developed on beans grown in fields treated the previous year with Contans died as rapidly as sclerotia treated with Contans after bean harvest. At-bloom Contans application resulted in 70% to 80% Cm colonization of sclerotia; high rate Topsin application resulted in the lowest colonization (15% to 21%), and the Contans/half rate Topsin tank mix resulted in an intermediate level of colonization (45%

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to 50%). Applying Contans to snap beans at bloom is effective but is not currently a registered use. Contans treatment may make it possible under western OR conditions to reduce white mold rotation length from 5 to 4 or 3 years. Contans should be used as one tool in a diverse white mold management toolbox including rotation, row spacing and orientation, nitrogen and irrigation management, resistant varieties, and fungicides.

Specified Source(s) of Funding: Western SARE SW09-031

(222) The Effect of Clopyralid Rate on Annual Strawberry Production and Black Medic (*Medicago lupulina*) Control

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Clopyralid is registered for control of broadleaf weeds in strawberry. A recent label permits application when fruit and flowers are present on the plant. The objective of the study was to evaluate rates of clopyralid in annual strawberry and black medic control. Clopyralid was applied at 45, 66, 132, 195, and 261 g a.e./ha. Treatments were applied with a backpack sprayer with XR11004 nozzles calibrated to deliver the spray solution at 284 L/ha. At the time of application, strawberry 'Sonata' had flowers and fruit present on the plants and the plants were producing new leaves. Black medic was 15 cm tall and 23 cm wide. No crop injury was observed during the experiment. Yield was not different among treatments. Strawberry yielded 99% to 123% of the nontreated control. At 14 days after treatment (DAT), clopyralid at 45 g/ha had the lowest black medic control (87%) and was similar to clopyralid at 66 g/ha. At 27 DAT, clopyralid at 45 g/ha had the lowest control (79%). The application of clopyralid may be cultivar specific, however, this cultivar had excellent crop tolerance. All rates provided excellent control of black medic. The registered rates provided the least control and the control was greater than acceptable amounts of control.

(223) Influence of *Trichoderma* Application on Seed Germination and Seedling Biomass of Jamaican Scotch Bonnet Peppers

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Jamaican Scotch Bonnet peppers, which exhibit inherent quality attributes such as flavor and pungency, could become a potential niche market for small farmers on the Delmarva Peninsula. However, the crop is highly susceptible to numerous soil-borne pathogens that may significantly affect yield. Beneficial microorganisms, notably *Trichoderma*, are plant symbionts that maybe used as seed treatment to control diseases and enhance plant growth and yield. This study was conducted to examine

the survival and persistence of *Trichoderma* and examine their effects on early stage germination of hot pepper seeds. Seeds were sown in sterile promix amended with three treatments, which included isolates from a commercial product RootShield® containing *Trichoderma harzianum* (T22), a Maryland *Trichoderma* isolate (GL13), and a control. Inoculation of the isolates were applied to the autoclaved promix via a cellulosic granular carrier Biodac® at a rate of 0.1% (v/v). Seeds were sown into 96-celled trays and placed in a growth chamber for 7 days at 27 °C and then placed in the greenhouse. Days to emergence, germination as well as seedling biomass were determined. Microbial samples of the potting mix were analyzed for survival and persistence of *Trichoderma* strains periodically over 21 days post-inoculation. Strains GL13 and T22 showed increased germination percentage of 15.6% and 15.3%, respectively, when compared to the control. Days to seedling emergence above the soil line was significantly lower in GL13 when compared to the control. Microbial population of T22 and GL13 was 3.9×10^5 CFU/g and 2.8×10^5 CFU/g, respectively, after 14 days. Microbial population of T22 declined by 1.3×10^5 CFU/g after 21 days, while GL13 increased by 2.0×10^5 CFU/g. GL13 increased root and shoot dry weight by 8.25% and 9.8%, respectively, over the control. Results show that *Trichoderma* may have a positive impact on hot pepper seeds at the early stages of germination and this may improve seedling quality and vigor.

(224) Heat-Induced Inactivation of Seed Germination in Canola (*Brassica napus*), Grain Amaranth (*Amaranthus caudatus*), and Proso Millet (*Panicum miliaceum*)

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Trade of grain crops across international borders where live seeds, especially weed seeds, present a problem in obtaining import permits from plant inspection services requires a simple, cost effective treatment to inactivate the problem seeds. One potential method of inactivating weed seeds is through heat treatment. However, little information is available on temperatures that inactivate weed seed germination but do not affect the utility of the grains. We evaluated the influence of heat treatment on the germination of Canola (*Brassica napus*), Grain Amaranth (*Amaranthus caudatus*) and Proso Millet (*Panicum miliaceum*) seeds as a reference. Most seeds maintained good germination (70% to 90%) after they were exposed to 80 to 100 °C for up to 40 minutes inside drying ovens. When seeds were exposed to 110, 120, 130 °C for 5, 10, 15, and 20 min in the oven, percent seed germination varied from 82.8% to 0%, depending on the temperature and exposure time. When treated with the same range of temperature (110, 120, 130 °C) for up to 20 minutes, canola, grain amaranth, proso millet seeds lost germination completely after they were exposure to 110 °C for 10 min, 120 °C for 15 min, 110 °C for 15 min, and 110 °C for 5

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min, respectively. When proso millet seeds were treated with a commercial flame burner (grain roaster) at seven different temperatures (82, 96, 99, 104, 110, 116, 118 °C) for one minute, they became completely incapable of germinating. Heat inactivation of weed seed germination appears to be a promising practice. For seed germination inactivation, the flame burner appears to be more efficient in term of treatment time and energy requirement especially for large volume handling than does an oven type of process.

Wednesday, July 24, 2013

12:15–1:00 PM

Crop Physiology

(306) Physiological Response of Non-acclimated Spinach to Repeated Freeze–Thaw Cycles

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While high tunnels offer growers a way to extend the local growing season, winter production limits productivity when plants are repeatedly exposed to freezing temperatures. During winter production, plants experience both sub-optimal growing temperatures and extreme diurnal temperature fluctuations. The focus of this study was to evaluate the effect of repeated freeze/thaw cycles on photosynthetic rates and efficiency in spinach. Spinach (cv. Space) was exposed over three days to various diurnal temperature regimes. After each cycle, photosynthesis (Ps) and chlorophyll fluorescence (Fv/Fm) were monitored for four hours with a Li-COR 6400. Non-cold acclimated plants were exposed to either a mild (10/0 °C day/night) or severe (10/–5 °C) freeze cycle that were compared to the controls (10/5 °C). Single or multiple freeze/thaw cycles (mild or severe) did not significantly lower steady state Ps rates, when compared to the controls. However, the rate of Ps recovery was significantly slower as freezing severity increased. Fluorescence ratios for cold exposed plants were not significantly different from the unstressed controls (0.832 ± 0.004) indicating no reduction in photosynthetic efficiency. Results support the finding that biomass production in winter grown spinach is governed more by how quickly photosynthetic rates recover rather than by an actual reduction in photosynthetic rate after exposure to freeze/thaw events.

(307) Changes in Aliphatic Glucosinolates Synthesis during Early Seedling Growth and Insect Herbivory in Radish (*Raphanus sativus* L.)

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Glucosinolates, which are abundant in Brassicaceae crops as secondary metabolites, play an important role in both plant growth and self-defense. The present study was carried out to find out the temporal relationship between aliphatic glucosinolates content in tissue and level of expression of the genes involved in the biosynthesis during early seedling growth and herbivory of *S. exigua* in radish. The major glucosinolates found in radish were glucoraphenin in seed and glucoraphasatin in tissues other than seed. Glucoraphenin content was high in radish seeds, showing 7-fold compared to the level of glucoraphasatin, and decreased fast during germination. Glucoraphasatin in radish seedlings increased abruptly up to 7 days during germination, ranging 8.5 to 10.8 mg/g dry weight, thereafter, decreased consistently. RT-PCR study of the genes involved in the biosynthesis of glucosinolates in radish revealed that the expression of CYP79F1, CYP83A1 are gradually increased after germination, however, the glucoraphenin sharply decreased. Herbivory with *S. exigua* increased the amount of glucoraphasatin by 1.3 fold in all three cultivars tested.

(308) Quantitative Analysis of the Major Aliphatic Glucosinolates in Doubled Haploid Lines of Radish Plants (*Raphanus sativus* L.) Obtained by Microspore Culture

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Glucosinolates (GSLs) are secondary metabolites commonly occurring in Brassica crops and more than 130 different GSLs have been reported in diverse plants. Recent studies have indicated that isothiocyanate (ITC) derived from GSL by hydrolysis had a potential for anticancer activity against several tumor cells on human. In addition, it was found that glucoraphenin (GRE) and glucoraphasatin (GRH) were abundant and differently regulated in radish plants, depending upon organs and developmental stages. Microspores isolated from radish flowers were cultured in vitro to obtain doubled haploid (DH) (but homozygous) lines in a short time period. Total 41 DH lines were selected based on flow cytometry analysis. The seeds, obtained by bud pollination from the DH lines, were planted and 3-week-old young seedlings were used for the major aliphatic

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GSLs analysis. Amounts of GRH were highly variable from the DH lines ranging from 2.3 to 31.5 mg/g dry weight (DW). The donor plant (DP) contained 18.4 mg/g DW. It was noticed that there were 6-fold differences in the amounts of GRE between the highest and lowest DH lines. Among 41 lines tested, 14 DH lines of radish plants were significantly reduced in the amount of sum of GRH and GRE compared those of the donor plant ($P < 0.05$), whereas only three lines increased. The results obtained in the present study will lend to select genotypes with low and high GSLs contents of radish plant. In addition, those DH lines will aid to elucidate a biosynthetic pathway of the aliphatic GSLs in radish plants, which remain for the most part unsolved.

(309) Comparison of Glucoraphasatin and Glucoraphenin Content from Radish Plant during Vegetative and Reproductive Growth

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Glucosinolates are secondary metabolites found abundant mainly in Brassica vegetables and the importance of this compound has been sharply increasing due to being health benefits. The amounts of glucoraphasatin (GRH) and glucoraphenin (GRE) were compared from the commercial radish cultivars with seeds, young seedlings, mature plant, and flowers. All five genotypes showed much higher concentration of GRE in seeds compared to the other organs, approximately ranging 40 mM per gram dry mass. The concentration was sharply declined during germination and maintained basal level of concentration for the subsequent vegetative growth period. Contrary to this, the amounts of GRH, which is an immediate precursor of GRE, was steadily increased during early growth period up to 8 weeks old and remained a similar level. As growth of seedlings progressed, inner leaves contain much higher amounts of GRH than outer leaves. In root, little amount of GRE was found compared to the other tissues. However, GRH was abundant in roots and young root showed the highest. The results taken together, the reproductive organs tend to accumulate mainly GRE than GRH, however, the latter was found relatively high in roots and young leaves.

(310) Polyamines Alter Fruit Size and Shape

by Regulating Cell Division and Expansion in Tomato

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Several genes regulating fruit size and shape have been identified, but the signals regulating these processes in fruit are not yet known. Polyamines (mainly putrescine, spermidine, and spermine) are small ubiquitous biogenic amines that play an essential role in eukaryotic cell division, but their role in determining plant architecture is not yet investigated. We have developed transgenic tomato lines by expressing yeast spermidine synthase under constitutive or fruit-specific promoters that exhibit higher spermidine and spermine levels. Fruits from these genetically altered tomato lines were digitally characterized for 40 different morphometric attributes, including fruit shape, blockiness, and pericarp thickness. High polyamines fruits exhibited increase in pericarp thickness ratio and height-to-width ratio, but reduced perimeter and proximal fruit-end blockiness, imparting more obovoid fruit shape compared to wild type (WT) fruits. Microscopic analysis of ovaries with high PAs indicated that polyamines alter fruit size and shape during early fruit development. The qRT-PCR showed that transcript levels of *SUN* and *OVATE*, two fruit architecture-related genes were up- and down-regulated respectively, during 10 days post-anthesis (DPA) by polyamines. Transcripts of *FW2.2*, a negative regulator of cell division, were not detected. Among the genes involved in cell cycle progression, *CDKAI* was upregulated whereas *CYCD3* and *CYCA2* were down-regulated from 5 days before anthesis to 20 DPA in PA accumulating fruits. The transgenic fruits also showed transient increase in transcript levels of *CDKB2* and *CYCB2* at 2 and 5 DPA, respectively. CDK-inhibitor *KRP1* was up regulated at 2 DPA before down regulation thereafter in high PA fruits. An increase in transcripts for *WEE1*, an endoreduplication associated gene, was also observed at 5DPA in one of the transgenic lines suggesting a possible role of endo-reduplication in this phenotype. Collectively, our results suggest that PAs influence fruit development by regulating both cell division and expansion.

(311) Glucosinolates Distribution during Growth and Development in Radish Plants

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Glucosinolates (GSLs) are a group of plant secondary metabolites in *Brassica* species. Isothiocyanates (ITCs) including sulforaphane (SFA) and sulforaphene (SFE) are two hydrolysis products from GSLs and are known to induce detoxification enzymes relating to cancer cell death. The diversity and content of GSLs are closely related with plant development and different plant organs. In this study, distribution of GSLs in radish plants (*Raphanus sativus* L.) were quantified in different plant parts during development using high performance liquid chromatography and ultra performance liquid chromatography equipped with ultraviolet and mass detector, respectively. Quantitative analysis conditions of desulfo-GSL extraction method were optimized. The total GSL contents are dramatically varied in different organs and development stages of radish plants. The concentration of total GSLs by different organs in mature stages (12 weeks-old) were varied—mostly 20-fold—ranging from 305.5 to 8282.9 nmol/g D.W. The amount of GSL in mature seeds was notably high compared with those in other organs. The highest content of total GSLs at the mature growth stages (12 weeks-old) were determined at mature seeds followed by flower stalk, flower, root (bottom), root (upper), inner leaves, outer leaves, root (middle) and silique. The total GSLs concentration in mature seeds (3394.0 nmol/g D.W.) was notably high compared with those in other parts. Glucoraphenin (GRE) was abundant. Of 10 GSLs in radish, the major GSL types were detected aliphatic GSLs containing GRE, glucoraphasatin (GRH) and glucoerucin (GER) in spring. However, different GSLs including glucoputrajivin (GPT), GRH, and GER were detected in radish plants in fall. The influence of planting season on GSLs content and composition in radish was clear. Total GSLs content harvested at spring season (2729.9 nmol/g D.W.) was 4.5 times higher than the content in fall. Individual GSLs harvested at spring was more diverse than the GSLs in fall. Radish in spring was occurred reproductive organs while the radish in fall was not. Thus, reproductive organs might be up-regulated GSL biosynthesis, which is related with defense mechanism and propagation in radish plants.

(312) Daily Light Integral Influences Production of Steviol Glycosides

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The genus *Stevia* consists of approximately 220–230 species, with one species, *S. rebaudiana* (stevia), distinguished by its relatively high production of non-toxic, non-nutritive, ent-kaurene diterpenoid glycosides. Some of these glycosides

are approximately 300 times sweeter than sucrose. Steviol glycoside concentrations vary widely among stevia genotypes. The influence of environmental factors, such as irradiance and photoperiod, on steviol glycoside synthesis is poorly understood. To investigate the effect of total accumulated irradiance, or the daily light integral (DLI), on steviol glycoside production, two stevia genotypes, 10-43-41 and 11-464, were grown in a greenhouse at Michigan State University under a range of DLIs and a constant 16-hour photoperiod. A total of six DLIs, ranging from 3.5 to 20.1 mol·m⁻²·d⁻¹, were achieved by growing plants under shade cloths varying in light transmission, and by growing plants at different times of year. Following two months of growth in treatments, steviol glycoside concentration was quantified from leaf material and plant height and leaf area were determined. Plant height of both genotypes decreased as DLI increased. Increasing the DLI reduced leaf size of 10-43-41 but not 11-464. Total steviol glycoside (TSG) concentration increased as DLI increased from 3.5 to 8.4 mol·m⁻²·d⁻¹, and was similar at DLIs of 8.4 mol·m⁻²·d⁻¹ or greater. In addition to affecting TSG, DLI also differentially influenced the concentrations and relative proportions of specific steviol glycosides. For example, stevioside concentration decreased as DLI increased, while rebaudioside A, B and C concentrations increased as DLI increased (up to max DLI observed). These results indicate that the total amount of photosynthetic light received can affect both total steviol glycoside production and production of specific glycosides.

(313) The Influence of Temperature, Amino Acid, and Polyamine on Pollen Germination of Pepper (*Capsicum annum* L.)

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Evaluation of pollen viability was conducted for peppers and methods for improving pollen germination under abnormally high temperatures were studied. Optimum temperature for pollen germination was 25 °C, but percent germination decreased at 27.5 °C and 30 °C. Concentration of sucrose and pH of the medium that is proper for higher pollen percent germination and pollen tube growth was 10~15% and 5.5~6.5, respectively. Pollen percent germination was different depending on the pollen collection time during a day. Generally, pollens collected

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at 10 in the morning showed the highest percent germination, while decreased pollen viability was observed as collected late in the afternoon. Pollen percent germination was improved when two amino acids, asparagine and glutamine, were added in the pollen germination medium. In addition, putrescine and spermine also improved pollen percent germination. Overall, an additive and its concentration for enhanced pollen germination at high temperature in pepper was found in the treatment of 1 mM of supermine, which increased germination rate by 15.0% as compared to control.

Specified Source(s) of Funding: Korea Rural Development Administration

Wednesday, July 24, 2013 12:15–1:00 PM

Environmental Stress Physiology

(236) Carbon Gain, Biomass Allocation, and Water Use by Garlic in Response to Elevated CO₂ and Nitrogen Availability

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The carbon–nitrogen balance is central to crop yield, and can be altered by nutrient deficient soils and atmospheric enrichment of carbon dioxide. Although aboveground responses to carbon dioxide and nitrogen (N) have been reported for a number of crops, little is known about the response of belowground components that function as storage and vegetative propagules such as tubers, rhizomes, and bulbs. We investigated growth, biomass allocation, leaf gas-exchange, and water use efficiency (WUE) in a hardneck garlic and tested whether elevated CO₂ and nitrogen availability alters carbon gain and allocation to bulbs, and plant WUE. The garlic plants were grown at three different N levels (Low-N, Mid-N, and Full-N) in sunlit CO₂ enrichment chambers. We quantified whole-plant growth and allocation by destructive harvests, determined leaf nitrogen content and stable carbon isotope (¹³C) fractionations, and performed leaf gas-exchange analyses. The results show that nitrogen deficiency primarily affected the aboveground plant parts with significant decreases in aboveground growth ($P < 0.05$) in the Low-N compared with the Full-N. Whereas CO₂ enrichment increased stem biomass ($P < 0.05$) and WUE as corroborated by both leaf gas exchange ($P < 0.05$) and stable carbon isotope analyses ($P < 0.001$). Significant interaction in WUE between CO₂ and N were only detected in stable carbon isotopes ($P < 0.01$). Biomass partitioning to bulb was similar across the CO₂ and N treatments. The consistency in biomass allocation patterns across all N and CO₂ treatments suggest that the use of bulbing ratio for making cropping decisions such harvest scheduling

may remain a robust method across N fertilizations as well as atmospheric enrichment of CO₂.

Specified Source(s) of Funding: Cooperative Research Program for Agricultural Science & Technology Development (Project No. PJ006403), Rural Development Administration, Korea

(237) The Effects of Fog Moisture Treatment on Reduction of Water Core Occurrence in Apple

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The objective of this study was to examine the efficiency of fog system for decrease of water core, one of the physiological disorders, in fruits of apple cultivar Hongro. Recently, global warming occurs abnormally high temperature in summer and it induces water core to increase in fruits. Therefore, we introduced a fog system to reduce temperature by exchange of heat energy, which decreases water core incidence. We performed field experiments at 9 orchards during the end of June to August in 2012. We tested 6-year-old+ ‘Hongro’ trees and the elevation of the orchards was 126 to 306 m. The fog system was sprinkled on at 3.5 L per a tree for half an hour twice at 6:00 and 8:00 p.m. when air temperature is over 28 ± 1 °C at 6:00 PM. The temperature of fruits and trunks showed higher than that of foliage. The fog system was sprinkled on average of 25 times during the experiment period. Temperature at the sprinkled by the fog system was lower 0.5 °C than that of control, regardless of the orchard environment. Fruit characteristics, such as weight, sugar degree, and acid content, were no different between treatments. However, severity of water core with fog system was reduced to average 22.7% and showed high significance between treatments and among orchards. In conclusion, the preceding results showed the possibility that the sprinkling of fog system reduces water core by exchanging heat energy in tree.

Specified Source(s) of Funding: Cooperative research program for agriculture science and technology development (Project No. PJ008796042013) of Rural Development Administration, Republic of Korea

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(238) The Effect of Water Stress on Leaf Aquaporin Expression in Sweet Orange Trees

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Water movement through cell membranes is facilitated by water channels called aquaporins (AQPs). These membrane proteins belong to the major intrinsic protein (MIP) family and play a central role in plant water relations. There are increasing evidences that AQPs are involved in the regulation of water transport in many physiological processes such as stomatal movement. It is also known that different environment stresses affect AQP expression and activity and as a result the cell membrane water permeability is modified. Under water stress conditions plants key concern is to minimize water loss to maintain plant water balance. It is well know that one of the main mechanisms of plants to avoid water stress is the reduction of stomatal conductance. According to this information the main objective of this study was to elucidate if water stress modify the expression of leaf AQPs in sweet orange seedlings. Two-year-old seedlings of Marrs Early sweet orange grafted onto C22 rootstock (Sunki mandarin x Swingle trifoliate orange) were grown in a greenhouse (Oct.–Nov. 2012). Plants were subjected to three different water regimes: control (well watered plants), 75% or 50% of the dose used to water control plants was applied 2–3 times per week. Control plants were kept under field capacity during the growing period. Leaf water potential and stomatal conductance were measured weekly. Six weeks after the beginning of the treatments, when significant differences in leaf water potential and stomatal conductance were observed among treatments, samples of xylem exudates were collected and the abscisic acid (ABA) content was determined. The expression of five citrus AQPs was quantified by reverse transcription-PCR in fully developed leaves. A decrease in water potential and stomatal conductance, and an increase in ABA content in the xylem sap were observed as the water stress treatment was more severe. The expression of AQPs was affected by the water stress treatment: the expression of one of the five AQPs tested was reduced by the most severe water stress treatment (50%) so that it reduced water transport in the leaf, which could explain the lower stomatal conductance and water potential observed

in this treatment with respect to the control and to the moderate water stress.

Specified Source(s) of Funding: This research was funded by the Universidad de Cordoba (Spain) and the Texas A&M University–Kingsville, Citrus Center

(239) Sound Practices to Effectively Perform Electrolyte Leakage Assays

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The effectiveness of electrolyte leakage assays was tested in order to develop simple and sound procedures and to evaluate cold tolerance in fruit tree research studies. Divergences in specific methodological details that may impact the accuracy of these types of assays have been found in the literature. In this methodological study, leaves from grapefruit trees grown in the field were used to evaluate: 1) the adequate ratio between the number of leaf disks and the volume of water in a sample tube; and 2) the addition of ice chips. These trials showed that using less than one leaf disk per mL of water per tube resulted in too much variability in electrolyte leakage, which decreased the effectiveness of this method to estimate the lethal freezing temperature. The addition of ice chips into test tubes to nucleate the water-soaked tissues did not have any effect on electrolyte leakage compared to the non-addition of ice chips when this addition was done after the immersion of the test tubes in the refrigerated bath; however, electrolyte leakage was different when the ice chips were added before the immersion of the tubes in the refrigerated bath since the ice melted before leaf disks were subjected to freezing temperatures.

(240) Interactive Effects of Hypoxia and Salinity on Perennial Ryegrass and Alkaligrass

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A lot of salt-affected soil in the world is also affected by compaction and waterlogging due to shallow water tables or decreased infiltration of water in soil because of sodicity. Waterlogging and compaction cause a reduced oxygen exchange (hypoxia). Research on the combined impacts of salinity and hypoxia on turfgrass growth is limited. The interactive effects of salinity and oxygen availability on nine perennial ryegrass lines (*Lolium perenne* L.) and one alkaligrass (*Puccinellia tenuiflora*) was studied. In a controlled greenhouse, grasses were exposed

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to four salinity levels (3, 6, 9, 12 dS·m⁻¹) with and without hypoxia condition for four weeks each. All entries exhibited decreased clipping yield with increasing salinity in both salinity and hypoxia + salinity treatments except Fults Alkligrass. Turf quality declined over time to unacceptable quality ratings with high salinity (12 dS·m⁻¹) treatment. In general, all entries had better turf quality in control and hypoxia treatments than in salinity and salinity with hypoxia treatments. All grasses were more severely affected (quality and yields) under combined hypoxia and salinity treatment compared to salinity or hypoxia only. The experimental lines that maintained acceptable turf quality under hypoxia plus moderate salinity (6–10 dS·m⁻¹) conditions were selected.

(241) Varietal Differences in Physiology of Drought Stressed *Phaseolus*

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Common bean (*Phaseolus vulgaris*) is the world's most important directly consumed food legume; however, in many areas of the world bean production is drought limited, and this is a particular food security problem in the developing world. In an effort to improve the efficiencies of breeding for drought tolerance, we have compared various drought tolerance mechanisms in a broad range of *Phaseolus* genotypes from Andean, Mesoamerican, and Sonoran populations, from both *P. vulgaris* (common bean) and *P. acutifolius* (teparty bean), that are known to exhibit significant differences in drought tolerance in field trials. Mesoamerican and tepary bean genotypes are commonly recognized as generally more drought tolerant and more productive under moderate levels of stress when compared to Andean populations. Although these differences have often been attributed to root architecture, our studies of gas exchange, fluorescence parameters, and growth data show that under root limited conditions there are major differences related to several shoot factors, including heat tolerance, photosynthetic capacity, stomatal behavior and conductance. Some genotypes, for example, show evidence of osmoregulation (accumulation of several compatible solutes), particularly when water stressed allowing for the maintenance of lower leaf water potentials. Other characteristics include more rapid stomatal closure when stressed and higher water use efficiencies, i.e., the ability to maintain photosynthesis as transpiration is decreasing. A/Ci analyses also show that the higher photosynthetic rates under both stress and well watered conditions are primarily due to differences in the generation of ribulose biphosphate for the Calvin-Benson cycle. These results suggest several productive strategies to improving drought tolerance in common bean.

Specified Source(s) of Funding: USDA–NIFA

(242) Initial Evaluation of Lettuce Collections for Drought Tolerance

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Lettuce (*Lactuca sativa* L.) production in California represents a 1.5 billion dollar accounting for nearly 80% of all lettuce produced in the United States. While California has an abundance of fertile farmland and a favorable climate for the production of leafy vegetables, a combination of factors pose a serious threat to the future of the lettuce industry. Limited water availability for irrigation arising from reduced precipitation along with regulatory reductions is already applying pressure on producers, while climate change threatens to exacerbate these effects. Leafy vegetables with high water content, such as lettuce, are particularly vulnerable to drought stress. A reduction in water applied could represent not only a substantial savings to the producer, but it could also represent the potential for an increase in production acres in order to keep up with rising demand due to population growth. In order to identify lettuce cultivars adapted to limited water availability, more than 1,500 lettuce varieties and germplasm were screened in greenhouses for drought-tolerance through a binary drought screen evaluating leaf relative water content, wilt-resistance, and shoot fresh weight. Selected varieties and germplasm, identified through initial greenhouse analysis, were further evaluated in the field under a gradient of water-stress conditions to identify cultivars showing resistance to limited water availability. With a combination of greenhouse and field evaluations, differences in the ability of lettuce genotypes to adapt to limited-water environments were identified. This initial screening of lettuce germplasm represents a substantial first step in developing cultivars improved for production in regions with increasing pressure on freshwater availability along with providing another tool by which producers and breeders can choose cultivars adapted for limited-water stress.

(243) Remotely Surface Reflectance Data for Irrigation Scheduling of Southern New Mexico Pecan Orchards

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Demand for New Mexico's limited water resources coupled with periodic drought has increased the necessity for developing advanced sensing technologies to optimize irrigation scheduling and drought monitoring of pecan orchards. The objective of this study was to use remotely-sensed surface reflectance derived from a hand-held spectroradiometer (ASD Fieldspec Pro Full

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Range Spectroradiometer), Landsat-7 Enhanced Thematic Mapper (ETM+), and Earth Observing One-Advanced Land Imager (EO-1 ALI) to detect moisture status of pecan trees exposed to cyclic flood irrigations. The study was conducted simultaneously on two southern New Mexico mature pecan orchards in 2012. Irrigation cycles were synchronized with satellite overpasses. In situ measurements of canopy spectral reflectance and pecan stem water potential (Ψ_{snd}) were taken shortly after irrigation and near the end of a flood irrigation dry-down cycle. In situ measurement of canopy reflectance at near infrared wavelengths (750, 960, 1050, 1075, and 1260 nm) correlated positively with Ψ_{snd} , whereas short wave infrared (SWIR) surface reflectance within the range 1450 to 2500 nm did not differ between well-watered trees and those at the end of irrigation cycle. Near infrared reflectance recorded by the ETM+ and EO-1 ALI sensors correlated with Ψ_{snd} , but unlike the in situ data, SWIR reflectance data from these satellite sensors was also significantly correlated with Ψ_{snd} . Our results suggest that remotely-sensed data from both satellite sensors and hand-held spectroradiometers can be used to detect moisture status of pecan orchards, but the difference in scale of observation needs further interpretation.

(244) Using Sap Flow, Stem Diameter Micro-variations to Assess Water Use in Grapefruit Trees under Water-saving Irrigation Strategies

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The objectives of this study were: 1) to study the response of grapefruit trees to regulated deficit irrigation (RDI) and partial rootzone drying (PRD); and 2) to evaluate the use of different methods, including stem water potential, sap flow, and tree trunk micro-variations, to estimate tree water use. A greenhouse experiment was conducted at the Texas A&M University–Kingsville Citrus Center during 8 weeks. Root systems of 2-year-old grapefruit trees were split into half and allowed to become established in adjacent pots. Four irrigation strategies were applied: 1) Control: irrigated with 100% of plant evapotranspirative needs (ET); 2) RDI60: 60% ET; 3) RDI30: 30% ET; and 4) PRD: 100% ET applied to only one-half of root zone, changing the side every four weeks. Stem water potential (SWP), stomatal conductance, leaf abscisic acid concentration, chlorophyll fluorescence, and plant growth (total plant dry weight and shoot length) were measured. The RDI strategies increased tree water use efficiency; trees with RDI60 and RDI30 used 30% and 52% less water than control, respectively, without showing differences in total plant dry weight or shoot length. RDI30 trees had a lower SWP than RDI60 at the end of the experiment, although the value (–1.48 MPa) was very mild and RDI30 trees were not considered to be drought stressed. PRD did not show any differences in water savings (probably because of the short duration of this experi-

ment), SWP or plant growth. Trees under RDI60, RDI30, and PRD treatments showed higher leaf ABA concentration at the end of the experiment as compared to control trees; however, no differences were found in stomatal conductance, which may indicate that hydraulic mechanisms played a role in water movement in the three irrigation strategies evaluated. Regulated deficit irrigation treatments (30 and 60 RDI) had smaller sap flow rates than control and PRD treatments. RDI60 trees had a smaller maximum daily shrinkage than control trees but no differences were observed between the other treatments. This study showed that sap flow sensors and stem diameter variations can be good indicators to detect water stress in grapefruit trees.

Specified Source(s) of Funding: CSIC (Spain) and Texas A&M University–Kingsville, Citrus Center

Wednesday, July 24, 2013

12:15–1:00 PM

Floriculture

(017) Temperature Affects the Development of Brown Spots on the Leaves of *Oncidium Sharry Baby*

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The development of brown spots has been recognized as a significant problem which occurs on the mature leaves of *Oncidium Sharry Baby*. The cause of brown spots is still not clear although it appears to be related to environmental conditions and cultural practices during production. This study was conducted to investigate how temperature influences the development of brown spots in *Onc. Sharry Baby* ‘Red Fantasy’. Propagules of *Onc. Sharry Baby* ‘Red Fantasy’ were obtained from a commercial orchid nursery at two developmental stages: 6-month-old plugs and 3-month-old plugs. Plants were planted and placed in a growth chamber maintained at day/night temperatures of 30/25 °C, 25/20 °C, or 20/15 °C with a 12h day, 60% RH, and 200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ photosynthetically active radiation (PAR). Regardless of temperature and plant age, all plants developed brown spots during the 5-month growing period, however, the degree of brown spot development varied among the treatments. The 6-month-old plants rapidly developed brown spots within a month in all temperature schemes, and additional brown spots developed with higher growing temperatures and continued appearing over time. Meanwhile, the 3-month-old plants developed brown spots 3 months later when grown at lower temperatures,

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and developed symptoms earlier when grown at higher temperatures. Our results suggest that the development of brown spots in *Onc. Sharry Baby* ‘Red Fantasy’ is strongly associated with plant developmental stage, and that higher growing temperatures induce the formation of brown spots, possibly by stimulating rapid vegetative growth.

(018) Evaluation of *Oncidium* Intergenerics as Potential Cut Flowers

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Oncidium intergenerics are popular potted flowering plants with showy flowers and diverse color variations. Despite the huge availability of intergeneric hybrids, only a few varieties of *Oncidiums* have been used as cut flowers. The objective of this study was to evaluate *Oncidium* intergenerics as potential new cut flowers. Propagules of 20 *Oncidium* intergenerics were obtained from a commercial orchid nursery, and were placed in a greenhouse under 40% shade. Plants were arranged in a completely randomized design with 6 plants per cultivar, and fertigated twice a week with alternating overhead irrigation. Length of flower spike, number of flower spike per plant, number of flowers per spike, and longevity of each flower spike was recorded. Among the tested varieties, *Rehfeldara* (*Rflda.*) Jerry ‘Pacific Empire’ produced the longest flower spike at length over 80 cm, while the spike length ranged from 50 to 70 cm in most of the cultivars including *Oncidioda* (*Oncda.*) Copper Scarab ‘Brass Brethren’, *Odontocidium* (*Odcdm.*) Mesmeric Melody ‘Mauna Loa’, *Wilsonara* (*Wils.*) Red Stars ‘Rooster’, and *Brassidium* (*Brsdm.*) Golden Gamine ‘White Knight’, *Oncda.* Copper Scarab ‘Brass Brethren’ and *Odcdm.* Mesmeric Melody ‘Mauna Loa’ were particularly floriferous and displayed more than twice number of flowers per spike compared to other cultivars because of higher number of sprays on the spike, and produced more flower spikes per plant. Longevity of flower spike varied among cultivars, and *Oncda.* Copper Scarab ‘Brass Brethren’, and *Odcdm.* Mesmeric Melody ‘Mauna Loa’ showed greater longevity compared to other tested cultivars. Taken together, *Oncda.* Copper Scarab ‘Brass Brethren’ and *Odcdm.* Mesmeric Melody ‘Mauna Loa’ appeared to be promising cultivars as cut flower crops.

(019) Biocontainer Use in *Petunia xhybrida* Greenhouse Production—A Cradle-to-Gate Carbon Footprint Assessment of Secondary Impacts

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While biocontainers (i.e., biodegradable, plant-based containers) are marketed as being more sustainable than conventional plastic pots, little scientific literature exists to substantiate these claims. Past research has instead shown that adoption of plant-derived containers under current greenhouse production practices often leads to greater use of irrigation water, increased damage and waste during filling and shipping, and differences in plant growth. Life cycle assessment (LCA) serves as a holistic accounting of all the material/energy inputs and waste/pollution outflows associated with a given product. This paper draws on LCA methods to assess how secondary production impacts (e.g., irrigation demand) differ as container type changes. The basis for these comparisons is cradle-to-gate assessment of all of the inputs and outflows associated with production of a common annual ornamental plant (e.g., *Petunia xhybrida*) in a plastic container. This work does not consider the inputs and outputs of manufacturing the containers themselves, since that information is propriety in many cases. Container-specific secondary impacts derived from controlled studies were then incorporated as model parameters to assess differences in overall production global warming potential (GWP). Results show that the container itself accounts for approximately 17% of overall CO₂e (i.e., carbon dioxide equivalent) emissions during petunia production using a conventional plastic pot. Though container was a significant contributor to GWP, electrical consumption for supplemental lighting during plug production and irrigation throughout the production process proved to be the leading sources of CO₂e emissions (over 44%). Differences in GWP were only minor in comparing the use of various biocontainers with standard plastic containers for secondary production impacts. Results demonstrate that biocontainers compete with plastic pots for secondary impacts, suggesting they could potentially be more sustainable than plastic pots once pot manufacturing data are considered. Use of more efficient supplemental lighting sources, however, may ultimately have the greatest impact on overall GWP.

(020) Bluing of *Hydrangea* ‘Endless Summer’ Sepals Is Influenced by Timing of Aluminum Sulfate Drenches or Aluminum Chelate Foliar Sprays in Three Different Locations and Production Systems

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Blue sepal coloration of hydrangea requires supplemental aluminum (Al) application in nursery and greenhouse production systems. Sepal bluing of *Hydrangea macrophylla* ‘Endless Summer’ was evaluated twice during its production cycle with application of two Al sources (Al_2SO_4 drenches or Al-chelate foliar sprays) at combinations of three times (summer, fall, and/or early spring) in three production systems (peat-based substrate in glass greenhouse, Manhattan, KS; Douglas fir-based substrate in an open retractable-roof greenhouse, Aurora, OR; or pine bark-based substrate in open container nursery, Virginia Beach, VA). Controls included pre-plant incorporation of Al_2SO_4 and no Al treatment. Sepal coloration was evaluated with both qualitative ratings and quantified colorimetric readings at one site. Substrate characteristics of pH, EC, and Al were measured before and one week after each application. In the greenhouse study, the use of Al-chelate as a foliar spray did not match blueness resulting from either Al_2SO_4 drenches or pre-plant Al_2SO_4 incorporation, though plants treated with Al-chelate had bluer sepals than the untreated control. As in the greenhouse study, Al-chelate applied to bark-based soilless substrates in Oregon and Virginia produced sepals with less blue color than with the application of Al_2SO_4 ; however, both incorporation and drench methods did not result in a blue color considered acceptable for sale of “blue” hydrangeas. Results of substrate chemical analyses varied across production systems based on the amount of leaching that occurred. Further research might evaluate the effectiveness of Al-chelate when applied using foliar-sprays under high humidity conditions or as a substrate drench.

(021) Water Use and Cold Hardiness of English Lavender

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English lavender (*Lavandula angustifolia*) is an herbaceous perennial that is utilized as a landscape plant and edible herb. This perennial is difficult to grow in greenhouse production and is not reliably cold hardy in hardiness zones lower than 6. Our primary objective was to determine the water requirements of two English lavender cultivars (‘Hidcote’ and ‘Munstead’) in greenhouse production. We also wished to determine whether substrate water content (Θ) of English lavender impacts cold hardiness. English lavender ‘Hidcote’ and ‘Munstead’ were grown at four different θ (0.1, 0.2, 0.3, 0.4 $\text{L}\cdot\text{YL}^{-1}$) in a capacitance

sensor automated irrigation system. Plant height, width, and dry weight of English lavender was significantly greater as plants were grown at higher θ . Inflorescence number of both cultivars was greater when plants were grown in substrates with more water. Leaf level net photosynthesis of ‘Munstead’ increased with increasing θ ; this was most likely due to an increase in stomatal conductance as plants were grown at higher θ . When cold hardiness was estimated by determining electrolyte leakage from leaves exposed to temperatures ranging from -2 to -42 °C, ‘Munstead’ grown at 0.10 $\text{L}\cdot\text{YL}^{-1}$, had a significantly lower T_{50} (temperature killing 50% of leaves).

(065) Wyoming Brown and Gold Fresh Cut Sunflowers

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In Wyoming, the number of farmers’ markets, community supported agriculture (CSA) outlets, and food co-ops have undergone a dramatic increase and are rapidly becoming important avenues for commerce surrounding locally-produced horticultural goods. As the interest in local horticulture becomes prevalent in Wyoming culture, so does the increased necessity for region-specific growers’ information. A 16-month study was conducted to provide the current and emerging horticulture industry with a quick and easy-to-grow niche cut flower crop that displays a brown and gold inflorescence, the well-known colors of the University of Wyoming (UW). Three cultivars of single-stem sunflowers were evaluated at the UW Laramie Research and Extension Center. Year-round production was conducted in a greenhouse facility and seasonal growth trials were undergone in two high tunnel structures. The trials concluded that production can be achieved in both environments, but, with marked differences in stem length and time from sowing to harvest depending on the cultivar and time of year. Despite sunflowers being traditionally categorized as short-day crops, the three cultivars, ‘Dafna,’ ‘ProCut Bicolor,’ and ‘Sunbright Supreme,’ displayed diverse responses to photoperiod. Days from sowing to harvest ranged from 41 days for ‘Sunbright,’ to 112 days for ‘ProCut Bicolor’. Stem length varied from 17 cm for ‘Dafna’ to 185 cm for ‘ProCut Bicolor’. Significant differences were demonstrated in regards to days from sowing to harvest between high tunnel and greenhouse production. Sunflowers in the greenhouse bloomed an average of 3 days faster than those in the high tunnels. Stem lengths, however, were not significantly different between locations. Although no economic analyses have been conducted to assess the business or market potential of cut sunflowers, information about year-round and seasonal cut sunflower production is the first step for growers to influence business decisions when considering adding cut sunflowers to a new or existing production outlet.

Specified Source(s) of Funding: Wyoming Department of Agriculture Specialty Crops Block Grant Program

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Wednesday, July 24, 2013

12:15–1:00 PM

Fruit Breeding

(416) Novel Carotenoid Pathway-related Gene Expression Patterns in Citrus Leaves and Maturing Fruits

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Carotenoids are abundant in citrus fruits and vary among cultivars and species. In the present study, HPLC and real-time PCR were used to investigate the expression patterns of 23 carotenoid biosynthesis gene family members and their possible relation with carotenoid accumulation in flavedo, juice sacs, and leaves of Valencia orange during fruit maturation. Violaxanthin and lutein mainly accumulated in fruit (flavedo and juice sacs) and leaves (young and mature), respectively, accounting for nearly 79%, 57%, 53% and 70% of corresponding total carotenoids in February. Violaxanthin content quickly began to increase in flavedo in December, but the increase in juice sacs began later in January. In mature leaves, lutein content was 3 times that in young leaves; α -carotene and β -carotene were also much higher in mature leaves than in flavedo or juice sacs. Most of the carotenoid biosynthesis gene members were expressed at higher levels in flavedo than in juice sacs, and the expressions of PSY-Contig22, ZDS-Contig23, CHYB-Contig25, and CHYB-Contig07 continued to increase in flavedo during fruit maturation. PSY-Contig10 and LCYE-Contig24 were not detected in juice sacs, and the expression of the other gene family members in juice sacs fluctuated. All CHYB members expressed at high levels and had similar patterns in juice sacs. The CCS members had similar expression levels and patterns in flavedo and juice sacs. In leaf, the expression levels of LCYB-Contig21 was much higher than in flavedo or juice sacs, but the CHYB members and CCS-Contig16 were expressed at low levels, and PSY-Contig10 and CCS-Contig19 were not detected. The expression of ZDS-Contig08 was not detected in any of the three tissues. Pearson correlation analysis showed that the expression of some gene family members had more significant correlations with each other in juice

sacs than in flavedo or leaves. Moreover, the expression of CHYB gene family members had significantly negative correlations with carotenoid accumulation in leaves. The expression patterns of these 23 citrus carotenoid biosynthesis gene members were also compared with their expression patterns in other plants. Taken together, these first-hand expression data will be useful to define the tissue-specific roles of each gene member in accumulation of different carotenoids in citrus leaves and maturing fruits.

(357) Application of Simple Sequence Repeat Markers for Fruit Soluble Solids Content and Titratable Acidity in the Arkansas Peach and Nectarine Breeding Program

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Peach [*Prunus perisca* (L.) Batsch] is the third-most important temperate tree fruit crop produced in the world. It is a diploid species that belongs to the Rosaceae family. Fruit quality characteristics such as flavor, acidity, color, flesh texture, size, shape, and shelf life are important attributes on which breeding programs focus to produce new and improved peach cultivars. The Arkansas peach and nectarine breeding program, which started in 1964, was initially focused on clingstone, non-melting, yellow-flesh peach cultivars destined for the baby food industry. In recent years, the objectives of the program have changed to breeding fresh-market cultivars with different textures, flavors, flesh and skin colors, and harvest date. Soluble solids content (SSC) and titratable acidity (TA) are two important components of flavor, and within the Arkansas breeding program a wide range of peach SSC and TA is present. As part of the RosBREED project (www.rosbreed.org), phenotypic and genotypic data were collected on important Arkansas peach breeding program germplasm for 2010, 2011, and 2012, with the objective of implementing marker-assisted breeding (MAB) to complement the traditional breeding process. The simple sequence repeat (SSR) markers BPPCT015a for SSC and CPPCT040a for TA were screened on 127 trees of five different populations and their parents. This was the first use of these markers in the program. The SSC values varied from 11.2 to 29.6 °Brix and averaged 16.1 °Brix in the years

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analyzed. Six different alleles were identified for SSC. Of these, allele 168 was present in 84% of the trees analyzed. The average content of malic acid was 0.5 g/100 mL with a maximum value of 1.1 g/100 mL and a minimum of 0.2 g/100 mL. For this trait, four different alleles were identified, with allele 312 present in 82% of the analyzed individuals. These promising results will foster future studies focused on developing more accurate DNA markers for these traits and expand the application of MAB in peach breeding programs.

Specified Source(s) of Funding: This work was partially funded by USDA's National Institute of Food and Agriculture—Specialty Crop Research Initiative project, “RosBREED: Enabling marker-assisted breeding in Rosaceae” (2009-51181-05808).

(358) Application of a Standardized Protocol for Fruit Quality Phenotyping in the Arkansas Peach and Nectarine Breeding Program

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Molecular techniques are becoming more commonly utilized in peach [*Prunus persica* (L.) Batsch] breeding programs for several purposes: to screen genotypes as juveniles before they produce fruit; to discard individuals that do not carry certain desired alleles; and to select parents for crossing based on specific alleles. Ultimately, this application will increase breeding efficiency and reduce operational costs, labor, and land. These new techniques are precise and when correctly applied can lead to accurate and useful results, but they only work if accurate and standardized phenotyping procedures are used over multiple years. Within the Arkansas peach breeding program a wide and unique range of flesh types are found, including melting-flesh (MF), non-melting flesh (NMF), non-softening flesh (NSF), and slow-melting flesh (SMF). These flesh types have different textures, firmness, and postharvest performance potential. As a part of the RosBREED project (www.rosbreed.org) the University of Arkansas peach breeding program has applied a standardized phenotyping protocol for fruit quality on seven peach populations and their parents since 2010 to relate genotypic and phenotypic data. This protocol involves

qualitative and quantitative trait characterization, such as: fruit and pit mass, fruit diameter, flesh firmness, flesh texture, flesh adherence to the pit, skin and flesh color, soluble solids content, titratable acidity, pH, bloom date, and ripening date. Along with phenotyping, endopolygalacturonase (endoPG) genotyping for flesh type differentiation was conducted on these genotypes in 2011. Phenotyping of fruit quality traits was conducted at the well-mature stage. Within these seven populations, the MF, NMF, and SMF textures were phenotypically distinguishable and matched the expected flesh firmness values. The MF individuals, which were expected to have the lowest firmness, had an average value of 1.9 Kg of force (Kgf), the SMF individuals (which have a reduced rate of melting phase) averaged 2.7 Kgf, and the NMF individuals averaged 3.3 Kgf. Endopolygalacturonase DNA markers were able to differentiate between MF, NMF, and NSF individuals but were unsuccessful in identifying SMF individuals. These findings facilitate further research in developing a more accurate characterization of the peach flesh types.

Specified Source(s) of Funding: This work was partially funded by USDA's National Institute of Food and Agriculture – Specialty Crop Research Initiative project, “RosBREED: Enabling marker-assisted breeding in Rosaceae” (2009-51181-05808).

(359) RosBREED: Functional Allele Distribution for Blush Development in U.S. Peach Breeding Germplasm

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Skin blush is an important trait for marketing peaches. The red skin pigmentation develops through the flavonoid and anthocyanin pathways, and both genetic and environmental stimuli, and their interaction, control the regulation of these pathways. Blush is under polygenic control with one major QTL locus and several minor QTL loci throughout the genome. A study of one major QTL locus, *Blush.Pp.ZC-3.1*, associated with blush in peach discerned functional alleles/haplotypes with high/low probability of producing high/low blush phenotypes. The U.S. *Prunus* germplasm under the RosBREED collaborative effort was phenotyped in 2011 and 2012 for the percentage of blush covering the fruit skin using a scale from 0–5; 0 indicating no blush and 5 indicating full red surface color. High resolution genome scanning of RosBREED material provided necessary DNA information for determining distribution of high/low blush functional alleles/haplotypes in breeding germplasm. Four functional alleles defined as ‘a’, ‘b’, ‘c’, and ‘d’ were detected at trait loci for high/low blush in U.S. breeding germplasm. Functional allele ‘c’ (i.e., *c/c*, *c/b*, *c/a*) was associated with significantly higher blush ($> 50\%$ $P < 0.001$; *Tukey-Kramer HSD) while functional allele ‘d’ when homozygous exhibited significantly lower blush ($< 10\%$; $P < 0.001$; *Tukey-Kramer HSD). In this presentation, functional alleles and functional genotypes of U.S. peach breeding germplasm will be revealed and possibility for marker assisted parent and seedling selection discussed.

Specified Source(s) of Funding: “RosBREED: Enabling marker-assisted breeding in Rosaceae” is supported by the USDA–NIFA–Specialty Crop Research Initiative by a combination of federal and matching funds (grant number 2009-51181-05808).

(360) Application of Whole Genome Sequencing and High Resolution Mapping to Characterize Brown Rot (*Monilinia* spp.) Resistance in Peach [*Prunus persica* (L.) Batsch]

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Sequencing, map development, and QTL discovery referenced to genome annotation are summarized for three peach genomes and their progeny, generated as part of the California peach/almond breeding programs. Three parents, ‘Dr. Davis’, ‘F8, 1-42’, and ‘Georgia Belle’ were sequenced to identify SNPs for genotyping two breeding populations, Pop-DF (‘Dr. Davis’ x ‘F8, 1-42’) and Pop-DG (‘Dr. Davis’ x ‘Georgia Belle’). A combination of Roche 454 and Illumina/Solexa sequencing were used to generate a consensus genome sequence for each parent. Burrows Wheeler alignment (BWA) with SAMtools were used to align raw data. Velvet/Columbus software was used to assemble the contigs, referenced to the draft Peach 1.0 genome from the International Peach Initiative. Comparison of aligned and overlapping sequences from both Roche 454 and Illumina-Solexa were compared to select 6654 high quality SNPs for ‘Dr. Davis’ vs. ‘F8, 1-42’ and ‘Georgia Belle’, distributed on the eight major peach genome scaffolds from the physical Peach 1.0 assembly. The eight scaffolds from our populations contained about 215–225 Mb of peach genomic sequences with one selected SNP/ ~40,000 bases. Populations DF and DG were scored for 1536 SNPs, evenly distributed across the eight major peach scaffolds, with the Illumina GoldenGate® Genotyping assay. There were 1,400 high quality SNPs used in Pop-DF and 962 were used in Pop-DG to construct two linkage maps with JoinMap®4.0. The Pop-DF map covered 422 cM (1,037 SNPs), Pop-DG map covered 369 cM (738 SNPs), and a consensus map with 588 SNPs in eight linkage groups covered 454 cM with ave. 0.81 cM between SNPs. Placements of SNPs on the ‘peach v1.0’ physical map were compared to placement on the linkage maps and several differences were

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observed. The Pop-DF map was used to identify QTLs for brown rot on linkage groups 1 and 4. SnpEff ver. 3.0c. software was used to identify 2,163 SNP effects, 282 effects were located in exonic regions (13.04%) and 294 placed in intronic regions (13.59%). SNP effects in brown rot QTL regions were evaluated for putative function.

Specified Source(s) of Funding: National Research Initiative of USDA's National Institute of Food and Agriculture (NIFA) grant 2008-35300-04432, UC Agricultural Experiment Station and USDA-CREES (Hatch Experiment Station funding).

(361) Comprehensive Assessment on Quality of Fresh-eating Jujube Cultivars

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Fruit quality of 13 fresh-eating jujube cultivars were assessed, compared, and ranked. Parameters, including fruit weight, fruit shape index, fruit uniformity, titratable acid, soluble sugar, Vc content, sugar-acid ratio, fruit texture, pulp thickness, and resistance to fruit crack, were measured. After the data were converted by the method of subordinate function, factor analysis and comprehensive evaluation were conducted using the software SPSS13.0. Results showed that five common factors (eigenvalue > 1) were extracted with the accumulative variance contribution being 84.57%. The No. 1 common factor was related to fruit taste with the accumulative variance contribution

being 22.904%. The No. 2 common factor was related to fruit nutrition with the accumulative variance contribution being 21.293%. The No. 3 common factor was related to fruit flavor with the accumulative variance contribution being 20.875%. The No. 4 common factor was related to fruit appearance with the accumulative variance contribution being 10.730%. The No. 5 common factor was related to Vc content with the accumulative variance contribution being 8.764%. According to fruit quality evaluation using factor analysis, the 13 cultivars were ranked as the following: 'Jinsi No. 4', 'Zhanhuadongzao', 'Jinsimiao', 'Jidanzao', 'Daguodongzao', 'Tangzao', 'Tezao No. 4', 'Pingguodongzao', 'Yuquan No. 8', 'Zaocuiwang', 'Mizao', 'Mangguodongzao', and 'Lizao'. Our results indicated that the factor analysis could be applied for comprehensive assessment on fruit quality of fresh-eating jujube cultivars.

(362) Phenotypic Diversity of Individual Sugars, Soluble Solids Content, and Acidity in RosBREED Apple Germplasm

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Marker-assisted breeding has been applied in traditional apple breeding programs to increase breeding efficiency and reduce costs of time, land, and labor by testing important parental genotypes to determine the best genetic combinations, discarding seedlings with undesirable traits, and verifying pedigree. In order to more efficiently and accurately identify molecular markers of interest, an extensive germplasm set representing the breeding program is essential. As part of the RosBREED project enabling marker-assisted breeding in Rosaceae, an apple reference germplasm set (crop reference germplasm and breeding pedigree germplasm sets) of 747 individuals was established

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based on the pedigree and allele representation of important parental cultivars, selections and seedlings at the apple breeding programs at Cornell University, University of Minnesota, and Washington State University. Sweetness is one of the important quality traits in apples, and sensory sweetness is a complex human sensation affecting by sweetness, acidity, and aroma. Phenotypic data of sensory sweetness, soluble solids content (SSC), and titratable acidity (TA) were collected using a standardized phenotyping protocol at all three sites at harvest, and after 10 weeks and 20 weeks of cold storage plus 1 week shelf life in 2010, 2011, and 2012. In addition, flesh concentrations of individual sugars (fructose, glucose, sucrose, and sorbitol) and malic acid from 735 and 625 individuals at harvest in 2010 and 2012, respectively, were also estimated using GC-MS. The ranges and means of these traits vary among three locations to account for each unique germplasm set and different growing environments. For example, concentrations of individual sugars are relatively higher in Washington State than the other two sites at harvest in 2011. The phenotypic data for SSC and TA in RosBREED apple crop reference set are available for the public in the Breeder Toolbox at the Genome Database for Rosaceae (GDR) (www.rosaceae.org).

Specified Source(s) of Funding: RosBREED funded by USDA and NIFA

(363) S2 Progeny of Japanese Pear (*Pyrus pyrifolia* Nakai) ‘Osa Nijisseiki’ Having Self-compatibility and Their Homozygosity Estimated By SSR Analysis

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In pear, any self-pollinated progeny are difficult to produce because they have self-incompatibility. Using a self-compatible cultivar ‘Osa Nijisseiki’ with a mutation about the style phenotype, we produced self-pollinated progeny of Japanese pear (*Pyrus pyrifolia* Nakai) in this experiment. Twenty-eight seeds were obtained by self-pollination of S1 cultivar ‘Nou 1 gou’. Twenty-two seedlings were germinated and established in the field. All seedlings were inspected such as true S2 progenies about 42 SSR loci on a reference map of ‘Housui’ (Terakami et al, 2009). Their homozygosity (no. of locus as homozygote/no. of locus scored) estimated by the 42 loci were varied among 0.69 to 0.82 higher than 0.64 in ‘Nou 1 gou’ and 0.24 of ‘Osa Nijisseiki’. The negative correlation observed between the homozygosity and plant height in S2 individuals in first year reflected a negative effect of the homogeneity on their growth. We concluded that the S2 progeny was valuable for the genomic research such as the recessive gene effects in pear.

Specified Source(s) of Funding: This research was supported by the grant no. 23658023 of Grants-in-Aid for Scientific Research, Ministry of Education, Culture, Sports, Science and Technology, Japan.

Wednesday, July 24, 2013

12:15–1:00 PM

Growth Regulators in Fruit and Nut Production

(276) The Use of ABA and AVG to Manage Fruit Set and Cropload of European Pear

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‘Comice’ and ‘d’Anjou’ pear trees are “shy” to bear fruit, the latter only typically during the initial 10–15 years from planting, despite profuse bloom. Poor fruit set of ‘Comice’ has been attributed to a short ovule viability period (1–2 d). The mechanisms limiting fruit set of ‘d’Anjou’ have not been elucidated. We tested the hypothesis that inhibition of ethylene via amino-ethoxy-vinyl-glycine (AVG) would improve ovule viability, and, hence, fruit set of ‘Comice’. For ‘d’Anjou’, we used AVG to gain biological insights regarding flowering and fruit set. Forty and 80 ppm AVG (ReTain, Valent) were applied at 80% bloom or 2 weeks after full bloom (wafb) to ‘d’Anjou’ and ‘Comice’ trees and compared to untreated controls. AVG markedly improved ‘d’Anjou’ fruit set and yield in proportion to rate, but only at the 2 wafb timing. At 2 wafb, 80 ppm increased tree yield ~3-fold compared to controls. Fruit from ReTain-treated trees, however, were significantly smaller than control fruit, a function, in part, attributed to the higher fruit densities induced by AVG. Interestingly, the number of seeds per fruit did not statistically differ between AVG and control fruit, implying that fertilization alone does not limit ‘d’Anjou’ fruit set. Fruit set and yield of ‘Comice’ were significantly improved in response to rate at both application timings relative to controls. At 80 ppm, the 2 wafb timing produced the highest yields. ‘Comice’ fruit size was reduced by AVG ~15%, but still attained commercially acceptable size. Return bloom of either cultivar was not affected by AVG, irrespective of rate or timing. Contrary to the fruit-setting habits of ‘Comice’ and ‘d’Anjou’, ‘Bartlett’ is precocious and productive. Hand thinning is required to achieve commercial fruit size in the Pacific Northwest (PNW). Current thinning agents do not consistently thin ‘Bartlett’ in the PNW. We, therefore, tested the postbloom thinning efficacy of abscisic acid (ABA) (ProTone, Valent) on whole-canopies of ‘Bartlett’ pear trees. Rates of 0, 125, 250, and 500 ppm were applied 21 dafb. Photosynthesis was significantly, negatively related to rate for a 2-week period following application. A highly significant, rate-dependent fruitlet abscission response was achieved by

An asterisk (*) following a name indicates the presenting author.

ABA; 125 ppm reduced fruits per tree to levels equivalent to the hand-thinned control. ABA at 250 ppm severely reduced fruits per tree and 500 ppm removed all fruit. Yield and final fruit size at harvest did not significantly differ between the control and 125 ppm ABA.

(277) Transplant Height Control and “Transplant Shock” Reduction with S-Abcisic Acid (S-ABA) in Vegetable Production

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Transplanting is a standard cultural practice in vegetable production to improve seedling survival and cropping characteristics (earliness, yield, crop quality). The major objective of vegetable seedling production for transplanting is to produce a plant that has a compact shoot and well-developed, strong root system that provides a better chance of survival when it is

moved from the protected environment to the field. S-ABA has been proven to successfully reduce undesirable excess shoot growth in the greenhouse with an increase in root-to-shoot ratio and improve seedling hardiness in a wide range of species. The dosage required varies between species or cultivars on a range of 200 to 2,000 ppm. Seedlings taken from the greenhouse and planted in the field often suffer transient water stress (i.e., transplant shock) due to root injury during transplanting and disturbed root-soil contact primarily in exposure to high evapotranspiration demand. Recently, foliar applications of S-ABA have gained interest in the vegetable industry as a method to improve post-transplant stress tolerance and increase transplant stand establishment. A series of greenhouse and field experiments was performed to determine the effects of exogenous applications of S-ABA on pepper, tomato, and watermelon transplants. Foliar applications of S-ABA significantly reduced water use, improved stand establishment and drought tolerance of the transplants. Latter seems important not just for seedling survival after transplanting but during shipping from the greenhouse to the field.

(278) Physiological Investigations of Chemical Thinner Efficacy in Apples

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Chemical fruit thinning of apples is a challenging task; it is influenced by many factors including weather conditions, tree health status, etc. As these factors vary year by year thinner efficacy also varies from one year to another. The aims of this study were: 1) to investigate the physiological background of thinner efficacy in apples using commercially available and test compounds; and 2) to measure how carbohydrate balance of trees affects fruit sensitivity to thinner applications. ‘Buckeye Gala’ trees on B.9 rootstock in an experimental orchard located at Wooster, OH, were sprayed at 10–12 mm fruitlet size with either of the following compounds: 100 ppm 6-benzyladenine (6-BA), 600 ppm carbaryl, 10 ppm of two different formulations of 1-naphthaleneacetic acid (NAA), 200 ppm metamitron, 200 ppm 1-aminocyclopropane carboxylic acid (ACC), 300 ppm S-abscisic acid (S-ABA), and water (control). Fruit set, cell division and cell size, relative chlorophyll content, chlorophyll fluorescence, photosynthesis, ethylene evolution, and fruit quality were measured. MaluSim Carbohydrate model was used to estimate daily carbohydrate balance of trees. Fruitlet response to thinners, i.e., fruit drop pattern, could be well correlated with the carbon balance of trees. According to

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the model calculations, during the thinner application period carbohydrate balance was positive. Sensitivity of fruitlets to thinners was therefore significantly reduced. ACC and metamitron had the greatest efficacy in causing fruit abscission. The greatest reduction in photosynthesis was measured for metamitron, followed by ABA, NAA, and ACC. Only metamitron caused damage to PSII efficiency or chloroplast ultrastructure, evident as leaf yellowing and reduced relative chlorophyll content of shoot leaves. Neither cell division nor cell enlargement of the fruits nor fruit quality was affected by thinner application; all showed similar patterns over the season in all treatments.

Wednesday, July 24, 2013 12:15–1:00 PM

Plant Nutrient Management

(266) Buffering Capacity of Substrates with Varying Amounts of Compost and Limestone

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Peat is the most popular greenhouse substrate component used today. Compost is another component that can be used in greenhouse substrates. However, the chemical properties of peat and compost are extremely different. Peat has an inherent pH range of about 3 to 4, whereas compost has an inherent pH range of 7 to 8.5. Typically, Limestone is added to peat based substrate to adjust pH. The rates of limestone must be adjusted accordingly when compost becomes a component of these substrates. The objective of this study was to compare pH buffering capacity of substrates that have had pH established by limestone, compost, or a combination of both. The experiment was a factorial design with four compost rates by volume (0%, 10%, 20%, and 30%), four limestone rates (0, 1.19, 2.37, and 3.56 g of limestone per l of substrate) and five replications. Each substrate treatment was titrated through individual incubations with six rates of sulfuric acid (0, 0.1, 0.2, 0.4, 0.7, and 1.0 moles of H⁺ per g of dry substrate). pH was measured at 24, 48, 96, and 168 hours to determine if buffering capacity changed over time. Electrical conductivity (EC) readings were also taken on treatments receiving 0 moles of H⁺ per gram of substrate. Generally, substrates that had the pH established by the addition of compost had similar buffering capacities compared to substrates that had pH established by limestone. Additionally, substrates with pH established by a combination compost and limestone also had similar buffering capacities. Limestone rate had a minimal effect on substrate EC. However, increasing compost rates from 0% to 30% caused the EC to increase on average from 0.27 to 0.77 mS. These results indicate compost can be used to establish substrate pH similar to limestone. Furthermore, substrates that

have had the pH established by compost rather than limestone will also have a similar pH buffering capacity. However, since the addition of compost can result in higher substrate EC, this practice should avoided with salt sensitive crops.

Specified Source(s) of Funding: Longwood Gardens

(267) The Hydration Efficiency of Two Pine Tree Substrate Components under Dry Conditions

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Pine tree substrate components are becoming more prevalent in greenhouse substrates. However, no research has been conducted to determine their wettability. In this study, the hydration efficiency of two differently manufactured pine tree substrate components were tested under dry conditions. Hydration efficiency was determined by developing a wetting curve from 10 hydration events and comparing these to container capacity values. One of the pine tree substrate components was manufactured to simulate the water holding characteristics of peat (SPW) while the other pine wood component was made to perform like an aggregate similar to perlite (PWC). These two components were compared to peat moss and aged pine bark. These four components were tested at 25% moisture content at four different wetting agent rates in order to determine their wettability at what is considered to be hydrophobic moisture content levels for both peat and pine bark. Wetting agent rate did not affect container capacity in the two pine tree substrates or the pine bark, but wetting agents did affect the container capacity of peat. Peat showed high levels of hydrophobicity, not reaching container capacity until the tenth hydration event. Both of the pine tree substrate components as well as the pine bark reached container capacity at all wetting agent levels between the second and fifth hydration event. The PWC and the aged pine bark had similar container capacities; the SPW water holding capacities was higher. The peat with any rate of wetting agent had higher container capacity than all of the other components. However with no wetting agents, peat at 25% moisture content had the lowest container capacity. The two wood components demonstrated little hydrophobicity compared to peat and bark and had better hydration efficiency.

(268) Processing Tomato Response to Nitrogen Fertilizer

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Efficient use of nitrogen (N) is important to reduce production costs, conserve natural resources, and minimize negative

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environmental effects of crop production. Field trials were conducted at a research center in northern Indiana to evaluate the need for new N fertilizer rate recommendations for processing tomatoes. Tomato cultivars (CV) 111 and 9704 (in 2010) and 611 and TR12 (in 2011) were grown at N rates from 0 to 240 lb/ac in a replicated trial on irrigated sandy loam soil in a corn–soybean–vegetable rotation. N was supplied from urea either before transplanting, or both before and 35 (2010) or 23 (2011) days after transplanting (DAT). Seedlings were transplanted on 11 June 2010, and 27 June 2011, at a density of 9,680 plants/acre, and harvested 88–91 (2010) and 109–112 (2011) DAT. Relative yields for each CV x N rate x Year mean were calculated by dividing the mean by the maximum CV x N rate mean for that year. Maximum yield of red plus turning fruit (RT) was 26.4 and 32.3 tons/acre in 2010 and 2011, respectively. Relative yield of RT showed a curved response that predicted increasing yield up to 100 lb/ac of fertilizer N, and decreasing yield at higher N rates when both years were analyzed together. Leaf nitrogen content (leaf N) was determined 2–3, 4–5, and 6–7 weeks after transplanting for N rates up to 180 lb/ac. Aboveground plant nitrogen uptake (N uptake) was estimated at those times and also near the time of harvest. Leaf N was greater than 4% through 34 DAT and greater than 3% through 63 DAT. N uptake and N in fruit near the time of harvest showed linear responses to N rate up to 180 lb/ac. Regression analysis predicted N uptake of 96 lb/ac with no fertilizer N, including 67 lb/ac in fruit. For each lb. of N applied, regression analysis predicted additional N uptake of 0.32 lb/ac, including 0.20 lb/ac in fruit. Existing recommendations suggest that N from fertilizer and credits from prior crops should total 80 to 100 lb/ac. This work suggests that no more than 100 lb/ac N from fertilizer are needed following soybeans. Research in additional environments, including on farms, will be valuable for improving N fertilizer recommendations.

Specified Source(s) of Funding: Mid America Food Processors Association and Red Gold

(269) The Ability of *Plectranthus parviflorus* and *P. ambiguus* to Regreen after Micronutrient Deficiency

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Plectranthus parviflorus has the ability to re-green nitrogen deficient leaves without loss from abscission. Yellow leaves remain intact and return to a healthy green color when given a complete nutrient supply. The purpose of this study was to determine the re-greening ability of *P. parviflorus* and *P. ambiguus* after various micronutrient deficiencies [iron (Fe), manganese (Mn), zinc (Zn), and molybdenum (Mo)] over 6 months. Fe deficient

treatments were switched from deficient to complete twice, Mn treatments were switched once, and zinc and molybdenum have yet to show symptoms of deficiency after 4 months. Fe-deficient plants of *P. parviflorus* were able to re-green yellow leaves to match control plants on both switches. *P. ambiguus* was able to re-green slightly yellowed leaves, but did not re-green leaves with more severe symptoms. These leaves were eventually lost, and the axillary buds broke. Mn-deficient plants of both species did not re-green the yellowing leaves, and upon regrowth some of the yellow leaves abscised. Yellowed leaves on *P. parviflorus* remained attached to the plant much longer than *P. ambiguus*. To date neither Zn nor Mo deficiency has affected plant growth of either species. Visual symptomology of roots and shoots including elemental analyses to confirm deficiencies as well as spectral reflectance curves created at the beginning and end of the experiment will be presented.

Specified Source(s) of Funding: Hatch Project NEB 22-341

(270) Urea Hydrolysis in Pine Tree Substrate Is Affected by Urea and Lime Rate

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Pine tree substrate (PTS) has relatively high C:N ratio that requires the application of more N fertilizer than used with other substrates due to immobilization. If PTS were pre-charged with urea, then growers would not have to add extra N to compensate for immobilization, however, the rate of urea hydrolysis as influenced by urea and lime rate is unknown in PTS. The objective of this experiment was to determine how urea and lime rate influence urea hydrolysis rate in PTS. Approximately 18-month-old PTS made from loblolly pine trees (*Pinus taeda* L.) was amended with 0 or 1.0 kg·m⁻³ dolomitic limestone in factorial combination with urea (46% N) rates of 0, 0.5, 1.0, 1.5, or 2.0 mg·g⁻¹ dry wt. Urea hydrolysis was quantified by the detection of NH₄-N in the substrate solution at 0, 48, 96, and 144 h. Substrate pH values were also measured. At 144 h, substrate solutions were incubated with jackbean urease to determine the remaining urea amount. After 48 h there was no increase in the amount of NH₄-N detected in solutions for the 0 and 1.0 kg·m⁻³ lime treatments and for all urea rates. However, NH₄-N amounts at 48 h for the 0, 0.5, 1.0, 1.5, or 2.0 mg·g⁻¹ urea dry weight treatments were 0, 0.06, 0.12, 0.17, and 0.22 mg·g⁻¹ dry weight substrate for PTS without lime, respectively; NH₄-N amounts for the 1.0 kg·m⁻³ lime treatment were 0, 0.08, 0.17, 0.25, and 0.34 mg·g⁻¹ dry weight substrate, respectively. Initial substrate pH values for the 0 and 1.0 kg·m⁻³ lime treatments were 4.5 and 5.6, respectively. After 48 h, the 0 kg·m⁻³ lime treatment pH values for the 0, 0.5, 1.0, 1.5, or 2.0 mg urea rate treatments were 4.6, 5.4, 6.2, 7.0, and 7.6, respectively;

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the 1.0 kg·m⁻³ lime treatment pH values for the 0, 0.5, 1.0, 1.5, or 2.0 mg urea rate treatments were 5.9, 6.5, 7.1, 7.6, and 7.9, respectively. Samples treated with jackbean urease had less than 2% of the initial urea amount. However, only 13% of the total amount of urea N added to PTS was detected as NH₄-N in the unlimed treatment after 144 h (for all urea rates); detected amounts for the 1.0 kg·m⁻³ lime treatment ranged from 10% to 16%. The large difference in the amount of unrecovered NH₄-N may be explained by microbial N consumption.

Specified Source(s) of Funding: Virginia Nursery and Landscape Association; Virginia Agricultural Council

(271) Content of Nitrogen, Phosphorus, and Potassium in Oregano (*Origanum vulgare* L.) Cultivated in Substrate

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The aim of this study was to determine the accumulation of above-ground biomass and nutrient removal of N, P, and K in oregano (*Origanum vulgare* L.) plants under five nutrient solution concentrations. The experiment was set up in a shade house located in Xalisco, Nayarit, in western Mexico during the Spring–Summer 2011, using a commercial variety of oregano. A randomized complete-block experimental design with five replicates and a time series arrangement was used. The harvest days were 20, 40, 60, 80, 100, and 120 days after transplant (DAT)—dates that shoots 15 cm in length, the required size in the international market—were obtained. Steiner solution was used at five concentration levels: 25%, 50%, 75%, 100%, and 125%. The growth medium was volcanic slag with 0.3–1 cm granulometry. Plant height, fresh and dry plant biomass and stem diameter were assessed. Nutrient content of nitrogen, phosphorus and potassium was determined in the different samples in order to understand the absorption dynamics of these elements under commercial management. The results showed that the 75% NS concentration increased plant height (PH) by 35%. Stem diameter (SD) had no significant differences among treatments. Above-ground fresh biomass (AGFB) and above-ground dry biomass (AGDB) were increased by 57.8% and 65.62% respectively. Nitrogen, P, and K (mg/kg) removal was dependent on the ionic concentration of the nutrient solution. In general, the economic yield (leaves) of oregano depends on the nutrient solution concentration.

Specified Source(s) of Funding: CONACYT convenio MOD-ORD-1-09-PCI-1103-11-10

(272) The Effect of Osmotic Potential of Nutrient Solution on the Yield of Hungarian Wax Pepper (*Capsicum annuum* L.)

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In Mexico, production of Hungarian wax pepper (*Capsicum annuum* L.) has grown significantly in recent years. The objective was to evaluate the effect of the osmotic potential of the nutrient solution on the yield of Hungarian wax pepper ‘Inferno’ (Seminis®). The experiment was set up in a greenhouse with plastic cover located in Xalisco, Nayarit, in western Mexico during Fall 2012–Winter 2013. The substrate used was red volcanic rock (locally called tezontle) of 1–7 mm. Plants were watered three times daily with Steiner nutrient solution with electric conductivity of 0.5, 1.0, 1.5, 2.0, and 2.5 dS·m⁻¹, corresponding to an osmotic potential of 0.018, 0.036, 0.054, 0.072, and 0.090 MPa, respectively. The experimental unit was a potted plant, a completely randomized design with 5 replications was used and commercial fruit yield per plant up to 140 days after transplantation was evaluated. With osmotic potential of 0.036 MPa of nutrient solution the highest yield per plant (1,910 g) was obtained.

Specified Source(s) of Funding: Programa para el Mejoramiento del Profesorado (PROMEP–Mexico).

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(273) The Effect of Osmotic Potential of Nutrient Solution on the Yield of Yellow Pepper (*Capsicum annuum* L.)

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The objective of this research was to evaluate the effect of the osmotic potential of the nutrient solution on the yield of yellow pepper 'Santa Fe Grande' (Caloro®). The experiment was set up in a greenhouse with plastic cover located in Xalisco, Nayarit, in western Mexico during Fall 2012–Winter 2013. The substrate used was red volcanic rock (locally called tezontle) of 1–7 mm. Plants were watered three times daily with Steiner nutrient solution with electric conductivity of 0.5, 1.0, 1.5, 2.0 and 2.5 dS·m⁻¹, corresponding to an osmotic potential of 0.018, 0.036, 0.054, 0.072, and 0.090 MPa, respectively. The experimental unit was a potted plant, a completely randomized design with 5 replications was used and commercial fruit yield per plant up to 183 days after transplantation was evaluated. With osmotic potential of 0.090 MPa of nutrient solution the highest yield per plant (2,049 g) was obtained.

Specified Source(s) of Funding: Programa para el Mejoramiento del Profesorado (PROMEP–Mexico)

(274) Mature Prune Trees in a Commercial Orchard Did Not Absorb a Measurable Amount of Potassium Analog Applied to the Soil Beneath an Adjacent Tree

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Can a soil applied, tree-specific nutrient application be exclusively accessed by the target tree? As a case study to address this question, rubidium (Rb) sulfate (100 g) and potassium (K) sulfate (1.5 kg) were both banded on 1.35 m of the soil surface equidistant from the trunk along the tree row of four mature, 15-year-old 'Improved French' prune (*Prunus domestica*) trees in a commercial orchard near Live Oak, CA, in Dec. 2009.

This application rate and method is common commercial potassium fertilizer practice in flood-irrigated prune orchards in the Sacramento Valley of California. The orchard layout was a square with a tree spacing of 6.1 m across the row and 5.5 m down the row. Trees treated with Rb/K were at least 18 m apart. The Rb was applied as a potassium analog. It was assumed that where Rb appeared in tree tissues potassium from the same application was also present. Leaf analysis in Summer 2010 revealed no significant ($P = 0.05$) difference in Rb concentration on a dry weight basis between bearing (12 ppm Rb⁺) and non-bearing (11 ppm Rb⁺) spur leaves. On 19 Aug. 2011, just prior to harvest, 30 non-bearing spur leaves were sampled from each tree treated with Rb/K as well as from each tree for a distance of 3–5 trees down and across (perpendicularly) the tree row from each of the treatment trees. Leaf Rb concentration on a dry weight basis was determined for each tree. Leaf Rb concentration was significantly greater for treated (13 ppm Rb) compared to untreated (6 ppm Rb) trees both down ($P = 0.005$) and across the tree row ($P = 0.0006$). Leaf Rb levels from untreated trees were not significantly different. We conclude that tree-specific potassium fertilizer applications in this specific orchard would not be accessed by roots of the adjacent trees.

(275) The Effect of Foliar-applied Acidified Iron Sulfate on Chlorophyll and Iron Contents in Leaves of 'Chandler' Walnut Trees

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Walnut production in Chile has expanded to areas where the crop was not previously grown. The central zone of Chile has climatic conditions that are conducive to walnut production. However, in the calcareous soils (pH > 8) of this region, lack of availability of ferrous iron (Fe²⁺) can result in tree iron deficiency. To prevent tree iron deficiency in these soils, very expensive chelated iron can be applied to the soil or leaves. Recent research with other fruit crop species in Florida showed that foliar applications of iron sulfate plus ascorbic acid and a surfactant was nearly as effective as chelated iron for preventing symptoms of iron deficiency of trees in calcareous soil. Based on those results, we tested the effectiveness of foliar-applied iron sulfate plus ascorbic acid and a surfactant on preventing iron deficiency in walnut (*Juglans regia* cv. Chandler) trees in calcareous soil (pH = 8.2) in Chile. Three treatments were applied to 6-year-old trees: T0 (Control): application of well water adjusted to pH 4

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with ascorbic acid (50%); T1: application of chelated iron to the soil (19 g/tree, 3 times during the growing season, at 30-day intervals); T2: foliar application of iron sulfate (500 mg/L) plus LI-700® surfactant (2 mg/L) in well water adjusted to pH 4 with ascorbic acid. For T0 and T2, applications were made 5 times during the summer season; applications were made at 15-day intervals, from the third week of January to the third week of March. Tree responses were evaluated by measuring leaf re-greening (with a chlorophyll index meter), leaf chlorophyll content, and leaf iron content (Fe²⁺ and total Fe). There was a significant treatment difference ($P < 0.05$) for leaf chlorophyll index only on the fourth week of March, where plants in T2 had the highest chlorophyll index. Leaf chlorophyll index and total chlorophyll content were highly correlated ($R^2 = 0.94$). Total leaf iron content was significantly different among treatments only on the last application date, when trees in T2 had higher total leaf iron content than trees in T0. In April (one month after the last treatment application), total Fe and Fe²⁺ concentrations were higher in T2 than T0 or T1. The results suggest that foliar application of iron sulfate plus ascorbic acid is a viable method of preventing iron deficiency in ‘Chandler’ walnut trees planted in high pH calcareous soils.

Wednesday, July 24, 2013

12:15–1:00 PM

Pomology

(096) Unique Fruit Development of Ornamental ‘Teapot’ Jujube

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Jujube (*Ziziphus jujuba*), or chinese date, has fruit that is developed mainly from ovary plus some nectary disk tissue, and the fruit itself can appear smooth or bumpy on the surface. Teapot is an ornamental jujube cultivar with protrusions on the fruit surface and the fruit with two protrusions are dominant which makes the fruit mimic a mini teapot. The objective of this study was to investigate the source and development of those protuberances on the ‘Teapot’ fruit surface. Cultivar Li, Lang and Teapot were used in this study to compare the fruit development and basic fruit quality characteristics. Unlike ‘Li’ and ‘Lang’, ‘Teapot’ jujube fruit had one to five protuberances on the shoulder of the fruit and few entirely lacked protuberances. The stamens of ‘Teapot’ jujube flowers were fewer in number, misplaced in location, and deformed in shape—some stamens were anthers only while others were filament only. Deformed stamens of ‘Teapot’ jujube were always anchored in the nectary disk instead of at their normal location—near the edge of the nectary disk. After bloom, the residue of stamens, nectary disk, and ovary were all constituents of the developing fruit. The deformed stamens developed into the fleshy protuberances and equaled them in number. Fruit with only two protuberances predominated, which is how the ‘Teapot’ jujube acquired its name, but the ratio among protuberance categories varied between trees. ‘Teapot’

had smaller fruit and higher titratable acid content than ‘Li’ or ‘Lang’. It contained 308 mg/100 g vitamin C content and the general fruit quality was acceptable but not as good as ‘Li’ or ‘Lang’. With its unique and decorative fruit shape, and acceptable fruit quality, ‘Teapot’ jujube could be used as a backyard tree, both as an ornamental and for its fruit.

(097) Searching for the Next Pawpaw Cultivar: Unique Germplasm Selections at Kentucky State University

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The North American pawpaw [*Asimina triloba* (L.) Dunal] is a tree-fruit that is in the early stages of commercial production. Pawpaw fruit have fresh market appeal for farmers markets, community supported agriculture, and organic markets. This fruit also has processing potential for frozen pulp production. New high yielding cultivars with excellent fruit quality would further assist in the development of the pawpaw industry. Kentucky State University serves as the National Clonal Germplasm Repository for Pawpaw. Two goals of the Repository research efforts are germplasm acquisition and evaluation. Three selections Hi7-5, Haz-1, and Hi 4-1 have been identified in the Repository collection with unique fruit types and promising new characteristics as new potential cultivars. Pawpaw varieties with fruit weights over 120 g per fruit are considered to have a large enough fruit size for commercial sale and processing. The selection Hi7-5 has a unique globular fruit shape, a pleasing orange flesh, and large fruit size (227 g). The selection Hi4-1 has a pleasing orange flesh and large fruit size (254 g). The selection Haz-1 has a pleasing dark orange flesh that would be excellent for processing and large fruit size (174 g). Two selections, Hi7-5 and Hi4-1, have been stably propagated via chip budding onto seedling rootstocks. Yield and fruiting characteristics will be examined for these selections. Haz-1 will be propagated this year to examine propagation success and characteristics of this selection.

Specified Source(s) of Funding: Evans-Allen 1890 Research Formula Funding

(098) Field Establishment and Vigor of Kentucky State University Pawpaw Advanced Selections

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Pawpaw (*Asimina triloba*), a tree fruit native to the Eastern U.S., is in small-scale commercial production with its popularity on the rise. New commercially available pawpaw cultivars are needed to increase the diversity and quality of pawpaw selections available to the public. However, field establishment of pawpaw orchards can be challenging due to drought and weed pressure. Seedlings contained in the Kentucky State University (KSU) National Clonal Germplasm Repository collection, established in 1995, were evaluated for fruit quality, yield, and size, and seven promising advanced selections were chosen for further trial and evaluation. In June 2011, a pawpaw variety trial including three commercially available cultivars (KSU-Atwood, Mango, and Sunflower) and seven advanced selections (G4-25, G5-23, G6-120, G9-109, G9-111, Hi4-1, and Hy3-120) was established at the KSU Research and Demonstration Farm in Frankfort, KY. The trial was planted in a randomized complete block design, with four blocks and two replicate trees per block, for a total of 80 trees. In Feb. 2013, trees were evaluated for survival and trunk diameters were measured to determine early vigor. Overall survival in the variety trial among all cultivars and advanced selections after two growing seasons was 65%. Survival varied significantly by cultivar, with 100% of the KSU-Atwood trees surviving, and only 25% of selection G9-109 and 37.5% of selection G4-25 trees surviving, with the remainder of the cultivars and advanced selections displaying 50% to 87.5% survival. Diameters of the surviving trees did not vary by cultivar and means ranged from 9.7–17.1 mm. Early results indicate that advanced selections Hy3-120, Hi4-1, G6-120, and G9-111 have good field survival (over 75% of trees surviving), and have shown higher than average vigor when compared to existing pawpaw cultivars in the trial, with the exception of KSU-Atwood.

Specified Source(s) of Funding: Evans-Allen 1890 Research Formula Funding

(099) Inflorescence Traits and Pollen Germination Characteristics of *Castanea henryi*

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A field investigation was conducted on the inflorescence characters, floral dynamic of male flower, and pollen viability of 14 cultivars of *Castanea henryi* by field observation and indoor trials. The results were as follow. 1) The male flowers initiated bloom in May and reached their full-bloom stage within 3 to 5 days. 2) The male inflorescence of 14 varieties had different length, but similar in the number of flowers. The male inflorescence of ‘Chushuhong’ was the longest one at 17.78 cm and ‘Yuandizi’ was the shortest at 10.51 cm. The length of male inflorescence was longer than the bisexual inflorescence and the shortest length between male and female flowers of bisexual florescence correlated with the total length of bisexual inflorescence. 3) There was significant difference on pollen germination percentage among cultivars. The pollen germination rate of ‘Yuandizi’, ‘Caizhen’, ‘Maisaizi’, and ‘Tiezhen’ was higher (> 30.00%) than the pollen germination rate of ‘Youzhen’, ‘Wenyanghong’, ‘Bailuzi’, ‘Chushuhong’, and ‘Huangzhen’ (< 20.00%). Growth regulators affected the pollen germination of ‘Changmangzi’. Pollen germination percentage under 0.10 g·L⁻¹ H3BO3 was 38.12%, which was significantly higher than that (29.59%) of the control. Proper concentrations of 2,4-D, GA₃ and IBA could significantly promote the pollen germination, especially, IBA at 5.0 mg·L⁻¹ increased the pollen

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germination rate to 56.48%, which was 26.89% higher than that of the control. No significant pollen germination percentage was observed under NAA and 2,4-D treatments.

(100) The National Strawberry Sustainability Initiative

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The National Sustainable Strawberry Initiative (NSSI) is a competitive grants program managed by University of Arkansas Division of Agriculture Center for Agricultural and Rural Sustainability (CARS) with funding from the Walmart Foundation to support the expansion of sustainable strawberry production throughout the country. The mission CARS is to increase prosperity for rural Arkansas through sustainable practices. CARS provides leadership in Arkansas and the world in balancing the demands of community, agriculture and ecosystems in order to meet the needs of current generations while enhancing the opportunity for future generations to meet their needs. The purpose of the NSSI program is to move sustainable production forward by supporting multidisciplinary projects focused on outreach, education and demonstration of innovative and new technologies that will result in increased production and supply of strawberries. The goal of the NSSI is to improve sustainability of the U.S. strawberry production system throughout the supply chain, from growers to consumers. To meet this goal, outreach, education, demonstration, and development priority areas include but were not exclusive to the following: 1) increase the production season and regional diversity of U.S. strawberry production; 2) reduce the chemical inputs for soil sterilization, fertilization, weed control, and pest management; 3) reduce the energy inputs in production, handling, storage, and transportation; 4) conserve and preserve water resources used in the production system; 5) improve soil quality and health in the production system for succeeding crops; 6) reduce the risk of human health pathogens spread on fresh berries; 7) reduce the postharvest product loss through the supply chain from production through distribution and sales; 8) increase product value and economic return to growers and participants through the supply chain; and 9) implement meaningful and constructive metrics for strawberry production sustainability. The NSSI program issued a request for proposals generating more than 70 preproposals. After

external review, proposals were selected based upon potential to achieve project goals across the United States. Projects will be initiated 1 July 2013 and conclude on 30 June 2014. This report will highlight funded projects. A program website and blog will feature reports, videos, outcomes and impacts from the funded projects.

Specified Source(s) of Funding: Walmart Foundation

(101) Pomegranate Variety Trial in Southern Arizona

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Pomegranate fruit have become popular in recent years for culinary use and for their potential health benefits. Thirty-two cultivars of pomegranates (*Punica granatum*) were planted in three locations in southern Arizona to determine their growth performance and potential as fruit crop when grown at different elevations and climatic conditions. Field sites were established in Yuma, Tucson, and Bowie at elevations of 50 m, 700 m and 1124 m, respectively. Twenty-seven cultivars are grown for their fruit and five cultivars for their ornamental value. Cultivars were propagated from stem cuttings and were grown in containers until transplanting. Plants were transplanted into the field from Spring to Fall 2012. All pomegranates planted in Yuma and Tucson survived and established by Spring 2013. In Bowie, transplant success was 74%. Budbreak in Spring 2013 started first in Yuma on 12 Feb. and within 1 month all plants showed new leaf growth. Anthesis began in Yuma on 15 Mar. and by 1 Apr. about 80% of all plants had open flowers. In Tucson, budbreak started on 5 Mar. and by 19 Mar. almost all plants had started to grow new leaves. First anthesis in Tucson was recorded on 1 Apr. In Bowie, plants were dormant until the middle of March. About 50% of the plants showed new leaf growth on 23 Mar. but no flower buds were observed at that time. The time of budbreak and onset of flowering differed by location and cultivar. Growth habit of the ornamental and fruit cultivars differed. Ornamental cultivars have a light canopy in a tight upright vase shape dominated by primary and few secondary branches. The other cultivars have a dense canopy with wider canopy diameter, sometimes weeping branches, and larger numbers of secondary branches.

(102) Regulation of Floral Induction in Apple

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Apple fruit production is highly dependent on flowering fre-

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quency. Irregular flowering can lead to irregular crop load and economic loss. Floral induction takes place through the summer; these flowers remain dormant and bloom next spring. Factors such as crop load, bourse length, and seed number influence floral induction. These factors are thought to influence gene expression and contribute to floral induction via affecting endogenous factors such as growth regulators. There are two hypotheses to explain the contribution of these factors on floral induction. The first hypothesis suggests that inhibition signals from seeds and fruits interact with promotion signals from leaves to induce floral induction. The second hypothesis suggests that fruits, seeds, or leaves compete with buds for the floral induction signal. Both hypotheses explain why high crop load leads to low floral induction. In this experiment we are trying to examine both hypotheses and explain how crop load, seed number, and bourse length work altogether to influence floral induction. ‘Honeycrisp’ apple trees were manually thinned to different flower numbers on the spurs. Fruit weight, seed number, bourse length, and return bloom for these spurs were recorded. One year data showed that both fruit weight and seed number have significant effect on return bloom, but surprisingly bourse length had no effect on flower induction. This evidence might favor the second hypothesis. Creating a better understanding of the interaction of different flowering signals will help us to identify their pattern and identify the genes responsible for flowering initiation.

Wednesday, July 24, 2013 12:15–1:00 PM

Postharvest

(400) Cultivar Differences in Gaseous 1-Methylcyclopropene Accumulation in Whole and Fresh-cut Apple Fruit

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A number of studies have shown that responsiveness of apple

fruit to 1-methylcyclopropene (1-MCP) can vary considerably among cultivars, with some requiring higher concentrations to control ripening. The present study was designed to determine if different cultivars show differences in accumulation of gaseous 1-MCP. Freshly harvested apple fruit were immersed in water or a wax/water (50:50; v/v.) suspension (Sta-Fresh 8711). After drying, fruit were placed individually in 1.76-L jars that were sealed and injected with 20 $\mu\text{L}\cdot\text{L}^{-1}$ 1-MCP. After 12 h, fruit were removed, immersed in diH_2O and 1 mL samples removed using a syringe. Accumulation of internal gaseous 1-MCP varied markedly among cultivars, ranging from 0.14 ± 0.06 , 0.22 ± 0.03 , and 0.77 ± 0.30 in unwaxed ‘Redcort’, ‘McIntosh’, and ‘Empire’, respectively, to 2.10 ± 0.28 , 3.33 ± 0.13 , and $6.93 \pm 0.35 \mu\text{L}\cdot\text{L}^{-1}$ in unwaxed ‘Gala’, ‘Cameo’, and ‘Honeycrisp’, respectively. Cultivars accumulating higher internal gaseous 1-MCP showed greater post-exposure off-gassing. Accumulation of gaseous 1-MCP was reduced from 17% to 78% in waxed fruit. The role of the epidermis at influencing 1-MCP ingress was determined by measuring gaseous 1-MCP accumulation in fresh-cut tissue. Apple slices from the different cultivars were placed in 244 mL jars and treated with 20 $\mu\text{L}\cdot\text{L}^{-1}$ 1-MCP for 1 h. Fresh-cut tissue of all cultivars rapidly depleted headspace 1-MCP (> 95%) over the 1 h exposure yet showed negligible accumulation of internal gaseous 1-MCP ($\leq 0.07 \mu\text{L}\cdot\text{L}^{-1}$). By contrast, fresh-cut tissue treated with L-ascorbic acid or aged for several hours prior to exposure showed markedly reduced consumption of headspace 1-MCP ($\approx 25\%$) and high accumulation of gaseous 1-MCP. Internal [1-MCP] in apple slices ranged from 0.23 ± 0.07 , 0.37 ± 0.18 , and $1.09 \pm 0.14 \mu\text{L}\cdot\text{L}^{-1}$ in ‘Empire’, ‘McIntosh’ and ‘Redcort’, respectively, to 2.40 ± 0.71 , 4.55 ± 0.15 , and 6.24 ± 0.85 in ‘Gala’, ‘Cameo’, and ‘Honeycrisp’, respectively. Maximum ingress in fresh-cut tissue is dependent on measures (antioxidants, tissue aging) that minimize wound-related metabolism. Although commercial wax clearly influences gaseous 1-MCP accumulation, the comparable accumulation capacities in unwaxed whole and ascorbate-treated fresh-cut apple fruit suggest that epidermal tissue/native waxes do not strongly influence 1-MCP ingress. The physical and biochemical bases for cultivar differences in gaseous 1-MCP accumulation could reflect differences in intercellular diffusivity as well as capacities for physical sorption and/or metabolism.

Specified Source(s) of Funding: Supported by USDA NIFA Award (SCRI) #2009-51181-05783, and by Federal formula funds NE1036.

(401) Quality of Fresh-cut Pineapple Cubes Treated by either High Pressure or Thermally Blanching

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The quality of fresh-cut pineapple cubes was assessed following treatments of either high pressure of 400 MPa for 5 min or thermal blanching in 97 °C water for 3 min and subsequent storage. Both treatments reduced the microbial counts from 4.5 log cfu/g for bacteria and 4.9 log cfu/g for fungi to non-detectable levels on pineapple cubes. Pressure treated cubes presented a similar color index (L^* and b^* values), rate of electrolyte leakage from tissue slices, and texture as untreated cubes. Thermally blanched cubes showed lower b^* values and a higher electrolyte leakage rate compared to the untreated cubes. A microstructural study revealed that cell wall disruption by the high pressure treatment was caused on only one cut side of the cubes but not on the other cut sides. During storage of pineapple cubes in modified atmosphere packages at 1 °C for 6 days, bacterial and fungal counts increased to approximately 5 log cfu/g on untreated samples but remained at non-detectable levels on either pressurized or blanched samples. The high pressure treatment induced color deterioration with the decrease in L^* and b^* values, increased the rate of electrolyte leakage, and changed the texture of pineapple cubes relative to untreated samples during storage, but these quality changes were less when compared with blanched samples. These results suggest that the high pressure application for fresh-cut pineapple may be commercially feasible as an alternative to thermal blanching.

(402) Evaluation of Quality and Sensory Attributes of Purple Passion Fruit (*Passiflora edulis* Sims) Harvested at Different Stages of Maturity

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Maturity at harvest significantly affects the eating and keeping quality of climacteric fruits such as purple passion fruit. This study's objective was to determine the effect of harvest maturity of purple passion fruits on selected quality and sensory attributes. Fruits were harvested from a commercial orchard in the Moiben district of Uasin Gishu County in Kenya at three stages of maturity based on intensity of the purple peel color as: $\leq 25\%$ (S1), 50% to 75% (S2), and 100% (S3). After initial measurements, the fruits were left to ripen at ambient room conditions (25 ± 1 °C and RH 60% \pm 5%). During the storage period, six fruits from each maturity stage were sampled regularly and evaluated for cumulative weight loss, peel color change, total soluble solids (TSS), total titratable acidity (TTA), sugars, ascorbic acid, and beta carotenes. At the end of the stor-

age period, untrained panelists evaluated the sensory attributes of the extracted juices including color, acidity, sweetness, aroma and overall preference. The data shows that S1 fruits failed to attain the full purple color, retaining a lower (greener) hue of $296^\circ \pm 3$ at the end of storage compared to $310^\circ \pm 4$ of S3 fruits. Similarly, other quality attributes of S1 fruits were inferior to those of S2 and S3 fruits. Juice from S1 fruits had high initial TTA, which remained relatively higher compared to that of S2 and S3 fruits throughout the storage period. The TSS content of the juices increased gradually from the initial 8.9 ± 0.7 , 12.5 ± 0.9 and 13.7 ± 1 to peaks of 12.6 ± 0.8 , 14.2 ± 0.9 and 14.8 ± 1 (°Brix) in S1, S2, and S3 respectively. Consequently, at the end of storage, S1 fruits' juice had the lowest TSS : TTA ratio. Ascorbic acid content decreased gradually from the initial 46.2 ± 4 , 43 ± 3 and 40 ± 3.8 to 27.1 ± 2 , 26.1 ± 4 and 25.4 ± 3 (mg/100 ml) in S1, S2, and S3 fruits' juice, respectively, at the end of storage period. Beta carotene and sugar levels increased gradually during storage, with S1 fruits having the lowest levels. Cumulative weight loss was most rapid in S1 fruits, which lost $37.4 \pm 2.5\%$ of the initial weight at the end of storage compared to $29.6 \pm 1.8\%$ in S3 fruits. The untrained sensory panelists showed preference for S3 fruits' juice as evidenced by high scores on the hedonic scale. This evaluation by untrained panelists' positively correlated with instrumental evaluation of the quality attributes. Results affirm the importance of harvest maturity on passion fruit quality attributes and overall consumer acceptance.

(403) Study of the Application of Technological Alternatives to Increase the Shelf Life of Mango (*Mangifera indica* L.) cv. Manila

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The aim of this work was to study the application of different postharvest techniques compatible with the approved quarantine treatments to develop an industrial process that would extend the shelf life, decrease moisture loss, and maintain firmness in 'Manila' mangoes. A sample of 480 fruits of 'Manila' mangoes from Guerrero, Mexico, harvested at ripeness maturity were

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treated at 53 °C for 6 min, and then separated in a completely random experiment with four factors: irradiation, 1-MCP, microperforated bags, and storage temperature at two levels each one, (irradiated and non-irradiated, with and without 1-MCP, with and without bags and 13 °C and transfer from 13 °C to 20 °C), and then stored for 23 days. During storage, samples of fruits were analyzed for their external and internal visual quality, weight loss, color, firmness, total soluble solids, acidity and pectinesterase, and polygalacturonase activities. After 17 days, the weight loss in fruits not packed in microperforated bags and transferred from 13 °C to 20 °C was higher (9.2% to 10.1%) than those packed in microperforated bags and stored at 13 °C (4.0% to 4.7%), which indicated that the packaging in microperforated decreased the weight loss while irradiation and 1-MCP application had no effect. Firmness was not affected by the factors studied and reached values of 5.5–7.2 N at the end of the storage period, which indicated that it is necessary to look at alternatives to maintain the firmness of the fruit. The enzymatic activities of pectinesterase and polygalacturonase in the skin were not correlated with the processes of wilting and/or softening of the fruits.

(404) Harvest Timing, Crop Load, and Preharvest GA₃ Application Affect Postharvest Quality of ‘Lapins’ and ‘Sweetheart’ Sweet Cherries

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Sweet cherries transported over long distances often arrive at distant markets with significant fruit quality issues, such as pitting, flavor loss, color darkening, and stem browning. Influences of preharvest factors on storage/shipping quality of late-maturing sweet cherry cultivars have not been fully investigated. The objectives of this research were to determine the effects of harvest timing, crop load level, and preharvest GA₃ application on fruit quality of ‘Lapins’ and ‘Sweetheart’ at harvest and after storage. As harvest timing was delayed, fruit of ‘Lapins’ and ‘Sweetheart’, darkened, accumulated soluble solids (SSC) and softened, while respiration rate and titratable acidity (TA) remained relatively unchanged. Fruit of late-harvested ‘Lapins’ and ‘Sweetheart’ (skin colors of 7 and 6 according to ctifl color chips, respectively) were more susceptible to pitting and showed duller skin color and increased stem browning after storage than less advanced fruit from earlier harvests. To achieve optimum postharvest quality under our conditions, harvest of ‘Lapins’ and ‘Sweetheart’ cherries should coincide with skin colors of 5.5 and 4.5 (ctifl color chips), respectively. Crop load level was positively related to yield but held an inverse relationship with fruit quality. Fruit from high crop load treatments were smaller and had lower SSC, TA, and fruit firmness (FF) at harvest

and greater incidence of pitting following storage. Preharvest GA₃ applied at 25, 50, and 100 ppm increased FF at maturity, reduced pitting susceptibility, and limited stem browning after cold storage. Fruit size, SS and TA were not consistently improved by GA₃. Pitting resistance and FF were optimized at 25 ppm; no additional benefits were observed at higher rates. Regardless of harvest timing, crop load, and GA₃ treatments, FF was negatively correlated with pitting susceptibility of both cultivars. Interestingly, 2 weeks of cold storage at 0 °C alone increased FF of all fruit, including untreated controls. In conclusion, appropriate harvest timing, proper management of crop load, and preharvest GA₃ application can markedly improve fruit quality, resistance to pitting, and storage/shipping quality of ‘Lapins’ and ‘Sweetheart’ sweet cherries.

(405) Grafting Rootstock, Scion, and Field Holding Effects on Seedless Watermelon Fruit Quality

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Watermelon is a good source of vitamin C and contains the antioxidants and anti-inflammatory compounds citrulline and lycopene. Quality of watermelon fruit is a combination of firmness, full red color, sweetness, and perceived shelf life in field and market, and fresh cut watermelon also needs low drip loss. Watermelon grafting is widely used outside of the United States to avoid soil borne pathogens and abiotic stresses. Commonly used rootstocks and seedless watermelon scions were used to determine best fruit productivity and marketable yield in the southeastern United States relative to non-grafted plants. Fruit identified as ripe were left in the field on vine 0 to 2 weeks to test the relative hold life, then used for fresh cut studies to determine firmness and drip loss. Interspecific squash hybrid rootstocks ‘Carnivor’ and ‘Super Shintosa’ resulted in highest yields for most of the scions, with yield increases of 20% to 80% relative to non-grafted watermelons. Of the scions tested, ‘Fascination’ and ‘Sugar red’ had best yields in 2012 compared to ‘Trix313’, ‘Sugar Heart’, and ‘Sugar Coat’. Lycopene content increased slightly (up to 10%), depending on cultivar, with grafting while citrulline content decreased 10% with grafting. Holding fruit in the field for 1–2 weeks increased lycopene content from 50 to 65 mg/kg and pH from 5.4 to 5.8. Firmness was increased 10% to 40% by grafting and held up as fresh cut product, but fruit harvested after 2 weeks in the field were below acceptable firmness after fresh cut storage. Total soluble solids were relatively unchanged by rootstock or holding system. The percentage of drip loss of fresh cut product was reduced by 50% to 100% using grafted watermelons regardless of fruit holding time in field. Citrulline content was stable across holding time, ranging from 2.5 to 4.5 g/kg. Our results indicate that grafted watermelon can improve firmness and reduce drip loss in fresh cut watermelon

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without loss of sugars or lycopene, and can help extend field shelf life by a week compared to non-grafted watermelons.

(406) Effects of Postharvest Heat Treatments on Chilling Injury, Diseases, and Quality of Tuscan Melons

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The cultivars of the so-called Tuscan or Italian cantaloupes (*Cucumis melo* Group *Cantalupensis*) have shown different response to low temperatures during storage. Heat treatments previous to storage at low temperatures have been shown to reduce chilling injury. Two cultivars expressing low and moderate sensitivity to the disorder, Diva and Venezia, respectively, were harvested at slip initiation and subjected to heat treatments by immersion in water at 60 °C for 0, 1, 2, 4, and 6 minutes. After drying and cooling, fruits were stored for 18 days at 0 °C, plus 3 additional days at 20 °C. Results after the storage period showed that, although slightly, heat treatments significantly decreased chilling injury in Diva, but had no significant effect on Venezia; heat treatments over 2 or 4 minutes induced heat injury in the fruits of Venezia and Diva, respectively. The effect of heat treatments on disease development was significant, with all treatments showing lower growth of pathogens than the control; the predominant diseases in both cultivars were fungi (*Alternaria* spp., *Cladosporium* spp., and *Rhizopus* spp.). Visual quality was higher in fruits heat treated for 1 or 2 minutes, mainly due to null or low disease development; internally, there were no significant changes in color or soluble solids, however, a significant reduction of firmness occurred in all treatments during storage, and most fruits heat treated for 4 or 6 minutes presented off flavors.

Specified Source(s) of Funding: Project financed by: FIA PYT-2008-0207.

(407) Effect of Harvest Delay of Southern Highbush Blueberry on Resistance to Impact and Storage Quality

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Fresh-market blueberries (southern highbush hybrids) are typically hand-harvested every 3 to 4 d during the picking season. However, in order for the fruit to be suitable for mechanical harvest, the harvest interval would need to be extended to every 7 to 10 d. This extended delay to harvest might cause fruit abscission or significant loss in quality. Additionally, the fruit experience several impacts during mechanical harvest; the most severe is when the fruit is detached from the bush and falls to the catch plates on the harvester. This initial impact is believed to be the major cause of fruit softening during storage. In each season in 2011 and 2012, individual fruit from ‘Star’ and ‘Sweetcrisp’ bushes were tagged at color break stage and fruit color was tracked. Half of the fruit were hand-harvested upon reaching blue stage and the remaining fruit were harvested 7 d later. At each harvest, 20 fruit/cultivar were individually dropped once from 60 cm and held for 3 d at 5 °C to evaluate softening. The remaining fruit were stored in commercial clamshell containers (n = 50 fruit) at 1 °C and evaluated after 7 and 14 d. Fruit most resistant to the impact were from the early harvest (EH) and from year 1; ‘Sweetcrisp’ had fewer soft fruit than ‘Star’. From the storage tests, ‘Sweetcrisp’ typically had fewer soft fruit and less shrivel than ‘Star’ for each treatment comparison. The EH fruit generally had fewer soft fruit than late harvest (LH) fruit, whereas there was variable effect on shrivel. Fruit from year 2 had higher soluble solids content than year 1, and LH ‘Star’ fruit was 3 to 4 °Brix higher than EH. For both seasons, however, total titratable acidity was consistently 40% to 50% lower for LH fruit and for both cultivars, making the Brix : acid ratio consistently higher for LH fruit. The treatments had minimal effect on overall appearance and there was no decay.

(408) Extending Cassava Root Market Life in Liberia with Improved Postharvest Practices

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Cassava is the second most important food crop in Liberia, comprising approximately 20% of the total caloric food intake by the Liberian population. Most farmers do not follow proper postharvest care practices for cassava, which results in rapid deterioration of the roots after harvest. Improved postharvest practices were introduced to significantly extend the market life and quality of cassava roots. Paraffin waxing and individual shrink film wrapping of freshly harvested roots were the two postharvest treatments that provided the longest extension of cassava market life. Paraffin waxed roots remained nearly free of decay after 2 weeks of partially air-conditioned/ambient temperature storage. Root weight loss ranged between 3% to 5% after 2 weeks and taste panel evaluations of the waxed cassava indicated that the vast majority of the roots

An asterisk (*) following a name indicates the presenting author.

were good to excellent in flavor. Individual shrink-wrapped roots (Bemis Clysar HPGF 100 gauge film) remained nearly free of decay after 1 week of partially air-conditioned/ambient temperature storage. However, approximately one-third of the roots decayed during the second week of storage. Individual root weight loss of the non-decayed, shrink-wrapped roots was only 1% to 2% after 2 weeks of storage and taste panel evaluations indicated the roots were good to excellent in flavor. Non-treated control roots suffered nearly total decay after 7–10 days of ambient temperature storage, with average weight loss ranging from 25% to 30%. The utilization of paraffin waxing for fresh cassava roots is a simple, affordable, and very effective postharvest treatment applicable to the vast majority of limited-resource farmers in Liberia without access to electricity or refrigerated storage.

(409) Market Life Extension and Fruit Quality Enhancement of Navel Oranges

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Louisiana-grown Navel oranges are a highly popular fruit in the late fall and early winter in local markets. However, the marketing period is limited due to insufficient refrigerated storage and inadequate postharvest care practices followed by the majority of small-scale citrus producers. Tests were conducted to determine the effect of postharvest temperature management and value-added packaging on market life and quality of 'Washington' Navel oranges. Fruit were individually shrink-wrapped in polyolefin film and stored at 4 °C and 21 °C. The market life of unwrapped fruit held at 21 °C, 40% relative humidity, was 3 weeks, with a weight loss of 22.0%. The market life of unwrapped fruit held at 4 °C was extended to 14 weeks, with a weight loss of 19.6%. In contrast, shrink-wrapping extended the market life of Navel orange fruit held at 21 °C for up to 16 weeks, with a final average weight loss of 5.0%. A maximum market life of 20 weeks was obtained from the shrink-wrapped fruit held at 4 °C, with a final weight loss of only 1.4%. The appearance and overall eating quality of the shrink-wrapped fruit was better than the unwrapped controls. The fruit sugar : acid ratio significantly increased during storage, primarily due to a decrease in the percentage of acidity. Sucrose constituted the major sugar in Navel orange fruit, followed by fructose and slightly lesser amounts of glucose. The total sugar content and sucrose content was slightly higher in wrapped fruit than unwrapped fruit after storage. Citric acid was the dominant organic acid in the Navel oranges, typically comprising over 80% of the total organic acid content. Malic and succinic acids, present in similar concentrations, constituted the other principal organic acids. The content of all three organic acids decreased during

storage, with greater losses occurring at the higher storage temperature.

(410) Suitability of Two Instruments to Determine Skinning Resistance in Sweetpotato

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Skinning or surface abrasion in sweetpotato (*Ipomoea batatas*) occurs during harvest and causes substantial losses in marketable products. Skinning occurs when abrasion forces the periderm to break across the phellem (tensile fracture) and along the phellogen (shear fracture) resulting in the separation of the phellem from the phelloderm. In this study, we evaluated two instruments to measure skinning resistance in sweetpotato and how differences in washing and handling to remove the soil, which may cause partial loss of the phellem, influence the subsequent measurements. Beauregard (B-14) plants grown in the field at the Pontotoc Experiment Station (Pontotoc, MS) were devined or treated with ethephon (1.5 kg·ha⁻¹) before harvest. Storage roots were taken at 3 and 7 d after treatment (DAT) and divided into two groups for measurements. Roots from one group were gently washed to remove the soil, while the other roots were washed by moderately rubbing the root surface. Skinning resistance was measured by both a digital force gauge (model DS2-11 3100; Imada, Northbrook, IL) that measures the force required to peel the skin (shear fracture) and a torque meter (model TQS050FUA; Snap-on. Kenosha, WI) that measures the torque to twist and snap off the skin (tensile and shear fracture). Skin phenolics and lignin/suberin contents were also measured. Both instruments were able to detect differences in skinning resistance among treatments, but handling methods had an effect on the results from the force gauge. In general, ethephon treatment increased skinning resistance in comparison to devining and untreated control. In contrast, ethephon reduced skin phenolics content at 3 DAT, but this difference was lost at 7 DAT. Handling, however, resulted in consistent differences in skin phenolics content. Finally, skin lignin/suberin content was not different among treatments as well as between handling methods.

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(411) Postharvest Storage Affects Sweetpotato Water-soluble Vitamin Composition

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Water soluble vitamins (WSV), including vitamin C and the B vitamins, are important nutritional quality components in fruits and vegetables. The WSV content has been found to be influenced by different postharvest conditions and storage durations in various fruits and vegetables. In sweetpotato, however, limited information exists on the influence of storage on water soluble vitamin content. The objective of this study was to determine the effect of curing (31 °C and 90% relative humidity for 7 days) and storage (14 °C for 3 and 6 months) on vitamin C, thiamine (vitamin B1), riboflavin (vitamin B2), and vitamin B6 content in four sweetpotato cultivars. Vitamin C (measured as total ascorbic acid) remained similar during curing in three cultivars (Beauregard, Covington, and Orleans), but decreased in LA 07-146. Storage for 3 months did not affect ascorbic acid content in three cultivars, but it declined in Covington. All cultivars, except Orleans, decreased in ascorbic acid content after 6 months of storage. Thiamine content did not change during curing in three cultivars, but decreased in Covington. Thiamine content generally did not decrease during 6 months of storage. Although riboflavin showed a reduction of one-third in all cultivars during curing, it remained stable during 6 months of storage. Vitamin B6 content did not change during curing or 3 months of storage. The overall results indicated that long-term storage for 6 months of most sweetpotato cultivars generally resulted in a loss in ascorbic acid content, but little or no loss in riboflavin, thiamine and vitamin B6.

(412) Differences in Storage Quality of Onion Bulb as Affected by Harvesting Methods

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Leaf length above the bulb at topping, or drying length has been considered one of the important factors for storage quality, but varies, depending on labors or growing regions. The study was executed to evaluate the effect of topping timings, drying length, and leaf length above the bulb at topping in relation with different harvesting times on storage quality of onion bulbs. For topping timing treatments, onions were topped at the harvest date and after field drying for a couple of days. For drying length treatment, onions were dried in the field for 1, 3, and 5 days. For leaf length treatments, onions were cut at 1, 4, 7, and 10 cm above the bulb at 90% top-down and 10 days after 100% top-down. Bulb rot loss was not affected by topping timings in cold storage. Longer leaf drying decreased bulb rot loss. Storage bulb rot decreased with increased leaf length above the bulb at topping, the effect of which was enhanced by harvesting at 10 days after 100% top-down. When leaf length above the bulb was short at topping, topped site was main target for some diseases such as Botrytis bulb rot or bacterial soft rot.

Specified Source(s) of Funding: This work was carried out with the support of “Cooperative Research Program for Agriculture Science & Technology Development (Project No.PJ007330)” Rural Development Administration, Republic of Korea.

(413) Application of Two Different MAP Systems in Order to Prolong the Shelf Life of Romaine Lettuce during Marine Shipment

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Romaine lettuce has been reported to be one of the most sensitive products during marine shipping of fresh fruits and vegetables for supplying U.S. military bases in the Pacific region. We hypothesized that the quality loss observed at the specified 0.5 °C shipping temperature is likely due to dehydration of leaves or from cross-contamination by ethylene in mixed load containers. Two modified atmosphere packaging (MAP) systems were tested with Romaine lettuce: 1) Breathe-way® Membrane Technology from Apio Inc. (California, USA) and 2) Xtend MAP from StePac L.A. Ltd (Israel). Romaine lettuce was obtained from South Bay, FL in waxed cartons. The product was transferred in an air-conditioned vehicle to the Postharvest Horticulture Laboratory of UF in Gainesville, FL and stored overnight at 0.5 °C. Lettuce was repacked into the two MAP systems and stored for 22 days at 0.5 °C plus 1 and 2 days at 20 °C. Romaine lettuce in the commercial

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packaging (without MAP) was the control. During the storage period, measurements of the atmospheres in the MAP systems were taken every other day. Neither of the two MAP systems proved to be beneficial for the products in delaying senescence. The Apio MAP system equilibrated at 14% O₂ plus 4% CO₂ during the storage at 0.5 °C and at 9% O₂ plus 4% CO₂ after 2 days of shelf life which resulted in CO₂ injury of the lettuce (brown stain). StePac bags equilibrated at an atmosphere of 19% O₂ plus 2% CO₂ during storage at 0.5 °C, which is not near to what is usually recommended as optimal for Romaine lettuce (i.e., a low O₂ atmosphere of 1–3%). When the lettuce was transferred to 20 °C, StePac bags established an atmosphere of 17% O₂ plus 4% CO₂, which resulted in CO₂ injury after 2 days at 20 °C but not after 1 day. Leaf wilting was a significant problem during 0.5 °C storage only for the control treatment and worsened after transfer of the control to 20 °C. We also tested the ethylene permeability of the two MAP systems at 20 °C and found the ethylene permeability rates to be extremely low. This suggests that cross-contamination by ethylene within mixed container loads of produce may not be a serious problem when the ethylene-sensitive products are in MAP.

Wednesday, July 24, 2013 12:15–1:00 PM

Viticulture and Small Fruits

(121) Muscadine Grapes: Evaluation of Genotypes and Field Fungicide Applications on Postharvest Storage Attributes

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A major limiting factor in muscadine grape (*Vitis rotundifolia* Michx.) commercialization is deterioration during storage. Research on table grapes has shown that field fungicide applications increase storability, but little is known of its affect on muscadines. The effect of field applications of fungicides on composition attributes during postharvest storage was evaluated on five muscadine cultivars ('Nesbitt', 'Southern Jewel', 'Summit', 'Supreme', and 'Tara') and five breeding selections from the University of Arkansas Fruit Breeding Program (based at the Fruit Research Station, Clarksville, AR). There were two field treatments (no fungicide and fungicide). For the fungicide treatment, alternating applications of two fungicides were applied at 14-day intervals during berry maturation. Fruit was harvested and composition attributes including berry volume, titratable acidity (TA), pH, soluble solids (%), color (L, chroma, and hue), firmness (force to penetrate berry skins), storage weight loss (%), and decay (%) were evaluated weekly for 4 week. The

initial berry volume among genotypes ranged from 86.3 to 193.5 cm³, TA ranged from 3.9 to 4.9 g/L, pH ranged from 3.3 to 3.9, soluble solids ranged from 16.9% to 26.8%, firmness ranged from 7.9 to 10.6 N, L ranged from 26.8 to 95.1, chroma ranged from 2.1 to 14.9, and hue ranged from 7.5 to 311.6. 'Supreme' and AM 01 had the highest soluble solids and 'Southern Jewel' the lowest. 'Supreme' had the highest firmness value. Berry volume, TA, pH, soluble solids, and color of muscadines did not change during storage. However, weight loss and firmness of muscadines decreased while decay increased during storage regardless of fungicide treatment. Soluble solids was positively correlated to pH ($r = 0.63$), pH was positively correlated to TA ($r = 0.96$). Decay and weight loss were positively correlated ($r = 0.88$) and firmness was negatively correlated to weight loss and decay ($r > -0.46$). Firmness was lower for muscadines in the no fungicide treatment compared to fungicide-treated vines, the effect of fungicide treatments varied among genotypes. Differences may have been minimal due to the unusually dry summer in 2012. Due to less decay, less weight loss, and greater firmness during storage, AM 27, 'Southern Jewel', and 'Supreme' had the highest potential for postharvest storage, while AM 01, AM 15, and 'Tara' had the least potential. Although field fungicide applications did not affect all postharvest attributes, differences among genotypes and fungicide treatments did occur during the four weeks of storage.

(122) Failure Tests of Intact Grape Berry Skins and What They Tell Us about Berry Cracking

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We developed a "Berry Balloon System" (BBS) in order to perform tensile failure tests on intact grape berry skins in their original 3D conformation. The mode (cell fracture) and position (stylar end in 'Flame Seedless') of skin failure in these lab tests were the same as those found in the field. Pressure, stress, and overall strain at failure of Flame Seedless berries progressively decreased over berry development, consistent with the observation that cracking susceptibility in this variety increases over time. Over three field seasons, excessive irrigation (%ETc) caused a clear increase in vine water status (midday stem water potential, SWP) compared to grower irrigation (%ETc), but did not cause increased fruit cracking. Irrigation cutoff prior to veraison caused a clear decrease in SWP and significantly more cracking than any other irrigation treatment. Under this treatment, vines experienced higher daily fluctuation in SWP, and hence there may have been higher daily fluctuations in berry size. Strain hardening of the berry skin was demonstrated using repeated BBS tests on the same skin, and may explain why deficit irrigation, which we hypothesized should have reduced

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stress and strain on the berry skin, actually caused higher berry cracking. Ethephon sprays, used to increase berry pigmentation, increased berry cracking compared to water-sprayed controls, but skin mechanical properties were not affected. However, exposing the berry skin to an ethephon solution (1.5 mM) during BBS testing caused significantly lower skin stress and strain at failure. The failure to detect differences in skin properties using field sampled berries may have been due to the fact that only sound (non-cracked) berries could be used for BBS tests, and may not have been typical of the berries that did crack in the field. The BBS was also used to compare skin mechanical properties of different grape genotypes. In the intact state, the skins of berries from all genotypes were found to be under significant “preload” strain caused by internal pressure of the flesh. Genotypes ranged from 3.7% to 13.1% in preload strain and also varied substantially in the relation between stress and strain. Among all mechanical properties measured, the increase in skin strain from the intact condition to the cracking threshold was best correlated ($R^2 = 0.65$) with cracking susceptibility as measured in a soaking test.

Specified Source(s) of Funding: The American Vineyard Foundation, The California Table Grape Commission

(123) Determining Survival of *Lobesia botrana* Larvae in Grapes Processed for Wine Making to Evaluate the Risk of Dispersal

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Lobesia botrana (Denis & Schiffermüller), European grapevine moth, was reported for the first time in North America by USDA–APHIS in Oct. 2009, in vineyards in Napa County, CA. Pheromone traps placed in vineyards subsequently detected moths in 11 California counties. In June 2010, a federal order established quarantine areas and with the State’s interior quarantine, safeguarding measures were established to restrict the movement of regulated articles including fruit and winery waste. In two harvest periods, we evaluated the fate of larvae in clusters processed for wine making. In 2010, individual ‘Chardonnay’ clusters, each infested with a single larva were sewn into mesh bags and processed with uninfested clusters in two separate loads (reaching 1.5 and 1.8 bars respectively) in a 200-lb capacity Willmes press at a commercial winery. One

larva survived the 1.5 bar press. Each cluster was treated as a single replicate of a completely randomized design and data analyzed by cross tabulation. There was no significant difference in mortality between press loads. In 2011, research on processed winegrapes was conducted inside a Biosafety Level 3 facility at the University of California, Davis, due to state quarantine regulations. Six replications of 46 individual ‘Merlot’ clusters were placed in paper cartons and each cluster inoculated with 5 live larvae of *L. botrana* then covered and held for 48 hours to allow larvae to web feeding nests. For each replication, 40 clusters were processed through a hand-cranked destemmer-crusher; 6 clusters were not processed to provide baseline mortality due to conditions other than grape processing. Larval status (dead or alive) was evaluated on: 1) 20% of the volume of solids processed; 2) 100% of the cluster stems processed; 3) the processing equipment prior to washing; and 4) rinsate from washed equipment containing berry solids and stem pieces. Total weight of clusters processed and subsequent weight and volume of fruit solids allow results on per cluster basis. Unequal variances of dependent variables were significant regardless of transformation thus preventing ANOVA. Live larvae were found in the solids in 5 replicates and in stems in 2 replicates; up to 0.5 and 0.025 larvae per cluster, respectively. Live larvae were observed on equipment prior to and post-washing; up to 0.08 and 0.10 larvae per cluster, respectively. Results indicate thorough washing of all equipment in contact with infested clusters is important and at harvest, truck-loads of grapes should be tarped or slack filled.

Specified Source(s) of Funding: California Department of Food and Agriculture Pierce’s Disease and Glassy-winged Sharpshooter Board; USDA APHIS Cooperative Agreement 11-8130-1499-CA

(124) Utilizing Pruning and Leaf Removal to Ripen Grapes and Encourage Cold Tolerance in North Dakota

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Experiments were conducted at three North Dakota vineyards located near Buffalo, Clifford, and Wahpeton, ND, in 2011 and repeated at the same locations in 2012 to evaluate the effects of pruning and leaf removal on yield and quality of wine grapes in North Dakota. The application of three pruning treatments limited the vine to a specific number of productive primary buds while the three leaf removal treatments exposed ripening grape clusters to increased sunlight. Variables

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included length of growth prior to dormant pruning, weight of growth prior to dormant pruning, rate of ripening, total weight of harvested grapes, average weight per grape cluster, average berry weight, average number of clusters per vine, soluble solids concentration, titratable acidity, and pH. Data were analyzed as a CRD with a factorial arrangement. Data were combined across environments where appropriate. Factorial analysis showed varied significance with pruning and shade leaf removal treatments interacting with specific cultivar traits to influence vine growth, grape yield, and grape quality. Pruning and shade leaf removal treatments both had significant impacts on growth with pruning treatments significantly influencing average growth of the longest 1-year-old cane and shade leaf removal significantly influencing weight of dormant cane pruning. While impact on yield was minimal, treatment impacts on grape quality showed potential for use of shade leaf removal as means of decreasing titratable acidity levels in harvested grapes. This research supports the use of pruning and shade leaf removal treatments when to influence grape vine growth, vine balance, and fruit ripening. However, proper timing and level of pruning as well as proper timing of shade leaf removal is essential to minimize injury and maximize potential results.

(125) Applying Precision Agriculture Technologies as a Problem Solving Tool to Improve Small-scale Vineyard Management in Western Nile Delta of Egypt

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Desert reclamation projects in the Western Nile Delta of Egypt targeting settlement of small-scale farmers (holders of 1 or 2 hectares) started in late 1980s and early 1990s. However, at present there is an increasing risk of agriculture instability (especially for small-scale farmers) due to several undesirable environmental impacts and production problems. In the 2010 season, an initial study conducted in the Tiba region—located in the western Nile Delta—concluded that there is a wide spectrum of problems facing small-scale farmers including high soil salinity, increased soil water table, lack of proper irrigation and fertilization management, and nematode infection. These problems lead to gradual decrease in production quantity and quality and threaten the sustainability of viticulture future in the area. Precision agriculture is a new approach to field management that precisely identifies areas within the field that differ, helps to classify the difference, provides practical maps for management, and measures the change before and after management. This is done with the aid of global-positioning systems (GPS), computer-based geographical information systems (GIS), and the remote sensing tools. In 2011 and 2012 seasons, a 2-ha Thompson Seedless table grape vineyard of 8-year-old grapevines with severe production problems was selected in Tiba to demonstrate the potential of targeted management by

using simple precision agriculture technologies. Spatial and temporal GIS maps of soil water table, soil salinity, soil pH, soil nematode infection, soil fertility, plant nutrient status, leaf water potential, canopy density, normalized difference vegetation index (NDVI), vineyard productivity, and fruit quality characteristics are demonstrated before and after applying precise agriculture management. The results demonstrated that soil conditions, table grape production, and fruit quality was significantly improved.

(126) Flavonoid Accumulation in Wine Grapes

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Consumption of “superfoods” is associated with a reduced risk of degenerative disease, but what makes these fruits and berries superb? These protective benefits are often associated with flavonoids a group of diverse plant phenolic compounds, most well known as pigments. Flavonoids are produced in the shikimate/phenylpropanoid pathway in plant tissues. Anthocyanins, a group of low molecular weight flavonoids, are highly soluble pigments that accumulate in grape skin cells, which contribute to the black and red color of grapes. Flavor properties of grapes and wine are all influenced by anthocyanin compound accumulation. One of the most valuable fruit crops cultivated worldwide, grapes produce wine, juice, raisins and table grapes, and are a practical model to study the regulation of anthocyanin accumulation. My research is based on the hypothesis that, although many genes play a role in pigment accumulation during grape development; identifying specific genes that control flavonoid accumulation is useful for efforts to modulate flavonoid content. Specific objectives include, investigating what are the key metabolites present in flavonoid biosynthesis throughout developing grape berries? By comparing metabolic imaging experimental results of in Cabernet Franc and Riesling grape samples, we can determine which compounds are involved in flavonoid gene regulation in red versus green wine grape’s tissue (epidermis, flesh, and seed). We analyze the metabolic profiles using MALDI imaging (matrix-assisted laser desorption ionization mass spectrometer), a relatively new and unique technology to determine the accumulation pattern of compounds present in grape tissue to continue validating the metabolite biosynthetic pathway in wine grapes.

(127) Evaluation of Two Sources of Organic Matter Applied to Soil and Their Effects on Grape Production

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There are about 8000 ha planted with grapes in Caborca, Sonora, 44% of that are for raisin grapes and the remaining for table grapes. This region has soil with very low organic matter, and that retains little moisture. Together with the intensive use for many years, the soil has little fertility or available nutrients to meet the needs of this crop. Also, the high cost of fertilizers combined with innocuity norms that are being implemented, has forced the search for ecological and economic alternatives for crop nutrition. Compost use can be a suitable alternative to recover soil fertility and productivity of grapes. The objective was to evaluate the effect of two organic matter sources, in the grape production and quality. In two different commercial vineyards—one with Superior Seedless for table grape and one with Flame Seedless for raisin grapes—we evaluated the commercial HUMIBAC compost and bovine manure in doses of 12.5 t·ha⁻¹ and compared with the control treatment (without organic matter application). There were no significant differences in the total production of table grapes (8.43 t·ha⁻¹ in the control and 13.69 t·ha⁻¹ with HUMIBAC); it was on the percentage of clusters with commercial quality, and was higher with HUMIBAC (70.5 %), and also, both HUMIBAC and control were highly significantly different in sugar content with 20.4 and 19.7 °Brix. On raisin grapes, as far as the yield, the compost affected statistically positively both the table grape and raisin grape, whereas the control yield was 6.9 and 1.5 t·ha⁻¹ (table grape and raisin grape, respectively); the compost (Bovine manure and HUMIBAC) yield was from 13.2 to 20.8 t·ha⁻¹ (table grape) and 2.55 to 4.65 t·ha⁻¹ (raisin grape).

Wednesday, July 24, 2013

1:00–1:45 PM

Herbs, Spices, and Medicinal Plants

(176) An Efficient Protocol for Direct Somatic Embryogenesis in Medicinal Tree *Murraya koenigii* (L.)

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Murraya koenigii (L.) Spreng, popularly known as curry leaf plant, is a small aromatic tree belonging to the family Rutaceae that grows widely in Southeast Asia. Its leaves are slightly pungent, bitter, and acidulous in taste. Fresh and dried leaves are used extensively as a flavoring agent in many Indian culinary practices. The fresh leaves of this tree possess antimicrobial, topoisomerases, and mosquitocidal inhibition and antioxidant properties. A reproducible protocol for direct somatic embryogenesis was established in *M. koenigii*. The hypocotyle, cotyledons and root segments were excised from 60-day-old in vitro grown seedlings. Globular somatic embryos were induced on MS medium supplemented with 2.0 mg/L 6-benzyladenine (BA), 0.5 mg/L αα-naphthaleneacetic acid (NAA) and 1.0 mg/l thidiazuron (TDZ). The best result obtained for the average frequency of somatic embryos was from hypocotyle explants, which was significantly higher than cotyledons and root explant. The highest frequency of somatic embryos was recorded from hypocotyle segments in 6 weeks. The age and type of explant and concentration of TDZ played an important role in the development of somatic embryos. The heart and torpid stages of all the somatic embryos were also recorded. Over 95% of the somatic embryos, irrespective of their origin, germinated after 4 weeks in one-half MS basal media. Well-rooted plantlets were successfully acclimatized.

(177) Photosynthesis and Harvest of Deltoid Synurus (*Synurus deltoides*) under Three Different Light Environments

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Many recent studies have reported on the properties of Deltoid synurus (*Synurus deltoides*), such as antimutation, antioxidant, and anti-inflammatory properties (Ham et al., 1997; Lee, 2003; Woo et al., 2010; Park et al., 2004; Jung et al., 2008). It contains β-cubebene and caryophyllene (Lee et al., 2012). This plant was acknowledged as a well-being food. Therefore, we researched the photosynthesis and harvest of *S. deltoides* under different light environment for high quality and yield. *S. deltoides* seeds were sown in 105 cells tray-pot in Mar. 2012 and raised in the grass house. In May, these were

An asterisk (*) following a name indicates the presenting author.

planted in a 30 x 20 cm field. Shading treatment was carried out in the last 10 days of May, using 35% and 55% shading net. The light density and temperature under the different shading treatments was measured at 1 meter from the ground from May to September. We examined the hardness of leaves, photosynthesis, and yield under different shading. The data were analyzed by SPSS Statistics Program (Version 19.0) and Duncan's multiple range test. Harvest weight per plant grown under 0%, 35%, and 55% shading treatments was 35.9, 52.6, and 21.1 g, respectively. The hardness under 35% shading was 1.8 kg/cm² compared with 2.3 kg/cm² under non-shading. The maximum photosynthesis rate was high under non-shading and 35% shading; 12.9 and 12.6 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of CO₂, respectively. The dark respiration under 35% shading was 22.2 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ compared with 28.5 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ under non-shading. The result indicated that the proper shading was 35% for high yield and quality of *S. deltooides*.

Specified Source(s) of Funding: This study was supported by the region agriculture research activity project(number : PJ0073272012) funded by the Rural Development Administration, Korea.

(178) Anti-inflammatory Activity of *Potentilla kleiniana* Extracts

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Potentilla kleiniana (PK) is a member of the Rosaceae family that is native to China, Japan, Korea, India, and Malaysia. It produces one or more erect stems from a branching caudex and system of rhizomes. It grows 20 to 60 cm tall, and is slightly hairy to nearly hairless. The leaves are ternate, divided into three leaflets. The basal leaves are largest, borne on long petioles. Each has oval leaflets up to 3 cm long that are deeply cut into blunt teeth. Smaller leaves occur higher on the stem. The inflorescence is a cyme of one or more flowers. The flower has usually five yellow petals up to a cm long on a calyx of pointed sepals and narrower pointed bractlets. *Potentilla kleiniana* is often used in Korean traditional systems of medicine as a remedy for hemostasis, dysentery cough, pertussis, sore throat, external bleeding, and neutralizes snake venom. Generally drugs that are used for arthritis have antinociceptive and anti-inflammatory properties. However, validity of the anti-inflammatory activity has not been scientifically investigated so far. Therefore, the aim of this study was to investigate the anti-inflammatory potential of PK using the ethanolic extract of PK and its sub-fractions. To evaluate the anti-inflammatory effects of PK, we examined the inflammatory mediators such as nitric oxide (NO) and prostaglandin E₂ (PGE₂) on RAW 264.7 cells. Our results indicated that ethanolic extract significantly inhibited the LPS-induced NO, and PGE₂ production in RAW 264.7 cells. The ethanolic extract inhibitory activity for NO and PGE₂ tests with IC₅₀ values showed in 49.57 $\mu\text{g}/\text{mL}$. This result revealed that ethanolic extract of PK is expected to be good candidate for development into source of anti-inflammatory agent.

(179) Phenolic Content and Antioxidant Capacity of American Persimmon Teas

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Regular consumption of green tea (GT), a rich source of phenolic compounds, has been linked to various health benefits, including lowering cholesterol, weight loss and cancer prevention. Green tea is made from *Camellia sinensis* (L.) Kunz, and domestic production is currently confined in South Carolina and Hawaii. Since most green tea available on market in the U.S. is imported, there have been concerns for contamination

An asterisk (*) following a name indicates the presenting author.

with heavy metals and pesticides. In Asia, leaves and other plant parts of various species are also used to make teas. One example is Asian persimmon (*Diospyros kaki* Thunb). Its leaves can be simply air-dried in shade, sometimes followed by steaming or immediately steamed and roasted. Asian persimmon tea has anti-allergy, anticancer, anti-inflammatory, and antioxidant properties, and contains phenolic constituents such as astragalin and isoquercitin. Leaves of American persimmon (*D. virginiana* L.), native to the eastern part of the U.S., have been similarly used to make beverages in the past, although its health benefits have not been studied. The objectives of the study were to examine phenolic content and antioxidant capacity of American persimmon tea processed by two methods. Leaves from five cultivars of American persimmon were harvested in May 2012. Leaves were washed and lightly dried with paper towel. The samples were weighed, a half of samples were placed in microwavable plastic bag for 30 s/50-g samples. Immediately after steaming, samples were roasted on an electric skillet at 200 °C. The rest of samples were dried in an oven at 50 °C for two nights. Folin-Ciocalteu assay was performed to determine phenolic content of teas. Phenolic content of GT was 14.6, and that of PT ranged from 3.9 to 8.2 for roasted samples and 3.2 to 4.0 for oven-dried samples in g of gallic acid equivalent per 100 g of dry weight. Ferric Reducing Antioxidant Power assay was performed to determine antioxidant capacity. This assay revealed that the antioxidant capacity of roasted teas were substantially higher (596.7~1152.7) than that of oven-dried teas (287.0~403.5) in μmol of Trolox equivalent, and comparable to that of GT (1142.5). Teas made from American persimmon leaves are a caffeine-free healthy alternative to regular or green tea.

Specified Source(s) of Funding: USDA 1890 Capacity Building Grant

(180) The Effect of Composts on Field Soils Affected by Bacterial Wilt of Edible Ginger in Hawaii

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Bacterial wilt caused by *Ralstonia solanacearum* is the most important disease affecting edible ginger (*Zingiber officinale*) in Hawaii. Serious outbreaks began occurring in 1993 and large losses continue every year. *R. solanacearum* is persistent in soil and following crop failure, fields are abandoned and left unsuitable for ginger production for many years. A reliable and sensitive method utilizing enrichment followed by PCR was

developed for detecting the pathogen in soil. This methodology proved to be a useful diagnostic tool in testing environmental samples and has become the method of detection for *R. solanacearum* testing on the Big Island of Hawaii at the University of Hawaii–Manoa College of Tropical Agriculture and Human Resources' Agricultural Diagnostic Service Center (ADSC). This method was used in a 10-week pot study to determine the effect of soil amendments on the survival of *R. solanacearum* in naturally infested Hawaiian soils. The soil amendments used included an initial application of vermicompost, vermitea, and IMOlizer at high, mid, and low rates. At the end of the 10-week period none of the treatments showed an ability to significantly reduce bacterial abundance over time. Some treatments showed an initial decline in bacterial abundance between 0–4 weeks but were followed by a sharp increase at the 6-week time point. A future experiment using repeated applications of these amendments may address the loss of suppression over time. A website explaining bacterial wilt, its symptoms, our method for detection, as well as management strategies, are now available at <http://www.ctahr.hawaii.edu/dnn/gingerwilt> for growers and the public to visit.

Specified Source(s) of Funding: Western SARE

Wednesday, July 24, 2013

1:00–1:45 PM

Organic Horticulture

(082) Groundcover Management System and Nutrient Source Impact Physical Soil Quality Indicators in an Organically Managed Apple Orchard

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In Mar. 2006, four groundcover management systems (GMS) and two nutrient sources (NS) were evaluated for their ability to alter the physical condition of newly-established orchard soil. Annual applications of municipal green compost (GC), shredded office paper (SP), wood chips (WC), and mow-blow (MB) grass mulch were utilized as GMS, and NS were sup-

An asterisk (*) following a name indicates the presenting author.

plied to trees from composted poultry litter and a commercial organic fertilizer in a 4x3 factorial study. An established, conventionally-managed orchard was located on the same soil series and adjacent to the organic research orchard. Physical soil characteristics were measured from the conventional orchard providing a subjective comparison of orchard management systems. Soil organic matter averaged 1.5% at organic orchard establishment. By 2012, soil organic matter increased to 5.6% in GC while all other treatments had approximately doubled, with values in MB, SP, and WC increasing to 2.6%, 3.0%, and 3.2%, respectively. The change in soil organic matter impacted physical soil characteristics. Mow-blow treatments provided the least change in physical soil quality and served as an informal control to which other GMS were compared. Greatest increases in estimated plant available water were noted in treatments receiving GC applied alone (18.1%) or in combination with commercial fertilizer (17.7%). Bulk density values averaged $1.34 \text{ g}\cdot\text{cm}^{-3}$ in 2006 but decreased in following years for all GMS. Most significant reductions occurred in WC ($1.01 \text{ g}\cdot\text{cm}^{-3}$) and GC ($1.02 \text{ g}\cdot\text{cm}^{-3}$) treatments. Increases were observed in the formation of large water stable macroaggregates. Green compost treatments resulted in a 4200% increase in 2.0 to 4.0 mm water stable aggregates taken from the upper 7.5 cm of soil. Infiltration rate was calculated for all treatments based on time required for complete drainage and over the total 18-min drainage time. The greatest infiltration rate was associated with SP treatments (11.1 mm/min) and was slowest in WC treatments (3.1 mm/min). Soil organic matter measured 2.7% in the conventional orchard in June 2012, and only MB (2.6%) was lower. With the exception of GC applied alone (18.1%) or in combination with commercial organic fertilizer (17.7%), estimated plant available water capacity was lower in the organic orchard than in the conventional orchard (17.2%). Soil bulk density was higher in the conventional orchard ($1.27 \text{ g}\cdot\text{cm}^{-3}$) than measured in all GMS treatments. All GMS treatments resulted in greater water stable aggregate formation. Only in WC was water infiltration slower than in the conventional orchard; otherwise GMS enhanced infiltration rate.

(083) Cover Crop Mixtures Build Soil Quality in Organic Hop Orchards

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Cover crops are well known for their capacity to improve soil physical, chemical, and biological properties; provide supplemental nutrients; and help suppress weeds in horticultural

production systems. Living cover crops planted between crop rows could also provide habitat for beneficial insects. Planting mixtures of cover crop species may provide greater system benefits than individual species, but the ideal combination to provide multiple benefits in organic hop systems has yet to be determined. We evaluated seven different cover crop mixtures alongside a no cover crop control at two on-farm research sites in Washington and Michigan over a period of 3 years. Each treatment was replicated with one of four hop varieties to test treatment x genotype interactions. Cover crop mixtures were sown each spring and terminated each fall following hop harvest. Soil samples were collected each spring, summer and fall, and ammonium and nitrate concentration determined using KCl extractions. Baseline and final year soil samples were analyzed for various soil chemical and biological properties. Results to date indicate that cover crop species mixtures differentially influenced soil properties in each trial, but results varied given location. For example, active soil carbon was greatest with the roadway mix treatment in Washington, while the rye/vetch/buckwheat provided the greatest active soil carbon in Michigan. Hop variety also influenced soil properties, with variety 1 resulting in greater active soil carbon than variety 3 in Michigan. In Washington, there was a significant interaction between hop variety and cover crop treatment with respect to active soil carbon, with variety 1 varying between treatments, while variety 3 was not impacted by cover crop treatment. These results indicate that cover crop mixtures can positively impact soil quality in organic hop orchards, but the ideal mixture will vary given location and hop variety.

(084) An Evaluation of Organic Fertilizers for Use in Container Media

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The “organic” movement in the United States has gained considerable momentum over the last 10 years. Consumers now consistently choose organically grown produce from supermarkets and restaurants. Gardeners have also adopted “organic” products. These are mostly fertilizers used in gardens or as container fertilizers. Gardeners are faced with a plethora of products to fertilize plants. Yet, efficacy testing is largely missing from the retail product market. Also, since there are many different and varied sources for fertilizer ingredients there are just as many possible mineral release possibilities. While organic fertilizers are generally believed to be “slow release” there is potential for nutrient loss from containers because organic fertilizers tend to be applied at higher rates or more frequently than soluble fertilizers. We investigated the effects of several fertilizer products, and a few experimental products, on their effects on the quality, growth, and chlorophyll content

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(via SPAD chlorophyll meter) of petunia and basil. The project was repeated for a second trial using broccoli and snapdragon plants. During the first trial, the two experimental products produced the greatest number of flowers on petunia, and the greatest quality on both petunia and basil. Chlorophyll content was not associated with quality in the first trial. In the second trial, the organic product Gro Power (solid and liquid forms) produced the greatest number of flowers, quality, and SPAD readings for both snapdragons and broccoli. For both plants, the untreated and ammonium sulfate treatments produced the lowest quality, least amount of flowers, and lower SPAD readings than other organic treatments.

(085) Effect of Late Summer Cover Crops on Weed Management in Organic Vegetables in the Great Lakes Region

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Organic vegetable growers rely on cover crops to contribute to their weed management by reducing weed seed rain and increasing weed seed mortality. We investigated whether late-summer planting of cover crops in the Great Lakes region would reduce fall weed escapes and subsequent weed growth in the following year's crop. We also investigated whether the effect of a late-summer cover crop is different if it is allowed to decompose over winter with the roots undisturbed or incorporated in the fall so that it is thoroughly decomposed. Furthermore, untreated bean seed is susceptible to many rot pathogens whose abundance might be affected differently by the various cover crop species, and by how recently and rapidly the decomposition occurred. To obtain results applicable to the broader Great Lakes region, we performed the experiment in New York, Michigan, and Illinois using organic practices. While fall tillage resulted in substantially lower stands of beans, that effect was the same whether there was a cover crop present or not. In spring-incorporated plots the stand was slightly better following sudangrass, with the other cover crops being equivalent to no cover crop. Fall weeds, and therefore, weed seed rain, were strongly suppressed by cover crops. The weed biomass was less than 20% of the unmanaged plots. Sudangrass was effective when it emerged quickly, but when drought delayed its

emergence, sudangrass failed to suppress weed establishment. Buckwheat, which was terminated in September, allowed some cool-season grasses to establish afterward. Weed pressure in the bean crop was measured in several ways relevant to a growers' weed management: initial flush of seedlings, post-cultivation emergence, and time required to hand weed after mechanical cultivation. There was no consistent effect of any cover crop on the subsequent weed pressure. At an individual site and year, there were sometimes large effects that may indicate a suppression mechanism that would be useable if it could be identified. While these cover crops were effective for reducing the weed seed production, and would therefore be valuable in long-term weed minimization, the benefit was not consistently detectable in the subsequent year.

(086) Nutrient Content of Field-grown Organic Heirloom Tomatoes as Influenced by Poultry Compost and Mycorrhizae Application

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Safety and healthfulness of produce relate to several factors, including fruit nutrient content. Fruit nutrient content can be influenced by the growing medium and soil additives such as poultry composts. In this 2012 field study, the objective was to determine whether poultry compost and vesicular arbuscular mycorrhizae (VAM) affected the nutrient content of organically produced heirloom tomato (*Lycopersicon esculentum*) fruits. Tomato cultivars, Debarao Plum (DP) and Brandywine Red (BR) were transplanted at the field site and subjected to four treatments; control, VAM, poultry compost, and VAM + poultry compost. Ripe fruits were analyzed for the nutrients; sulfur, phosphorus, calcium, aluminum, zinc, iron copper, arsenic, and lead. The amendments did not have a significant effect on fruit nutrient concentrations except for sulfur, which was the lowest (0.13%) in DP fruits from the VAM treatment. Cultivar, DP had higher levels of calcium than BR, with values ranging from 0.12% for DP to 0.09% for BR. Copper levels of DP fruits were generally lower than BR fruits across treatments, and ranged from 7.0 ppm for DP to 9.8 ppm for BR. Total arsenic and lead levels ranged from 0.8 to 1.0 ppm and 0.0 to 0.1 ppm, respectively. These nutrient results indicate that the soil amendments used in this study did not pose a food safety risk factor to tomato fruits of Debarao Plum and Brandywine Red.

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(087) Organic Production of Sunflowers in High Tunnels

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This study evaluated the organic production of sunflower cut flowers in high tunnels. Cover crops were grown over the winter and incorporated into the soil in the following spring and subsequently sunflower plants (Infrared Mix F1) were grown in the high tunnels. There were four cover crop treatments: Annual ryegrass (*Lolium multiflorum* Lam.) (75 lb/acre), Annual ryegrass (50 lb/acre) + hairy vetch (*Vicia villosa*) (31 lb/acre), Caliente 199 mustard blend (*Brassica juncea* + *Sinapis alba*) (10 lb/acre), and no cover crop (control). Results showed that in general, sunflower plants grown in the no cover crop plot were taller than plants grown in the cover crop plots, especially earlier in the season. However, the total number of cut stems was similar among all treatments, with plants grown in mustard plot produced slightly less stems. The soil analysis data showed that prior to tilling the cover crops, soil nitrate concentrations in the top 20 cm were higher in the no cover crop plot than in the cover crop plots. Further studies will be conducted to look at the long-term effects of cover crops on soil properties and crop production in high tunnels.

(088) Vegetable Yield and Soil Quality as Affected by Organic Cropping Systems

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An organic vegetable cropping system experiment was initiated in sandy soils at Citra, FL, in Spring 2011. Different organic management practices were evaluated with respect to their influence on vegetable yield and on soil quality. Six vegetable production systems were established including two polyethylene mulch systems with or without cover crops, two unmulched bed systems with or without cover crops, and two reduced-tillage systems with cover crops and varying fertilization rates. Two crop sequences, i.e., spring yellow squash-fall broccoli and spring tomato-fall lettuce, were also evaluated. The experiment was arranged in a split-plot design, four replications, with crop sequences as the

whole plots and production systems as the subplot treatments. Hairy vetch and cereal rye were grown prior to the spring vegetables in the cropping systems with cover crop incorporation and reduced tillage. Sunn hemp and sorghum-sudangrass were used as summer crops before planting the fall vegetables. Soil samples (0–15 cm) were collected before seeding cover crops in Spring 2011 and after the final harvest of fall vegetables in late winter. A wide range of soil quality parameters were measured, including pH, electrical conductivity (EC), bulk density, soil organic carbon (SOC), total soil nitrogen (TN), particulate organic matter carbon (POMC), potentially mineralizable nitrogen (PMINN), microbial biomass carbon (MBC), and Mehlich-extractable P, K, Ca, Mg, S, Fe, Mn, Cu, and Zn. Overall, the plastic mulch treatments resulted in the highest vegetable yields while cover crops did not show any significant effect. The yield reduction in the reduced tillage systems and tilled plots without mulches varied with the vegetable crops. The plots without cover crops showed the lowest level of root-knot nematode infestations despite the use of plastic mulch. There were no consistent treatment differences in soil quality among the 6 production systems across the two cropping sequences. At the end of the 2011 production cycle, Mehlich-extractable Mg was significantly higher under reduced tillage compared to the other production systems. The reduced tillage system also showed the highest level of soil EC. Temporal changes in soil quality parameters were greater than production system and cropping sequence comparisons. Total soil N, PMINN, Mehlich-extractable P, Ca, and Mn trended higher compared to data collected before spring cover crop planting. These results suggest that improvement of soil quality in sandy Florida soils will be challenging, warranting future research to evaluate the long-term effects of organic vegetable cropping systems on the soil.

Specified Source(s) of Funding: USDA ORG

Ornamental Plant Breeding

(376) In Vitro Chromosome Doubling of *Prunus laurocerasus* ‘Otto Luyken’

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Prunus laurocerasus (2n=22x=176), common cherry laurel, is an evergreen shrub often used as a hedge or screen. This species has become naturalized in parts of northwestern U.S., which has led to concern regarding its invasive potential. Therefore, a sterile form of common cherry laurel would be useful in curbing its escape from cultivation. As part of a breeding program to develop sterile common cherry laurel cultivars we

An asterisk (*) following a name indicates the presenting author.

attempted to induce polyploidy using in vitro exposure of 'Otto Luyken' shoots to oryzalin. Shoots that were 1.5 cm long with two to three meristems each were placed on solid media in 30 x 200 mm culture tubes. Shoots were treated by covering with 10 mL of liquid MS media supplemented with oryzalin. Each experimental unit was one culture tube containing a single shoot. The experiment was completely randomized with 20 replications. Shoots were treated for 1, 2, 14, or 28 days with 0, 6.25, 12.5, 25, 50, 100, or 150 μM oryzalin. After treatment, the liquid phase was removed and shoots were transferred to fresh media. Ploidy level of surviving shoots was determined using flow cytometry analysis of DAPI stained nuclei. The 14 d treatment had reduced survival compared to 1 d and 2 d treatments and there was still greater mortality in the 28 d treatment. Duration affected mortality more than oryzalin rate. Percentage of surviving shoots that were 22x was similar among all treatment durations. As the rate of oryzalin increased, percent 22x decreased up to 100 μM and then increased. For the 28 d treatment, there were no 22x shoots except at 0 μM . Percentage of surviving shoots that were mixoploid increased with rate of oryzalin for 1, 2, and 14 d to a maximum at 86, 86.5, and 85 μM , respectively, before decreasing. The 28 d treatment had 100% mixoploid shoots at each oryzalin rate except 50 μM , at which survival was 0%. Percentage of surviving shoots that were 44x increased with rate in the 1 and 2 d treatments. Percentage of surviving shoots in the 14 d treatment reached a maximum at 90 μM and no surviving shoots were homogenous 44x. In addition to analyzing each tube as a whole, individual shoots were collected and the ploidy level of each was determined. As expected, when each meristem was analyzed individually, there was a reduced number of mixoploids, as more of the separated meristems were 22x and 44x.

Specified Source(s) of Funding: Oregon State Agricultural Research Foundation and Oregon Department of Agriculture

(377) Breeding Heat Tolerant Abutilon

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Abutilon xhybridum, a member of Malvaceae, has gained popularity in the southeastern United States as a spring and fall flowering herbaceous plant. To further breeding Abutilon with heat tolerance and diversified flowers, ten cultivars were selected, propagated, and grown in the greenhouse for artificial hybridization. Stem cuttings of Abutilon rooted easily with aid of 1000 $\text{mg}\cdot\text{L}^{-1}$ K-IBA in about 2 weeks. All transplanted cut-

tings reached full bloom in about 2 months. Although we did all reciprocal crosses among all 10 cultivars, only A08-1603 (pure yellow, light bloom), A08-1607 (yellow with red throat, heavy to medium bloom), and A08-2112 (red, heavy bloom) set fruit and yielded seeds. A08-1607 was selected as a parent since it shows good heat tolerance and continual blooming through the summer and fall months. A08-1607 X A08-2112 had 41.7% fruit set and produced 7 seeds per fruit. The cross, A08-1603 X A08-2112, set 25.5% fruits and 14 seeds per fruit. If crossing A08-2112 (female) with A08-1607 (male), only one out of 43 crosses set fruit with a yield of only 3 seeds. The low percentage of successful crosses and limited fruit set might be due to incompatibility and higher temperatures in the greenhouse. Further studies should focus seed germination and evaluation of new germplasm. The mechanism of cross-incompatibility should also be investigated.

(378) Characterizing Crop Timing and Quality Traits of a *Petunia integrifolia* x *P. axillaris* Recombinant Inbred Line Population under Different Temperatures

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Petunia (Petunia xhybrida) is often produced in greenhouses in northern climates in the United States during the late winter and early spring. However, providing optimal temperatures in the early of the year for petunia can cause greenhouse heating costs to be very high. Minimizing energy costs could be achieved by manipulating crop timing traits to reduce production time, such as increasing the leaf unfolding rate (i.e., development rate), or decreasing the number of leaves below the first flower. *Petunia integrifolia* and *P. axillaris*, the progenitor species of the cultivated petunia, exhibited a faster development rate than the modern cultivated petunia and may be useful genetic sources to breed faster-developing cultivars. A population of F7 recombinant inbred lines (RIL) derived from a *P. integrifolia* x *P. axillaris* F2 population was phenotyped in two experiments representing a range of temperatures during Summer 2012 (24 °C) and Winter 2013 (14, 17, 20 °C). The population exhibited considerable variation for several crop timing traits, including leaf unfolding rate and the number of leaves below the first flower, and quality parameters. The population distribution for development rate increased as temperature decreased. At 24 °C, the average leaf unfolding rates of the 10 fastest and 10 slowest lines were 0.820 and 0.458 leaves per day, respectively. In contrast, at 14 °C, the average leaf unfolding rates of the fastest and slowest lines were 0.422 and 0.130 leaves per day. Therefore, as the temperature dropped from 24 °C to 14 °C, the fold change in development rate of the fastest lines compared to the slowest lines increased from 1.8-fold higher to 3.2-fold higher. These results indicate that the leaf unfolding rates of slower-developing lines are more

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subject to cool temperatures than the fast-developing lines. Thus, introducing the faster-developing trait into the modern cultivated petunia could increase the feasibility of producing petunia at lower temperatures to reduce heating fuel usage. Also, the observed range of variability for a wide range of phenotypic traits observed in the population indicates that these RILs will be very useful for mapping traits of interest.

Specified Source(s) of Funding: USDA–SCRI, USDA–Floriculture and Nursery Research Initiative

(380) In Vitro Callus Induction of *Dendranthema indicum* var. *Aromaticum*, a Scented Chrysanthemum

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Dendranthema indicum var. *aromaticum* is a fragrant, medicinal chrysanthemum variety that has hairy stems and leaves, producing desirable aromas. A breeding objective is to create selections that also possess large, showy flowers for a new product of fragrant cut, potted, or garden chrysanthemums. Several methods are being used to create new interspecific hybrids with cultivated chrysanthemums, *D. xgrandiflora*: interspecific hybridization, protoplast fusion, and genetic transformation. Breeding requires polyploidization of *D. i.* var. *aromaticum* (a diploid, $2n=2x=18$) to cross with cultivated *D. xgrandiflora* (hexaploid, $2n=6x=54$). In order to transform this species, a regeneration system has to be developed. The effects of different plant growth regulators at different concentrations on callus induction were investigated using stem segments, leaves, petioles and buds of *D. i.* var. *aromaticum* as explants. The best in vitro propagation was achieved with axillary buds from nodal stem segments cultured on MS medium, based on callus induction rate, callus hardness, growth potential and the number of shoots differentiated. The optimal induction mediums were MS + 1.0 mg/L 2,4-D + 0.2 mg/L 6-BA. Rooting of shoots was also achieved.

(381) Variation in Nuclear DNA Content and Chromosome Number among and within *Caladium* Species

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Cultivated caladiums (*Caladium xhortulanum*) are a major floriculture crop in the United States, especially in the southern and southeastern states. Genetic improvement of cultivated caladiums has been primarily through hybridization among existing cultivars. To broaden the genetic base of cultivated caladiums and/or introduce biotic and/or abiotic stress tolerance traits may necessitate more interspecific hybridizations with other caladium species. In addition, the number of species in the genus *Caladium* is still a matter of discussion. Plant taxonomists have divided the genus into seven to 17 species. The main debate is about the classification of *Caladium bicolor*, *Caladium marmoratum*, and *Caladium picturatum*, and the status of *Caladium xhortulanum*. The present study was undertaken to determine the variation in nuclear DNA content among and within nine caladium species and chromosome number of four caladium species. Flow cytometric analysis revealed significant variation in nuclear DNA content among species, ranging from $2n = 2.98$ pg in *Caladium lindenii* to $2n = 9.89$ pg in *C. xhortulanum* cv. Chang Suek. Significant variation was also observed within certain species, such as *Caladium steudneriifolium*. All four caladium cultivars examined have $2n = 2x = 30$ chromosomes. Lower somatic chromosome numbers were observed in some caladium species. Results from this study have provided new insights into the relationships among and within caladium species and shed light on the origin of cultivated caladiums. The available information will be also very valuable for designing sexual crosses for caladium breeding.

(382) Haploid Production through Anther Culture in *Saintpaulia* Species

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African violet (*Saintpaulia ionantha*) cultivars are generally not fixed as homozygotes because the plant is easily propagated by leaf cutting. However, homozygotes are useful for breeding. Anther culture is a rapid method of obtaining homozygotes via doubling the anther-derived haploid chromosome set. In this study, the optimal anther culture conditions for highly-efficient haploid production were investigated using seven natural species and eight cultivars in the genus *Saintpaulia*. Anther culture of African violet was performed to determine the appropriate phytohormone concentrations for shoot formation. Microspores at uninucleate stage that were suitable for culture

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were observed in anthers of length 2.5–3.0 mm (natural species) or 3.0–5.0 mm (cultivars) at 8–9 days after bud formation began. Treatments contained 0.1, 1.0, or 10.0 mg/L of N6-benzyladenine and of naphthaleneacetic acid in a total of nine concentration combinations. The most effective combination for shoot formation was 1.0 mg/L of each phytohormone in the cultivar ‘Tomahawk’. In that treatment, shoot formation percentages from anthers ranged from 0% to 62.5% for natural species and 0% to 93.8% for cultivars. Three of seven natural species and five of seven cultivars showed statistically similar shoot formation percentages to ‘Tomahawk’. These results suggested that the applicability of these anther culture conditions was 43% in natural species and 71% in cultivars. Microscopic observations of chromosomes in root-tip cells of anther-derived plants showed an average haploid efficiency of 64.3%. Some haploids had different phenotypes from their parent plants in both leaf and flower color and shape. Recessive traits, such as single flowers, white flowers, and plain foliage, were observed in haploids. Colchicine treatment of ‘Tomahawk’ was performed to produce doubled-haploid plants. The most effective conditions for producing doubled haploids were 0.05% colchicine for 3 days. Most of the doubled haploids retained the characteristics of their parent haploid. Stomatal cell lengths in polyploids were ranked as tetraploid (doubled diploid) > diploid > doubled haploid > haploid. Although the doubled haploids should be confirmed the homozygous through progeny tests, they may be used practically as breeding stocks. This new method allowed the production of doubled haploids of African violet in as little as 392 days.

attached inside the systems. CO₂ response time of plant under light condition was compared between two kinds of culture media, perlite and artificial substrate, for plant pot. After one hour of treatment, in perlite pot, the CO₂ concentration was sharply decreased by 333 ppm, however, in artificial substrate pot, the CO₂ concentration was rather increased by 7 ppm. Therefore, to observe CO₂ absorption by leaves in 40 minute class, inorganic media is more efficient than organic media with lots of microorganisms. For experiment time zone, the response of vegetables and foliage plants in the systems were tested in the morning or in the afternoon. The both time zones were possible to observe CO₂ decrease by both plants. Transpiration was shown by much H₂O increase in the pot with leaves than in the pot without leaves. Although little change was shown according to temperature and humidity, after 30 minutes of treatment on average, moisture on the system walls was visible. This teaching aid for leaf function was applied to 4th grade students in Seoul and the students checked the CO₂ and H₂O change by plants in the systems with or without light and with or without leaves. The academic achievement regarding plant leaf function was significantly higher in experimental group compared to the students in control group.

(185) Do Plants Play a Part in Student Satisfaction?

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Prior research in environmental psychology indicates that there is a relationship between plants, nature, and satisfaction. Satisfaction of students is of importance across the grade levels. Two studies were conducted concerning the effect of interaction with plant life on student satisfaction. In the first study, a quasi-experimental nonequivalent control group design was used to determine how participation in garden labs would affect high school student satisfaction with school. Ecology students in the variable group participated in 10 gardening labs during the semester. Labs were centered on hands-on gardening activities that took place in the school greenhouse and garden. The garden component was taught by the teacher in order to minimize bias that could result from a third party teaching the lab. Students in the control group did not participate in the garden program that was offered as a part of the experiment. Students in the variable group and a similar control completed a questionnaire prior to and after the time of participation in the garden labs. Questionnaire items pertaining to student satisfaction with school, knowledge of and affinity for gardening were used for statistical analysis. Random selection was not feasible for this study, and participants were a convenience sample based on teacher availability to participate. The second

Wednesday, July 24, 2013

1:00–1:45 PM

Teaching Methods

(184) Development of Teaching Aid for Leaf Function and Evaluation of Its Impacts on Student Academic Achievement

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This study was conducted to develop teaching aid for photosynthesis and transpiration of plant and to evaluate its application effect on elementary school students. In Korea, the 4th grade students take lessons on the function of leaves among other plant organs during science classes. For the observation of CO₂ and H₂O change by plant indoor, closed systems (26.5 x 18.0 x 49.0 cm) were made with transparent acryl with LED lights on the top of them. Sensors of temperature, CO₂, and H₂O were

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study involved the development of a survey instrument that would be used to measure how much undergraduate students interact with plant life, gauge student satisfaction, and control for extraneous variables. Survey results could be used to better provide services for undergraduate students that may increase student satisfaction. For the purposes of this survey, time spent interacting with plant life was broken into two groups. Active interaction included activities where the individual has sought out plant-based activities, such as gardening. Passive interaction with plants would include activities where the individual may not have desired a plant-based activity, but would be in a “green” environment that has live plants, like walking outside and reading outdoors. Pre-testing and a pilot test would be used to generate items pertaining to interaction with plant life for the population of interest. The validated Brief Multidimensional Student Life Satisfaction Scale—College version was used to measure student satisfaction, in addition to questions that were focused on aspects of satisfaction with school. Analysis of data for both studies was done with SPSS 20.

(186) A Webinar Series to Provide Advanced Training for Iowa Nursery and Landscape Professionals

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Surveys of the Iowa Nursery and Landscape Association (INLA) membership in 2008 and 2010, showed that members were interested in educational programming beyond the basic training provided to prepare for the Iowa Certified Nursery Professional exam. Further, members were interested in program delivery methods that were flexible and that could accommodate their schedules. To address this educational need, a series of nine webinars on advanced topics were developed (four in 2011 and five in 2012). Webinars were delivered using Adobe Connect and were available as a live interactive session and asynchronously afterward via the INLA website. A total of 21 individuals participated in the nine live webinars and many participated in multiple webinars. Overall attendance to all nine webinars was 64. In the 12 months after the 2012 series was completed, 87 members accessed the webinars. A follow up survey was sent to the 18 participants in the five 2012 webinars and 10 participants returned the survey for a 55.5% response rate. Participants answered three questions using a four point Likert-type scale (1 = strongly disagree; 4 = strongly agree) regarding: new knowledge gained by participating in the webinar; likelihood of implementing one or more new practices/concepts learned in the webinar; and if they expected to increase profitability as a result of participation in the webinar. Overall scores for each of the three questions were between agree and strongly agree. Participants rated gaining new knowledge 4.25, the likelihood of implementing a new practice or concept 4.25 and the likelihood increasing profitability 4.1. Continuing education webinars have proven to be an effective way to reach nursery and landscape professionals.

(187) An Undergraduate Independent Study Project Developing a Golf Course Tree Inventory for Audubon Sanctuary Certification

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Developing a tree inventory is one of the initial steps toward golf course Audubon Cooperative Sanctuary Certification. The Audubon Sanctuary Program is a cooperative effort between the United States Golf Association and Audubon International, Inc., with the goal to promote environmental sustainability and education on U.S. and international golf courses. As part of an undergraduate independent study project we initiated this certification process for the 140-acre Weibring Golf Club on the campus of Illinois State University by completing a tree inventory of the course. Course Vision® software was used to catalog and inventory golf course site elements. The senior undergraduate student involved in the project had a strong background in woody plant identification through coursework and internship experiences. Prior to the start of the project, Course Vision® field technicians visited campus and mapped the location of all the trees on the golf course, assigning each a number and GPS coordinate. It took approximately 60 hours over a 15-week semester to visually identify, rate, and enter the genus and specific epithet of each tree specimen into the Course Vision® program. A rating system of 1 to 5 was used with 1 signifying a tree that needed removal or replacement and 5 signifying a tree in excellent physical condition. Of the 1,055 tree specimens identified from among 37 different species, ratings were as follows: rating 1 = 9.8% of the total number of trees, rating 2 = 13.6%, rating 3 = 33.5%, rating 4 = 35.7%, and rating 5 = 11.0%, respectively. Completion of this project is helping the course superintendent develop a tree budget and replacement program and to begin the process of applying for Audubon Cooperative Sanctuary Certification.

(188) Introducing the Flipped Classroom in Several Horticulture Courses

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In the “traditional” classroom, the instructor lectures and students do homework outside of class. To reduce the amount of lecturing and promote more student engagement in class, the flipped classroom technique was introduced in several horticulture courses. In a flipped classroom, lectures are assigned for homework, and students do in the class what used to be done outside the classroom. The objective of this presentation is to

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discuss some of the ways the flipped classroom approach was introduced into Tropical Plant & Soil Sciences (TPSS) Department courses. The TPSS courses were TPSS 674 Plant Growth Development, TPSS 300 Tropical Production Systems, and TPSS 654 Communications in the Sciences. Various lectures were replaced by YouTube videos, websites, and HortTalks presentations. Students viewed these on their own outside of class. They reviewed the Virtual Plants online computer simulation, Flower Power wheat flowering model, Prune Chilling Prediction Model, chilling accumulation models, and a growing degree-days phenology model. They viewed videos on soybean yield potential, soybean maximum yield, hydroponics, computer modeling and simulation, and scientific conferences. Class time was used for activities in which students engaged in small group discussions, class discussions, and hands-on activities. They brought their laptops, e-tablets, and smartphones to class to do Internet searches for relevant information for class and small group discussions. For example, when analyzing graphs and tables from scientific articles, they sometimes searched for the original article to get additional information. In class, students ran online computer simulations such as the Virtual Plants computer simulation, Flower Power model, Prune Chilling Prediction Model, and chilling accumulation models. For homework, students searched for an online crop model or simulation and brought its URL to class to share with the other students. Each student ran their model and discussed it while the class followed along on their own laptops. Introducing the flipped classroom approach helped create a collaborative learning environment in the classroom in which students were actively engaged in the learning material.

(189) Fruit Quality Measurements in a Segregating Blueberry Population: Plant Breeding Training for Undergraduates

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At U.S. institutions, plant breeding is rarely offered as an

undergraduate major. For many undergraduates majoring in plant sciences, plant breeding is a higher level elective, and for those not majoring in plant sciences, plant breeding is often an entirely new concept. Even when offered as a course, hands-on training in plant breeding is not common. Our participation in a multi-institutional research project to develop a linkage and quantitative trait locus map for tetraploid highbush blueberry (*Vaccinium corymbosum* L.) has given the opportunity to offer laboratory and plant breeding training to several undergraduate students. The cohort of students involved in this project were recruited primarily through guest lectures on blueberry history, culture, and breeding given in introductory horticulture and biology courses at the University of Florida. Fruit was collected from a segregating tetraploid highbush blueberry F1 population that was created from an intra-specific cross between the northern-adapted cultivar Draper and southern highbush cultivar Jewel. The population is clonally replicated in several locations including Gainesville, FL, and Homerville, GA, where berries from each genotype were harvested once each plant had 50% fully ripe fruit. Because many of the fruit quality traits measured in this population required objective measurements, we focused on these as training opportunities. For fruit size (g) and firmness (g/mm compression force as measured on a FirmTech 2 firmness analyzer), samples were held in a cooler (4 °C) and measured within 48 hours. For total solids (g dry weight/10 g fresh weight), soluble solids (°Brix measured on a handheld refractometer), titratable acidity (citric acid equivalent), and anthocyanin content (mg/L of cyanidin-3-glucoside equivalents), berry samples were held in a cooler (4 °C) for up to 48 hours, and then frozen (–20 °C) prior to processing. Students were required to contribute to sample processing, measurement, and analysis. Mini-experiments were designed to take students from hypothesis to statistical analysis, and illustrate the variation for many fruit quality traits possible through plant breeding. For example, the correlation between total solids and soluble solids was tested to determine whether soluble solids could predict total solids as in other processed fruits and vegetables. For this population Spearman's rank correlation indicated total solids and soluble solids were correlated for fruit collected from the Florida ($r = 0.34$, $P = 0.004$) and Georgia ($r = 0.72$, $P < 0.0001$).

(190) Understanding Student Perceptions and Industry Expectations for Viticulture and Enology Careers

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With the recent development of commercial wine grape in-

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dustries throughout many states in the United States, there has been an increase in job potential in the area of viticulture and enology. Universities have developed various forms of curricula to provide specialized education in viticulture and/or enology. However, there are no published needs assessments specific to the career field. A research study was developed to address student perceptions of preparedness and industry expectations of students entering viticulture and enology careers. A multiple-tool approach was used to gather information from students, employers, and current industry professionals. Students within the Viticulture and Enology Degree Programs at Oregon State University were surveyed for competencies, weaknesses, and perceptions of skills, knowledge, and attributes required in viticulture and enology careers. Required skills, knowledge, and attributes were also assessed through industry employer interviews. These were compared against data obtained from current industry professionals, the majority of whom were from Oregon. Students were more confident in knowledge than skills, and they cited most confidence in viticulture, vine physiology, enology, and laboratory analyses. They were least confident in their knowledge and skill level for vineyard and/or winery management and equipment operation and maintenance. Students realized work experience was required to gain knowledge, skill, and confidence in those areas. Industry employers indicated greater preference for personal attributes (reliability, work ethic, and teamwork) and work experience combined with the degree, citing the importance of core science and agricultural background knowledge for BS-level jobs in viticulture and/or enology. Rarely did industry employers indicate that a degree specific to viticulture and/or enology was required. Specialization in the work experience related to the career area outweighed degree specialization. These data confirmed the strength of OSU's program where the viticulture and enology options are within horticulture and food science degree programs and reinforces the importance of student internships.

(191) The Use of Creative Nonfiction in a Floriculture Production Course to Introduce Concepts of Plant Conservation, Industry Internationalism, and Consumer Motivations for Plant Purchases

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The need exists to make horticultural science content more socially and culturally relevant. Students can be introduced to topics such as plant conservation, industry internationalism, and consumer motivations for plant purchases through a wealth of popular literature about horticulture. During Spring 2009, 2011, and 2013 semesters, students enrolled in the lab-based course HORT 625 Floral Crops Production and Handling (2-credits) at Kansas State University were given a reading, reflection, and discussion assignment about the book *Orchid Fever*, which relates a factual but entertaining account of the international

orchid industry. A pre- and post-assignment survey was administered to students to evaluate their changes in perceptions because of the assignment. Student gains for all assessment items were highly significant, suggesting that the assignment was successful at introducing the intended concepts grounded in social science. Specifically, students indicated familiarity with international laws that govern plant commerce, developed an opinion about plant conservation, learned how the same plant is used differentially across cultures, and understood motivations that drive consumers to purchase ornamental plants. In addition, students strongly indicated that the in-class discussion was a critical part of the assignment, that the assignment was more interesting than they had initially thought it would be, and that the assignment should be included in future offerings of the course.

(192) How To: Making an Informative Video from Start to Finish

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As social media increases in popularity for distributing information and communicating with others, the traditional method of transferring information through print and workshops are now often supplemented or replaced by web-based outlets. In 2012, The University of Arizona, Fresh Produce Safety Program initiated a social media campaign as a method of distributing educational information while gaining recognition as a source for fresh produce safety (FPS) resources. A website, Twitter and Pinterest accounts, and Facebook and YouTube pages were developed to provide an alternative means to engage clients and communicate new information and ideas. The resulting social media campaign has proven successful in facilitating networking and client communication. One of the leading methods used to communicate information and ideas using social media outlets is through the incorporation of content specific videos. Three useful strategies to consider when creating credible videos include developing appropriate subject material, choosing appropriate lighting, and using innovative editing techniques. Subject matter is one of the chief considerations when creating a video and consists of determining a target audience, defining message outcomes, and selecting careful locations for shooting raw footage. For example, when videos are targeted for teenaged students, they tend to be fast-paced, are short duration, have limited vocabulary, and are fun. Videos that target adult learners are more medium-paced, have longer durations, and use a wider vocabulary. Planning subject matter also includes developing a concise script and selecting appropriate locations for videography. During the editing process,

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selecting appropriate music, creating clever graphics, or using software templates and lower thirds will embellish the video for a more polished and professional look. All video graphics should be coherent and match the theme of the video. Filters and scene transitions, that likely accompany editing software, can also make videos stand out. Finally, many videographers will note lighting intensity, direction, and angle when shooting raw video footage and that costly lighting equipment is not necessarily required for success. Subjects or background should be well lit and not overexposed and unnecessary objects should be excluded from the shot as they could be distracting. The combination of a great video and social media can be an operational outreach tool used by learning communities around the world, and for some, can be effective for learners that would be otherwise unreachable.

Specified Source(s) of Funding: USDA-NIFA-OREI Grant No. 2010-51300-21760

Wednesday, July 24, 2013 1:00–1:45 PM

Temperate Tree Nut Crops

(128) A Reduced Early Season Irrigation Schedule for Southeastern Pecan Production

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Pecan are known to be a high water use crop; however most pecan irrigation research has been conducted in the western pecan growing regions of the United States. The pecan-growing region of Georgia receives significantly more rainfall than the pecan growing regions of the desert Southwest. Yet, because the timing of rainfall does not usually coincide with the period of greatest water demand by the pecan tree, irrigation remains necessary in the southeastern U.S. for consistent production of high-quality pecans. Very little research based information is available regarding the true water requirements of pecan in the Southeastern U.S. With increasing agricultural water use, a growing population, and current groundwater levels at record lows, irrigation efficiency in the region is necessary for sustainability. A study was developed in 2012 to test the validity of a proposed reduced-rate early season irrigation schedule for southeastern pecan production utilizing micro-sprinkler irrigation. Three treatments were evaluated; 1) current recommended irrigation schedule; 2) reduced rate schedule; and 3) non-irrigated control. Treatments were arranged in a randomized block design with each treatment replicated five times in single-tree plots. Water stress was measured weekly by stem water potential using a pump-up pressure chamber. Soil moisture was measured at the same time using a Field Scout TDR 300 Soil Moisture Meter. Shoot length, pecan yield, nut weight, and percent kernel were measured annually. Water stress on pecan occurred at about 113 psi using the pressure chamber to measure stem water potential. Regression analysis suggests

that irrigation scheduling for mature pecan trees may be needed when volumetric water content reaches 10% to 11% on Tifton loamy sand. The reduced rate irrigation schedule provided a 38% reduction in irrigation water use with no significant effect on pecan tree water stress, yield, or quality.

Specified Source(s) of Funding: Georgia Agricultural Commodity Commission for Pecans

(129) Efficiency of California Trunk Shaking Pistachio Harvesters

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Pistachios are long-lived with an extended juvenility; they generally require 8 to 10 years to achieve full bearing. Pistachios have been harvested by trunk shakers since the industry was established in the 1970s. Some orchards are now over 30 years old with trunk girths over 30 inches in circumference. Preliminary data in 2009 indicated trunk shaking harvester efficiency was decreasing with increasing trunk girth. In September 2010, 4 commercial and 2 experimental trunk shakers were tested on trees ranging from 30 to over 50 inches in girth. The trees were shaken for 8 seconds, followed by hand gleaning. Both samples were field weighed, hulled, dried and graded using standard industry grading procedures. The resulting calculated trunk shaker final percentage efficiency and grading analysis demonstrated 79% to 86% final efficiency for the commercial shakers versus a significantly better 96% average final for the two experimental trunk shakers. A regression analysis demonstrated 30% of the decrease in efficiency was associated with the increasing trunk girth. These results strongly suggest the pistachio industry should begin evaluating improved trunk shaking technology, pruning that enhances trunk shaker efficiency, and alternative harvesting technologies versus the economics of replanting orchards.

Specified Source(s) of Funding: California Pistachio Research Board

(130) Feeding Preference of *Conotrachelus retentus* on Black Walnut Tissues

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Black walnut curculios (*Conotrachelus retentus*) were collected in a mature black walnut repository at New Franklin, MO, on 2, 9, 10, and 15 May 2012. A total of 138 female and 150 male curculios were collected and used for feeding preference trials. Insects were provided water, but food was withheld for 24 h before the feeding trial. For this test, four types of plant material were placed in each quadrant of a 140 mm-diameter x 25 mm-deep petri dish lined with moist filter paper. Plant material included a pistillate flower (≈ 2 cm-long), a similar length of a catkin, and a 2 cm x 1 cm section of a black walnut or pin oak leaf. One insect was placed in the center of each petri dish lined on a laboratory bench in a lighted room at 0900 HR and the occurrence of feeding on any plant material was recorded after 15, 30, 45, 60, 75, 90, 105, 120, 180, 240, 300, 360 min. After this time, lighting was eliminated until 0800 HR the next morning when data were recorded again at hourly intervals for 4 h. Insects were removed from petri dishes and the number of eggs within each ovipositional scar on each pistillate flower was recorded. Male and female curculios had similar feeding preferences. Both sexes were observed feeding on catkins most often and female flowers to a lesser extent. The probability of females and males feeding on the catkins was 3.0 and 4.7 times greater, respectively, than that of feeding on pistillate flowers during the trial. Insects were never seen feeding on walnut or oak leaves. Pistillate flowers had the greatest number of ovipositional scars on 9 May and the fewest on 15 May. Also, females oviposited an average of five eggs per pistillate flower on 9 May and less than one per flower on 15 May.

(131) Characterization of the Relationship of Manganese Nutrition to Photosynthesis of Pecan in the Mesilla Valley, New Mexico

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In the past several decades, there has been a shift in U.S. pecan (*Carya illinoensis*) plantings from the southeastern to the southwestern U.S. In acidic soils manganese (Mn) may reach toxic levels in pecan trees. Soils in the southwest pecan growing areas are typically alkaline and calcareous; thus phosphorus and most micronutrients, including Mn, are poorly available for root uptake. Manganese is essential for photosynthesis specifi-

cally in the oxidation side of the PSII complex. Mn also acts as a coenzyme for biosynthesis of chlorophyll. The Extension recommendations for New Mexico (NM) pecans are 100–300 ppm Mn in July sampled leaflet tissue. A published survey of NM pecan orchards showed, on average, only 85 ppm Mn in leaf tissue. Previous research showed that severe Mn deficiency (11 ppm in leaf tissue) negatively impacts photosynthesis, but the level of Mn at which photosynthesis is optimum is not yet known. Our objective was to characterize Mn impacts on photosynthesis over a broad range of leaf Mn concentrations. In 2011 and 2012, an experiment was conducted on 24 second leaf ‘Pawnee’ pecan trees in Las Cruces, NM. There were four treatments in which Mn (as an amino acid chelate) was applied foliarly with three applications in the first season and five in the second season at four different concentrations: 3% (High), 1.5% (Medium), 0.75% (Low), and 0% (Control) Mn. Gas exchange was measured using a portable photosynthesis system and correlated to leaf Mn tissue concentrations. Mean leaf Mn concentration in 2011 was 38, 52, 149, and 302 ppm in the Control, Low, Medium, and High treatments, respectively. Concentrations in 2012 were 53, 84, 147, and 329 ppm in the Control, Low, Medium, and High, respectively. All other nutrients were within normal ranges. Leaf Mn concentrations were not significantly different across treatments on May 2012 (prior to 2012 Mn applications), indicating no carryover of Mn from 2011. Analyzed across dates the Medium Mn treatment had significantly higher photosynthesis and stomatal conductance ($\alpha = 0.05$) than the other treatments. Our data confirm a relationship between photosynthesis in pecan and Mn nutrition. Furthermore, our results suggest that photosynthesis in NM pecan orchards is limited by Mn.

(132) Investigating Physiology of Salt Processing in Pistachio

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Soil salinity in California’s San Joaquin Valley may be developing into a limiting factor in the performance of even the most saline tolerant of the region’s tree crops: pistachios. Differences in the salinity tolerance of diverse rootstocks have motivated investigation of the biological mechanisms that lead to these differences, and whether or not a rootstock’s response to salt (here, NaCl) offers some protection to the scion. We begin this investigation of whole tree salt management in pistachios by looking at two potential levels of tolerance: 1) Na⁺ retrieval from xylem sap as a varying mechanism of salinity tolerance in pistachios across rootstock–scion combinations; and 2) phloem

An asterisk (*) following a name indicates the presenting author.

recycling and sequestration of Na⁺ as a varying mechanism of salinity tolerance in pistachios across rootstock-scion combinations. Our material is unbudded, self-budded and *P. vera* ‘Kerman’-budded *P. integerrima*, and *P. ‘UCB1’ (P. atlantica x P. integerrima)* rootstocks. This work may help explain the contributions of rootstocks to scion Na⁺ tolerance, information valuable to the industry for its potential application to water management and breeding.

Specified Source(s) of Funding: California Pistachio Research Board

Wednesday, July 24, 2013 1:00–1:45 PM

Vegetable Crops Management

(160) Symbiotic Performance of Diverse Cowpea Genotypes on the Delmarva Peninsula

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Cowpea (*Vigna unguiculata* L. Walp) is a promiscuous legume which has the ability to fix atmospheric nitrogen by establishing an effective symbiotic relationship with *Bradyrhizobium* spp. in a process called biological nitrogen fixation. This symbiotic relationship has the potential to maintain soil fertility and reduce soil amendments with inorganic nitrogen fertilizers. This study was conducted to identify 1) high performance genotypes of cowpea that can be grown as an alternative crop on the Delmarva Peninsula and 2) efficient *Bradyrhizobium* spp. strains that are very effective with cowpea genotypes. This study evaluated the symbiotic performance of 27 diverse cowpea genotypes evaluated in the field, at the University of Maryland Eastern Shore Agricultural Experiment Station, in a split randomized complete-block design with 27 treatments and four replications each. The genotypes were assessed using the following parameters; nodulation, yield, and maturity. At the flowering stage, five plants were randomly selected from each replicate; nodule numbers and weight were recorded. *Rhizobia* (n=106) were isolated from the nodules and phenotypically and genetically characterized. Confirmation test using growth pouches and cowpea plants in nitrogen- free nutrient solution under greenhouse condition showed that 104 out of the 108 isolates obtained were effective in nodulating cowpea plants. Ten additional nodules were randomly selected from each replicate for visual nitrogen fixing activity, of which 85% were effective in fixing nitrogen. Genotypes 524B, IT85F-867-5, and cv. CB46 exhibited the highest number of nodules per plant producing 31, 25, and 24,

respectively. The 50% date to flowering, podding, and days to mature were also determined. Results show variability among diverse cowpea genotypes in their seed yield, plant biomass, harvest Index, and days to maturity. Genotypes IT85F-867-5, TX128BE and IFE Brown produced the highest biomass 5.64, 4.35, and 4.14 Kg·m⁻², respectively. Genotype 524B produced the highest yield and harvest index (1.272.6 Kg·m⁻² and 25.71%) compared to cv. TX2015-2-1-1 (0.341 Kg·m⁻² and 12.9%). In conclusion, cowpea genotypes varied in nodulation, yield, and maturity when grown on the Delmarva Peninsula, and the elite genotypes could be planted as alternative crops in this region whenever severe drought and elevated temperature are expected in the growing seasons.

(161) Grafting and Number of Polyplastic Film Layers Affect Yield of High Tunnel Tomatoes

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High tunnel tomatoes play an important role in season extension in the Midwest. Farmers always request the latest information on high tunnel tomato varieties and management techniques. The objectives of our trials were to evaluate new hybrid tomato varieties and to investigate the grafting effects on heirloom tomatoes grown in 30 ft x 96 ft Zimmerman high tunnels covered with either single-layer or double-layer polyplastic film at Lincoln University’s Carver Farm in Jefferson City, MO. In 2012, four determinate varieties (Mt. Glory, BHN-589, Charger, and Rocky Top) and seven indeterminate varieties (Arbason, Bigbeef, Bigdena, Geronimo, Panzer, Rebelski, and Trust) were tested. Heirloom tomatoes German Pink and Ananas Noire were grafted onto rootstocks Maxifort, Beaufort, Multifort, Colosus, and RST04-106-T, with own-rooted scions as controls. Grafting was done in a greenhouse using the Tube Grafting method. All trials in the high tunnels were conducted in a completely randomized-block design with four replications per variety and four plants per replication. Plants of indeterminate varieties and grafted heirlooms were trained to a single leader. Determinate varieties were pruned up to the first fruit cluster. All other management techniques were similar to local high tunnel tomato production standards. Data showed that yield and number of fruit were similar among determinate varieties. For indeterminate varieties, Geronimo yielded the most, while Trust yielded the least. Mt. Glory, BHN-589, Rocky Top and Geronimo yielded higher in the single-layer high tunnel than in the double-layer high tunnel. Yield was higher for grafted heirloom varieties in the double-layer high tunnel than in the single-layer high tunnel. Colosus rootstock greatly enhanced the early yield of the German Pink

An asterisk (*) following a name indicates the presenting author.

variety. All varieties experienced severe blossom-end rot with the worst incidence occurring on Ananas Noire. Rootstocks did not reduce the incidence of blossom-end rot disorder.

Specified Source(s) of Funding: Specialty Crop Block Grant

(162) Effects of Grafting and Landscape Fabric on Productivity of Three Organically Grown Heirloom Tomato Varieties in High Tunnels

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Consumers continue to become more health conscious and seek out organically and sustainably grown produce such as tomatoes (*Solanum lycopersicum*) to support healthy diets. With the high demand for early fresh produce and the premium price it commands, achieving maximum yield from each tomato plant is very desirable. Organic tomatoes, especially heirlooms, have been favored at direct markets such as farmers' markets and Community Supported Agriculture. With high tunnels becoming widely used, season extension of tomato production is practical but not without challenges, among which are soil-borne diseases, weeds, and low soil temperatures in early spring. The objective of this research was to examine if grafting and landscape fabric would increase the yield potential of tomatoes grown organically in high tunnels for early season harvest. In this 2-year study, heirloom tomatoes (German Johnson, Cherokee Purple, and Red Brandywine in 2010; Paul Roberson replaced Red Brandywine in 2011) were grafted on Maxifort rootstock using the silicon tube method in the greenhouse. Grafted and non-grafted transplants were either planted on bare ground or on black landscape fabric (BLF) covered ground with holes cut for transplants in high tunnels. Trials were conducted at North Carolina A&T State University Farm in Greensboro. The BLF was used primarily for weed control and to promote possible higher soil temperatures in early spring. In 2010, no significant difference was observed between grafted and non-grafted cultivars or between the bare soil and BLF treatments in terms of total marketable yield, which was highest with German Johnson, followed by Cherokee Purple and Red Bran-

dywine. In 2011, total yield and number of fruit were also not different between the grafted and non-grafted cultivars, or between the bare soil and BLF treatments. For early yield, there was an interaction between cultivars and BLF treatment. No difference existed between grafted and non-grafted tomato varieties grown in bare soil. In BLF treatment, grafted Cherokee Purple and German Johnson had significantly lower yields than the non-grafted ones, while grafted Paul Roberson had significantly higher early yield than the non-grafted. Our 2-year data suggest that grafting may not be an economical approach in organic heirloom tomato production if disease pressure is not evident in high tunnel soils.

Specified Source(s) of Funding: North Carolina Agricultural and Technical State University Cooperative Extension Program

(163) Low Tunnels and Shading Influence Total and Marketable Yield of Bell Pepper Fruit

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In Utah, bell pepper fruit losses are often attributed to sunburn, resulting in large numbers of culls that reduce the overall value of the crop. We evaluated biological and mechanical approaches to reduce fruit losses on pepper varieties with superior fruit quality. The effect of low tunnels and shading on pepper varieties Aristotle and Paladin were evaluated during Summer 2012 in northern Utah. The varieties were planted in a single bed (north-south orientation), furrow irrigated system, managed using commercial production practices. Perforated plastic low tunnels (\pm) were used during plant establishment and after fruit set shade cloth (\pm) was installed over the west side of each row. Tunnels were tested to improve early season growth (leaf cover) and shade was used to reduce heat load during the afternoon. Total and red marketable yields were higher with Aristotle regardless of treatment. Low tunnels increased total yield in both varieties when compared with the uncovered plots. Shading increased marketable red yield in Paladin but had mixed results with Aristotle. In general, lower total yields were seen in the shade treatments however, the yield of cull fruits decreased significantly with shading for both varieties. In conclusion, low tunnels increased total yield while shading increased marketable yields by reducing the number of culls.

(164) Evaluating Extended Season Head Lettuce Production in West Virginia

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Lettuce (*Lactuca sativa* L.) is a high-value crop for many retail and wholesale markets in West Virginia. Lettuce is a cool season crop, yet it may be possible to grow a head lettuce crop year-

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round in the Mid-Atlantic region using a combination of suitable genotypes and season extension technology. The objective of this comprehensive lettuce evaluation was to examine heat and cold tolerance of diverse bibb and select romaine lettuces within West Virginia during 2012 using low and high tunnels for extended season production. Lettuce seed of 30 cultivars was acquired from several cooperating seed companies and seeded for transplants on 3 Apr., 3 July and 25 Sept. 2012. Plugs were hand-transplanted into rows on black or white plastic mulch within a high tunnel on 5 May, 6 Aug., and 7 Nov. 2012. The high tunnels were located in central West Virginia (37°N lat.) Each mature head was weighed and head diameter recorded. Bolting, flavor and tip burn incidence were noted for each variety. Shade cloth (~50% black) was used for mid-summer lettuce production of select varieties. Row covers were used for winter high tunnel production. Storage quality of washed and unwashed bibb and romaine lettuce was also evaluated in September. Economic analysis of extended season lettuce production was conducted. The 2012 growing season had record high temperatures and was the warmest summer on record in West Virginia. The following lettuce cultivars performed very well across all planting dates: ‘Australe’, ‘Buttercrunch’, ‘Coastal Star’, ‘Dancine’, ‘Helvius’, ‘Nancy’, ‘Nevada’, ‘Regina delle Ghiacciole’, ‘Rex’, ‘Rouge Grenoblois’, and ‘Sierra’. ‘Parella Rosa’, ‘Passion Brune’, ‘Brune D’Hiver’, ‘Regina di Maggio’, and ‘Quatro Staggioni’ were not heat tolerant lettuce cultivars and bolted rapidly during the summer heat. Butterhead and romaine lettuce which was washed in chlorinated water and stored at 2 °C had excellent quality for more than 16 days. Head lettuce is a 60–80 day maturity crop depending on the season of the year. Thus it is possible to have as many as four lettuce crops per year in West Virginia. Estimates of profitability have shown lettuce can produce a net return of \$1600–2700 per 1000 ft² within a high tunnel. A commercial high tunnel with approximately 2800 ft² could produce as many as 5400 single heads of lettuce per crop cycle.

(165) Fruit Yield and Composition as Functions of Grafting and Irrigation Regimen in an Organic High Tunnel System

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Grafting, rootstock (RS) and irrigation regimen effects on the yield and composition of tomato (*Solanum lycopersicon* L.) fruit taken from organic high tunnel plots were documented in 2009 and 2010. Four 5-week-old scion (S; ‘Cherokee Purple’) seedlings were grafted, using the cleft method, to seedlings of two experimental rootstocks (314, 338) developed at OARDC. Ungrafted S control plants were also prepared. Grafted plants produced three-four new leaves during the healing phase and were scored and sorted according to quality and vigor. There-

after, in late April of each year, a uniform subset of high quality plants were set into single-row, raised-bed, drip-irrigated, 6.5-m² plots containing 9 plants of a single genotype. Plots were replicated four times and arranged in a randomized complete block design within a 9 m x 24 m single poly-layer high tunnel. All plots were covered at the soil line by black, semi-permeable polyvinyl fabric and supplied by a standard drip irrigation line plumbed to operate independently from others within the different irrigation regimen. After being set, plants were pruned to the third node and trellised using a Florida stake and weave system. All plots were irrigated concurrently for the first 30–40 days after establishment, followed by the onset of flowering. Thereafter, irrigation events occurred every 3 (“standard”) or 6 (“reduced”) days depending on regimen with approximately 6.4 mm water delivered per event regardless of regimen. Irrigation in “standard” plots totaled approximately 12 cm over the final 60 d and 17 cm over the final 90 d of the study in 2009 and 2010, respectively. Total and marketable fruit yield (number, weight) were recorded at weekly–biweekly intervals 9 times in 2009 and 11 times in 2010 before fruit production and ripening stalled. Total and marketable yield were greater in grafted than ungrafted “standard” plots in both years and in “reduced” plots in 2009. Yield in “reduced” plots was unaffected by grafting in 2010, possibly due to two instances of water infiltration from rainfall-fed surface flow. Fruit Brix values were greater in grafted plants under both irrigation regimens in 2009 and in “standard” plots in 2010 but were lower in “reduced” plots in 2010. Brix values tended to increase through time in all treatments in both years. Fruit pH was unaffected by either grafting or irrigation regimen. Overall, the data suggest that water relations and fruiting characteristics may differ between grafted and ungrafted tomato plants.

Specified Source(s) of Funding: The Ohio State University; USDA–NIFA Integrated Organic Program

(166) Production and Quality of Grafted Watermelon Cultivars

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Grafting of seedlings is an emerging technique for watermelon production in many countries. Due to higher costs, the use of grafted seedlings can only be recommended if it provides clear biological and economic benefits. Since rootstock performance is influenced by compatibility with the cultivar, by the existing disease pressure, and by the climate conditions, it is necessary to evaluate rootstocks with predominant cultivars to appraise

An asterisk (*) following a name indicates the presenting author.

possible benefits in a given area. With this objective, four seeded watermelons cultivars (Catira, Delta, Santa Amelia and 1414) and some combinations of these with two commercial rootstocks, Macis (*Lagenaria ciseraria*) and Marathon (*Cucurbita maxima* × *Cucurbita moschata*) were grown, in Curacaví (33°26'18"S, 71°01'31"W), Chile, in a soil that two years before had been used for watermelon production. Results showed a significantly greater fruit number (0.9 to 1.3 fruits/plant) and fruit mass (4.6 to 6.9 kg/fruit), which translated into higher marketable yields (38.2 to 89.2 ton/ha), in all grafted combinations compared to cultivars. All four cultivars were progressively affected by *Fusarium* wilt, while the grafted combinations were not visibly affected by the disease. In terms of quality, no significant differences were found in pulp color ($a = \pm 24.2$), firmness (11.8 N), and soluble solids content (10.1 °Brix) between fruits from cultivars and from grafted combinations. The higher yields and larger fruits resulting from grafted plants would lead to a higher income that would largely offset the costs of grafting, and the technique appears highly recommendable for the given conditions.

Specified Source(s) of Funding: Project financed by: FIA PYT-2008-0207.

(167) Influence of Grafting and Planting Density on Fruit Yield and Root-knot Nematode Control in Tomato Production

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The high cost of grafted seedlings still remains the main barrier for widespread adoption of grafting among vegetable growers in the United States. Given the improved disease resistance and enhanced growth and yield in grafted plants, it is suggested that plant population may be reduced to lower the cost associated with the use of grafted plants while maintaining desirable yields. In this study, 'Tribute' tomato as the scion was grafted onto two commercial tomato rootstocks with root-knot nematode resistance, 'Multifort' and 'RST-04-106-T'. Non-grafted and self-grafted 'Tribute' were included as controls. The study took place in a certified organic field in Citra, FL, during the Fall 2012 season. A split-plot design with three replications was used with spacing as the whole-plot factor and grafting treatments in the subplots. The four in-row spacing treatments evaluated were 0.61 (recommended spacing), 0.76, 0.91, and 1.07 m, with a constant between-row spacing of 1.83 m. In addition to fruit yield assessment, the effectiveness of resistant rootstocks for root-knot nematode control was also examined.

Total marketable fruit yield was significantly affected by the spacing and grafting treatments ($P < 0.01$), moreover, there was a significant spacing × grafting interaction ($P < 0.01$). At the in-row spacings of 0.91 and 1.07 m, grafting with the two rootstocks resulted in similar marketable yields compared with non-grafted and self-grafted 'Tribute'. In contrast, at the in-row spacings of 0.61 and 0.76 m, plants grafted with 'Multifort' showed significantly higher marketable yields than the 'Tribute' controls and plants grafted with 'RST-04-106-T'. Grafting with 'RST-04-106-T' also led to a significant increase of marketable yield in comparison with non-grafted 'Tribute' at the 0.76-m spacing. The spacing treatments did not demonstrate significant impacts on marketable yields of non-grafted 'Tribute' and 'Tribute' grafted onto 'RST-04-106-T', while self-grafted 'Tribute' tended to have a higher yield at the 0.61-m spacing than other spacing treatments. Interestingly, the marketable yield of grafted plants with 'Multifort' did not differ significantly between the spacings of 0.61 and 0.76 m, whereas yields in these two lower spacing treatments were significantly higher than those at 0.91 and 1.07 m. A significant reduction ($P < 0.01$) in root galling was observed in plants grafted with the two rootstocks relative to non- and self-grafted 'Tribute'. Under an intermediate level of root-knot nematode infestation, results from this study indicated the potential of decreasing planting density as a cost-saving approach in grafted tomato production.

Wednesday, July 24, 2013

1:00–1:45 PM

Water Utilization and Management

(255) Influence of Nitrogen Rate and Drip Application Method on Pomegranate Fruit Yield and Quality

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Currently, 98% of domestic commercial pomegranate fruit (*Punica granatum* L.) are produced in California on over 13,000 ha. Developing more efficient methods of water and fertilizer application are important in reducing production costs. In 2012, a pomegranate orchard established in 2011 with a density of 558 trees/ha, was supplied nitrogen as N-pHURIC (urea-sulphuric acid, 10% N) and AN-20 (ammonium nitrate, 20% N) at rates of

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52, 166, and 279 kg N/ha delivered by surface (DI) and subsurface drip irrigation (SDI) (at 61 cm depth). Water replacement was based on rainfall, tree water removal, and soil surface water loss as measured by weather station ETo and a weighing lysimeter. An additional 10% more water was applied by the DI system to compensate for efficiency differences between the two water delivery methods. A fresh market (FM) harvest was made on Oct. 30 and a juice market (JM) harvest was then made on Nov. 8 to remove remaining fruits. Total season yields (FM+JM) and average fruit weights were higher from trees irrigated by the SDI system compared to the DI system. Fruit aril weight was greater, but soluble solids (SS) and juice color were lower in fruits from trees supplied by SDI compared to DI. The Nov. 8 harvested fruits were smaller but had greatly enhanced juice color (measured spectrometrically and by CDM) compared to FM fruits. Nitrogen rate had no effect on FM or total season yield, but fruit from trees supplied with 52 kg/ha were smaller in weight compared to fruit supplied higher N rates. Increasing N rate had no effect on aril weight, SS (%) or juice color, but did reduce juice pH. Total season yield was significantly improved by SDI only at the 52 kg/ha nitrogen rate. JM juice color, but not FM juice color, was most intense (darkest) at the highest N application rate. External FM fruit appearance (color) was not affected by N rate or water delivery method.

(256) Container-grown Lavender Affected by Oxygenated Irrigation Water

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Watering crops can be one of the most difficult jobs in nursery production and requires careful attention. Underwatering crops can lead to cell dehydration, while overwatering can reduce the oxygen content of the substrate and lead to reduced root respiration. In addition, root respiration can be limited by plastic containers where gas diffusion is restricted to the surface and drain openings. Reduced root respiration can limit nutrient uptake, reduce energy production, and suppress plant growth. By elevating the dissolved oxygen level of irrigation water, roots would be exposed to more oxygen in the root zone, which could improve root growth. On 16 Mar. 2012, twenty *Lavendula angustifolia* 'Provence' liners were potted into 5-inch azalea containers and topdressed with Osmocote 18N–2.6P–10K, 8- to 9-month control release fertilizer at a rate of 5 g per container on 9 Apr. 2012. To determine the effects of elevated dissolved oxygen levels of irrigation water there was a control level (7.2 mg·L⁻¹ average over the experiment) and an elevated dissolved oxygen level (13.3 mg·L⁻¹ average over the experiment). Irrigation water was elevated using a portable oxygenator (The Oxygenator, O₂ Marine Technologies, Shorewood, MN). Dissolved oxygen levels were determined

with a LDO101 dissolved oxygen probe attached to a portable dissolved oxygen meter (HQ30d, HACH Company, Loveland, CO). Experiment was initiated on 10 May 2012, and ended 2 Nov. 2012. Data collected included initial and final growth indices [GI = (height + width + perpendicular width) ÷ 3], shoot biomass (all plant material above the first root) and root biomass (all plant material below the first root). Shoot and root biomass were oven dried for 72 hours at 55 °C. Experiment was a randomized complete-block design with 10 single pot replications. There were no differences in growth indices or shoot biomass of lavender irrigated with elevated dissolved oxygen compared to lavender irrigated with the control level. However, root biomass ($P = 0.0401$) was greater for lavender irrigated with elevated dissolved oxygen compared to plants irrigated with the control level. Based on these results, elevating the dissolved oxygen level of irrigation water can improve root growth of container-grown lavender.

Specified Source(s) of Funding: J. Frank Schmidt Family Charitable Foundation

(257) Response of Mexican Lime to Partial Rootzone-drying: A Water-saving Strategy

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The effects of alternate and fixed partial rootzone drying (PRD) on leaf gas exchange and water use efficiency (WUE) of citrus were evaluated. Three-year-old split-root potted Mexican Lime trees were grown in a greenhouse. Two irrigation trials were developed, and three treatments were applied in each trial. In the first trial, the treatments were: a) well-watered trees, where both rootzone halves were watered with 50% crop evapotranspiration (ET_c) each day (Control1); b) one-half of the rootzone received no water while the other half was daily irrigated with 100% ET_c (fixed PRD, FPRD1); and c) one-half of the rootzone was allowed to dry while the other half was irrigated with 100% ET_c by alternating wet and dry halves every 2 weeks (alternate PRD, APRD1). In the second trial, the distribution of water in the three treatments was the same (control, fixed PRD, and alternate PRD) but water was applied every 3 days so that every treatment received 300% ET_c in every irrigation event. The FPRD1 plants used 16.3% significantly less water than Control1. Whole plant WUE was higher in APRD1 plants than in Control1 and FPRD1 plants. Leaf abscisic acid (ABA) concentration in FPRD1 plants was higher than in Control1 plants. FPRD2 and APRD2 plants used 14.7% and 17.3% less water than Control2 plants, respectively. Leaf ABA concentra-

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tion was significantly higher in FPRD 2 and APRD2 plants than in Control2 plants, but there were no differences in stomatal conductance among treatments. PRD did not affect other leaf gas exchange or growth parameters since all treatments had similar CO₂ assimilation, and leaf area development. Thus, PRD treatments FPRD1, FPRD2 and APRD2 resulted in water savings without compromising growth.

Specified Source(s) of Funding: Texas Water Development Board, Texas A&M University–Kingsville Citrus Center, Universidad Autonoma Agraria Antonio Narro

(258) Strategies for Reduction of Irrigation Applications for Bare-root Strawberry Transplant Establishment in Central Florida

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Typically, establishment of bare-rooted strawberry transplants in central Florida is accomplished using overhead irrigation applied continuously at a rate of 0.5 cm/hour/ha for 10 to 12 hours/day. This practice results in significant amounts of water withdrawals from a hydrologically sensitive growing area. A multi-season study was conducted to investigate reducing these typical overhead irrigation amounts used by three distinctive approaches: 1) using intermittent irrigation (cycling applications on and off) for specific time periods using an alternative lower volume sprinkler head; 2) using crop protectants applied to transplants at a determined stage of the establishment period; and 3) a combination of treatments 1 and 2. Results showed that the use of the alternative sprinkler head (NanDan Jain Super 10) alone reduced application rates from 0.5 cm/hour/ha to 0.35 cm/hour/ha and that use of intermittent irrigation with a 10 min on/off cycle resulted in no detrimental effect on transplant establishment, thus saving an additional 50% of the amount of water normally applied. Use of a crop protectant ‘Surround’, a clay-based foliar spray resulted in reducing the number of days needed for establishment from 10–12 days to 7 days, thus reducing application amounts to 30%–40%. A study combining both approaches 1 and 2 and the use of the crop protectant resulted in a minimum 70% reduction of normal applications. These results give commercial producers several approaches used alone or in combination to reduce the amount of water applied for transplant establishment purposes.

Specified Source(s) of Funding: Southwest Florida Water Management District

(259) Sensor Integrated Automatic Irrigation System to Reduce Runoff and Nutrient Loss without Affecting Plant Growth

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Container-grown woody ornamentals were irrigated with four different treatments based on daily water use (DWU) to study the impact on plant growth, leachate electrical conductivity and pH, and runoff water volume and nutrient content. A completely randomized design was used with four overhead irrigation treatments: 1) irrigation scheduled to replace 100% DWU per application (100DWU); 2) irrigation alternating every other application with 100% replacement of DWU and 75% DWU the following application (100-75); 3) irrigation scheduled on a three-application cycle replacing 100% DWU followed by two applications replacing 75% DWU (100-75-75); 4) irrigation scheduled on a four-application cycle replacing 100% DWU followed by three applications replacing 75% DWU (100-75-75-75). The substrate volumetric moisture content (SVMC) was determined by soil moisture sensors (Model 10 HS, Decagon Devices, Inc., Pullman, WA) placed in a subset of containers. Plant DWU was calculated as the difference between SVMC 1 hour after irrigation and SVMC immediately before irrigation the following day. The irrigation amounts were scheduled by a programmed data logger (CR3000, Campbell Scientific Inc., Logan, UT) based on the highest DWU calculation from the sensors in each zone. Irrigation applications were separated by at least 24 hrs. *Hibiscus syriacus* ‘Bricotts’, *Euonymus alatus* ‘Select’, *Weigela florida* ‘Alexandra’, *Spiraea japonica* ‘Yan’ were grown in 10.2-L (#3) containers in 2011. The average daily irrigation amount applied for 100DWU, 100-75, 100-75-75, and 100-75-75-75 were 513, 424, 473, and 423 mL, respectively. *Viburnum dentatum* ‘Ralph Senior’, *Potentilla fruticosa* ‘Happy Face’ and *Thuja occidentalis* ‘Sunkist’ were grown in 10.2 L containers from June to October in 2012. The average daily irrigation amount applied for 100DWU, 100-75, 100-75-75 and 100-75-75-75 were 900, 980, 970, and 910ml, respectively with little differences among treatments. There were no differences in final plant growth, final electrical conductivity and pH, and runoff NO₃ and PO₄ concentrations among treatments for both years. The seasonal average runoff NO₃ and PO₄ loads among treatments in 2011 was not different; in 2012, the seasonal average runoff NO₃ load of 100–75 for 2012 was the highest versus 100–75–75–75 which was the least compared to other treatments. PO₄ load was not different among treatments. Seasonal average runoff volume was similar for both years. These results indicate

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that irrigation water could be applied at plant DWU or a slight deficit without affecting plant growth.

(260) Seasonal Water Use of Southern Highbush Blueberry in Florida

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Non-weighing lysimeters were used to measure seasonal water use of mature 'Emerald' southern highbush blueberry plants grown in pine bark beds and in pine bark amended soil in north-central Florida. In the absence of rain, irrigation was applied daily with microsprinklers at approximately 150% of reference evapotranspiration as either one or two applications. The lysimeter dimensions were 1.2 m across the row by 0.9 m in the row by 0.5 m deep. A section of 25.4-cm-diameter PVC pipe attached to the bottom of each lysimeter was used to collect leachate. Leachate was collected and its volume determined from each lysimeter at about weekly intervals throughout the study. Soil moisture was monitored with TDR sensors at three depths in representative lysimeters and changes in soil moisture content across measurement periods were negligible since irrigation or rainfall occurred daily. Water use, expressed as liters per plant, was calculated as the difference between the amount of irrigation/rain added to lysimeters and the amount of leachate collected from lysimeters during each measurement period. Average daily water use was calculated for monthly intervals beginning in Apr. 2010 and ending in Aug. 2012. Water use increased rapidly during spring foliation and peaked during the final stages of fruit ripening and harvest (May) and again during late summer (August and/or September). A temporary decline in water use was observed immediately following postharvest pruning during early summer. Few significant differences in water use were observed between soil management or irrigation treatments. Monthly averages for daily water use during the 29-month period ranged from 1.6 L/plant in January to 8.2 L/plant in August.

Specified Source(s) of Funding: Southwest Florida Water Management District

(261) Identification of Plant-endophytic Bacteria from Bell Pepper (*Capsicum annuum* L.) Grown under Different Production Systems and Water Regimes

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Endophytic bacteria can be defined as several species of bacteria primarily derived from rhizospheric soil that can ubiquitously reside in the internal tissues of host plants for all (or part of) their life span, promote plant growth, and impose non-pathogenic symptoms. It has been shown that the species populations recovered from plant tissues varied by different production and management practices. We investigated the diversity of the isolated endophytic bacteria from seed-surface sterilized bell pepper plants grown under organic and conventional production systems and subjected to different tillage (strip tillage and plasticulture) applications with two irrigation (well-watered and drought) regimes in 2011 and 2012 in order to determine the effects of each production system on the presence of endophytic bacteria. Endophytic bacteria were isolated from plants grown under each management system. Plants were uprooted and then separated into root, shoot, leaf, and fruit prior to isolation. Endophytes were isolated from those tissues and cultured on Tryptic Soy Agar (TSA) Medium. After cultivation, colonies were separated based on morphological characteristics and their DNA were extracted and stored for future use. Two pairs of primers, 8F (5'-AGAGTTTGATCCTGGCTCAG-3') and 1520R (5'-AAGGAGGTGATCCAGCCGCA-3'), and 22F (5'-CTCAGATTGAACGCTGGCG-3') and 1085R (5'-ACATTTCAACAACGAGCTG-3'), were used for PCR reaction to amplify the 16S rRNA gene. Sequence results were tested through BLAST for their homological identity. Results indicated that there were unique 57 species and 3 phyla present. Approximately 52% of the total isolates from both years were identified into Firmicutes, 33% into Proteobacteria, and 12% into Actinobacteria. Within the Firmicutes, *Bacillus* is the most abundant genus, which proportioned over 60% of total isolates. *Bacillus* sp., *B. amyloliquefaciens*, *B. Pumilus*, *B. Subtilis*, *Pseudomonas* sp., and *Enterobacter* sp. were the most abundant species. The isolates from 2011 were more diverse than isolates from 2012. There were 9 species presented in the isolates of both 2011 and 2012. Generally, a total of 21 species were only originated from organically grown plants, while 15 species were only from conventionally grown plants. However, 11 species were only from plants under water stress. The results suggested that production system and environment may influence the presence of endophytic bacteria in pepper plants.

(262) Comparing Hydraulic Properties of Soilless Substrates with Natural Soils: A More Detailed Look at Hydraulic Properties and Their Impact on Plant Water Availability

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Moisture release curves are often used when assessing plant-water relationships in soilless substrates. However, differences between natural soils and soilless substrates make traditional assumptions about plant available water potentially invalid. If soilless substrates are supposed to be treated like natural soils; why do plants begin wilting at very low water potentials (–10 to –30 kPa) and there is anywhere between 20% to 40% water left (on a volumetric basis) in the soil (Abad et al., 2005; Arguedas et al., 2006; Ristvey et al., 2008). We hypothesize that the fault lies in the methods used and the assumption that water potential is the only limiting factor in water availability to plants. Hydraulic properties, including the relationships that exist between plant available water, water content, and hydraulic conductivity of soilless substrates have traditionally been characterized using instrumentation such as pressure plates, hanging water columns, and tempe cells. These approaches typically take a months and only provide data on select segments of the soil moisture release curve, and in the case of pressure plates and hanging water columns hydraulic conductivity is ignored and not very well understood. Using the Wind/Schindler Evaporation method, more detailed measurements of these hydraulic properties can be measured in a less than a week. A more detailed look at the hydraulic properties of soilless substrates and how they compare with natural soils may give us more insight into soil–plant–water–relations and what limits availability of water to plants. Soil moisture release curves and hydraulic conductivity curves of different soilless substrates were compared with curves from typical agriculture soils to give insight into how these properties compare. Results of the soil moisture release curves showed that some soilless substrates had comparable moisture release curves to agricultural soils while others had bimodal curves indicating gap-gradation in the pore size distribution. These soils that showed this non-typical curve had hydraulic conductivities that dropped very low (500 times lower than agricultural soils) at low water potentials (around 10 kPa). This dramatically lower hydraulic conductivity could lead to zones of depletion around the roots hindering plant water uptake.

(263) Seasonal Landscape Crop Coefficients

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Amenity landscapes require irrigation during periods of insufficient rainfall. Significant water use savings may be achieved if landscape irrigation is based on reference evapotranspiration (ET_o). The objective of this study is to determine seasonal landscape crop coefficients (KL) for model landscapes comprised of turfgrass and woody plant vegetative cover. The KL is determined from the ratio of actual evapotranspiration and a modified Penman equation reference. Irrigation quantity is based on 100% replacement of ET_o minus rainfall. The KL is determined for St. Augustinegrass [*Stenotaphrum secundatum*

(Walt.) Kutz.]], yaupon [*Ilex vomitoria* ‘Nana’], dwarf Burford holly [*Ilex cornuta* ‘Burfordii Nana’], and privet [*Ligustrum sinense* Lour.] combinations, on a Falba fine sandy loam (fine, montmorillonitic, thermic Typic Albaqualfs). Plant treatments comprised turfgrass/woody plant combinations at 20%/80%, 50%/50%, and 80%/20% vegetative cover. Soil was systematically placed into lysimeters containing a drainage system and soil moisture probes. Lysimeters (1586 L) were placed in-ground in a randomized complete-block design with three blocks. Soil moisture measurements were made at 0 to 20, 20 to 40, and 40 to 60 cm depths. The KL was determined after a rainfall or irrigation event for periods of 2 to 5 days. Seasonal differences between early-, mid-, and late-season KLs have not been significant. The KLs ranged from 0.8 to 1.1 among the plant treatments across the three growing seasons.

(264) Containment, Remediation, and Recycling of Irrigation Water for Sustainable Ornamental Crop Production: Results of a SCRI Planning Grant

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Nursery, floriculture, and propagation production accounted for 81% (\$9.48 billion) of the 2009 specialty crop production in the United States. Access to high quality water sources is increasingly limited for irrigating these economically significant crops. Given the production, environmental, and economic issues associated with the use of water—including recycled, reclaimed, surface, and ground water—it is critical to develop sustainable runoff, containment, and remediation technologies, and to identify alternative sources of water. To better understand current practices and future water-related needs as

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perceived by grower stakeholders, we conducted a national survey effort collecting information from 388 industry stakeholders (44% completion rate). Baseline data related to current production practices, which included irrigation, fertilization, and best management practices, was collected from growers producing ornamental crops in greenhouses, open container nurseries, and field operations. In addition, five in-depth round-table discussion sessions were conducted at the Mid-Atlantic Nursery Trade Show, Gulf States Horticultural Expo, California Grown Show, OFA Short Course, and the Farwest Show with a total of 36 industry participants. A team of research and extension specialists facilitated by a Specialty Crops Research Initiative Planning Grant (NIFA Project #2011-51181-30633) distilled the results from the survey and the round-table discussions. We will present some of the specific research and extension related priorities identified by growers that must be addressed before conservation-based water use and management practices can be widely adopted by the industry, and discuss potential new methods to achieve these goals. Our objective is to address the concerns and priorities identified by specialty crop producers while addressing gaps with current and future research.

Specified Source(s) of Funding: NIFA Project # 2011-51181-30633

(265) Use of Rainfall Simulation to Determine the Persistence and Transport of *Escherichia coli* and *Salmonella* in Runoff Water

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Manure applied to cropland to increase its productivity may harbor pathogenic bacteria such as *Salmonella* and *E. coli* O157:H7. Runoff water simulated by heavy rainfalls may carry these bacteria to nearby water bodies that are used to irrigate fresh produce; causing human illnesses once these vegetables are consumed. This study examined the persistence of *E. coli*, *E. coli* O157:H7 and *Salmonella* in runoff water yielded from soil amended with different types of animal manure. Four rainfall events were conducted where soil was packed in stainless runoff boxes, 20 cm long, 29 cm wide and 5 cm deep with back walls 2.5 cm higher than the soil surface, and 5-mm drainage hole in the base. Soil was amended with poultry litter, poultry litter incorporated, broiler manure, dairy manure, or ammonium sulfate as a control, and each treatment was replicated five times. Runoff water was collected from each box to determine the concentrations of the target bacteria using IDEXX Quanti-Trays TM/2000. Water samples were also incubated in the Quanti-Trays at 35 °C for 18–24 hours where Most Probable Number (MPN) for each sample was determined. Water samples were also spiral plated onto Xylose- Lysine-Tergitol 4 (XLT4) and MacConkey sorbitol agar (CTSMAC) to detect for the presence of *E. coli* O157:H7 and *Salmonella*. Furthermore, BAX PCR was used to confirm the presence of these bacteria in water samples; however, this test failed to confirm the presence of *Salmonella* and *E. coli* O157:H7. Results showed that the population of *E. coli* was declined by 98.2%, 99.9%, and 94.3% in soils amended with incorporated, and broadcasted poultry litter, and dairy manure respectively. In general, there was no significant difference in *E. coli* concentrations among the types of manure.

Specified Source(s) of Funding: USDA-NIFA

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