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Book of Abstracts

**Growing strawberries
in the next decade:
Innovation,
the key to success?**

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Cultivation

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Oral presentations

Improving water use efficiency and fruit quality in field-grown strawberry.

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Most soft fruit produced commercially in the UK is grown under cover and so irrigation is essential to ensure high yields of good quality fruit. However, the major soft fruit growing areas in England are in regions where public, industrial and agricultural demands on water supplies are already high. If growers are to maintain or increase yields against a backdrop of increasing summer temperatures, dwindling water supplies, and government demands for greater environmental protection, new production methods that improve water use efficiency are needed.

A scientifically-based irrigation scheduling tool was developed for field-grown strawberries at EMR. Our approach was to use the plant to detect when soil water availability became limiting for important physiological processes that impact on fruit yield and quality. Setting the lower irrigation set point at a soil matric potential above the value at which stress responses were first triggered should deliver significant water savings without reducing marketable yields or fruit quality. The frequency and duration of irrigation events were adjusted to maintain soil matric potential within the rooting zone between upper and lower set points.

Partial stomatal closure in response to drying soil was first detected at a soil matric potential of -120 kPa while rates of photosynthesis were unaffected until -200 kPa. Using this information to schedule irrigation to field-grown crops at EMR, we were able to reduce water inputs by 80% without reducing Class 1 yields or quality. A low risk irrigation strategy was then developed for commercial growers. Over two years of grower trials, on-farm water savings of up to 36% and increases in Class 1 yield of up to 18% were achieved; aspects of fruit quality were also improved.

The project outcomes are challenging the soft fruit industry's preconceptions about how wet the soil needs to be to sustain high yields of good quality Class 1 fruit.

The 'Flying Doctors system': an innovative way to combine pollination and crop protection.

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Bumblebees, are already widely applied in the pollination of strawberries due to the fact that they pollinate effectively under adverse weather conditions as well as in protected crops. However, bumblebees are also especially suited to act as vector of microbial crop protection products to control flower associated pests and diseases such as grey mould (*Botrytis cinerea*), which causes huge yield losses annually.

Biobest has worked intensively on developing an effective vectoring system by generating a new (patented) dispenser that is available as a fully integrated option to the new standard bumblebee hive. As the bumblebees leave their hive, they walk through a tray of specially formulated microbial product, which clings to their legs and body. They then deliver this product directly to each flower they visit. The bumblebees' hairy bodies and unique "buzz" pollination make them especially effective as product vectors.

Here we present various steps in the development of this innovative concept and present results from a range of trials addressing issues including flight activity, product uptake, product delivery, impact of the microbial products on bumblebee colonies. In terms of crop protection efficacy, results from field trials will be presented in which standard chemical control practice was compared to the vectoring of Verdera B4 by the Biobest Flying Doctors system. Parameters assessed included, *Botrytis* incidence at harvest, as well as following storage (post harvest); fruit set and fruit size. Our repeated field trials show that the Flying Doctors system in combination with Verdera B4 represents an effective alternative to chemical control during the strawberry flowering period.

Through its continuous and targeted application, the flying Doctors system saves labour, minimizes volume of microbial product use, reduces chemical residue levels, and thus also helps reduce the risk of pesticide resistance. This makes the Flying Doctors system a truly sustainable agricultural solution. In addition to its demonstrated benefits in strawberry production, the system can also be used in other fruit or vegetable crops. Although the focus is currently on flower-associated diseases such as grey mould and pests like flower thrips, we are also exploring the potential of this new technology to combat foliar diseases and pests.

Automation technologies on strawberry harvesting and packaging operations in Japan.

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Automation of harvesting and packing operations in strawberry production is more desirable because they require heavier works and longer time compared with the other operations. Japanese researchers have overcome many challenges to automate fruit harvesting operations not only for strawberries but also other fruits so far.

The researches on strawberry harvesting robots were started in universities since 1995, while a Japanese national research institute (BRAIN) and a company reached a prototype of commercial model. The latest results showed 55% harvesting success rate, 6.3 s cycle time of harvesting operation, and 94.5 m/h work efficiency (traveling speed with harvesting operation) as their average values, while 97 % shippable fruit rate under a condition of movable growing beds in a greenhouse (48 m X 6 m) at a season from April to June.

In packing facilities, many types of fruits have been handled by robots for grading and packing operations since 15 years ago, but strawberry fruits were too delicate to be handled by mechanical hands. Recently, BRAIN and a company are developing a commercial model of strawberry packing robot based on discussions on appropriate fruit variety, physical properties, working speeds and its constrains. An internal quality inspection system of strawberry fruit was also developed by use of the near infrared spectroscopy. Possibility of practical use of those automation systems will be discussed in this presentation.

Supplemental LED growth light in remortant strawberry at high latitudes.

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Growing remortant strawberries at high latitudes is challenging because of short days and low light levels from late September and beyond. However, in Norway current day and night temperatures in coastal areas up to 64 degrees N are normally sufficient for growth and fruit development, and even higher temperatures can be expected in the future according to climatic scenarios, prolonging growing season. It is therefore of interest to examine the effects of using supplemental light when photosynthetic active radiation (PAR) falls below a critical level for development of high fruit quality.

In this two-year study, remortant cvs 'Everest' and 'Rondo' were grown in polytunnels on black polyethylene mulched beds using drip irrigation and fertigation. Two LED lighting levels were applied when light intensity fell below $400 \mu\text{mol m}^{-2} \text{s}^{-1}$ in September, and compared to ambient light (control). Fruit yield, soluble solids (Brix°), fruit firmness, temperature (°C), dewpoint (°C), and PAR light ($\mu\text{mol m}^{-2} \text{s}^{-1}$) were recorded.

The results show that LED improved fruit yield and quality more at 800 than at 258 $\mu\text{mol m}^{-2} \text{s}^{-1}$, but the highest light level was probably beyond the saturation point for photosynthesis, at least in late autumn and in early morning and late evening because of low temperatures. Arthropods were sampled from 'Rondo' leaves 2-3 times per season.

Key words: extended season, cultivars, fruit yield, Fruit tension, Brix°, arthropods.

Predicting potential and spreading through flower bud analysis of strawberry plants.

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Growers try to create plant material adapted to the different cultivation periods. Plants with a high production potential are wanted in spring, in autumn the spread between the flower trusses becomes more important. Plants can be created by applying the correct nutritional scheme in autumn during the plant production phase. Through flower bud analysis the architectural structure of the plants is mapped out and predictions in potential flower trusses can be made.

Under a microscope the flower buds are dissected to determine the development stage (1-9) of the growing point. After the plant production phase in 2011 trayplants from 17 growers were submitted to analysis. In spring plants of each grower were planted in a plastic greenhouse. The emerging flower trusses were marked. After the harvest period, the plants were mapped out and the placement of the trusses became clear. Postharvest observations were related back to the flower bud analysis.

The theory of flower bud analysis states that a flower truss can be expected when a bud contains a growing point in at least stage 4. Observations made by the centre prove the incompleteness of the theory and show the importance of the location of the buds on the plant axis. The axis can be divided into three zones, each zone requires a different stage of the growing point to be sure of a flower truss in the cultivation phase. Also the spread between the trusses can be predicted relating it to the first flower truss and the occurrence of different stages in the various zones on the plant axis. Based on these findings the centre is able to predict the number and to evaluate the spread of the flower trusses.

Development of sustainable nitrogen, phosphorus and potassium fertilization practices on strawberry cultivars in Florida, United States.

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A series of studies were conducted to determine the effects of: a) preplant and early-season nitrogen (N) and phosphorus (P) fertilization rates and b) late-season N and potassium (K) rates and ratios on fruit yield and quality of diverse strawberry cultivars. On the first study, it was shown that application of granular preplant N fertilizer at rates between 35 to 57 kg/ha was not needed to improve 'Strawberry Festival' transplant establishment and early yield. The second study found differential responses of 'Strawberry Festival' and 'Florida Radiance' to early drip-applied N rates, ranging between 0 and 1.6 kg/ha/day, with rates between 1.1 and 1.6 kg/ha/day having the best results for the former cultivar, whereas yields of the latter leveled off at 0.8 kg/ha/day of N. On the third study, an early P rate of 0.6 kg/ha/day improved 'Florida Radiance' early yield by 26% in comparison with no early P application, while no biomass and yield differences were observed with 'Strawberry Festival'. Another study determined that switching N to K rates from a 1:1 up to 1:1.5 (1.1:1.7 kg/ha/day) starting on mid-December failed to improve fruit yield, soluble solid content, and storability of 'Strawberry Festival', 'Florida Radiance', and 'Winterstar', as assumed by the common grower practices. These results allow growers in deep sandy soils to better use N and K during the production season, while reducing potential leaching to ground waters.

Posters

Effect of position on the stolon, age and harvest date on uniformity of strawberry cuttings and final plant production.

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In strawberry cultivation in greenhouses, high production levels are required to compensate for the high production costs. Data from a commercial farm showed that plants can differ considerably in number of fruits produced, in spite of apparent uniformity at planting. A literature survey revealed that cutting size appears to affect the timing of production but not total fruit production. Cutting size was primarily determined by the position on the stolon. Cuttings originating from a position closer to the mother plant were heavier with a larger crown diameters and more leaves. Most of this research was conducted with field-grown strawberries, both for production of cuttings and fruits. In current strawberry production in The Netherlands, high yielding greenhouse production has become the standard, requiring high quality uniform cuttings. In this research, we aim (1) to determine the effect of the quality of the cutting on final fruit production and (2) to control the uniformity of a batch of cuttings via the position on the stolon, age and harvest date of the cuttings.

Elsanta stock material was planted on hanging gutters in a commercial greenhouse in March 2012. Newly formed cuttings were labelled weekly to denote the moment of appearance. In July, 9 batches of cuttings were harvested and planted in the tray nursery field. The batches varied in moment of harvest (5 July vs. 25 July), position on the stolon (1, 2 or 3) and week of appearance (week 20 to 26). Stolon diameter and crown width were determined of all cuttings (300 per batch), as well as leaf weight and leaf area of 100 plants per batch. Rooted cuttings were taken from the field on 10 December 2012 to be stored at -1.5 °C.

Fruit production will be determined on 100 individual plants per batch in a hydroponic system at a commercial strawberry company, to be correlated to the cutting characteristics. In this way, plant propagators and growers will obtain information that will link quality of the cutting to final strawberry production per plant supporting their future decisions.

Micropropagation of Elsanta strawberry plants in relation to field production – Walloon expertise (GFW-CRAW)

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Elite vegetatively propagated strawberry plants are required to ensure homogeneity of fruit production and optimal selling prices. As pesticides use is more and more controlled and restricted by EU legislations, the field classical propagation method faces difficulties in preventing the spread of parasites and pathogens.

To face these problems, Boxus described already in 1974 the potential of micropropagation in order to ensure mass production of pathogen-free strawberry plantlets.

With the support of Federal and Walloon funds, CRAW has developed advanced strategy of R&D activities in order to increase by the time the quality of such a system. The continuous implementation of the technique permitted to describe a full technology where all parameters are described and controlled ensuring quantity and quality of conformable strawberry mother plants by the end of the process.

So, comparing classical propagation versus micropropagation, we demonstrated that the production and the quality of fruits issued from micropropagated plants can be increased by 10% in the first year of production and even show some earliness. These differences disappeared in the second production year.

In the frame of the Walloon strawberry plant nursery sector, the CRA-W has also developed successful hydroponic propagation techniques to obtain well developed Elsanta strawberry runners from micropropagated mother plants. These propagation techniques maintain strawberry mother plants and runners free from soil diseases, pests, mites and herbicide residues risks. By the end, Elite plants having 0 % Phytophthora contamination tolerance (against 2 % of tolerance in classical propagation using CAC/EU legislation) are delivered to growers.

From this expertise, CRA-W is able to provide the necessary support to nurseries that are interested to develop quality strawberry plants which are already available to Walloon producers. Indeed, during the last few years, the final field multiplication stage has been initiated with a producer interested by the nursery's activities. These

plants were commercialized as bare-rooted plants or as tray-plants. The Walloon Strawberries producers Group (GFW) has advised the producer to achieve the commercial goals and to ensure that positive results were obtained. All the plants have been commercialized with a high quality standard.

This overall expertise of CRAW in strawberry plant production is still a mark of competence and competitiveness in this high value sector. Preserved micropropagation stock of non-registered varieties is still available for rapid mass propagation such as Elsanta, Selva, Ostara, Gento, Gento nova,...

Comparison of two irrigation management systems in strawberry

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Comparison of two irrigation management systems in strawberry

In Switzerland, the major part of the 420 ha of strawberry crops are cultivated on plastic covered raised beds equipped with drip irrigation. The irrigation management is based on the monitoring of the soil moisture. Such a monitoring, if based on the visual reading of tensiometers combined with a manually operated irrigation system, is time consuming. In Switzerland, salaries are high and are a major production factor. The use of fully automatic irrigation management systems might help to reduce production costs, and eventually reduce the amount of water used for irrigation. A trial comparing two irrigation management systems was conducted during three years at the Agroscope ACW at Conthey located in the southern part of Switzerland. The variety Clery was grown under two tunnels. The irrigation of each tunnel was managed with a different irrigation system. The first used tensiometers to monitor soil moisture at 20 cm depth. Irrigation cycles were started manually at a 20 cbar threshold. This corresponded to 1 – 2 irrigation cycles per week.

The second irrigation management system was based on Watermark sensors at 20 cm depth and was piloted by WEM (Watermark Electronic module). Up to three irrigation cycles could be delivered per day. An irrigation cycle was started when the 20 cbar threshold was reached at any one of three times per day: 7h30, 11h00 and 15h00. During the irrigation period from March 28 to June 10, the average daily amount of water was 2.4 l/m² for the manually managed irrigation and 1.2 l/m² for the WEM-piloted irrigation management system. There were no significant differences between yield and fruit size between the two irrigation management systems. In the manually managed system, the higher water consumption can be explained by over-irrigation during the spring period. The WEM-piloted systems avoided such a waste of irrigation water. Even though irrigation water is cheap in Switzerland (1.4 €/m³), the WEM allowed savings of € 1254/ha. The reduction in labor between the WEM system and the manually operated system was estimated to be 20 hour/ha, which resulted in savings of € 540 in labor costs. The amount of money saved (€ 1794) was greater than the costs for a WEM-set (€ 1746). Given an expected duration of the WEM-system of 3 – 5 years, a switch from a manually managed to an automatic managed irrigation system is fully justified.

Evaluation of nursery plants production of strawberry mother plants propagated in vitro and in vivo.

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The use of micropropagation in strawberry nursery production chain is not allowed in many countries, because of the risk of a high phenotypic, and some time genetic, instability. Therefore, the aim of this research has been to verify the use of well defined micropropagation protocols for the production of high quality strawberry plants.

Strawberry plants of Alba produced in vivo (frigo-plant of category "A") and by micropropagation (protocol developed by Vitroplant) were compared in the last step of two nursery production cycles. The plantation follow the randomized complete block design with three plots of fifty plants each for both type of plant. Nursery production data were collected at the end of both nursery seasons (NewFruits nursery). The agronomic performances of in vivo and in vitro plants were studied in the two production cycles by evaluating the plant vegetative, productive and fruit quality parameters.

This study allowed to better verify the phenotypic stability and the agronomic performance of micropropagated plants in comparison with standard in vivo plants. Data from the two cycles of nursery production highlight that the 2 types of plants (frigo and vitro plants) produced the same number of stolons per plant that also did not differed in their classification in the percentage of the various plant classes. No differences were observed for both production cycles also for their agronomic performance and fruit quality.

This study reveal that the use of micropropagated mother plants for Alba nursery production is giving a high phytosanitary guarantee without any effects on plant productive and quality traits.

Determination of maturity indices of strawberry under sub tropical climatic condition of Bangladesh.

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The experiment was laid out in a Randomized Completely Block (RCB) at Fruit Research Field of Pomology Division, HRC, BARI, Gazipur; during the period from August 2010 to May 2012 with five strawberry genotypes to select the suitable maturity stages for harvesting of strawberry under sub tropical climatic condition like Bangladesh and to study the effect of maturity stages on shelf life and nutritive quality of selected strawberry genotypes. In these studies, firmness, surface colour, TSS, sugar to acid ratio, ascorbic acid content and sensory evaluation of harvested fruits were considered. Considering surface colour the lightness, chroma and hue angle were decreased with increase in maturity which indicating darkness, colour intensity and redness become prominent with maturation, in all the causes. Irrespective of genotypes 1/3rd matured fruits exhibited maximum firmness and shelf life but inferior in quality and nutrition. While, full matured fruits having highest amount of TSS, sugar to acid ratio and ascorbic acid content and considered suitable for harvesting. On the other hand, the 2/3rd matured fruits of Festival and Camarosa had substantial amount of surface colour, TSS, sugar to acid ratio and shelf life. Thus 2/3rd matured fruits of Festival and Camarosa were suitable for distance marketing and storage. From this experiment it was revealed that the TSS content of fruits more than 7 % and sugar to acid ratio more than 5 are important indicators for strawberry harvest.

Effect of two diurnal temperatures during simulated natural chilling of 'Gariguettes' strawberry.

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In southern France with Mediterranean climatic conditions, forced Gariguettes cultivar crops are chilled by natural temperature conditions from November to January, except in the case of trayplants. Chilling is traditionally assessed in France based on the number of hours below 7°C. This research was carried out to evaluate the effect of two diurnal temperatures (11°C, 16°C) with a night temperature below 7°C for chilling effect. 'Gariguettes' cv. potted plants were grown with temperatures above 10°C in 2009 and above 14°C in 2010 until the onset of chilling conditions (18th November 2009, 17th November 2010). Plants were transferred into controlled conditions during 68 days and exposed to 11°C / 2°C or 16°C / 2°C day / night temperatures, with the same duration under 7°C (815 hours to 820 hours in 2009, and 828 h to 830 h in 2011) to differentiate four treatments : a) "mild" conditions (16°C / 2°C day / night) during 64 days; b) "cold" conditions (11°C / 2°C day / night) during 68 days; c) "mild then cold" conditions (34 days each); d) "cold then mild" conditions (34 days each). Potted plants were then transferred to a heated plastic tunnel for fruit production assessment during the first fruiting period. The "mild" treatment showed a lower fruit yield and a lower number of marketable fruits than the "cold" treatment. This negative effect of the "mild" treatment was compensated when plants were exposed to the "cold" treatment during half of the chilling duration ("cold then mild" or "mild then cold" treatment), no matter the position of this period. These results indicated that temperature fluctuations above 7°C have to be taken into account in case of a long chilling period.

Changes on quality of fruit and yield of strawberry under supplemental LED lights cultivation.

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Cultivation systems & technologies

Recent unusual weather due to global warming causes shortage of daily sunlight and constitutes one of the primary reasons for agricultural damages. LED lights are utilized to compensate for the shortage of sunlight in greenhouse agriculture. This study was conducted to confirm the changes on quality of fruit and yield of strawberry (*Fragaria × ananassa*) under supplemental LED lights cultivation.

The sample plants were used two strawberry cultivars that being grown mainly in South Korea as 'Daewang' and 'Seolhyang'. Treatment supplemental lights were blue (441 nm), red (659 nm) and mixed (blue:red = 3:7) LED lights. Respectively LED lights were supplied daily from 17:00 to 23:00 h, throughout growth period (from Nov. 10 to Mar. 20), with light intensity being adjusted to $75 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. Incandescent bulbs were used as a control. which are usually supplemented for winter strawberry cultivation in South Korea. Strawberries were grown in a coir medium, nutrient solution was supplied through drip irrigation system. Yield of strawberry for whole growing period was investigated. Sugar contents, organic acids and phytochemicals of fruits were analyzed by HPLC, IC, and UV-Visible spectrophotometer.

In two cultivars, yield was increased under blue LED, and all three types of LEDs enhanced fruit hardness, while acidity was highest in red LED. Anthocyanin contents in fruit were significantly increased by both blue and mixed LED lightings in 'Daewang', while in 'Seolhyang' only by the blue LED, compared to the incandescent bulb control. Blue and mixed LED lights enhanced glucose contents in 'Daewang' fruit, while did the mixed LED light in 'Seolhyang' fruit. As for fruit organic acids, red LED significantly increased malic and oxalic acid contents in 'Daewang' and 'Seolhyang', respectively. In 'Daewang', fruit phenolic compounds contents were significantly higher in red LED or incandescent bulb control than other LED treatments, while in 'Seolhyang' seemed to be highest in the incandescent bulb control. Considering its positive effect on yield and fruit quality, blue LED could be a potential supplemental lighting source for strawberry cultivation winter season.

Effect of pot size and soil media on the growth and yield of strawberry.

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An experiment was carried out at the Fruit Research Farm, HRC, BARI, Gazipur during October 2009 to March 2010; to find out the effect of pot size and soil media on the growth and yield of strawberry. The variety was BARI strawberry -1. There were three pot size viz P1 (10"), P2 (12") and P3 (14") pot and seven soil media viz S1 (Soil + Chemical Fertilizer), S2 (50% Soil + 50% cowdung), S3 (25% Soil + 25% Sand + 50% cow dung), S4 (25% Soil + 25% coco Dust + 50% cow dung), S5 (50% Soil + 50% Poultry refuse), S6 (25% Soil + 25% Sand + 50% Poultry refuse), S7 (25% Soil + 25% coco Dust + 50% Poultry refuse) was included in the study. The biggest (40.25 g) in weight and (5.03x4.37 cm) fruit was observed in P2S5. The maximum number of fruit per plant was obtained from P2 S7 (23.00) closely followed by P1 S3 (22.67). Yield per pot was the highest P2 S5 (863.8 g) closely followed by P3 S7 (856 g), P3 S7 (720 The lowest yield was obtained from P1 S6 (531.7g).

Use of poly tunnels for the reliability and quality improvement of organically grown strawberries.

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Strawberries (*Fragaria × ananassa*) are the most favoured soft-fruits in Germany. However, the demand is larger than the production in the organic sector. The reasons are found mainly in the lack of possibilities to regulate fungal infections such as *Botrytis cinerea*. Poly tunnels are one possibility to minimise fungal infections and they extend the sales period by up to three weeks. So the aim of this work was to study how much a roofing system increases the production reliability of ecologically produced strawberries for fruit growers and extends their sales period.

The effect of two different roofing systems (closed tunnel, rain shelter) compared to the open field were investigated in a field experiment during the seasons 2009 to 2011 at the Chamber of Agriculture North-Rhine Westfalia, Germany. Four shortday varieties ('Clery', 'Darselet', 'Elsanta' and 'Sonata') were used. Considered quality features were yield, the behaviour of the fruit during storage, fruit quality such as fruit firmness and sugar- and acid contents of strawberries.

The yield was highest in the tunnel in years with normal and cold temperatures; under hot conditions the yield was reduced. The rain shelter prevented freezing during a cold period. At high temperatures it reduces heat stress. The result was a higher yield under the shelter. In general, the lowest yield was found in the open field. In the closed tunnel the fruits showed the highest quality. This was found for nearly all analysed parameters, especially for the shelf-life of the fruits. The fruits from the open field decayed fastest due to the influence of rain; the fruits from the rain shelter ranked between the tunnel and the open field. Under economic conditions the open field production is profitable for prices between 3.10 € and 3.50 € per kg marketable fruits. The cultivation in the tunnel and the rain shelter, respectively, is profitable between 4 € and 4.50 € per kg marketable strawberries. The production of shortday strawberries under a roofing system can be recommended.

Rubis des Jardins, a new strawberry adapted to organic cultivation.

Carmagnat C., Ciref ; Chartier P, Ciref

Ciref, Création Variétale Fraises Fruits Rouges (strawberry and soft fruit breeding)

Ciref is an association that aims at finding adapted varieties for French and European conditions. Rubis des Jardins, created in 2012, is one of these varieties. It has shown very abilities for soil and especially organic cultivation: hardiness, vigor, strength of the plant. The fruit is also interesting (good quality, high sugar rate...).

After many years of trials in France and other European countries, we will present the most significant results to identify Rubis des Jardins. The last results in organic and conventional cultivation (2013) will be presented to confirm the previous observation. Producers' observations and opinions will also be reported.

The multiannual effect of using compost in a sandy soil open field strawberry cultivation.

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Adding compost to the soil might have beneficial effects to plant fitness since nutrients are available in the compost, soil characteristics could be improved and disease resistance could be increased. The multiannual effect of using compost is examined in a sandy soil for an outdoor strawberry crop.

Two different compost types are added to the soil: biowaste compost (BWC) and green waste compost (GWC). The doses of BWC were 15 ton/ha annually and 45 ton/ha triennially, for GWC 20 ton/ha annually and 60 ton/ha triennially. The trials started in 2010 to end up in 2012. Each year a strawberry crop was grown on the different objects. The nutrition given to the plants was a standard feed recipe, equal in all objects. Soil analyses were taken during these three years, but also yield and grading were registered and fruit characteristics were measured. The fruits were stored to determine shelf-life of the different treatments.

The addition of compost increased the presence of nutrients in the soil. The results show that the yearly (lower) dose is more beneficial than the triennial higher dose. Yield and grading could be increased by using compost. The effect is more explicit for BWC than for GWC. The advantage is more pronounced the second and third year. The trials show an advantage of using compost in a sandy soil cultivation of strawberries.

Vegetated filter basins: a solution for treatment of drainage water from soilless cultures.

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To limit nitrates and phosphates impact of soilless cultures, filter basins planted with reeds or *Scirpus* were evaluated in the south west of France.

The filter basin is a biofilter through which effluent flow. In these installations, denitrification is mediated by bacteria which transform nitrates into gaseous nitrogen and phosphorus is fixed on the substrate. A carbon supply is needed to ensure sufficient activity of bacteria. This research focused on the effectiveness of filter basins to treat nitrates and phosphates with acetic acid as a carbon supply. Therefore, six basins with different substrates (gravel, mayennite and clay) and different plants (*Phragmites Australis* and *Scirpus Lacustris*) are compared.

The results demonstrate that all basins are equally effective for denitrification. This process is near to 100% until early September. On the other side, the basin with *Scirpus* and clay was more effective for the treatment of phosphates. This research proves that pH of 7,5-8 in the basin is important to avoid the release of phosphorus fixed in the substrate.

Strawberry Variety Trial in Sicily.

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The Sicilian strawberry area differs from other Italian strawberry areas for its high earliness with productions that start in November-December. The earliness due to the very low plant winter chilling requirement is a very important characteristic to define the variety adaptability to this environment. Through the "Liste varietali Fragola" project funded by MiPAAF, many new varieties and advanced selections are evaluated annually in Sicily. Here, at the moment, the main variety is Florida Fortuna, followed by Candonga ® Sabrosa and Naiad ® CIVL35. Florida Fortuna, released in Florida, showed to be very interesting especially for its outstanding earliness, a high yield and good fruit quality traits, but it is quite susceptible to biotic and abiotic factors that may affect the survival of plants.

The study was carried out in 2011-'12 at the experimental fields located in Marsala (TP). The cultural technique adopted was the typical Sicilian one. The performance of 7 new varieties and 4 selections are here described. Three of these selections were obtained by the Sicilian breeding program - carried out by the S.Ag.A Department and coordinated by CRA-FRF.

Florida Fortuna confirmed to be the earliest and productive variety. Sabrina, coming from Spain, provided the firmest fruits with the highest total soluble solid content, while the Italian Rania produced the biggest fruits. The following selections are at the final stage of evaluation and they may be released in the near future: PA 260.3 showed to be early and to produce firm and sweet medium-small fruits. PA 20, which provided the yield as Florida Fortuna, has an early ripening and its fruits are firm with an high content of total soluble solids. PA 3 and Pir 2 stood out for high firmness, sweetness and very bright red-orange fruit colour.

Strawberry early harvest opportunities in Latvia using FVG high tunnels.

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In Latvia strawberries mainly are grown for fresh consumption, and high quality is very important for the successful realization of berries. Considering that the weather in Latvia is very volatile, film coverage use is one of the opportunities for high berry quality, in the traditional harvest season, as well as outside it. Although strawberry cultivation under cover is common in many countries around the world, in Latvia high tunnels are being used very rarely.

To find the possible use of high tunnels in strawberry production for early harvest evaluation was done for four years (2009 – 2012). The study was carried out at the Latvia State Institute of Fruit-Growing. FVG (FOLIEN-Vertriebs GmbH) type of high tunnels with film cover "SUN SAVER 5 PRO" as well as few additional covers as Agryl (17 and 23 g m⁻²) and perforated film (perforation 500 m²) were tested.

Following parameters were evaluated: fruit yield, yield dynamic, average fruit weight and quality, as well as the factors influencing these parameters - air temperature and relative air humidity. Cultivars 'Honeoye', 'Polka' and 'Sonata' were used in trial. Cultivar 'Honeoye' was the most appropriate for early harvest according its harvest time production dynamics. The highest percentage of quality fruit yield was for cultivar 'Sonata'. In the trial most productive was 'Polka', but this cultivar wasn't suitable for obtaining of early harvests under covers, because of long production period.

Application of of animal origin biostimulators in strawberry production.

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Biostimulators usage today growing permanently in crop production. Usage of animal origin biostimulators, specifically porcine blood, had positive effect on plant growing and thermal stress.

During vegetation period in year 2011 different varieties of strawberries were included in experiment: Asia, Alba and Clery. In three treatments (0.5 g, 1,0 g and 1.5 g per plant + control treatment) we studied the effects of biostimulator peptone on strawberry yield and pomological characteristics. All substances were applied in root zone separately in total 4 different treatments during vegetation and have been compared with the control. Experiment set up in ecological conditions of continental Croatia in open places in plots in two rows covered with a white mulch and drip irrigation system placed under the mulch. The aim of this study was that in terms of environmental conditions northwestern Croatia explore importantly pomological characteristics of studied varieties under the influence of biostimulators, wishing that in these new plantations be represented by the manufacturer best varieties.

This paper presents the results of research of peptone influence on: duration of maturity, plant yield, average fruit weight and number of fruits per plant caused by influence of biostimulant.

Winter injuries - a problem in the strawberry cultivation.

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A winter injury is the most important factor limiting strawberry cultivation in many northern regions located in the cooler part of the temperature climatic zone. Typical trait of such a zone is great variability of the climate. Frequently occur years with predominance of the maritime climate characterized by the high rainfall in the summertime and mild and wet winters. There are, however, also years with a predominant influence of continental climate. The summers are then very dry and hot when the temperature increases well above 30oC and very cold winters in which the temperature drops below minus 30oC. In such climatic conditions, injuries caused to the strawberry plants by the winter cold are common. If snow cover is not thick enough or not present, the soil freezes deeply and after such winters severe winter damages to strawberry plants are observed. With regard to Poland severe winters appear every 10-15 years and as a result of them big losses to strawberry plantations are noted.

The range of the winter injuries is very wide and depends on many biotic and abiotic factors like origin of genotype, plant health and nutritional status of plants in the vegetation season, weather conditions during fall hardening, age of the plants, presence and thickness of snow cover, level of low temperature drop and duration of the freezing stress. Symptoms of winter injuries are different – from very light and almost invisible to very distinct when all plants die. The most sensitive parts of the plant are flower buds. Winter cold can injure or kill them, causing crop losses. Fruit yield losses can also be caused by plant growth reduction as a result of cold stress.

There are several methods allowing the estimation of the sensitivity of strawberry plants to the low temperature stress. However, the most reliable method is verification of the plant sensitivity level in the field conditions after severe winter. The aim of the presentation is to discuss different symptoms of winter injuries observed in Poland after winter 2011/2012 with the underlying the differences between cultivars originating from different breeding programs.

Testing different nitrogen (N) strategies to assure a sustainable open field strawberry production.

Miet Boonen and Jan Bries

Pcfruit - experimental station for small fruits Soil Service of Belgium

The Flemish environmental legislation and the EU nitrates directive enforce a more restrictive nitrogen (N) policy to avoid nitrate pollution of the groundwater and high residual soil nitrate levels. Since 1996, the Experimental Station for Small Fruits of pcfruit, Sint-Truiden in co-operation with the Soil Service of Belgium is studying different nitrogen fertilizer strategies in order to obtain high yields and an optimum quality of the fruit taking into account the environmental constraints. In the Manure Action Plan (MAP4) of the Flemish government, strawberries are classified as a crop with low nitrogen requirement. The ceiling for nitrogen application on strawberry fields is fixed at 225 kg N per hectare, but at the same time, the mineral nitrogen reserves in the upper 90 cm of the soil in the autumn should not exceed 90 kg NO₃-N/ha. The aim of this research is to define the optimum N dose for strawberries and to establish the optimum moment and method of nitrogen application to avoid excessive residual soil nitrate levels in the autumn.

The experiments were carried out according to a split-plot design on one year old fresh 'Elsanta' plants, planted at the end of August on raised beds at a rate of 4 plants per square meter.

N application before planting at different doses: 0, 80 and 120 kg N/ha. No fertilizer supplement was provided in spring. For each dose there was a soil treatment with black polyethylene film and one without groundcover.

Split application of N in spring: Different N doses were applied spread over a period of three months (April-June)

At higher rates, more soil N was present in the autumn. However, because of high winter rain fall, most of the nitrogen was leached out, negating any effect of different N doses during the following springtime. Moreover, crop analysis has shown that N uptake in the autumn did not exceed 10-15 kg N/ha, whatever the dose applied.

The more N was applied during spring time, the more was found in the soil. The highest yields were obtained with the highest fertiliser dose; however the effect of the soil cover on the yield was much more important. The firmness of the fruits was negatively affected only when fertigation continued during the harvest period. Export of N by strawberry fruits ranged from 15 to 83 kg/ha.

Cultivation

Healthy fruit in European perspective: EUBerry & EUFruitbreedomics.

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The main objective of the European funded project 'Healthy fruit in European perspective' is to bring together the necessary knowledge and tools to provide European consumers with high-quality fruit (apple, peach) and fresh berries at a competitive cost price. The activities of Wageningen UR in the various parts of EUBerry and EUFruitbreedomics are carried out in cooperation with a wide range of European partners.

Production of (small) fruit in Europe is performed under a large variety of climatic and growing conditions. Increase of sustainability (economic sustainability, competitiveness, environmental sustainability) by developing environmentally friendly farming systems is necessary.

Development of sustainable control strategies in strawberry

Minimizing spraying of fungicides and reduce residues to an absolute infection

Optimize timing of spray application

Use of decision support system (DSS) to control Botrytis

Linking sporulation of powdery mildew to weather conditions and infection pressure

Development (DSS) to control powdery mildew

Refine control strategy

Choice of fungicides with low environmental impact

Compare traditional open field cultivation technique with cultivation on ridges

Developing strategy for non-chemical thrips control in strawberry

Only at the first season plantations of strawberry an effective thrips control by deltamethrin was realized compared to biological control: it needs time to establish natural enemies

Later in the season fully biological control could be realized at presence of natural enemies: Orius sp., predatory mites and predatory flies

Mulching with plastic film is also a possibility to reduce significantly the number of thrips larvae and thrips damage

Development of effective monitoring methods, lure and retain predatory bugs and other natural enemies can sharply reduce the use of chemicals against thrips

Application of DSS, optimizing the fungicide choice and adapting the cultivation technique in the practice of strawberry production, will reduce sharply the residues of fungicides on the fruits. Further development of application methods of predatory bugs, mites or flies is necessary and will be assessed. Improvement of systems for 'lure & retain' Orius spp. are required. Alternative cultivation systems by application of mulching in combination with natural enemies can improve the tolerance against thrips attack.

EFFECT OF PHOTOPERIOD ON PLANT GROWTH AND DEVELOPMENT IN THE NEW SELECTIONS OF STRAWBERRY

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Introduction

The economic value of the crop is mainly determined by the two most important factors: genetic (varietal) characteristics and the conditions of cultivation. Light environment appears to be one of the key factors. In order to optimize the production process and evaluate the possibility of successful strawberry cultivation with artificial lighting with various light sources, first it is important to study plant photoperiodic responses and to find the optimal light and temperature conditions for plants growth and development.

Methods

Effect of photoperiod on the induction of flower buds, morphological and physiological processes was studied in four new strawberry varieties: Bohema, Govorovskaya, Carnival, and Snezhana. Plants were raised in pot culture in the climatic chambers Fisons Fi-totron 600H with fluorescent lamps; photoperiods 12 h and 18 h, PPF 180 $\mu\text{mol}/\text{m}^2\text{s}$. Air temperature - 16 °C.

Results

Flower bud formation was observed in Bohema and Carnival varieties at the same time both under short-day and long-day conditions. Plants of the Govorovskaya variety developed 3 weeks earlier under photoperiod 18 h. In Snezhana, there was a 1.5 month delay in flower bud formation under long-day conditions; no fruiting was observed. Bohemia and Snezhana, despite of flowering, did not produce fruits under long-day conditions. The varieties Bohema, Govorovskaya, and Carnival under long-day conditions were flowering continuously, and the second wave of fruiting was observed 1.5 months earlier than under short-day conditions. Photosynthetic rate, stomatal conductance, and transpiration rate in the varieties Govorovskaya, Carnival, and Snezhana were higher at photoperiod 18 h. In Bohema, these indicators were the same under both light regimes.

Strawberry F1 hybrids in very early greenhouse production with grow light.

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Fragaria x ananassa, F1 hybrid, seed, greenhouse production, grow light.

The near saturation of the strawberry market in the main season in NW Europe is responsible for a low price and so a loss for strawberry producers. In order to be able to sell strawberry with a high price, the production should be starting more early in late winter. This can be realized by new varieties and an adapted environment. This study was conducted to evaluate the performance of F1 hybrids in very early production from mid February onwards in a greenhouse with grow light in the Netherlands.

Three new F1 hybrids from ABZ Seeds were tested in a greenhouse compartment at the Demotuin (Honselersdijk, NL) during a very early culture in 2013. These new F1 hybrids are seed propagated (disease free) and day neutral.

During the entire production season, fruits qualities are going to be measured. Fruit appearance (color, shape), firmness, storage life and taste (tasting and measurement of sugars and acids) are the main observation points.

The quantity of fruits produced is monitored also with a special attention to the production spread during the season.

Recent evolution and trends in the soil fertility of Flemish strawberry fields.

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The Soil Service of Belgium (SSB, spin-off of the KULeuven) formulates each year hundreds of fertilization recommendations based on soil analyses in strawberry in open field. Soil samples are taken in the ploughing layer (0-30 cm) in order to determine the soil fertility (salt concentration, pH, C, P, K, mineral N, Mg, Ca, Na). In the last 5 years (2006 - 2012), SSB determined the soil fertility of more than 2000 soil samples from fields with different strawberry varieties (june bearing, late season varieties, everbearing varieties, strawberry breeding). In this contribution, the statistics and trends of the soil fertility will be discussed for the different strawberry varieties. Differentiation is made between fertilization in preparation the growing season, before planting, and complementary fertilization during the growing season. Statistics are shown for sand, silt and loam which the main soil types on which strawberries are cultivated in Flanders.

Photoperiod extension effect on everbearing strawberry (*Fragaria x ananassa* Duch.) cv Capri trayplant nursery.

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Photoperiod affects everbearing strawberry flowering response and consequently the architectural structure of the plant, representing an essential precondition to obtain plants suitable for programmed production. A photoperiod extension experiment was carried out in an high altitude (approx. 1000 m ASL) trayplant nursery as an attempt to overcome the environmental limits which generally cause a low flower load.

Runner tips of strawberry cv Capri were rooted directly in 150 cm³ traypots in 2 tunnels draped with black hail nets on July 17, 2012. From August 15 to September 15, one of the tunnels was exposed to a 24-hour photoperiod extension with low intensity light. At the beginning and end of the treatment 6 plants per thesis were morphometrically analysed. From November 27 the trayplants were cold stored at -1,5°C until the transplant date on April 10, 2013. The structure of 10 plants per treatment was evaluated on June 5.

Until September 15, 2012, no significant differences could be observed.

In spring, instead, the photoperiod treatment determined a significant increase on the total flower number per plant (30,5 vs. 14,3), caused by a higher number of trusses per plant (4,4 vs. 2,2) especially concerning secondary inflorescences (2,2 vs. 0,5). Furthermore the BBCH phenological growth stages showed that the extended photoperiod thesis reached a significant later stage (median value: 'Seeds clearly visible on receptacle tissue' (73) vs. 'First flowers open' (60)).

The experiment proved the effectiveness of the technique. The effect of the extended photoperiod on flower load results from the light interference on flower induction, initiation and differentiation processes. The later phenological stage suggests an advance and/or an acceleration of these processes, allowing the production of more secondary inflorescences.

Breeding, genetics and functional genomics

Chairman: Zurawicz E.

Oral presentations

Keynote speaker: David Simpson

Strawberry breeding: Past achievements and visions for the future

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Strawberry breeding effectively began in Europe in the 1760s when the modern cultivated strawberry, *Fragaria x ananassa* was created from a chance hybridisation between *F. virginiana* and *F. chiloensis*. The two wild species from North and South America had been introduced into botanic gardens in Europe and it was Antoine Duchesne in Paris who first recognised and described the large fruited hybrid *Fragaria x ananassa*, the pineapple strawberry.

The early pioneers of breeding the new strawberry species were in England, where Andrew Knight and Michael Keens developed improved varieties. 'Keen's Seedling' released in 1821, marked the beginning of truly commercial strawberry production and was grown in England for nearly 100 years. 'Keen's Seedling' was quickly taken up in other European countries, where it was used by other breeders. It was a parent of 'Vicomtesse Hericart de Thury', which was bred in France and became an important cultivar in the second half of the 19th century.

These early breeders concentrated on improving fruit size and developing robust varieties that could be cropped successfully for several seasons. Later the objectives broadened as the strawberry progressively gained in importance as a commercial crop. Strawberries were bred for different climatic conditions in many different countries and varieties were developed to suit the local markets. Systematic breeding for disease resistance began in the 1930s when red core, caused by *Phytophthora fragariae*, became a very serious problem for growers in both Europe and North America. Programmes in Scotland and at the USDA in Maryland focussed strongly on resistance to red core. The variety 'Auchincruive Climax' released in Scotland in 1947 was strongly resistant to red core and rapidly became the dominant variety in the UK, although it later developed June Yellows so its success was short-lived.

In the last 60 years there have been many strawberry breeding programmes around the world developing varieties for different markets, climatic conditions and growing systems. Two of the most successful have been the University of California programme at Davis and the Netherlands programme, originally at Wageningen. Both these programmes have been notable for developing varieties that have been successful in many countries and not just in their region of origin. Over this period there have been very large improvements in yield, fruit size, firmness and uniformity of shape. The cultivated strawberry is highly heterozygous and, in the past, breeding has been largely empirical, relying on the skill of the breeder to choose the best cross combinations and then select the outstanding individuals from the best families. However, several programmes are now employing molecular markers for marker-assisted breeding, particularly for disease resistance traits. This approach will improve the precision of strawberry breeding and make it more likely that future varieties will combine resistance with excellent fruit quality and high yield. Looking further ahead, it is likely that genomic selection will be used to take advantage of the data generated from the many molecular genetics studies that are currently underway with cultivated strawberry and related wild species.

A core collection of modified strawberry germplasm as a resource tool for funghi infection and fruit texture studies.

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Strawberry has been extensively used as a model organism for functional genomics of genes related with fungi infection (Amil-Ruiz et al, 2011) and fruit ripening, specially fruit texture (Posé et al, 2011). These studies implied the genetic transformation and subsequent characterization of a wide range of traits, resulting in a considerable number of lines being created and more or less extensively studied.

A preliminary data survey was performed previous publications, laboratory notebooks and project reports. Main categories and the relevant features (like cultivar, transgene sequence, germplasm availability, plant phenotype, experiment results, etc) were identified, establishing the appropriate relationships. The project followed the Chado schema used by the GMOD initiative <http://www.gmod.org>.

The germplasm collection currently hosts two strawberry cultivar (Camarosa and Chandler), nine transgenic lines with resistance genes against fungi infections and over a dozen for fruit texture related genes. Collected information includes in vitro and in planta leaf symptomatology and fungus spore germination, as well as gene expression for each transgene, plant production, fruit color, shape and firmness. Data on cell wall fractionation, pectin and soluble sugars quantification, FT-IR and size exclusion chromatography, AFM pectin structure characterization and Immunohistological analysis.

The intrinsic value of these studies makes necessary to preserve both the germplasm and the data generated, and to make it available to the community for further study and reuse. Community driven formats will facilitate the use of the data in new studies. The present project aims to increase the value of the transgenic strawberry plants in the collection, using standard data formats and open source tools to facilitate access to the research and breeding communities as well as to facilitate the distribution of the germplasm.

Using plant traits to estimate production cost and profitability of strawberry genotypes in southeast Queensland.

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In Queensland the subtropical strawberry (*Fragaria ×ananassa*) breeding program aims to combine traits into new genotypes that increase production efficiency.

The contribution of individual plant traits to cost and income under subtropical Queensland conditions has been investigated. The study adapted knowledge of traits and the production and marketing system to assess the economic impact (gross margin) of new cultivars on the system, with the overall goal of improving the profitability of the industry through the release of new strawberry cultivars.

Genotypes varied widely in their effect on gross margin. The advantage of new genotype was also affected by the proportion of total area allocated to the new genotype.

Characterizing nutritional traits in a diploid strawberry NIL population.

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Diploid strawberry has a small genome (240Mb), and shows a high degree of synteny with the octoploid cultivated strawberry. This allows using diploid strawberry as a simplified model of the commercial varieties. Agronomical interesting traits are usually inherited in a quantitative way (QTLs) and they need to be selected in large segregating populations well characterized with molecular markers. Near Isogenic Lines (NILs) populations are tools to simplify and refine the QTLs association studies by reducing the heritance of the traits to mendelian-like model.

NILs are fixed homozygous lines that share the same genetic background from a recurrent parental except for a single introgression region from a donor parental. These populations cover the whole donor parental genome in overlapping introgressions and have previously shown great success in mapping QTLs in other agronomic species.

We have developed a NILs collection in *Fragaria vesca* (PI 551824 cv. Reine des Vallées) with *Fragaria bucharica* (PI 657844) as a donor parental. NILs population was genotyped using microsatellite markers (SSR) and 3 biological replicates were phenotyped in 2011 and 2012 in two locations. This population segregates for many agronomic and nutritional quality traits.

Nutritional quality traits of strawberry were analyzed by a biochemical profiling of the NILs fruits measuring sugars composition and content by HPLC and total polyphenol content by the Folin-Ciocalteu method. QTLs were detected and validated statistically using the software R 2.15.1. We have mapped at least 9 QTLs for agronomic traits and 3 for nutritional traits.

The NILs population in *F.vesca* can significantly facilitate and improve the research for new QTLs in diploid strawberry by reducing the experiments in sample size, time and cost.

Screening and testing of new Junebearing strawberry varieties and selections.

Miet Boonen and Hendrik Trekels

Pcfruit, Experimental Station for Small Fruits

The Belgian strawberry market is dominated by the Dutch variety Elsanta. It is possible to guarantee a continuous supply 10 months a year because of the use of this variety in a diversity of crop systems. The high productivity, the fresh red color and the enjoyable taste are the most important plant/fruit characteristics of this variety. Nevertheless the disadvantages of this variety became also visible during the years. The plant produces fruits with a lower fruit classification under certain circumstances. These fruits are more sensitive for pressure and transport damage and after storage, fruits became pale. The biggest disadvantage of Elsanta regarding diseases is the susceptibility for *Verticillium*. The growth of full soil crops can become problematic in the future due to the possible strengthening of the regulation of soil fumigation. The Experimental Station for Small Fruits of pcfruit started an intensive search for a new variety with characteristics that can compete with these of Elsanta.

New varieties and selections are tested in an extended variety trial and compared with reference varieties as Elsanta and Darselect. Every variety is planted (in small blocks of 2.3 m with 14 plants) at the end of August on raised beds on a rate of 4 plants per square meter and in three replications. The following fruit and plant characteristics are tested:

Production, fruit classification, mid harvest date, berry weight, fruit color (inside and outside), taste, firmness, sugar content, sensitivity for pressure and transport, susceptibility for diseases, ...

During the variety trial of 2009, the British variety Elegance (Meiosis) attracted attention with his productivity, good fruit classification and attractive, shiny uniform conical shaped orange red fruits. Also the good shelf life and the low rain sensitivity and the long harvest period are advantages of this variety. This variety confirmed these plant/fruit characteristics also during the trials at the Experimental Station for Small Fruits of pcfruit during the following years (2010-2012). The 2012 variety trial had some other varieties that attracted the attention because of one or more plant and/or fruit characteristics; Vibrant and selections 1677, 1764 and 1832 of East Malling, Flair and 06-07-05 from Flevoplant, Garda (ISFR).

Posters

Stability parameters of strawberry under different climatic condition of Bangladesh.

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The experiment was laid out in a Randomized Completely Block (RCB) at Fruit Research Field of Pomology Division, HRC, BARI, Gazipur; Fruit Research Station, Binodpur, Rajshahi and Agricultural Research Station, Pahartali, Chittagong during the period from August 2009 to May 2010 with five strawberry genotypes to screen the stable genotype(s). All the genotypes were significantly different from each other for most of the characters. Observing the combined analysis of variances and stability parameters it was found that fruits plant-1, single fruit weight, yield (t ha⁻¹), and ascorbic acid content of fruit were insignificant for linear portion of genotype x location interaction, indicating those characters were more stable under climatic variation, but level of stability for a particular genotype were not consistent for all the characters. But the genotype Camarosa considered as stable for number of fruits plant-1, single fruit weight, yield and TSS content of fruit and suitable for cultivation under a diverse area.

‘Snow White’, a new strawberry cultivar with white fruits.

K. Olbricht, U. Gerischer, A. Ludwig, D. Ulrich, B. Casas, A. Darbonne, S. Kraege, H. Obers, A. Vissers, P. Walpole, S. Walpole

K. Olbricht, U. Gerischer, A. Ludwig, B. Casas, A. Darbonne, S. Kraege, H. Obers, A. Vissers, P. Walpole, S. Walpole
Hansabred GmbH & Co. KG, Radeburger Landstraße 12, 01108 Dresden, Germany

D. Ulrich

Julius Kühn Institute (JKI), Federal Research Centre for Cultivated Plants, Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Erwin-Baur-Str. 27, D-06484 Quedlinburg, Germany

Strawberries with white fruits are cultivated about centuries longer as red cultivars. The Chilean strawberry with white or pale pink fruits, *Fragaria chiloensis* forma *chiloensis* (L.) Miller, was introduced to Europe in 1714. It became an ancestor of the cultivated *Fragaria ×ananassa* Duch. next to *Fragaria virginiana* Miller from North America which was already cultivated in Europe since 1623. "White cultivars" always were interesting for cultivation. The cultivar *Fragaria ×ananassa* ‘Weisse Ananas’, bred in 1867, survived in house gardens due to its fruit colour and its fresh-fruity taste. Meanwhile, "White cultivars" became interesting for strawberry production as a niche product with the specific use for the gourmet fruit sector.

Cross-combination of ‘Weisse Ananas’ and clone numbers which arose from open pollinated Chilean Landraces and backcrosses with ‘Weisse Ananas’ resulted in interesting clone numbers. Selection was performed under greenhouse and field conditions assisted by human sensory evaluation and by aroma analysis (Headspace solid phase micro-extraction, gas chromatographic separation, FI and MS detection followed by data processing using Chromstat™)

‘Snow White’, a new cultivar with white fruits is presented. It is winter hardy, more vigorous than ‘Weisse Ananas’, highly tolerant to Powdery Mildew and other leaf diseases. Fruits are larger than ‘Weisse Ananas’ and ripen later than the old cultivar. Fruit firmness is higher, the colouration is white under greenhouse conditions and partly pale pink under field conditions in the same way like ‘Weisse Ananas’. The flavour is very pleasant, fresh fruity with a note of "kiwi fruit", a higher acceptance and with a better mouth feeling than the old cultivar. ‘Snow White’ and ‘Weisse Ananas’ are clearly to discriminate to red fruit cultivars of *Fragaria ×ananassa* by their volatile pattern and also from each other by data processing via Chromstat™.

Analysis of Strawberry Genes Expression-stability and Evaluation as References for Transcript Normalization.

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In the last few years, an increasing number of important molecular studies in strawberry are being reported, as this worldwide horticultural important crop species has been proposed as an interesting model for the development of basic genomics and recombinant DNA studies among Rosaceae. Very often, these studies involve relative quantification of gene expression as this methodology is extensively used to estimate the expression of genes under experimental conditions of interest. However, its accuracy and reliability is dependent upon the choice of an optimal endogenous control gene. So far, there is no information available on suitable endogenous reference genes to be used for studies involving strawberry-pathogen interactions.

The present data constitutes the first systematic study in strawberry to identify and validate optimal reference genes for accurate normalization of gene expression in strawberry plant defense response studies. Thirteen potential pre-selected strawberry reference genes, and different tissues and strawberry cultivars under biotic stress, ripening and senescence, and SA and JA treatments were considered. Evaluation of their goodness was deeply analyzed by five different methodologies available to date, and individual information was merged with appropriate algorithm to take advantage of the goodness offered by these five methods.

The resulting superior reference genes is strongly recommended to be used as control genes for relative quantification of gene expression in strawberry plant-pathogen interaction and plant defense studies under all the experimental conditions here described, and also as a starting pool for assessing suitable reference genes under new conditions.

Italian Strawberry Breeding Activities coordinated by CRA FRF.

Walther Faedi, Gianluca Baruzzi

Consiglio per la Ricerca e la Sperimentazione in Agricoltura – Unità di Ricerca per la Frutticoltura – CRA-FRF

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CRA-FRF carries out and coordinates several strawberry breeding activities, co-funded by public and private authorities. The purpose is to obtain new genetic material adapted to each cultural area, characterized by high yield, good taste and high qualitative bioactive compounds.

In order to achieve these goals we carry out the traditional breeding activity: choosing parents; planning and making intervarietal crosses; selecting seedlings in the reference field; evaluating selections in fields at 1st and 2nd level through specific remarks, analysis and determinations.

Ten breeding actions are now in progress. Since 2006, a public-private program co-funded by Soc. Piraccini Secondo: the main purpose is to obtain early varieties marked by low winter chilling requirements fully adapted to Southern areas, Metaponto in particular. Released in 2010, Pircinque, matches high fruit quality and high earliness. The PIR 2 selection, which will be released soon, is interesting also in other Italian Southern areas for its high earliness and productivity.

In Verona area, the objective is to create new genetic material adapted to the traditional "fall culture". The Province of Verona and the 2 growers' organizations, Aposcaligera and COZ co-finance this breeding activity started in 1995. The latest variety, released in 2012, is Garda being particularly interesting for its good agronomic behaviour combined with fruit firmness and sweetness. The selections VR 4 and VR 12 are at the final stage of evaluation involving several strawberry growers. Since 1978, in Cesena area the objective has been to obtain cultivars adapted both to the open-field culture and the protected organic one. The activity has almost always been funded by the Emilia-Romagna Region, through the CRPV of Cesena, and by the three main regional Growers' Organizations: ApoConerpo, Apofruit Italia and Orogel Fresco. The selections FC 15, FC 30.8 and FC 32 are at the final stage of evaluation.

Breeding value of the strawberry cultivars.

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The main goal of the strawberry breeding program carried out at the Research Institute of Horticulture, Skierniewice, Poland, is to develop novel dessert cultivars well adapted to the Polish agro-climatic conditions.

The aim of the study was to estimate the breeding value (general combining ability) of 13 dessert strawberry cultivars: 'Figaro', 'Salsa', 'Palomar', 'Granda', 'Camarosa', 'Elianny', 'Aromas', 'Diamante', 'Portola', 'Charlotte', 'San Andreas', 'Monterey' and 'Albion'.

The crossing program was made in the winter 2010/2011 in greenhouse following the diallel cross design according to IV Griffing's method. Progenies of 78 families obtained have been evaluated in the field conditions (randomized complete block design, 4 replicates, 15 plants per plot). In the season 2012 the observations of the following traits were recorded: time of fruit ripening, marketable yield, fruit weight and attractiveness, soluble solid and ascorbic acid content in fruits as well as plant vigor, and plant susceptibility to leaf spot, leaf scorch and powdery mildew.

Statistical analysis of data was performed according to the fixed Griffing's model.

The highest breeding value was estimated for 'Salsa' for marketable yield, ascorbic acid content and low plant susceptibility to leaf spot and powdery mildew. Lower breeding value for estimated traits was noted for 'Elianny', 'Granda', 'Camarosa', 'Palomar', 'Monterey', 'Diamante', 'San Andreas' and 'Figaro'. The least breeding value for the evaluated traits possessed 'Aromas', 'Portola' and 'Charlotte'. The last three cultivars can be considered as the least suitable for the breeding programs oriented at obtaining novel dessert strawberry cultivars.

Screening and testing of new ever bearing strawberry varieties and selections.

Miet Boonen and Hendrik Trekels

Pcfruit, Experimental Station for Small Fruits

After the disappearance of the ever bearer Selva from the Belgian market, the search for a new replacing variety was open. Every year the Experimental Station for Small Fruits of pcfruit is looking for new candidates in the variety trial. Until now, the Californian variety Portola seems to be the most promising variety in the open field. But the search is still open for a new variety with good fruit and good plant characteristics.

New varieties and selections are tested in an extended variety trial and compared with the reference variety in the open field: Portola. Every variety is planted in small blocks of 3.12 m with 14 plants on raised beds on a rate of 3 plants per square meter and in three replications. The following fruit and plant characteristics are tested:

Production, fruit classification, mid harvest date, berry weight, fruit color (inside and outside), taste, firmness, sugar content, sensitivity for pressure and transport, susceptibility for diseases, ...

The variety Verity attracted the attention in 2011 and confirmed the good results for production, fruit classification, fruit color, shelf life, ... in the trial of 2012. Favori and Florina (Flevoplant), Vivara (CIV) and the selection FC 06.081.02 of ISFR are other varieties from the 2012 trial that seems to have some nice fruit/plant characteristics.

Using somaclonal variation as a tool to develop an improved skin colour variant of.

Adam Whitehouse and David Simpson

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The short-day cultivar 'Florence' (1997) has been a successful cultivar in Northern Europe due to its late-season of production, multiple disease resistance and high yield. However its acceptability in the UK retail market has been limited by its dark skin colour. Therefore a series of experiments were performed to induce somaclonal variation in strawberry plants regenerated from leaf -derived callus of 'Florence'. Four hundred and seventeen regenerants were successfully weaned from in vitro culture and 38 variants were identified. Of these, 14 were judged to have beneficial horticultural traits, including improved plant habit, fruit display, flavour, fruit size, skin colour and later season of production. Two clones (F62 and F64) had a significantly lighter skin colour than the standard 'Florence' clone of which one, F62, has subsequently been protected and released as the cultivar 'Serenity'. A description of 'Serenity' follows.

Three new strawberry cultivars from the East Malling Strawberry Breeding Club.

Adam Whitehouse, Abi Johnson, Kirsty McLeary, Andy Passey and David Simpson

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Since 2008 strawberry breeding at East Malling Research has been financially supported by the East Malling Strawberry Breeding Club (EMSBC) and the Department for Environment, Food and Rural Affairs (Defra). During this period three new cultivars have been released; two short-day types, 'Serenity' and 'Malling Centenary', and one everbearer 'Buddy'. 'Serenity' (2012) is a somaclonal variant of the late-season cultivar 'Florence'. It has a lighter skin colour than 'Florence' but in every other respect is very similar to its progenitor. 'Malling Centenary' (2013) is an early-mid season cultivar that has outstanding fruit quality, particularly in terms of its flavour and appearance, and is well-suited to substrate production. 'Buddy' (2012) crops from July-September, but is most productive from mid-July to mid August in the UK, although an earlier crop can be taken in late May-June, if the plants are not de-blossomed. It has excellent fruit quality traits and is suitable for all types of market outlets. The berries are large, firm and sweet and the plant shows intermediate resistance to crown rot (*Phytophthora cactorum*).

EUBerry: a new project on sustainable improvement of European Berry Production.

Bruno Mezzetti

Department of Agricultural, Food and Environmental Sciences (D3A) – Università Politecnica delle Marche, Ancona - Italy.

The main objective of the EUBerry project is to provide the necessary knowledge and tools to facilitate development of high quality, consumer-desirable fresh berry fruits of high nutritional quality optimal for human health at a competitive cost.

The EUBerry platform will be developed and validated by using berry as model crop species. Specific critical points related to improvement of berry fruit quality and reduction of production costs will also be considered for currants and blackberries.

EUBerry will apply the most recent technical advances in: a) Identifying germplasm of the main berry fruit Genera appropriate for sustainable production throughout the EU, with respect to fruit quality and environmental adaptation and expanding use of modern breeding strategies; b) Ensuring and expanding high-quality production systems to improve the availability of high-quality fresh berries for consumers through the modern cultivation techniques for berry season extension, on adaptation to different cultivation conditions and systems and on reducing the impact on environment; c) Developing and applying validated methods to control and maintain fruit nutritional quality, improving shelf-life of fresh berries and increasing their availability to consumers; d) Developing economic studies to verify the impacts of the new technologies in increasing berry economic viability, farmer and consumer attractiveness; e) Disseminate and communicate the results to research scientists, academia, technical services, growers, market organizations, consumers, food industries, health authorities and regulatory and legislative authorities.

Effect of Calcium dips Combined with Mild Heating on Postharvest Life and Quality of Strawberry.

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Strawberries are extremely perishable due to their relatively high metabolic activity, high softening rate and sensitivity to fungal attack, which cause severe postharvest loss in Bangladesh. So, postharvest life of fresh strawberries is needed to be extended for proper marketing of the fruit. Thus, the effect of calcium dips combined with mild heat treatment on quality and postharvest life of strawberries (cv. BARI strawberry-1) was studied.

Immediately after harvest, strawberries were treated for 15 min at 45 °C by dipping in distilled water, CaCl₂ solutions (1%, 2% and 3%) and left untreated. Subsequently, the fruits were stored at 10 °C with 80 ± 5% RH for 8 days. The effectiveness of the treatments was assessed by evaluating their impact on surface damage, quality attributes and overall visual appearance.

Dipping strawberries in 1% CaCl₂ solution at 45 °C was the most effective treatment for decreasing surface damage, maintaining better firmness, reducing weight loss and delaying both fungal decay and external colour changes compared to untreated and control samples. To a lesser extent, titratable acidity and pH were also affected by calcium dips. Moreover, 1% calcium dips increased the nutritional value by incrementing 31% of calcium content that did not affect the sensorial quality of fruits.

Distribution of the genus *Fragaria* in Croatia.

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Data from existing Croatian literature and data from our own investigations were compared with the list of *Fragaria* plant taxa that grow in Europe. The genus *Fragaria* comprises a relatively small number of species. In Europe exists only five taxa (*F. moschata*, *F. vesca*, *F. virginiana*, *F. viridis* and *F. ananassa*). In Croatia three of them are native (*F. moschata*, *F. vesca* and *F. viridis*). All species mentioned here, as well as many of their hybrids, are, or have been, cultivated for their edible fruits. The common cultivated strawberry of Europe belongs to *F. ananassa*. The most expanded species in Croatia is certainly *F. vesca* L. (wild strawberry) whose berries are gathered seasonally as wild fruits. This fruits can still be found on local fruit and vegetable markets.

They often contain higher amount of nutrients and bioactive compounds in comparison to cultivated varieties. Therefore, wild strawberries gain the focus of interest owing to its beneficial effects to human health, and the large advertising campaign undertaken by pharmaceutical industry. They have also high potential for breeding programmes as a source of genes for pest resistance and adaptability to abiotic stresses and genes for improvement nutritional and sensory characteristics of fruits.

Systematically, the research on the genus *Fragaria* species distribution in Croatia has not been carried out, and so is the case with many others wild growing fruit species in Croatia. However, because of a number of individual citations and observations, it is possible to get a quite good idea of their distribution. There have been no breeding programs or introduction of our native *Fragaria* species to production which is the reason why further research on their distribution is required. At the same time, collections of live native plant specimens with superior traits should be established to facilitate further research and their evaluation for breeding purposes.

Marionnet : Breeding Company - News strawberry varieties.

Marionnet Pascal, Chausset Laurent

breeding and genetics

Marionnet is a nursery specialized on the soft fruit plants production. Since 50 years Marionnet company work also on the breeding aspect, especially on the raspberry and strawberry.

Since several years Marionnet breeding have develop highly qualitative varieties (thus very gustative). This allowed us to create the most perfumed and most aromatic variety of strawberry market: Mara des Bois.

Some news varieties are being evaluated in various cultivation conditions and strawberry areas. Marigquette®, Magnum, are been launched on the market since this year. "M" and Macao are news emerging selections.

Some figures of strawberry breeding program:

- 300 in 350 hybridizations (cross combinations) each year
- 8000 to 10 000 seedling every year.
- 200 in 250 selections in evaluation under tunnels.

The most important breeding objective is to combine agronomics values to very high and original gustative qualities. With the partnership of trials stations and professional growers, in France and in Europe, the advanced selections are tested in various cultures conditions and areas.

Macao, Magnum are two news June bearers varieties
Marigquette®, "M" are two news everbearers varieties.

Marigquette® and Magnum are the most advanced of these emerging varieties.

Marigquette® : a new everbearer with a typical presentation (bi-conical shape, orange-red and shiny coloration). Very gustatives fruit qualities with a typical fragrance.

Magnum: a new June bearer varieties (mid-season), present a good yield and a large berry size. The fruit presentation is very homogeneous and attractive. The taste is very sweet.

With Marigquette® and Magnum, Marionnet have found news varieties with typical perfume. With Mara des bois and, today with Marigquette® and Magnum, Marionnet Company confirm that the gustatives criteria are perhaps the most important for the development of news strawberry varieties.

Increasing strawberry (*Fragaria x ananassa*) polyphenol content: Development and selection of new markers for Marker Assisted Selection based on co-localization of QTLs and e-QTLs.

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The wild strawberry, *Fragaria vesca* ($2n=2x=14$), is a diploid specie which genome has already been sequenced and is considered a model organism for cultivated strawberry (*Fragaria x ananassa*), an octoploid specie ($2n=8x=56$). In general all berries, including strawberries, are known for their rich nutritional profile, mainly for the high content in polyphenols which confers a greater antioxidant capacity. Understanding the genetic bases controlling the production of these phenolic compounds is extremely important for the selection of new varieties with a greater nutritional profile.

In this work, the LC-MS analysis for polyphenol metabolites in full ripen fruits from an F2 population of cultivated strawberry (Camarosa x Dover) allowed the quantification of 22 different metabolites and a further mapping of 146 QTLs in the genetic linkage map of this F2 population. CxD genetic linkage map has been improved, possessing now 192 loci distributed along the 28 expected linkage groups, representing each homeologous group a high coverage (>70%) when compared with the genome of *F. vesca*. Similarly, the expression levels in the full ripen fruit were also analyzed with a microarray containing the 35000 genes described for the genome *F. vesca* hybridizing with RNA of the individuals of the population. Those genes which expression levels vary significantly have been selected for an analysis of expression QTLs (e-QTLs), which allowed the detection of 333 e-QTLs.

The co-localization between metabolomic QTLs and expression QTLs indicate a possible direct implication of the candidate gene and the accumulated metabolite. All co-localization were detected and the best results were then selected for a deeper analysis for trying to understand the biological context of those co-localizations. Target markers close to the position of QTLs and e-QTLs co-localization were considered as great candidates for marker assisted selection (MAS).

The cultivated strawberry breeding: toward the development of the Marker Assisted Selection. (MAS)

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The octoploid cultivated strawberry is the most cultivated berry worldwide. Strawberry is also a significant component of many rural economies as in South Western of France, mainly in terms of employment and value added crop. Breeding programs are of great importance since it is crucial to possess a range of cultivars, which are well adapted to local conditions and can be grown in a sustainable manner.

Optimizing breeding selection by the use of MAS (Marker Assisted Selection) complementary to classical selection offers a useful tool for breeder to save time and money. MAS in strawberry are already developed for character of interest like disease resistance but not use by the breeders. In our work we develop markers for MAS strategy for the seasonal flowering trait.

We use a segregating population between Capitola (seasonal flowering genotype) and CF1116 (once flowering genotype) to phenotype this character. We developed two genetic maps for both parents and performed a QTL analysis for the seasonal flowering trait. Some of the markers lined to the trait were tested on a set of cultivated strawberry. Also we use a population of recombinant individuals to do the fine mapping of the character.

We were able to demonstrate that the seasonal flowering trait in our population is controlled by a major QTL localized in the Capitola parent. In addition, at least one of the markers we developed was associated with the trait in different strawberry cultivars. This marker is a good candidate to performed MAS. With a fine mapping strategy we narrow down in the QTL zone a 900 000pb region with 185 genes.

Pollinators discriminate against herbivore-damaged plants – breeding for increased resistance needed for organic farming.

Dr. Stenberg Johan

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There is an increasing demand for organic strawberries. However, pesticide-free farming implies that pest problems may increase. Here I present data showing that herbivores affect pollinator behavior, with negative implications for pollination and yield. Fortunately, genetic variation in resistance opens up possibilities for breeding.

Experiment 1. The behavior of all major insect pollinators (honey bees, bumble bees, wild bees, and hover flies) in relation to *Fragaria vesca* (Rügen) plants that were either intact or damaged by leaf beetles (*Galerucella* spp., Coleoptera: Chrysomelidae) was studied. The study was carried out in a common garden and visitations by naturally occurring pollinators were observed over one month.

Experiment 2. Pollination success, and the resulting yield (fruit weight) of damaged and undamaged plants was studied in a common garden. In addition to open pollination by naturally occurring insects, half of the flowers were hand-pollinated. The percentage of pistils pollinated was estimated for each flower, and all mature fruits were weighed.

All pollinators strongly discriminated against herbivore-damaged plants. Pollination success was significantly lower for damaged plants, leading to significantly lower yield. Hand-pollination of damaged plants resulted in restored high fruit weights, showing a casual relationship between damage, reduced pollination, and reduced yield. These results indicate that pesticide-free farming of strawberries is associated with reduced cropping security, which stresses the need to breed for increased resistance against herbivores.

I am currently screening wild *F. vesca* genotypes for resistance against *Galerucella* herbivores. Resistant and susceptible lines will be established for experimental and breeding purposes.

Patholgy

Chairman: Baets W.

Oral presentations

Drosophila suzukii in Switzerland: monitoring and mass trapping.

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Drosophila suzukii in Switzerland: monitoring and mass trapping
Drosophila suzukii is an Asian vinegar fly native that was recently introduced to Europe and invaded Switzerland in 2011. The pest was found in all regions of the country, from low altitudes to the timberline. Due to its fast reproduction rate and the infestation of fruits shortly before harvest D. suzukii is difficult to control. Our main objective was to establish an efficient monitoring campaign all over Switzerland. In 2012, a total of 60,000 D. suzukii were captured, whereupon it represented between 25 and 75% of all vinegar flies trapped. The range of this pest's host plants is very broad and does not only include crops, but also wild fruits. In 2012 most individuals were captured close to or within cultivated raspberry, blackberry and grapevine as well as wild shrubs such as elderberry. Probably as a result of a consequent application of the recommended sanitation measures, only very few cases of economic damage were reported by the producers in 2012. Monitoring traps can reliably detect the occurrence of the pest in a region. In case of local presence, setting up a dense net of mass-traps around the crop to protect or between a hedge and a culture should allow to capture most vinegar flies before they attack ripe fruits. In close collaboration with national and international partners, Agroscope will try to identify pragmatic and sustainable crop protection measures against D. suzukii.

Characteristics of *Xanthomonas fragariae* and expression of angular leaf spot in Belgian conditions.

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Angular leaf spot can cause damage in strawberry fields in some years. The bacterial pathogen *Xanthomonas fragariae* (Xf) is quarantine within the EU. Quarantine regulation focusses on the pest free status of traded plants for planting. However, concerns exist on the availability of effective inspection, prevention and intervention strategies to support this regulation. Moreover, there has been confusion about the involvement of Xf in several other plant health problems, such as plant collapse and reduced growth.

The research consortium studied the disease in the field during four consecutive production years and the mechanisms of spread in the cultures and also endophytically. It developed and applied a quantitative PCR for sensitive detection of Xf in plant material, constructed a fluorescent Xf strain to visualize different infection stages microscopically, and looked to the relatedness of the Xf strains present in our strawberry production systems by genome profiling. The study of the specialized interaction of Xf with the strawberry plant has also been underpinned by sequencing and analyzing the whole bacterial genome.

We have a stable basis to conclude on the symptoms that can be attributed to Xf. Xf is a typical leaf pathogen and its spread inside the plant system can sporadically occur, but does not seem to be of main importance. Moreover, Xf is shown to be a weak pathogen, rather an endophyte, that is only stimulated for growth and symptom expression in the leaves in conditions of somewhat warmer and wet climate. But there are clearly some technical measures to take that limit further spread of the disease in the field. The Xf population present in the Flemish fields is very homogenous and has most similarity to US strains, from where it is probably introduced. Trade of Xf-contaminated planting material can't be ruled out, due to occurrence of very low contamination levels which are undetectable. This hampers the implementation of a zero-tolerance for this quarantine bacterium. There is also new insight gained in the strategy of the bacterium to reside unnoticed and symptomless in the plant, and information from the genome sequences supports the observations from natural and artificial infection tests.

The sector and the phytosanitary authorities are informed on our results and conclusions that have implications for strawberry growth and the quarantine status of Xf.

Natural elicitors of plant defence response in strawberry and other crops.

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Plant pathogens are responsible for considerable losses in agricultural production and control is mainly based on application of agrochemicals and resistance breeding. However, successful plant defence relies on fast and specific response to pathogens during plant-pathogen interaction. Recognition of diverse elicitors, effectors and modulators by specific and unspecific plant receptors activate signal cascades eventually leading to gene expression and defence responses. Therefore, natural substances as elicitors of plant defence response are a prerequisite for sustainable and ecological agriculture and are greatly appreciated in crop protection.

We are searching for new elicitors in collaboration with AGROMETODOS, S.A., testing the effectiveness of some of these new natural products together with the main commercial product of AGROMETODOS S.A., BROTOMAX®, on strawberry plant and cell suspensions. To validate these compounds, RTqPCR gene expression analysis is being performed on strawberry gene markers associated to the well-known SA- and JA-dependent plant defence pathways.

Results are very promising as one of the new substances is able to induce significantly the expression of gene markers from both signalling pathways. Moreover, this substance produces an increase in the amount of phenolic compounds and antioxidant activity in strawberry cell suspension cultures. RTqPCR gene expression analysis shows similar elicitor activity to that of BROTOMAX® and a strong synergy when both elicitor compounds are used together. In addition, preliminary results in strawberry plants grown under greenhouse conditions reveal increased resistance of these plants to *Colletotrichum acutatum* infection.

This work was supported by the Spanish Ministerio de Ciencia e Innovación (MICINN) by grant PROYECTO INNPACTO IPT-2011-1153-060000.

CATT as a non-chemical pest and nematode control method in Strawberry Mother Planting Stock.

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Insects, nematodes and mites that damage postharvest plant products can result in severe quality losses or trade restrictions in case of quarantine or pest organisms. With the ban of the ozone depleting methyl bromide (MeBr), the most widely used chemical for phytosanitary treatment, effective and sustainable alternatives are needed. A physical method, Controlled Atmosphere Temperature Treatment (CATT), can be a sustainable alternative for the control of pests on living plant products.

Until 2008 methyl bromide (MeBr) was used in The Netherlands for fumigation of strawberry runners, intended as mother planting stock, to make them free of infestation by strawberry tarsonemid mites (*Phytonemus pallidus*). As an alternative of MeBr fumigation a 48h CATT method was developed and scaled up by Wageningen UR in cooperation with the plant propagation organization Plantum. In 2011 this CATT method was successfully modified to eradicate also root knot nematodes *Meloidogyne hapla* (>99.7% mortality), which was not effectively controlled by MeBr fumigation. For an effective killing of the root knot nematodes, temperature must be raised to 40 °C. In several experiments the optimum for a high mortality of both tarsonemids and nematodes was studied. This leads into an adapted CATT of 20 hours at a temperature of 35 °C and 50 % CO₂ followed by 20 hours at a temperature of 40 °C.

In 2012 this adapted CATT method was successfully tested under field conditions with a wide range of mother planting stock, originating from different nurseries. In this field experiment no harmful irreversible results of this adapted CATT on vitality of mother plants and on runner production were noticed. Propagation companies are promoting the CATT treatment and two commercial treatment companies provide the CATT protocol as phytosanitary treatment of strawberry runners. Application of this optimized CATT will prevent further dispersion of plant parasitic nematodes in the strawberry chain. In the chain of the international trade of other plant materials and products certainly there will be more possibilities for application of CATT for sustainable treatment of insect, mite and nematode pests.

Improving strawberry IPM in California with botanical and microbial pesticides.

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Important strawberry pests in California include lygus bug, spider mites, thrips, and whiteflies. Predominant use of chemical pesticides does not provide complete and satisfactory control of certain pests such as lygus bug. Biological control is limited to the release of predatory mites against twospotted spider mites. Microbial control is an unexplored area in California strawberries. Limited pest control with current practices, risk of resistance development, and concern for environmental safety associated with excessive use of chemical pesticides prompt the search for safer and effective alternatives. Azadirachtin, a botanical insect growth regulator and the entomopathogenic fungus, *Beauveria bassiana* are active against most of the strawberry pests. Following greenhouse and small plot field trials, a large field study was conducted in Santa Maria using chemical pesticides, azadirachtin, and *B. bassiana* in different combinations against various strawberry pests. A small plot trial was also conducted with chemical miticides and *B. bassiana*.

In the miticide trial, each treatment had single 20' long bed with four rows of strawberries. Treatments were applied with a CO₂-pressurized backpack sprayer. Number of spider mite and predatory mite eggs, nymphs, and adults were periodically sampled. In the large plot trial, each treatment had seven 75' long beds. Treatments were applied three times at weekly intervals with tractor-mounted equipment. Aphids, lygus bugs, spider mites, thrips, whiteflies, and various species of natural enemies were sampled using standard protocols 5 or 6 days after each application. A randomized complete block design with four replications was used in both studies.

Azadirachtin and *B. bassiana* showed promise for strawberry pest management by providing control comparable to chemical pesticides against certain pests. They can reduce the use of chemical pesticides and improve overall pest management.

Posters

The 50-years results of garden strawberry breeding for fungal pathogens and pests resistance.

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This paper presents results of 50-years researches and confirms the high practical efficiency of programs on immunology and selection developed by the author on the culture of strawberry.

The specific complex of diseases and pests of garden strawberries and resistance to them of the new garden strawberry varieties (Bogema, Luch Vira, Olimp, Rannyaya Plotnaya, Bravo, Karnaval, Govorovskaya, Yubileinaya Govorovoy, etc.), allows cultivation of the garden strawberry without application of pesticides is presented in the report.

First Report of Strawberry Gray Mold Caused by *Botrytis cinerea* in Maragheh area, NW Iran

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Gray mold caused by *Botrytis* spp. is one of the most economically important diseases of cultivated strawberry (*Fragaria × ananassa*) worldwide. This study is conducted to identify the most serious disease of strawberry in East – Azerbaijan province during 2011 and 2012 years.

In 2011 and 2012 strawberry fruits that were symptomatic of gray mold disease were collected from fields and markets of Ajabshir and Maragheh cities in East-Azerbaijan province. Fruits had brown lesions and were covered with green-gray masses of spores followed by a soft rot. Tissues were excised from diseased fruits, immersed in a solution containing 3% sodium hypochlorite and 70% ethanol for 1 min, washed three times with sterile water, and then cultured on potato dextrose agar (PDA) medium. Morphological characters such as conidiophore length and conidial and sclerotial dimensions were measured. Pathogenicity tests were conducted by inoculating 12 surface-sterilized strawberry fruits with single agar plugs containing actively growing mycelium; 6 control fruits received agar plugs without mycelium. The inoculated fruit were incubated for 3 days at room temperature in plastic bags.

All isolates produced abundant mycelium on PDA medium when incubated at 24°C and were at first colorless, later became gray to brown when the conidiophores and conidia developed on PDA. Koch's postulates were fulfilled by the reisolation of *B. cinerea* from symptomatic fruits. The morphological features were consistent with *Botrytis cinerea*. To our knowledge, this is the first report of *B. cinerea* strawberry in this area.

Evaluation of spruce biomass extract for control of gray mold (*botrytis cinerea*) on strawberry.

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Gray mold (caused by *Botrytis cinerea* Pers.) is one of the most important diseases for strawberry in Latvia. Especially high damage can be caused in organic farms where chemical plant protection products are not allowed to use. Previous studies had shown some antifungal effect of different components of coniferous trees. The development of new environmentally friendly plant protection product from coniferous tree biomass against gray mold was started in 2010. Several preparative forms were developed. The aim of these studies was to evaluate the effectiveness of spruce biomass extract for control of gray mold in strawberry plantings.

Two field trials were established in 2012 in two different places. The first trial was established in the Pūre Horticultural Research Centre, where spruce biomass extract was evaluated in two different concentrations – 1% and 2% and with two application rates – one time and two times per week from the beginning of flowering till the beginning of fruit harvesting. Cultivar 'Senga Sengana' was used in the trial. The second trial was established in the farm Kekavas Darzs Ltd., where spruce biomass extract was evaluated in three different concentrations– 1%, 2% and 4%. It was applied one time per week from the beginning of flowering till the fruit harvesting. Cultivar 'Induka' was used in the trial. A randomized block design with four replicates was used in both trials.

The effectiveness of spruce biomass extract on gray mold control decreased with the increase of concentration applied. In both trials the lowest percentage of rotted fruits was observed in the treatments where spruce biomass extract of 1% concentration was applied. Though none of tested treatments showed significant reduction of rotted fruits compare to control in both trials. More investigations on lower concentrations of spruce biomass extract are necessary.

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Jasmonate and salicylate signaling pathways seems to be manipulated in strawberry by *Colletotrichum acutatum* during infection.

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Plant resistance to pathogenic agents usually operates through a complex network of defense mechanisms mediated by a diverse array of signaling molecules. Whereas the salicylic acid (SA) signaling pathway is mainly activated against biotrophic pathogens, the jasmonic acid (JA) signaling pathway is activated against necrotrophic pathogens. Antagonism between these two signaling pathways also occurs.

To gain insights into the physiological and molecular processes which strawberry is able to activate in response to the hemi-biotrophic pathogen *C. acutatum*, transcriptional analysis using a proprietary cDNA microarray, and measurements of the acidic hormones SA, ABA, and JA were accomplished in *Fragaria ananassa* after challenge with this pathogen.

Enrichment in the expression of genes controlling important steps within SA signaling pathway was mainly detected, and the expression of genes encoding components of the jasmonic acid mediated defense response was also induced. Contrastingly, the induction of known salicylic-acid and jasmonic acid-responsive defense genes as PR1, PR5 and LOX2, PDF1.2, VSP1, and GST, respectively, was not detected. Both, salicylic acid, and jasmonic acid accumulated in strawberry after infection but no changes in ABA were detected. These data indicate that SA and JA pathways are partially promoted in strawberry against *C. acutatum*, and evidence a putative strategy used by this pathogen to overcome the strawberry plant defense system and to spread within the host by manipulating the fine crosstalk between both hormonal pathways.

FresaProtect: a mix of parasitoids to control all common aphid species on protected strawberry crops. Case studies from three years of experience.

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A parasitoid is a wasp able to parasitize aphids in a relatively host-specific way. These natural enemies of aphids are used in organic and/or Integrated Pest Management (IPM) strategies. Strawberry plants can be attacked by at least 15 different aphid species. To control all these different aphid species, several parasitoid species are needed. A mix of 6 different parasitoid species, FresaProtect, can control all these aphid species. Moreover, each aphid species is parasitized by at least two different species of parasitoids included in the mix which increases the efficiency of the control.

All parasitoids included in FresaProtect are individually efficient in the control of a large host range. However, the strength of a mix lays also in the synergy of the different parasitoid species, i.e. combination of the different research capacities, daily oviposition rates, lifespan, affinities to their hosts, behavior modification, host-feeding activity, temperature range, etc. This reinforces the action of FresaProtect. A population dynamics model, highlighting the importance of a preventive use of FresaProtect to keep aphids level below the economic damage threshold, is shown.

Here, we show also the case studies of FresaProtect between 2011 and 2013 in different European countries in strawberry crops in IPM and organic production systems. With three releases, one every three weeks, FresaProtect offered an excellent protection against the different aphid species attacking. With its ready-to-use unit it is easier and less time consuming than any other biological or chemical aphid control method.

UV-c radiation as an alternative tool to control powdery mildew on strawberry.

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The most used and effective strategy to control fungal diseases in fruit growing is the application of fungicides. The use of fungicides, however, can have a negative impact on the environment and its frequent use enhances the risk of fungicide resistance. Moreover, stronger limits concerning the maximum residue levels (MRLs) on fruits are set up by retailers and the export industry. In the future it will be a great challenge to produce fruits of high quality with a minimal input of pesticides.

As such, a search for alternative methods, like biological control agents or physical treatments, which are able to efficiently reduce fruit diseases, is required. To this end a physical technique, ultraviolet light in particular, was tested for its capacity to reduce powdery mildew infestation on strawberry leaves. The applied exposure doses ranged from 5 to 60 mJ/cm². The effect of UV-c radiation was tested on the establishment of powdery mildew on leaves of strawberry plants.

The powdery mildew infestation was significantly reduced by exposing the leaves to UV-c light, without negative effects on plant tolerance. The obtained efficacy levels were comparable with specific fungicide treatments. A regular application in the time was better than using higher dose rates with longer intervals between applications. Results of these trials under controlled and field conditions will be presented.

The impact of coniferous trees biomass extracts on important strawberry pathogens.

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To protect strawberries from harmful activity of pests and diseases, more attention should be paid to development and establishment of environmentally friendly regulation actions. Conifer trees produce a wide variety of compounds, such as terpenoids and phenolics. Several studies on different components of coniferous fungicidal activity are known. The aim of the research was to develop new environmentally friendly plant protection product from coniferous trees biomass against important strawberry diseases, caused by fungal pathogens.

Various products of processing of pine (*Pinus sylvestris* L.) and spruce (*Picea abies* L.) biomass were tested. During 2010 to 2012 several in vitro experiments were carried out to test the effectiveness of pine and spruce biomass extracts against different phytopathogenic fungi isolated from strawberries: *Botrytis cinerea*, *Colletotrichum acutatum*, *Phytophthora cactorum*, *Mycosphaerella fragariae*, *Verticillium dahlia* and *Rhizopus* sp. The inhibition of intensity of mycelium growth, sporulation and spore germination was determined using methods described by Zambonelli et al. (1996). The impact of extracts on plants after spraying was evaluated using micro-propagated strawberry plants.

Radial test showed that coniferous biomass extracts inhibit *B. cinerea*, *C. acutatum*, *P. cactorum* mycelia growth. Extracts had the highest inhibitory effect on *B. cinerea* three and six days after inoculation ($p < 0.05$). Our results show that *M. fragariae* and *Rhizopus* sp. are more resistant to the impact of extracts ($p < 0.05$).

This study has been supported by ERAF Nr. 2010/0249/2DP/2.1.1.1.0/10/APIA/VIAA/168

First population dynamics data of thrips (Thysanoptera: Thripidae) in Belgian strawberry growing.

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Preferred presentation: poster

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Thrips (Thysanoptera: Thripidae) is a major pest in all Belgian strawberry growing areas. Often an intensive calendar based spraying program is applied in an attempt to control these pest insects. After high damage levels in 2009 a working group was founded to tackle the problem.

In order to get a view on the thrips population dynamics in Belgian growing conditions a thrips monitoring in function of time was organized in the years 2010, 2011 and 2012 by Proefcentrum Hoogstraten, Proefcentrum Fruitteelt (pcfruit vzw), Provinciaal Onderzoeks- en Voorlichtingscentrum voor Land- en Tuinbouw (Inagro) and the Flemish Department for Sustainable Agricultural Development (ADLO).

In order to collect as much information as possible a systematic monitoring schedule was organized in different strawberry growing systems in the major Flemish strawberry growing regions (Noorderkempen, Zuid-Limburg and West-Vlaanderen). Monitoring was executed by means of blue sticky traps (type Bug-scan, Biobest) on a weekly basis. Thrips were not determined further to species level on the sticky traps, but *Frankliniella occidentalis* is assumed to be the main thrips species causing problems in Belgian strawberry production.

Based on the results of these monitoring data we obtained for the first time insights into the general development of the thrips populations throughout the season, i.e. the build-ups, peak activities and the declines of the populations. In addition, the weekly registered thrips numbers were analyzed in function of recorded climatological data during these periods.

Especially in open field strawberry, obvious correlations were present with temperature data. These results form a first basis to guide growers in adapting their control schedules from calendar sprayings to an integrated pest management (IPM) strategy, with specific positioning of crop protection agents based on monitoring and weather forecasting data.

Emerging regulated pests and diseases in strawberry.

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To protect plant health the Belgian Federal Agency for the Safety of the Food Chain (FASFC) enforces controls and restrictions on the import, movement and keeping of certain plants, plant products or soil/substrate infected with high risk diseases and pests. The FASFC is also responsible for laying down, implementing and enforcing measures related to the analysis and the management of risks that may affect plant health. Recently, presence of three viruses and of the spotted wing fruit fly (*Drosophila suzuki*) was confirmed in Belgium and could have an impact on strawberry growing in the near future. This study reports specifically on the current status in Belgium of these harmful organisms for which we have to be vigilant.

The most important strawberry viruses are those transmitted by aphids. This virus group has always been a major problem wherever the strawberry aphid (*Chaetosiphon fragaefolii*) is present (Converse, 1987). Among the seven known aphid-transmitted viruses in strawberry, we reviewed the status of Strawberry mild yellow edge virus (SMYEV) and Strawberry crinkle virus (SCV).

Even if both viruses were only found in a limited number of locations, they seem to be established and particularly pose a risk in both field-grown and protected cultures of strawberry.

Modern strawberry cultivation has minimized the impact of nematode-borne viruses, but the reduced options in products for soil disinfestation may lead to the re-emergence of this group of viruses in the future.

There are five nematode-transmitted viruses found in the crop: Tomato ringspot (ToRSV), Strawberry latent ringspot (SLRSV), Arabis mosaic (ArMV), Raspberry ringspot (RpRSV) and Tomato black ring virus (TBRV). All are primarily found in Europe. During a two year survey for RpRSV and SLRSV, only a limited presence of the SLRSV was confirmed. The other nematode-transmitted viruses will be subject of another survey in the near future.

The fruit fly *D. suzukii* (EPPO A2 listed) was detected for the first time in Belgium in Ostend in 2011. This was the first record of the species occurring in temperate northwestern Europe. The results of the Belgian monitoring program in 2012 showed that *D. suzukii* is now present in both the northern and southern regions (Flanders and Wallonia) and in various cultures (sweet cherries, plums, strawberries, blueberries and raspberries).....

Finally, we also have to pay attention to other emerging (non-regulated) pathogens that have an impact on the quality of products, such as *Pilidium concavum*, a fungus causing tan-brown rot on strawberry fruits and for the first time put in evidence in strawberry transplants and production fields in Belgium in 2010.

Postharvest technology and quality

Chairman: Schenk A.

Oral Presentations

Keynote speaker: Bruno Mezzetti

Are there some strawberry more healthy than other, can we claim it?

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Nowadays strawberry is one of the most commercialized and appreciated fruit because of its attractiveness and the hedonistic pleasure that gives to the consumers but it is also one of the most investigated in relation of its nutritional and nutraceutical properties.

In fact, strawberry fruits are rich in bioactive compounds, such as phenolic acids, anthocyanin, vitamin C and possess high antioxidant capacity. The content of these compounds varies in function of the strawberry genotype, so all different cultivars produce fruit with different nutritional and nutraceutical value. Cultivation conditions also affect the content of fruit bioactive compounds, while specific cultivation systems can even enhance the content of the same compounds. The unawareness of the consumers towards the nutritional and nutraceutical attributes of strawberry fruit and of the importance of the cultivar still cause a low interest towards fruits characterized for their high health-related benefits. Moreover, also growers still don't recognize the benefits to grow new cultivars selected for their fruit health value. The availability of new varieties able to produce, at standardized cultivation techniques, fruits with high content of bioactive compounds inducing high benefits for the consumer is the first step to be achieved. Claims for high contents of some specific bioactive compounds (Vitamin C) have been accepted by EFSA for some products but not yet for strawberry.

Many studies are carried out also to demonstrate the effect of strawberry as, for example, "anti-cancer", "anti-ageing", "skin anti-ageing agent" and for CVD consumer protection.

The acceptance from EFSA of such claims for a fresh new strawberry probably still is quite difficult to be obtained but a proper integration of genetic, agronomic and biomedical researchers will bring important achievements to be taken in consideration for the release of new commercial products. Then the discussion will be if and how to claim and communicate such health benefits to the consumer.

Breeding of hypoallergenic strawberry fruit.

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Allergy to food is the hypersensitivity of the immune system when contacting to proteins or components in food. The incidence of food allergy continuously increases year by year particularly in industrial countries, and by now has become a serious problem worldwide. Food allergy is mainly treated by systematic medication or removal/avoidance of the causal food. Another promising solution for allergenic patients is the development of hypoallergenic food. Selection and breeding of low-allergenic variety is the conventional strategy to produce hypoallergenic food. The strawberry fruit allergens Fra a 1.01E, Fra a 1.02 and Fra a 1.03 are homologous of the major birch pollen allergen Bet v1. These allergens are known to have essential biological functions in pigment formation and ripening of strawberry fruits and seem to be responsible for allergic reactions to strawberry fruit.

We expressed the different Fra a allergens in host organisms and evaluated the cross allergenic potential of the proteins in birch pollen allergic patients by a basophil activation test. Anti-Fra a 1.02 antibodies were used to screen for allergen deficient strawberry lines.

Although Fra a 1.01E, Fra a 1.02 and Fra a 1.03 have sequence similarities of 70, 71 and 74% with Bet v 1, the basophil activation of birch pollen allergic patients differed substantially between these isoforms. Fra a 1.02 showed the highest allergenic potential of the three different Fra a isoforms. This underlies the fact that small changes in amino acid sequence can change orthologs in their allergenic characteristics. The data also support the role of the ripening-related expression of Fra a 1.02 as the major allergen for individuals affected by a strawberry allergy. Screening of a strawberry population with anti-Fra a 1.02 antibodies detected strawberry genotypes with significantly reduced levels of the allergen that might serve as starting material for the breeding of hypoallergenic strawberry varieties.

Towards an integrated platform for the objective measurement of strawberry quality.

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Strawberry (*Fragaria×ananassa Duch.*) is an important export product of Flanders. In spite of the importance of flavor and taste related aspects the players in the logistic chain mainly focus on visual quality aspects when judging the quality of incoming batches of fruit. Quality control of strawberry is very much limited to inspection by the human eye or taste bud which, by definition, are prone to subjective interpretation. To provide the market with fruit of consistent quality there is a need for objective tools to screen incoming fruit quality.

The aim of this work was to come to an integrated platform for the objective measurement of strawberry quality. Starting from the quality evaluation protocols currently in place at the auctions, procedures were standardized and objective measures were defined. Subsequently a versatile system was designed to replace the human eye and interpretation by a computerized vision system based on prevalent webcam technology. This vision system was aligned with the turntable of the Firmtech firmness measurement equipment (BioWorks Inc.) which enables the serial measurement of large amount of fruit.

This system can be complemented with NIR equipment to collect information on soluble solid content (brix) at the same time. This integrated setup allows for the efficient and objective measurement of a large number of visual strawberry quality attributes in conjunction with the two main taste related aspects of firmness and brix.

Analysis of IgE binding capacity and stress inducibility of strawberry allergen Fra a 1.

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Consumption of strawberries (*Fragaria × ananassa*) can cause oral allergy syndrome, primarily because of the presence of proteins such as Fra a 1, Fra a 2, Fra a 3 and Fra a 4, which cross-react to the birch pollen allergen Bet v 1. To produce strawberries with low allergen content, the expression profile of proteins with high immunoglobulin E (IgE) binding activity should be demonstrated. In this study, we compared allergenicity of Fra a proteins. Expression profile of Fra a1 were also investigated under stress condition and during fruit ripening.

His-tagged recombinant Fra a 1 proteins were purified and their reactivity to IgE from 6 birch pollen-allergic patients were analyzed by western blotting. Homology search was carried out on EST libraries of *F. vesca* produced under several stress conditions. Fruits (receptacles and achene) were harvested at seven different ripening stages. Salt stress treatment was performed soaking fruits in 150mM NaCl for 1h to 24h. Real-time PCR was carried out using primers to detect Fra a 1.

IgE binding capacity of Fra a 1 was higher than those of other isoforms, suggesting that Fra a1 plays an important role to determine the allergenicity of strawberry fruit. As a result of a survey of EST, Fra a 1 gene seemed to express higher than the other paralogs under salt stress. The transcript level of Fra a 1 was highest at the early stage of ripening and decreased with maturation progress to 1/70th at the red-colored stage, however, was induced again by 5 hours' treatment with salt stress. It indicates that allergenicity of strawberry can be affected by development and environmental stimulation.

Diversity of metabolite patterns and sensory characters in wild and cultivated strawberries.

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Introduction. The wild strawberry *Fragaria vesca* L. is the most widely distributed species of the genus *Fragaria* and appears circumpolar throughout Europe, northern America, and northern Asia. Its impressive diversity with four subspecies and different forma is believed as an adaptation to the different requirements of the ecosystems which were occupied by this strawberry species. In breeding programmes this diversity is used as donor for interesting sensory and resistance traits. Therefore, the patterns of volatile and non-volatile metabolites as well as sensory characters were estimated in comparison to some standard cultivars of *Fragaria ×ananassa* (Duch.).

Berries of sixteen accessions of *F. vesca* L. and six standard cultivars of *F. ×ananassa* were harvested during two seasons. Beside brix value and titratable acids the patterns of volatile organic compounds (VOC) were measured by headspace stir bar sorptive extraction GC (HS-SBSE-GC) from enzyme stabilized homogenates. Sensory characters were estimated with fresh fruits by a trained panel.

Using a non-targeted data processing approach around 200 conjoint peaks were detected in the yearly data set. By MS detection 67 compounds were identified and semi-quantified in both years. Regarding VOCs qualitative and quantitative differences up to a factor of 500 occur. The comparison of terpenoid and ester patterns give important insights to domestication and breeding effects regarding sensory characters as well as to the so-called funnel effect which is interpreted as a gain and loss of metabolites and their bio-functionality.

Posters

New strawberry advanced selection with improved nutritional quality: wild genotype influence.

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Strawberry nutritional quality is well known recognized of playing a main role in breeding programs. Indeed the choose of new genotypes with high nutritional standards has taking place as selection criteria. This is also confirmed by the high number of researches linked with strawberry bioactive compounds contents and their in vivo effects. Most researches focused their attention on antioxidant capacity, phenols and anthocyanin content, furthermore their vitamins content. With the aim to improve strawberry nutritional quality, advanced selections generated by consecutive inter specific back crossing of *F. virginiana* ssp. *glauca* X *F. x ananassa* have been evaluated either for agronomic, sensorial and nutritional attributes.

Strawberry fruit agronomic, sensorial and nutritional quality generated by *Fragaria* inter and intra-specific crosses was evaluated on 29 advanced selections derived from 8 families: two originating from *F. x ananassa* intra specific; three from back crossing of BC1 – FVG x *F. x ananassa*; three from back crossing of BC2 – FVG x *F. x ananassa*. Selections and their respective parents has been evaluated for fruit weight, commercial yield, acidity and sugar content, antioxidant capacity, phenol and anthocyanin content, folate and ascorbic acid content.

The advanced selections evaluated in this research have shown substantial improvement either for agronomic than for quality parameters, both sensorial and nutritional parameters. The influence of wild genotypes in their genetic background confirm the importance of germplasm resources to produce new genotypes with wider genetic background and enhanced quality.

Comparison of transcript and protein levels of strawberry allergen Fra a 1 among different cultivars.

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Fruit allergies are a serious health problem that limits the quality of life. In patients with a fruit allergy, the symptoms are generally mild and mostly limited to the oral cavity, thus the term so-called oral allergy syndrome. It is essential to develop a method for screening hypoallergenic genotypes in strawberry. A major strawberry allergen of strawberry is Fra a 1, which is an orthologous protein to the major birch pollen allergen Bet v 1. In this study, Fra a 1 transcript and protein levels were compared among some strawberry cultivars.

Strawberry fruits (receptacles and achene) of eleven different cultivars were purchased from local markets, or harvested directly from a working or an experimental farm. Real-time PCR and immunoblot were performed to analyze transcript and protein levels, respectively. Strawberry cultivars were selected to obtain fruits under the same growth condition in a glass greenhouse. Seedlings were transplanted into pots filled with palm peat and grown hydroponically with nutrient solution.

The eleven strawberry cultivars were screened and ranked by relative expression ratio of Fra a 1 to EF1 α as internal control. Accumulation of protein was compared among these cultivars by immunoblot using guinea pig polyclonal antibody raised against His-tagged recombinant Fra a 1. The cultivars 'Tohchiotome' and 'Akihime' were selected for further analysis since they showed significantly different expression of Fra a 1 gene. Both cultivars were grown in the same condition and showed a same rank order in both Fra a 1 transcript and protein levels. These results suggest that gene expression can be utilized for basic estimation of allergenic differences among different cultivars.

What determines consumers' liking of strawberries.

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In het evaluation of new strawberry varieties the consumer plays an important role. New strawberry varieties have to meet the needs and expectations of consumers to be successful on the market. But which attributes of strawberries are important to consumers?

In 2010, 2011 and 2012 we performed several consumers tests on established and new strawberry varieties. Consumers (n = 63 to 302 depending on the test) evaluated general acceptance on a 9-point hedonic scale together with more specific sensory attributes such as appearance, odour, taste and texture. The results of these studies were statistically analysed by analysis of variance (ANOVA), principal component analysis (PCA), Pearson correlation analysis and/or penalty analysis.

General acceptance of strawberries, how tasty strawberries are for consumers, seems to be strongly correlated with taste intensity, sweetness and appreciation of the odour of the fruits. Other attributes seem to be less important. By penalty analysis it became clear that especially sweet- and sourness, but also juiciness and firmness to a lesser extent have an important effect on the general acceptance scores of strawberries. These scores significantly drop when the fruits are perceived as too little sweet. Preference scores also drop with almost 2 points when the fruits are perceived as too little sour or as too sour.

Using this knowledge in combination with instrumental and analytical sensory data will facilitate the selection of promising new strawberry cultivars.

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Strawberry Supply Chain in Germany.

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This contribution to the Congress will show first results of an analysis of the market situation for fresh strawberries in Germany. With more than 80 million consumers, Germany is one of the major business markets for berries in Europe. This task is an integral part of the economic work package of the European project EUBerry. The aim of this subproject is to provide detailed knowledge about market structures and market behaviour in the fresh berry business in order to find important key factors to be integrated into marketing strategies of sustainable berries validated for improved health benefits.

The analysis is based on desk research among available statistics as well as on guideline interviews carried out with experts along the supply chain in August and November 2012. The guideline included aspects about available volumes and prices, seasonality of domestic production and imported strawberries, cooling, market preparation and packaging, exchange of market information and future prospects.

Based on the desk research, selected structural elements of the fresh strawberry market will be depicted. Derived from expert interviews, a draft of the national fresh strawberry supply chain will be constructed.



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