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Grafting suitability of Sicilian eggplant ecotypes onto *Solanum torvum*: Fruit composition, production and phenology

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Abstract

The eggplant (*Solanum melongena* L.) is one of the most widely cultivated crops in tropical and temperate regions around the world and is suitable for propagation through grafting. In many parts of the world, grafting is a routine technique used in continuous cropping systems, because in the horticulture field is a sustainable technique that allows cultivators to overcome abiotic or biotic stress. The objective of this research was to evaluate the suitability at the grafting of four Sicilian eggplant ecotypes grown in open field in Sicily, Italy. Vegetables in general are a great source of minerals in the human diet and the eggplant (*Solanum melongena* L.) provides significant quantities of various minerals, among which are P, K, Ca and Mg. The study demonstrated that grafting increased marketable yield. Furthermore, grafting has increased the amount of Ca, Fe, Zn and Cu in the fruit, while reducing the amount of Na, Mg and Mn. This variation is of significant interest, as lower levels of Na and Mn favour a reduction in hypertension and help keep blood pressure under control. Grafted plant height after 35 days is positively correlated with the average number of marketable fruits per plant (r = 0.607) and percentage of discard production (r = 0.583). Furthermore, after 35 days, the non-grafted plant's height was also negatively correlated with the total average production (r = -0.528), the average marketable production (r = -0.558), and the average weight of marketable fruits (r = -0.815).

This research confirmed that *Solanum torvum* selection Australys rootstock gave Sicilian eggplant ecotypes increased vigor in the initial 35 days from planting, increased yields while increasing the number of marketable fruit, and creating fruit with more healthful qualities.

Key words: Grafting, ecotype, eggplant, *Solanum torvum*, minerals.

Introduction

Vegetables in general are a great source of minerals in the human diet [3, 32] and the eggplant (*Solanum melongena* L.) provides significant quantities of various minerals, among which are P, K, Ca and Mg [10, 34]. The quantities in which they are found is highly dependent upon cultivation technique [12, 33, 34]. It has been shown that fertigation affects the mineral composition of the fruit [33], as does the saline level of the water used in cultivation [34].

The eggplant (*Solanum melongena* L.) is one of the most widely cultivated crops in tropical and temperate regions around the world and is suitable for propagation through grafting [1, 7]. A lack of genetic material tolerant or resistant to abiotic or biotic stress together with a ban on soil sterilization using methyl bromide has led to increased interest worldwide in the technique of grafting in vegetable species [2, 8, 9, 17, 24].

Solanum torvum Sw. is considered one of the most suitable rootstocks for the eggplant, providing resistance to a large number of soil pathogens (*Verticillium dahliae* Klebahn, *Ralstonia solanacearum* (Smith) Yabuuchi *et al.* [38], *Fusarium oxysporum* (Schlechtend:Fr.) f. sp. *melongenae* Matuo and Ishigami, and *Meloidogyne* spp. root-knot nematodes [1, 7, 37, 18].

As mentioned above, it is possible to cultivate high quality genetic material of eggplant, such as local populations, even if susceptible to soil pathogens, by grafting onto tolerant or resistant rootstocks [5], such as *Solanum torvum* Sw. The use of ecotypes has always been dependent upon their ability to adapt to the environment of origin thanks to their distinct genetic characteristics.

The selection process, used by farmers over the years in order to increase yields or other useful characteristics by using mass selection and without any attempt to control fertilization, has led to the preservation of a large part of the biodiversity [36]. This has also preserved intraspecific variability, providing genotypes which are suited to the growth environment and possibly resistant to environmental stress, plant diseases and with improved qualitative and organoleptic properties [35].

An important aspect, which is often overlooked, concerning the technique of grafting, relates to differences in the quality of the fruits produced from grafted or non-grafted plants [8], that frequently change due to genotype [25]. In the case of ecotypes, as they are high-quality genetic materials, this aspect is of even greater importance.

Some studies reported positive effects on the quality of the fruit from grafting, such as with mini-watermelons (*Citrullus lanatus* (Thunb.) Matsum. and Nakai) from plants grafted onto intraspecific hybrids of *Cucurbita moschata* Poir. x *Cucurbita maxima* Duch, which showed higher levels of K, Mg, lycopene and vitamin C compared to the control group [30].

However, negative effects were obtained from grafting tomato plants onto *Solanum integrifolium,* which gave an extremely high incidence of fruits affected by rot [27]. In the case of eggplant grafted, for example, onto *Datura inoxia* P. Mill., grafting caused levels of atropine and scopolamine which were high enough to cause poisoning [29].

The aim of this study was to look at aspects regarding the quality of the fruit, production and phenology of four Sicilian eggplant ecotypes grafted onto *Solanum torvum* Sw. Ecotypes that are distinguished by their morphological and agronomical characteristics are very different [6].

Materials and Methods

Plant material: The plant material used in this study comprised 4 ecotypes found in Sicily in the provinces of Palermo, Trapani and Agrigento, which exhibited very different morphological characteristics (Table 1).

For the production of plant material for the tests, on the 20th February 2011, seeds for the rootstock (*S. torvum* Sw.) were planted in 44-cell seedling trays at a density of one seed per cell in order to calculate the germination rate, under a temperature regime of 25 °C/18 °C (day/night) in a propagation greenhouse. After 20 days, seeds from the 4 ecotypes were planted in 100-cell trays and given the same temperature regime and planting method as the rootstock.

Seventy-five days after planting the *S. torvum* Sw., both the rootstock and scion had reached an adequate diameter to allow for grafting. The grafting involved cutting off the rootstock at a 45° angle and making a similar cut on the scion. Care was taken to be sure that the diameters of the rootstock/scion were nearly identical so that the two exchange sites fitted perfectly. Grafting was completed by attaching a clip to ensure the correct fit and the correct amount of pressure was applied. The grafted plants were kept at a temperature of 20°C and a humidity rate of 95% for 10 days in order to encourage histological processes.The substrate used contained peat moss Thechinic (Dueemme marketing s.r.l.).

Setting up and managing the test trial area: The test trials for the evaluation of grafting on the ecotypes in the study started on 15th May 2011 at the experimental fields of the Department Agricultural Science and Forestry in Palermo.

For all of the ecotypes, both grafted and non-grafted, 3 replication of 10 plants were used in a randomized block design. The plants were placed in soils classified as Alfisols "Red Mediterraenan soils".

A good seedling bed was prepared by carrying out medium-depth ploughing (35 cm) and de-clodding of soil clumps using a rotary harrow. Aged manure was added as a soil amendment at a rate of 40 t ha^{-1}. A drip irrigation system was installed under a 20 μm black PE film.

A planting distance of 0.5 m and an inter-row distance of 1 m were adopted, thereby obtaining a density of 2 plants/m^2. A type of free cultivation technique was used, and pruning and de-leafing took place only when required. On the grafted plants, the shoots coming from the rootstock were eliminated.

The number of fertilizing units used for fertigation was calculated on the basis of hypothetical uptake (Kg t^{-1}), expected yields and soil mineral content [19] , and was as follows: N 250, P_2O_5 150 and K_2O 250 kg ha^{-1}. Six manual harvests were carried out as soon as the berries reached commercial ripening.

Morphological, production and phenological data collection: Morphological data were collected on plant height 35 and 60 days from planting, and leaf number 35 days after planting. Production data included average total yield/plant, average marketable yield/plant, average number of marketable fruits/plant, average marketable fruit weight and percentage of discarded fruits. The length of the different phenophases was also recorded.

Sampling: Sampling for the quality analysis of the fruits was carried out using 3-5 commercially ripe fruits for each replication from the 2nd and 3rd harvests; only healthy fruits were chosen. Care was taken to ensure that each sample contained the same percentage weight of apical, middle and distal parts of the fruit.

Quantative analysis of the fruit: The water content was determined in a ponderable way and the ash content was determined on a 5 g sample rate. The eggplant sample was weighed in a platinum capsule, calibrated at 550°C and heated to 150°C for 6-8 h. The sample was subsequently incinerated on a flame and then in a muffle furnace at 550°C for 6-8 h. The ash content was obtained by quantitative determination of the residual product. The water content was obtained, in ponderable way, through the dehydration of the sample, in the presence of sand, in a heater at 105°C per 6-8 h. Protein determination was obtained following the Kjeldal method. A sample rate was subjected to acid-catalyzed mineralization in order to turn the organic nitrogen into ammoniacal nitrogen, which was distilled in an alkaline pH. The ammonia formed during this distillation was collected in a boric acid solution and determined through titrimetic dosage. The value of ammoniacal nitrogen was multiplied by 6.25.

The ash, water and protein contents were analysed according to standard official analytical methods [13, 16]. Ca, Mg, Na, K, Fe, Mn, Z and Cu were determined using atomic absorption spectroscopy following wet mineralization [26]. Phosphorus levels were determined using colorimetry [11].

Statistical analysis: Data for each of the characteristics being evaluated were subjected to one-way analysis of the variance (ANOVA). Before each elaboration, all the percentage values were subjected to angular transformation ($\Phi = \arcsin(p/100)^{1/2}$).

Furthermore, in order to evaluate the average effect of the

Table 1. Origin and brief morphological description of the ecotypes in the study.

Ecotypes	Geographical Coordinates	Shape of fruit	Colour of fruit	Intensity of fruit colour	Ribbing	Blotching
B1	38°4'49''44N 38°30'36''72 E	Ovoid	White	-	Weak	Absent
B2	37°30'33'48N 13°5'20''04E	Pear-shaped	Purple	Very dark	Weak	Absent
B3	37°49'20''28N 12°29'28''80E	Globular	Purple	Medium	Medium	Present
B4	37°39'54''72N 12°35'20''04E	Cylindrical	Purple	Very dark	Absent	Absent

Solanum torvum Sw. Australys selection, (Agri Seeds s.r.l.) was used as a rootstock.

grafting on the characteristics recorded, orthogonal comparisons were made between the ecotypes which were grafted *versus* non-grafted. Linear correlations were also carried out to perform pairwise comparisons of some characters.

Results and Discussion

Seed germination and graft-take: All the ecotypes reached a germination rate of over 95% (Table 2), whereas the average results for *S. torvum* were around 85%. Graft-take was 100% for all ecotypes.

Table 2. Percentage of seed germination in 4 eggplant ecotypes.

Ecotypes	Germination (%)
B1	98 ns
B2	99.5 ns
B3	97.67 ns
B4	98.33 ns

Figures followed by the same letter were found to be not statistically different, based on the Duncan test (P≤0.05).

Morphological, production and phenological data: Grafting in eggplants is a propagation method which aims to increase water and nutrient uptake to the plant [31]. In our case, 35 days after planting, the grafted plants were more developed; in particular grafted ecotype B4 was found to have a statistically greater height than all the others. However, it is also worth noting that the same observation made after 60 days gave differences that were not found to be statistically different between the different propagation techniques, although B4 continued to have the greater height. Significant differences were found regarding leaf number 35 days after planting; ecotype B4, both grafted and non-grafted, was found to be the greatest for this characteristic, too. The lowest leaf number at this stage of the biological cycle was found for ecotypes B2 and B3, both grafted and non-grafted, compared to ecotype B4 grafted and not. Grafting did not influence this characteristic (Table 3).

As regards productivity, the most productive ecotype was B1 which, both grafted and non-grafted, gave significantly higher yields than B4 grafted and non-grafted (which gave the lowest yields). The ecotypes behaved in the same way for both total and marketable yield. Grafting significantly increased marketable yield but it did not affect the percentage of discarded fruit.

The largest average number of fruits per plant was produced by the ecotype B4 both grafted and non-grafted, whilst statistically significant differences were not found between the other ecotypes. It is also worth noting the fact that, concerning all the above mentioned production characteristics, grafting was found to be a useful technique for increasing the production potential [4]. As regards the average fruit weight, ecotype B4, both grafted and non-grafted, produced fruits which weighed least.

Excellent results were obtained with ecotype B2 concerning the percentage of discarded fruits, although a comparison of both grafted and non-grafted ecotypes did not produce any significant differences. This shows that the greatest production potential of the ecotypes in the study was given by a greater number of marketable fruits, meaning also that the increment of production potential mainly concerned the marketable fruits (Table 4).

Data on the berry dry matter and that of the plant at the end of the production cycle (Table 5) were of great interest. The berry dry matter produced by the grafted plants was higher, whilst the plant dry matter of the grafted plants at the end of the production cycle was lower, even though the grafted plants were taller 35 days after planting. The explanation for this may be due to the fact that the greater nutrient and water uptake by the grafted plants during the initial stage of the biological cycle were used for the vegetative activity of the plant, whereas, when the reproductive phase started, nutrients and water were channelled towards the strongest sink - the fruit. This hypothesis seems to be confirmed by the fact that production on the grafted plants was higher and the plant, at the end of the production cycle, was more exhausted and had a lower level of dry matter compared to the non-grafted plants, at least under the growth conditions of this study. Furthermore, ecotype B4 reached the flowering stage approx. 7 days before the others (Table 6). It is worth noting that grafting did not determine any changes in the length of the various phenophases.

Table 3. Morphological data on 4 eggplant ecotypes grafted and non-grafted.

	H 35 days	H 60 days	Leaf no. at 35 days
B1 grafted	62.80 abc	107.53 ns	38.37 bc
B1 non grafted	58.87 abc	109.53 ns	41.00 abc
B2 grafted	58.00 abc	110.40 ns	29.40 c
B2 non grafted	56.67 bc	101.47 ns	29.73 c
B3 grafted	61.13 abc	106.87 ns	30.53 c
B3 non grafted	56.60 c	105.73 ns	34.67 c
B4 grafted	67.07 a	115.27 ns	53.47 a
B4 non grafted	65.50 ab	108.40 ns	51.30 ab
Grafted vs non grafted	*	ns	ns

In each column, figures followed by the same letter are not statistically different, based on the Duncan test (P≤0.05). Significance of orthogonal comparison between grafted *vs* non grafted accessions is reported.

Table 4. Production data on 4 eggplant ecotypes grafted and non-grafted.

	Average total production/plant (kg)	Average marketable production/plant (kg)	Average number marketable fruits/plant (n)	Average Weight marketable Fruits (g)	Discarded production (%)
B1 grafted	5.18 a	4.38 a	7.61 b	684.33 a	15.50 b
B1 non grafted	4.26 ab	3.62 ab	6.51 b	667.67 a	14.93 b
B2 grafted	4.12 abc	3.79 ab	8.57 b	543.00 a	8.10 c
B2 non grafted	3.77 abc	3.48 abc	6.96 b	487.00 a	7.67 c
B3 grafted	3.38 bcd	2.81 bcd	5.64 b	639.00 a	16.93 ab
B3 non grafted	3.06 bcd	2.57 bcd	4.79 b	608.33 a	16.03 ab
B4 grafted	2.77 cd	2.27 cd	16.34 a	170.33 b	18.00 a
B4 non grafted	2.23 d	1.82 c	14.00 a	160.67 b	18.37 a
Grafted vs non grafted	*	*	*	ns	ns

In each column, figures followed by the same letter are not statistically different, based on the Duncan test (P≤0.05). Significance of orthogonal comparison between grafted *vs* non-grafted accessions is reported.

Table 5. Phenogram of 4 eggplant ecotypes grafted and non-grafted.

	Date plant	Date flower	Date harvest
B1 grafted	05-15-2011	06-20-2011	09-30-2011
B1 non grafted	05-15-2011	06-20-2011	09-30-2011
B2 grafted	05-15-2011	06-20-2011	09-30-2011
B2 non grafted	05-15-2011	06-20-2011	09-30-2011
B3 grafted	05-15-2011	06-20-2011	09-30-2011
B3 non grafted	05-15-2011	06-20-2011	09-30-2011
B4 grafted	05-15-2011	06-13-2011	09-30-2011
B4 non grafted	05-15-2011	06-13-2011	09-30-2011

Table 5. Composition and mineral content of 4 eggplant ecotypes grafted and non-grafted.

	Proteins (g/100g)	K (mg/100g)	Na (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	P (mg/100g)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Ceneri (g/100g)	Soluble solids (Brix°)	DM berries (%)	DM plant (%)
B1 grafted	13.33 ab	307.38 ab	71.21 bc	107.04 b	16.84 b	340.59 b	38.17 a	40.33 b	3.70 ab	4.79 ab	8.43 a	4.46 bcd	6.21 b	2.62 bcd
B1 non grafted	12.71 ab	341.47 ab	78.14 ab	103.72 b	19.70 b	387.06 ab	29.20 c	32.93 c	2.26 b	7.03 a	7.95 ab	4.01 d	4.99 e	3.41 ab
B2 grafted	13.73 a	332.14 ab	74.73 abc	105.17 b	16.54 b	369.41 b	30.80 bc	40.83 b	3.83 ab	5.93 ab	8.27 ab	4.10 cd	7.81 a	2.31 d
B2 non grafted	13.52 a	350.71 a	81.35 ab	105.14 b	18.64 b	392.43 a	28.97 c	39.60 bc	2.33 b	6.00 a	7.94 ab	4.27 bcd	5.41 d	2.57 cd
B3 grafted	12.46 b	291.43 b	64.39 c	101.26 b	19.05 b	366.72 b	36.63 ab	48.37 a	2.60 b	2.60 b	7.12 ab	4.82 bc	5.66 cd	3.21 abc
B3 non grafted	12.17 b	321.52 ab	65.92 c	100.43 b	19.69 b	391.49 a	35.77 ab	39.73 bc	2.00 b	5.33 ab	7.01 b	5.83 a	5.50 d	3.47 a
B4 grafted	12.54 b	305.63 ab	80.09 ab	143.06 a	16.69 b	359.67 b	38.23 a	40.50 b	5.23 a	3.30 ab	8.04 ab	4.93 b	7.65 a	3.34 abc
B4 non grafted	12.15 b	346.47 ab	84.38 a	103.42 b	25.70 a	378.00 ab	34.93 abc	35.60 bc	3.30 ab	5.30 ab	7.81 ab	4.11 cd	6.10 bc	3.85 a
Grafted vs non grafted	*	ns	**	***	**	ns	***	**	*	**	ns	ns	*	***

In each column, figures followed by the same letter are not statistically different, based on the Duncan test ($P \leq 0.05$). Significance of orthogonal comparison between grafted *vs* non grafted accessions is reported.

Qualitative analysis of the fruit: Based on analysis carried out regarding the metal content in the fruit, grafting did, indeed, seem to have an effect both on the macro- and microelement contents (Table 5).

This is in agreement with previous studies which claimed that grafting can affect the quality of the final product [22]. Grafting onto *Solanum torvum* was found to lead to an increase in the contents of protein and some macronutrients, such as K and Ca, but also microelements, such as Fe, Zn and Cu. Furthermore, evaluation of the berries from the grafted plants showed lower levels of Na, P, Mg and Mn compared to the fruits from the plants propagated by seed. Of the ecotypes in the study, ecotype B2 was found to have the highest protein levels.

As regards Ca, ecotype B4 when grafted produced the highest levels, showing that this technique greatly affects the content of this element in the berries. The P content, however, in grafted plants was lower, although the differences with fruits from seed propagated plants were not significantly different. In any case, the ratio Ca/P for all of the ecotypes was well below 1, which is the value considered to be optimal for a good uptake of both elements[23].

A marked difference concerning the micronutrient Cu content was between fruit from the grafted and the non-grafted plants. The highest content was found in ecotype B4 with an increase of 63.1% in the same ecotype which had been grafted. This is confirmed by other authors who evaluated the presence of metals in the berries of eggplant varieties with purple, green and white epicarps [10].

The ash content was also affected by the propagation method, found to be slightly higher in the berries of the grafted plants. The soluble solids content was found to be highest in ecotype B3 non-grafted, although grafting was not found to affect this parameter. The results of this study would seem to agree with literature where, in some cases, fruit quality is negatively affected by grafting [20, 28] and, in other cases, it improves the characteristics of the fruit [1].

Correlations: Correlations between plant height 35 days from planting and production data (Table 7), in the case of non-grafted plants, were found to be negative for total average yield per plant, average marketable yield per plant and average weight of marketable fruits. Positive correlations were found, however, between plant height after 35 days and the number of marketable fruits, as were found between plant height after 35 days and the percentage of discarded fruits. This means that, in the non-grafted plants, greater plant vigour is to the detriment of yields, which were found to be lower.

The plants propagated using grafting behaved very differently;

plant height after 35 days was positively correlated only with the number of marketable fruits produced on average per plant and the percentage of discarded yield. This means that greater plant height in this production phase leads to greater production potential, although in part due to an increase in the production of non-marketable fruits.

Other correlations concerned the plant dry matter at the end of the production cycle and production data (Table 7). From these analyses, the non-grafted plant dry matter resulted as being negatively correlated to the average production of marketable fruit per plant and positively correlated to the percentage of discarded fruits.

We might deduce from these results that when seed propagated plants accumulate nutrients in the vegetative parts, a smaller quantity of marketable fruits are produced, due to an increase in the discarded fruit production.

Two negative correlations were found on the grafted plants between the plant dry matter at the end of the production cycle and both the average total yield per plant and the average marketable yield per plant. This may be explained if we refer back to the source-sink theory, or rather, that within the plant there is a hierarchy for the translocation of assimilates as follows [21] : seeds > fleshy parts of fruit = apical shoots and leaves > cambium > roots > reserves. Therefore, the greater production potential of the grafted plants, in this case, determine an impoverishing effect on the plant.

Regarding the correlations protein/metals and protein/ash (Table 8), fruits from non-grafted plants did not produce any significant correlations, whereas fruits from grafted plants produced two negative correlations between protein and P, and protein and Fe. As far as fruit yields from non-grafted plants are concerned, correlation analysis between berry dry matter (DM of berries) and metals, and berry dry matter and ash produced a positive correlation between DM of berries and K, whereas, as regards fruits from grafted plants, DM of berries was positively correlated to Ca, Na, Fe and Cu, and negatively to Zn.

Conclusions

Results from this study highlighted the importance of grafting in the exploitation of local eggplant populations. Genetic material from these populations, as it is, although having excellent organoleptic qualities, does not represent a realistic alternative to the hybrids used commercially today. In addition, the research showed that some metals, such as Na and Mn, fell in level in the fruits from grafted plants. This variation could be of significant interest as lower levels favour a reduction in hypertension and help keep blood pressure under control.

Ecotypes in the study may represent a good source of biodiversity for breeding programmes for the improvement of fruit quality.

In conclusion, this research confirmed that the rootstock used gives the ecotypes in the study greater vigour in the initial 35 days from planting, an increase in production due to the greater number of marketable fruits and more wholesome fruit.

Table 7. Linear correlations between morpho-physiological characteristics and production characteristics.

		Average total production/plant	Average marketable production/plant	Average number marketable fruits/plant	Average Weight marketable Fruits	Discarded production
Non grafted	H 35 days	-0.528*	-0.558*	0.829 **	-0.815**	0.510 *
Grafted		-0.298 n.s.	-0.374 n.s.	0.607 *	-0.462 n.s.	0.583 *
Non grafted	DM plant	-0.444 n.s.	-0.531 *	0.211 n.s.	-0.280 n.s.	0.755 **
Grafted		-0.671 *	-0.670 *	0.080 n.s.	-0.251 n.s.	0.283 n.s.

ns, *, **, *** indicate non-significant, or significant at P = 0.05, = 0.01 and = 0.001, respectively.

Table 8. Linear correlations between proteins and dry berry matter with metals and ash.

		Proteins	P	K	Ca	Na	Mg	Fe	Zn	Cu	Mn	Ash
Non grafted	Proteins		0.401 n.s.	0.001 n.s.	0.370 n.s.	-0.006 n.s.	-0.38 n.s.	-0.270 n.s.	-0.394 n.s.	-0.234 n.s.	-0.203 n.s.	0.495 n.s.
Grafted			-0.600*	0.340 n.s.	-0.285 n.s.	0.107 n.s.	-0.031 n.s.	-0.520*	-0.228 n.s.	-0.335 n.s.	0.379 n.s.	0.399 n.s.
Non grafted	DM. berries	0.408 n.s.	0.215 n.s.	0.657*	0.06 n.s.	0.,384 n.s.	-0.333 n.s.	-0.270 n.s.	0.493 n.s.	-0.347 n.s.	-0.180 n.s.	0.227 n.s.
Grafted		-0.344 n.s.	-0.263 n.s.	0.426 n.s.	0.920**	0.579*	-0.434 n.s.	0.569*	-0.657*	0.593*	-0.312 n.s.	0.259 n.s.

ns, *, **, *** indicate non-significant, or significant at P = 0.05, = 0.01 and = 0.001, respectively.

References

[1]Bletsos, F., Thanassoulopoulos, C. and Roupakias, D. 2003. Effect of grafting on growth, yield and Verticillium wilt of eggplant. HortScience **38**:183-186.

[2]Bletsos, F. A., 2005. Use of grafting and calcium cyanamide as alternatives to methyl bromide soil fumigation and their effects on growth, yield, quality and Fusarium wilt control in melon. J. Phytopathol. **153**:155-161.

[3]Cao G., Sofic, E. and Prior, R. L. 1996. Antioxidant capacity of tea and common vegetables. Journal of Agricultural and Food Chemistry **44**:3426-3431.

[4]Colla, G., Rouphael, Y., Cardarelli, M. and Rea, E. 2006. Effect of salinity on yield, fruit quality, leaf gas exchange, and mineral composition of grafted watermelon plants. HortSci. **41**:622-627.

[5]Colla, G., Cardarelli, M. and Leonardi, C. 2010. L'innesto erbaceo in orticoltura: potenzialità e prospettive. Italus Hortus **17**:9-14 (in Italian).

[6]D'Anna, F. and Sabatino, L. 2013. Morphological and agronomical characterization of eggplant genetic resources from the Sicily area. Journal of Food, Agriculture and Environment. Journal of Food, Agriculture & Environment **11**(1):401-404.

[7]Daunay, M. C. 2008. Eggplant. In Prohens, J. and Nuez, F. (eds). Handbook of Plant Breeding: Vegetables II. Springer, New York, USA, pp. 163-220.

[8]Davis, A. R., Perkins-Veazie, P., Hassell, R., Levi, A., King, S. R. and Zhang, X. P. 2008a. Grafting effects on vegetable quality. HortScience **43**:1670-1672.

[9]Davis, A. R., Perkins-Veazie, P., Sakata, Y., López-Galarza, S., Maroto, J. V., Lee, S. G., Huh, Y. C., Sun, Z., Miguel, A., King, S., Cohen, R. and Lee, J. M. 2008b. Cucurbit grafting. Crit. Rev. Plant Sci. **27**:50-74.

[10]Flick, G. J., Burnette, F. S., Aung, L. H., Ory, R. L. and St. Angelo, A. 1978. Chemical composition and biochemical properties of mirlitons (*Sechium edule*) and purple, green, and white eggplants (*Solanum melongena*). Journal of Agricultural and Food Chemistry **26**:1000-1005.

[11]Fogg, D. N. and Wilkinson, N. T. 1958. The colorimetric determination of phosphorus. The Analist **83**:406-414.

[12]Hanson, P. M., Yang, R. Y., Tsou, S. C. S., Ledesma, D., Engle, L. and Lee, T. C. 2006. Diversity in eggplant (*Solanum melongena*) for superoxide scavenging activity, total phenolics, and ascorbic acid. Journal of Food Composition and Analysis **19**:594-600.

[13]International Official Methods of Analysis (AOAC) 1985a, 1985b, 1985c, pp. 30-35.

[14]International Official Methods of Analysis (AOAC) 22.026, 1985a, 22, 362.

[15]International Official Methods of Analysis (AOAC) 3.140, 1985b, 3, 50.

[16]International Official Methods of Analysis (AOAC) 14.018, 1985c, 3, 69, pp. 60-62.

[17]King, S. R., Davis, A. R., Liu, W. and Levi, A. 2008. Grafting for disease resistance. HortScience **43**:1673-1676.

[18]King, S. R., Davis, A. R., Zhang, X. and Crosby, K. 2010. Genetics, breeding and selection of rootstocks for Solanaceae and Cucurbitaceae. Sci. Hortic. **127**:106-111.

[19]La Malfa, G. 1990. Scienza e tecniche delle produzioni vegetali. Orticoltura. Pátron, Italy, pp. 793-811 (in Italian).

[20]Lee, J. M. 1994. Cultivation of grafted vegetables I: Current status, grafting methods and benefits. HortScience **29**:235-239.

[21]Wardlaw, I. F. 1990. The control of carbon partitioning in plants. New Phytologist **27**:341-381.

[22]Lee, J. M. and Oda, M. 2003. Grafting of herbaceous vegetable and ornamental crops. Hort. Rev. **28**:61-124.

[23]McDowell, L. R., 2003. Minerals in Animal and Human Nutrition. Elsevier Science Health Sciences, Amsterdam, The Netherlands, 644 p.

[24]Miguel, A., Maroto, J. V., San Bautista, A., Baixauli, C., Cebolla, V., Pascual, B., López, S. and Guardiola, J. L. 2004. The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of Fusarium wilt. Sci. Hortic. **103**:9-17.

[25]Moncada, A., Miceli, A., Vetrano, F., Mineo, V., Planeta, D. and D'Anna, F. 2013. Effect of grafting on yield and quality of eggplant (*Solanum melongena* L.). Sci. Hortic. **149**:108-114.

[26]Morand, P. and Gullo, J. L. 1970. Mineralisation des tissus vegetaux en vue du dosage de P, Ca, Mg, Na, K. Ann.Agron. **21**(2):229-236 (in French).

[27]Oda, M., Nagata, M., Tsuji, K. and Sasaki, H. 1996. Effects of Scarlet eggplant rootstock on growth, yield, and sugar content of grafted tomato fruits. J. Jpn. Soc. Hortic. Sci. **65**:531-536.

[28]Nisini, P., Colla, G., Granati, E., Temperini, O., Crino, P. and Saccardo, F. 2002. Rootstock resistance to Fusarium wilt and effect on fruit yield and quality of two muskmelon cultivars. Scientia Horticulturae **93**:281-288.

[29]Oshiro, N., Kuniyoshi, K., Nakamura, A., Araki, Y., Tamanaha, K. and Inafuku, Y. 2008. A case of food poisoning due to ingestion of eggplant, *Solanum melongena*, grafted on devils trumpet, *Datura metel*. Shokuhin Eiseigaku Zasshi **49**:376-379 (in Japanese).

[30]Proietti, S., Rouphael, Y., Colla, G., Cardrelli, M., de Agazio, M., Zacchini, M., Rea, E., Moscatello, S. and Battistelli, A. 2008. Fruit quality of mini-watermelon as affected by grafting and irrigation regimes. J. Sci. Food. Agric. **88**:1107-1114.

[31]Rouphael, Y., Cardarelli, M. and Colla, G. 2008. Grafting of cucumber as a means to minimize copper toxicity. Environ. Exp. Bot. **63**:49-58.

[32]Rubatzky, V. E. and Yamaguchi, M. 1997. World Vegetables: Principles, Production and Nutritive Values. Chapman & Hall, New York, USA, 431 p.

[33]Russo, V. M. 1996. Cultural methods and mineral content of eggplant (*Solanum melongena*) fruit. Journal of the Science of Food and Agriculture **71**:119-123.

[34]Savvas, D. and Lenz, F. 1996. Influence of NaCl concentration in the nutrient solution on mineral composition of eggplants grown in sand culture. Angewandte Botanik **70**:124-127.

[35]Schiavi, M., Masera, R., Lorenzoni, C. and Soressi G. P. 1991. Metodi utilizzati per il miglioramento genetico della Dorata di Parma. Agricoltura Ricerca no. 82. Ismea. Roma, pp. 21-30 (in Italian).

[36]Schippmann, U., Leaman, D. J. and Cunningham, A. B. 2002. Impact of Cultivation and Gathering of Medicinal Plants on Biodiversity:Global Trends and Issues. Biodiversity and the Ecosystem Approach in Agriculture, Foresty and Fisheries, FAO, Rome, 21 p.

[37]Singh, P. K. and Gopalakrishnan, T. R., 1997. Grafting for wilt resistance and productivity in brinjal (*Solanum melongena* L.). Hortic. J. **10**:57-61.

[38]King, S. R., Davis, A. R., Liu, W. and Levi, A. 2008. Grafting for disease resistance. HortScience **43**(6) 1673-1676.