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Evaluation of rootstocks for watermelon grafting with reference to plant development, yield and fruit quality

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Abstract

The effect of grafting and post-grafting temperature on the plant development of two watermelon cultivars at transplantation and on subsequent fruit quality was studied. Watermelon cv. Sugar Baby and Crimson Sweet were self-rooted or grafted onto rootstock RS 841 F_1 (*Cucurbita maxima* × *C. moschata*) or bottle-gourd [*Lagenaria siceraria* f. *clavata*] (year 1), plus *L. siceraria* f. *pyrotheca* (year 2). After grafting, plants were held at 8 °C or 16 °C (minimum) until transplantation (28-29 days), at which stage growth was compared with that of the self-rooted control held under the same conditions. Plants were planted in the field and fruit quality assessed at harvest. At the time of transplantation in year 1, plants at 16 °C were taller and had a higher total fresh weight than those at 8 °C. The grafted plants of both cultivars were taller and had a higher leaf area and fresh weight than the self-rooted plants, irrespective of rootstock. In year 2, the grafted plants of both cultivars had better development (height, leaf area, leaf number, fresh weight) than self-rooted plants. The plants of Crimson Sweet × *L. siceraria* f. *pyrotheca* were taller than those of the other two scion-rootstock combinations, irrespective of temperature. Mean fruit weight at harvest was higher in grafted plants than in self-rooted plants, and sugar content varied with scion-rootstock combination. Grafting of watermelon results in better plant growth by the time of transplantation, whereas the scion-rootstock combination affects fruit quality. A minimum temperature of 16 °C is indicated during the post-grafting stage.

Keywords: *Citrullus lanatus*; Scion; Sugar content; Grafting; Fruit quality.

Introduction

Watermelon (*Citrullus lanatus* [Thunb.] Mansf.) is a major horticultural crop within the Mediterranean region, and in Greece annual production amounts to 557.000 tons. Although the bulk of this production is consumed on the domestic market (Passam, 2003), approximately 108.000 MT were exported from Greece in 2007, yielding high profits for regions with intensive watermelon cultivation. Because of the prevalence of soil-borne diseases, almost all watermelons are grafted on to disease-resistant rootstocks (Traka-Mavrona et al., 2000), and the employment of grafting techniques is imperative for intensive watermelon farming.

Grafting of watermelon was first introduced in the 1920's and by 1998, in Korea, Japan and Taiwan, 95% of watermelon and melon plants were grafted on to resistant rootstocks, resulting in up to 200% higher yields in comparison with self-rooted plants (Lee and Oda, 2003). Rootstocks that are commonly used for grafting watermelon are *Cucurbita moschata*, *C. maxima*, *C. pepo*, *Benincasa hispida*, *Lagenaria siceraria*, *Sicyos angulatus* as well as hybrids of the above-mentioned species, e.g. *C. moschata* × *C. maxima* (Lee, 1994).

According to many studies, scion-rootstock combination may affect plant growth and development, as well as fruit quality features, such as pH, sugar content, carotenoid content, chemical composition of the fruit, flesh color, flavor and aroma (Khah, 2011; Gisbert et al., 2011; Bletsos and Passam, 2010; Bekhradi et al., 2011; Yilmaz et al., 2011). This effect is mainly attributed to a scion-rootstock interaction which influences various plant physiological processes such as nutrient and water uptake and translocation, hormone synthesis, photosynthesis and other metabolic processes (Rouphael et al., 2010). Grafting also affects growth, whereas under low temperatures it can ensure higher yields than in self-rooted plants (Davis et al., 2008; Sakata et al., 2007). A beneficial effect of grafting on total yield was also reported for cv. Crimson Sweet, Crispy and Ingrid grafted on to various rootstocks (Alan et al., 2007; Alexopoulos et al., 2007; Proietti et al., 2008).

In southern Greece, watermelons are cultivated under low cover for early production, but because these plants can still be exposed to sub-optimal air and soil temperatures it may be advantageous to use rootstocks that tolerate low temperatures. Although rootstocks with tolerance to low temperatures are known, they must be compatible with the scion (Bletsos and Passam, 2010). In the present paper we investigate the effect of grafting and post-grafting temperature on the plant characteristics of two watermelon cultivars at the time of transplantation and on subsequent fruit quality.

Materials and Methods

Two watermelon (*Citrullus vulgaris* [Thunb.] Mansf.) cultivars (Sugar Baby and Crimson Sweet) were either self-rooted or grafted on to *Cucurbita maxima* × *C. moschata* rootstock RS 841 F_1 (Royal Sluis) and *Lagenaria siceraria* (Molina) Standl. *f. clavata* in year 1, with the addition of *L. siceraria f. pyrotheca* in year 2. Seeds of scions and rootstocks were soaked in distilled water at room temperature, a day prior to sowing. Seeds of the watermelons were sown on 6 February (year 1) and 20 February (year 2), while the seeds of the rootstocks were sown 4 or 8 days later (years 1 and 2 respectively). For each watermelon and rootstock cultivar, the seeds were sown in two trays containing a substrate of soil and peat (Klasmann KTS_1, Deilmann) in a ratio of 1:1 (v/v), enriched with 120-160 mg N, 140-180 mg P_2O_5 and 160-200 mg K_2O per m^3 and with a pH of 5.5-6.5. The seed trays were covered with transparent polyethylene film and maintained at a temperature of 16 ^oC. After emergence, one tray of each cultivar was held at 16 ^oC (minimum) while the second tray was transferred to 8 ^oC (minimum) until transplantation to the field. Grafting took place on 1 and 22 of March (years 1 and 2 respectively) using the tongue-approach technique (Oda, 1999) and the grafted plants were transplanted to plastic pots (6.5×6.5×7 cm) containing the same substrate as described above. The grafted plants were maintained at 8 ^oC or 16 ^oC (minimum temperature) until 29 March (year 1) or 26 April (year 2) at which stage they were transplanted to field prior to assessing for height, leaf area, leaf number and fresh weight in comparison with the self-rooted controls. The earlier transplantation in year 1 comparing to year 2 (27 and 34 days after grafting respectively) was mainly due to the delayed sowing of rootstock in year 2 (4 and 8 days after scion sowing for year 1 and 2 respectively). The statistical design was that of completely randomized blocks, with each block consisting of 5 plants per treatment and three replications.

One plant per replicate (from both 8 ^oC and 16 ^oC) was transplanted to the field together with the self-rooted plants in year 1, spaced at 1.5×3.5 m and cultivated by established cultivation techniques, while in year 2, only plants from the 16 ^oC treatment were planted. On the day of harvest (mid-July in both years) fruit fresh weight and total soluble solids content were recorded. Leaf area was measured using a LI-COR area meter (Model 3100, Nebraska USA). Total soluble solids (°Brix) within the fruit flesh, were measured with the aid of a hand refractometer (Schmidt and Haensch HR 32 B, Berlin, Germany).

Statistical analysis was carried out with the aid of the Statgraphics 5.1.plus programme (Statistical Graphics Corporation) and Microsoft Excel 2007 (Microsoft Corporation). Data were evaluated by analysis of variance for the main effects, whereas the means of values were compared by Duncan's multiple range test (DMRT) and the least significant difference (LSD) test (P=0.05).

Results

At the time of transplantation (27 days after grafting in year 1 and 34 days after grafting in year 2) the grafted plants of cv. Sugar Baby were taller than the self-rooted plants of the same cultivar and had a higher fresh weight, leaf number (except the plants at 8 ^{o}C in year 1) and leaf area (Table 1). In year 1 the plants that were held at a minimum temperature of 16 ^{o}C after grafting were more developed at the time of transplantation than those held at 8 ^{o}C, but in year 2 the post-grafting temperature did not affect plant development during the post-grafting period. This was due to the fact that although the minimum temperature of the greenhouse was set at 8 ^{o}C, the later time of grafting in year 2 meant that the temperature and light conditions during the post-grafting stage of year 2 were better than those in year 1. For example, the mean minimum temperatures during the post-grafting period were 9.6 ^{o}C and 11.8 ^{o}C for years 1 and 2 respectively. The development of the Sugar Baby scion did not differ significantly between the two rootstocks used for grafting in year 1 (*L. siceraria* f. *clavata* and RS 841 F_1), and in year 2 the only characteristic that differed significantly was the increase in plant height when grafted on to *L. siceraria* f. *pyrotheca* compared to the other two rootstocks and the self-rooted plants (Table 1).

Similarly, at the time of transplantation in both years the grafted plants of cv. Crimson Sweet were taller than the self-rooted plants of the same cultivar (except CS × *L. siceraria* f. *clavata* and CS × RS 841 F_1 at 8 ^{o}C) and had a higher fresh weight, leaf number (except the plants at 16 ^{o}C in year 1) and leaf area (Table 2). No significant differences between rootstocks were observed in year 1, but in year 2 plant height and leaf area at 8 ^{o}C was higher in plants grafted on to *L. siceraria* f. *pyrotheca* than on the other two rootstocks. In contrast, plant fresh weight was highest in plants grafted on to *L. siceraria* f. *clavata* in year 2. Overall, all the growth characteristics of the grafted plants of cv. Crimson Sweet were better at the minimum temperature of 16 ^{o}C, but not always to a statistically significant level (Table 2).

The mean fruit weight of cv. Sugar Baby ranged from 2.4 to 4.2 kg in year 1 and from 2.65 to 4.6 kg in year 2. Over the two years of the experiment, the mean weight of fruit from self-rooted plants (3.15 kg) was lower than that of the grafted plants: 3.65 kg (SB × *L. siceraria* f. *clavata*), 3.48 kg (SB × RS 841 F_1) and 4.63 kg (SB × *L. siceraria* f. *pyrotheca* in year 2). Additionally, in contrast to the self-rooted plants, the mean fruit weight from the grafted plants that were held at 8 ^oC until transplantation in year 1 was lower than that of the plants at 16 ^oC (Figure 1). The mean fruit weight of cv. Crimson Sweet was significantly higher than that of Sugar Baby and ranged from 4.0-5.5 kg (year 1) and 5.6-7.6 kg (year 2). Over the two years, the mean fruit weight from the self-rooted plants was lower (6.16 kg) than that of the grafted plants CS × *L. siceraria* f. *pyrotheca* in year 2 (6.83 kg), higher than CS × RS 841 F_1 (5.29 kg), but did not differ from CS × *L. siceraria* f. *clavata* (6.14 kg). The lower mean fruit weight of CS × RS 841 F_1 compared with the other rootstocks was due to the reduction in fruit weight from plants held at 8 ^oC in year 1 (Figure 2).

Table 1. The effect of rootstock-scion combination on plant height, leaf number, leaf area (the first two leaves) and plant fresh weight of watermelon cv. Sugar Baby measured 27 days (year 1) and 34 days (year 2) after grafting.

Scion × Root	Plant height (cm)		Leaf number		Leaf area (cm^2)		Fresh weight (g)	
	8 °C	16 °C	8 °C	16 °C	8 °C	16 °C	8 °C	16 °C
Year 1								
Sugar Baby (self-rooted)	5.1 b (b)	7.6 b (a)	4.8 a (a)	4.0 b (a)	34.5 b (b)	38.8 b (a)	3.7 b (b)	5.6 b (a)
Sugar Baby× *L. siceraria* f. *clavata*	7.5 a (b)	13.1 a (a)	4.5 a (a)	5.6 a (a)	42.6 a (b)	48.5 a (a)	4.8 a (b)	6.7 a (a)
Sugar Baby× RS 841 F_1	7.5 a (b)	15.4 a (a)	4.5 a (a)	5.4 a (a)	44.9 a (a)	44.9 a (a)	4.5 a (b)	6.9 a (a)
Year 2								
Sugar Baby (self-rooted)	11.8 b (a)	10.8 b (a)	6.0 b (a)	5.8 b (a)	37.4 b (a)	34.7 b (a)	6.0 b (a)	5.3 b (b)
Sugar Baby× *L. siceraria* f. *clavata*	14.0 a (a)	12.5 b (a)	6.7 a (a)	6.8 a (a)	47.0 a (a)	40.8 a (b)	7.1 a (a)	7.0 a (a)
Sugar Baby× RS 841 F_1	14.2 a (a)	12.4 b (a)	7.1 a (a)	6.3 a (b)	44.5 a (a)	38.6 a (b)	7.8 a (a)	6.5 a (b)
Sugar Baby× *L. siceraria* f. *pyrotheca*	15.7 a (a)	14.2 a (a)	7.0 a (a)	6.6 a (a)	45.0 a (a)	40.1 a (b)	7.2 a (a)	6.5 a (b)

Mean separation in rows and columns by DMRT (P=0.05). Different letters outside parenthesis represent significant differences between the means within the same column, whereas letters within parenthesis represent significant differences between means of the same row.

Table 2. The effect of rootstock-scion combination on plant height, leaf number, leaf area (the first two leaves) and plant fresh weight of watermelon cv. Crimson Sweet measured 27 days (year 1) and 34 days (year 2) after grafting.

Scion × Root	Year 1							
	Plant height (cm)		Leaf number		Leaf area (cm^2)		Fresh weight (g)	
	8 °C	16 °C	8 °C	16 °C	8 °C	16 °C	8 °C	16 °C
Crimson Sweet (self-rooted)	5.6 b (b)	7.8 b (a)	3.8 b (b)	4.6 a (a)	39.9 b (a)	43.8 b (a)	4.1 b (b)	5.4 b (a)
Crimson Sweet× *L. siceraria* f. *clavata*	8.3 a (b)	12.7 a (a)	4.3 a (b)	5.2 a (a)	45.9 a (a)	46.6 b (a)	5.3 a (b)	6.5 a (a)
Crimson Sweet× RS 841 F_1	8.3 a (b)	13.0 a (a)	4.1 ab (b)	5.1 a (a)	42.2 b (b)	51.4 a (a)	5.0 a (b)	7.0 a (a)
Scion × Root	Year 2							
	Plant height (cm)		Leaf number		Leaf area (cm^2)		Fresh weight (g)	
	8 °C	16 °C	8 °C	16 °C	8 °C	16 °C	8 °C	16 °C
Crimson Sweet (self-rooted)	10.6 b (a)	10.5 c (a)	5.7 b (a)	5.5 b (a)	39.9 c (a)	44.0 b (a)	4.4 c (b)	5.6 c (a)
Crimson Sweet× *L. siceraria* f. *clavata*	12.3 b (b)	13.7 b (a)	6.2 a (a)	6.5 a (a)	42.1 b (b)	48.3 a (a)	6.8 a (b)	8.7 a (a)
Crimson Sweet× RS 841 F_1	12.5 b (b)	14.7 b (a)	6.2 a (a)	6.3 a (a)	42.6 b (b)	48.9 a (a)	6.3 b (b)	8.1 ab (a)
Crimson Sweet× *L. siceraria* f. *pyrotheca*	14.9 a (b)	16.7 a (a)	6.3 a (a)	6.4 a (a)	47.6 a (a)	51.6 a (a)	6.3 b (b)	7.5 b (a)

Mean separation in rows and columns by DMRT (P=0.05). Different letters outside parenthesis represent significant differences between the means within the same column, whereas letters within parenthesis represent significant differences between means of the same row.

The total soluble solids (sugar) content of Sugar Baby was positively affected by grafting on to RS 841 F_1 (higher brix value compared to the self-rooted plants) but not by the other scion-rootstock combinations. In Crimson Sweet, the total soluble solids content was higher in plants grafted on to *L. siceraria* f. *clavata* than in the other two scion-rootstock combinations, but did not differ from that of the self-rooted plants. In contrast, Crimson Sweet grafted on to RS 841 F_1 showed a lower brix value in comparison with the self-rooted plants (Figure 3).

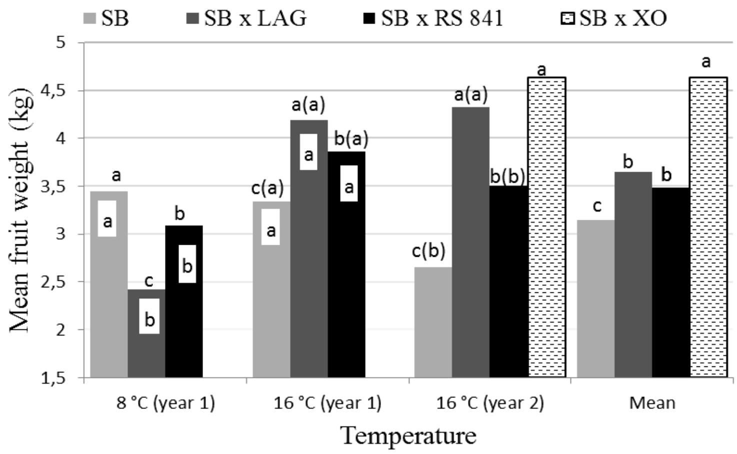

Figure 1. Mean fruit weight of cv. Sugar Baby in self-rooted and grafted plants. The rootstock-scion combinations are: Self-rooted (SB), Sugar Baby×*L. siceraria* f. *clavata* (SB×LAG), Sugar Baby×RS 841 F_1 (SB×841), Sugar Baby×*L. siceraria* f. *pyrotheca* (SB×XO). Means separation was carried out by DMRT (P=0.05). Different letters outside bars and parenthesis show significant differences between means of the same year and temperature, whereas letters in parenthesis refer to means of the same temperature (16 °C). Letters within bars refer to means of the same year (year 1).

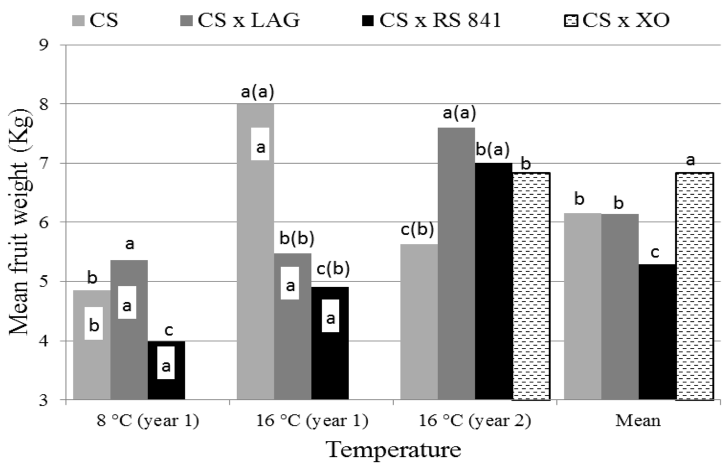

Figure 2. Mean fruit weight of cv. Crimson Sweet in self-rooted and grafted plants. The rootstock-scion combinations are: Self-rooted (CS), Crimson Sweet × *L. siceraria* f. *clavata* (CS × LAG), Crimson Sweet × RS 841 F_1 (CS × 841), Crimson Sweet × *L. siceraria* f. *pyrotheca* (CS × XO). Means separation was carried out by DMRT (P=0.05). Different letters outside bars and parenthesis show significant differences between means of the same year and temperature, whereas letters in parenthesis refer to means of the same temperature (16 °C). Letters within bars refer to means of the same year (year 1).

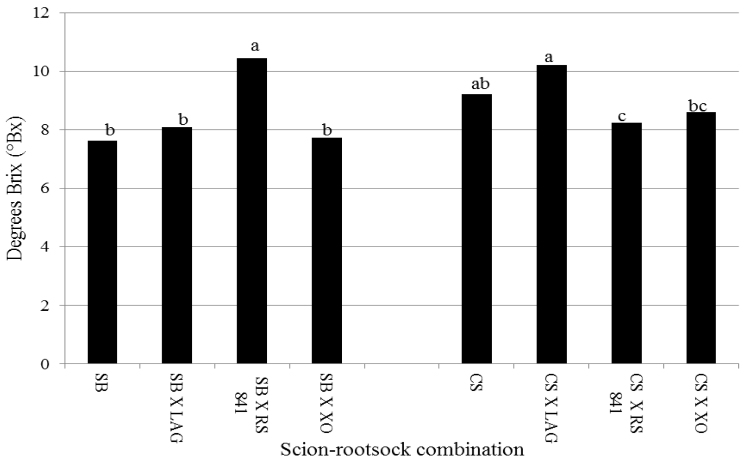

Figure 3. Mean values of Brix degrees of cv. Crimson Sweet and cv. Sugar Baby in self-rooted and grafted plants at 16 °C. The scion-rootstock combinations are: Crimson Sweet (CS), Sugar Baby (SB), *L. siceraria* f. *clavata* (LAG), RS 841 F_1 (841), *L. siceraria* f. *pyrotheca* (XO). Different letters indicate statistically significant differences between columns of the same cultivar (P=0.05).

Discussion

The results of the present experiments demonstrate that at the stage of transplantation to the field, the grafted plants were more robust in terms of plant height, leaf area and fresh weight than those of the self-rooted controls. Moreover, grafting increased fruit size at harvest, as also observed by Balaz (1982) and He and Fu (1988). A beneficial effect of grafting on total yield was also reported for cv. Crimson Sweet, Crispy and Ingrid grafted on to various rootstocks (Alan et al., 2007; Alexopoulos et al., 2007; Proietti et al., 2008), however in the case of cv. Crimson sweet, higher yield resulted from larger fruit size rather than a higher fruit number as reported in our study. The increase in growth of grafted plants relates to the stronger root growth of the rootstock (Yetisir and Sari, 2004; Khah, 2011; Khah et al., 2011).

Regarding fruit quality, the scion-rootstock combination employed in our experiments significantly increased fruit weight, but either increased, decreased or had no effect on the total soluble solids (sugar) content of the flesh. The variable effect of scion-rootstock on fruit soluble solids content may explain the contradictory results reported in the literature, where grafting either increases (Yao et al., 2003; Qian et al., 2004; Liu et al., 2006;

Yetisir and Sari, 2003; Salam et al., 2002; Lopez et al., 2004; Cushman and Huan, 2008), or decreases (Miguel et al., 2004; Colla et al., 2006; Huitron-Ramirez et al., 2009) fruit sugar content. Therefore, the scion x rootstock combination is of major importance in terms of fruit quality, whereas the choice of the right combination could be a useful means in producing fruit of better quality.

In year 1, the better growth of the young plants at a minimum temperature of 16 ^{o}C during the post-grafting phase, in comparison with 8 ^{o}C, indicates the need for a relatively high temperature during the healing process. In year 2, grafting was performed later and the climatic conditions (temperature and light) were better than in year 1, so that even though a minimum temperature of 8 ^{o}C was employed, in fact temperatures seldom fell to this level during healing. Because of the demand for early watermelons, the use of rootstocks that exhibit low temperature tolerance is desirable (Bletsos and Passam, 2010). According to Liu et al. (2003) and Liu et al. (2004), grafted watermelons tolerate low temperatures because the leaf antioxidant concentrations and antioxidative enzyme activities are higher than in self-rooted plants. Although CS × *L. siceraria* f. *pyrotheca* was included only in the experiment of year 2, this rootstock appeared to support better scion growth of Crimson Sweet, as indicated by the increase in plant height and leaf area at > 8 ^{o}C as well as a high fruit weight (both cultivars). It is therefore suggested that this rootstock may be worthy of further investigation with respect to possible low temperature tolerance.

References

Alan, O., Nilay, O., Cunen, Y., 2007. Effect of grafting on watermelon plant growth, yield and quality. J. Agron. 6 (2), 362-365.

Alexopoulos, A.A., Kondylis, A., Passam, H.C., 2007. Fruit yield and quality of watermelon in relation to grafting. J. Food Agric. Environ. 5 (1), 178-179.

Balaz, F., 1982. Possibilities of grafting certain watermelon cultivars on *Lagenaria vulgaris* to prevent Fusarium wilt. Sauvemena Poljiprivieda, 30, 563-568.

Bekhradi, F., Kashi, A., Delshad, M., 2011. Effect of three cucurbit rootstocks on vegetative and yield of 'Charleston Grey' watermelon. Int. J. Plant Prod. 5 (2), 105-109.

Bletsos, F., Passam, H.C., 2010. Grafting: an environmentally friendly technique to overcome soil-borne diseases and improve the out of season production of watermelon, cucumber and melon. In: Sampson, A.N. (Eds.), Horticulture in the 21st Century, Nova Science, N.Y. pp. 81-120.

Colla, G., Rouphael, Y., Cardarelli, M., Rea, M., 2006. Effect of salinity on yield, fruit quality, leaf gas exchange, and mineral composition of grafted watermelon plants. HortScience, 41 (3), 622-627.

Cushman, K.E., Huan, J., 2008. Performance of four triploid watermelon cultivars grafted onto five rootstock genotypes: yield and fruit quality under commercial growing conditions. Acta Hort. 782, 343-350.

Davis, A.R., Perkins-Veazie, P., Sakata, Y., Lopez-Galarza, S., Maroto, J.V., Lee, S.G., Huh, Y.C., Zhanyong, S., Miguel, A., King, S.R., Cohen, R., Lee, J.M., 2008. Cucurbit grafting. Crit. Rev. Plant Sci. 27 (1), 50-74.

Gisbert, C., Prohens, J., Nuez, F., 2011. Performance of eggplant grafted onto cultivated, wild and hybrid materials of eggplant and tomato. Int. J. Plant Prod. 5 (4), 367-380.

He, Z.L., Fu, X.Y., 1988. Trials on watermelon grafting for resistance to wilt. Fujian Agric. Sci. Technol. 3, 4.

Huitron-Ramirez, M.V., Ricardez-Salinas, M., Camacho-Ferre, F., 2009. Influence of grafted watermelon plant density on yield and quality in soil infested with melon necrotic spot virus. HortScience, 44, 1838-1841.

Khah, E.M., 2011. Effect of grafting on growth, performance and yield of aubergine (*Solanum melongena* L.) in greenhouse and open-field. Int. J. Plant Prod. 5 (4), 359-366.

Khah, E.M., Katsoulas, N., Tchamitchian, M., Kittas, C., 2011. Effect of grafting on eggplant leaf gas exchanges under Mediterranean greenhouse conditions. Int. J. Plant Prod. 5 (2), 121-134.

Lee, J.M., 1994. Cultivation of grafted vegetables I. Current status, grafting methods, and benefits. HortScience, 29 (4), 235-239.

Lee, J.M., Oda, M., 2003. Grafting of herbaceous vegetable and ornamental crops. Hortic. Rev. 28, 61-124.

Liu, H.Y., Zhu, Z.J., Lu, G.H., Qian, Q.Q., 2003. Study on relationship between physiological changes and chilling tolerance in grafted watermelon seedlings under low temperature stress. Sci. Sinica Agric. 36, 1325-1329.

Liu, Y.Q., Liu, S.Q., Wang, H.B., 2004. Effect of salt-tolerant stock on growth, yield, and quality of watermelon, Shandong. Agric. Sci. 4, 30-31.

Liu, H.Y., Zhu, Z.J., Diao, M., Guo, Z.P., 2006. Characteristic of the sugar metabolism in leaves and fruits of grafted watermelon during fruit development. Plant Physiol. Commun. 42, 835-840.

Lopez-Galarza, S., San Bautista, A., Perez, D.M., Miguel, A., Baixauli, C., Pascual, B., Maroto, J.V., Guardiola, J.L., 2004. Effects of grafting and cytokinin-induced fruit setting on colour and sugar-content traits in glasshouse-grown triploid watermelon. J. Hort. Sci. Biotech. 79 (6), 971-976.

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

Oda, M., 1999. Grafting of vegetables to improve greenhouse production. Food and Fertilizer Technology Center, Extension Bulletin 480, Taipei city, Republic of China on Taiwan, 11p.

Passam, H.C., 2003. Use of grafting makes a comeback. Fruit Veg. Technol. 3 (4), 7-9.

Qian, Q.Q., Liu, H.Y., Zhu, Z.J., 2004. Studies on sugar metabolism and related enzymes activity during watermelon fruit development as influenced by grafting. J. Zhe-jiang Univ. 30, 285-289.

Proietti, S., Rouphael, Y., Colla, G., Cardarelli, M., De Agazio, M., Zacchini, M., Rea, E., Moscatello, S., Battistelli, A., 2008. Fruit quality of mini-watermelon as affected by grafting and irrigation regimes. J. Sci. Food Agr. 88, 1107-1114.

Rouphael, Y., Schwarz, D., Krumbein, A., Colla, G., 2010. Impact of grafting on product quality of fruit vegetables. Sci. Hort. 127, 172-179.

Sakata, Y., Takayoshi, O., Mitsuhiro, S., 2007. The history and present state of the grafting of cucurbitaceous vegetables in Japan. Acta Hort. 731, 159-170.

Salam, M.A., Masum, A.S.M.H., Chowdhury, S.S., Dhar, M., Saddeque, M.A., Islam M.R., 2002. Growth and yield of watermelon as influenced by grafting. J. Biol. Sci. 2 (5), 298-299.

Traka-Mavrona, E., Koutsika-Sotiriou, M., Pritsa, T., 2000. Response of squash (*Cucurbita* spp.) as rootstock for melon (*Cucumis melo* L.). Sci. Hort. 83, 353-362.

Yao, F.J., Huang, D.F., Zhang, H.M., Liu, Y.Q., 2003. Effects of rootstocks on growth and fruit quality of grafted watermelon. J. Shanghai Jiaotong Univ. (Agricultural Science), 21, 289-294.

Yetisir, H., Sari, N., 2003. Effect of different rootstock on plant growth, yield and quality of watermelon. Aust. J. Exp. Agric. 43, 1269-1274.

Yetisir, H., Sari, N., 2004. Effect of hypocotyl morphology on survival rate and growth of watermelon seedlings grafted on rootstocks with different emergence performance at various temperatures. Turk. J. Agric. Forest. 28, 231-237.

Yilmaz, S., Celik, I., Zengin, S., 2011. Combining effects of soil solarization and grafting on plant yield and soil-borne pathogens in cucumber. Int. J. Plant Prod. 5 (1), 95-104.