J. Plant Production, Mansoura Univ., Vol. 7(6): 603 - 609, 2016

Effect of Rootstocks and Grafting Methods on Watermelon (*Citrullus lanatus*) Production

El-Gazzar, T. M.*; K. K. Dawa*; E. A. Ibrahim and A. M. El-Awady****
***Veg. and Ornamental Dept., Fac. Agric., Mansoura Univ., Egypt.**
****Cross Pollinated Veg. Crops Res. Dept., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt.**

ABSTRACT

The present study was carried out at a private nursery in Mansoura city and a private farm at Zayyan region, Belqas district, Dakahlia Governorate during the two summer seasons of 2014 and 2015 to study the effects of different rootstocks and grafting methods on growth, yield and fruit quality of watermelon cv. Aswan F_1. The experiment included thirteen treatments resulted from the combinations of four rootstocks [Jumbo F_1 and Nun 6001 F_1 hybrids *(Cucurbita maxima* × *Cucurbita moschata*), Bottle gourd (*Lagenaria siceraria* Standl.) and Pumpkin *(Cucurbita moschata* L.)] and three grafting methods [Hole insertion (HIG), Splice (SG) and Tongue approach (TAG)] as well as non-grafted plants (control). The treatments were arranged in a randomized complete blocks design with three replicates. The results indicated that grafting, especially onto Jumbo rootstock using Tongue approach grafting method, recorded the greatest values of vegetative growth parameters (lateral stems number, leaves number and foliage dry matter %), female flowers number and early and total fruit yield compared to non-grafted plants in both seasons. Grafting combinations didn't show any significance differences with regard to sex ratio. Furthermore, there was a balance between number of fruits per plant and average fruit weight which eventually led to early and total yield increasing compared to non-grafted plants in both seasons. The highest values of total soluble solids (TSS), reducing sugars, vitamin C and Lycopene were estimated in the fruits of grafted plants onto Jumbo rootstock compared to other rootstocks in both seasons. On the other hand, the grafting methods had insignificant effects on fruit quality during both seasons. Therefore, the using of Jumbo as rootstock and Tongue approach as grafting method may be a successful strategy to increase vegetative growth, yield and fruit quality of watermelon cv. Aswan F_1 under similar conditions of this study.

Keywords: Rootstocks, Grafting methods, Watermelon, *Citrullus lanatus*.

INTRODUCTION

Watermelon (*Citrullus lanatus* (Thunb.) Matsum and Nakai) is one of the most important vegetable crops grown in Egypt, which occupies a great figure in the local consumption and export. Egypt is the fifth largest watermelon producer in the world, it produces approximately 1.7 % from globally watermelon production; 1.894.738 ton harvested from around 60.554 ha with an average of 31.29 ton/ha (FAOSTAT, 2013). Grafting commercial cultivars onto desirable rootstocks is an effective method to decrease the harmful effects of biotic and abiotic stresses as well as improve yield and fruit quality of watermelon (Lee and Oda, 2003; Yetisir and Sari, 2003). Recently, Egypt had a strong competition in grafting industry to provide grafted *Cucurbitaceae* crops to growers with high quality and better performance. The grafting success depends on the appropriate choice for scion/rootstock combinations, using of proper grafting method and grafts maintaining.

Rootstocks can exhibit excellent effects on watermelon growth. Alan *et al.* (2007) found that grafting increased main stem length, number of lateral branches and root dry weight as vegetative growth characters of watermelon. The stem length, number of lateral branches, number of internodes and fresh and dry weights of foliage were improved by grafting watermelon cv. Charleston Gray onto different rootstocks (Bekhradi *et al.*, 2011). Many reports demonstrated that fruit yield varied depending on both rootstock and scion combinations. The grafting of watermelon cv .Crimson Sweet clearly improved fruit yield by increasing fruit weight comparing to non-grafted plants (Alexopoulos *et al.*, 2007). Using Dynamo, RS-841 and Shintosa rootstocks significantly increased watermelon yield represented as fruit weight, total yield and marketable yield compared to non-grafted plants (Turhan *et al.*, 2012).

The quality characteristics might be affected by grafting as a result of the translocation of metabolites associated with fruit quality to the scion through the xylem and/or modification of physiological processes of the scion (Rouphael *et al.*, 2010). Moreover, El-Semellawy (2005) found that fruit quality parameters (fruit length, fruit diameter, fruit shape index, rind thickness, average fruit weight, acidity %, pH, TSS, dry matter of flesh % and fruit sugars content) of watermelon were affected by grafting onto differnet rootstocks. The results clarified that grafted watermelons onto *Lagenaria siceraria*, *Cucrbita moschata* and *Cucrbita maxima* rootstocks recorded the highest means of physical and chemical fruit quality.

Many investigators reported that the type of grafting technique significantly affected vegetative growth parameters and fruit yield of watermelon. The Tongue approach grafting was the best among three grafting techniques studied by Mohamed *et al.* (2014). Also, Alkharpotly (2009) grafted watermelon (Aswan F_1 and Taws F_1 cultivars) onto different rootstocks by two grafting methods (Cut and Tongue approach). He found that Cut grafting method gave the higest values of most vegetative growth parameters along with early and total yield, while Tongue approach grafting method produced the greatest number of fruits. Concerning watermelon fruit quality, Abd El-Wanis *et al.* (2013) reprted that using Splice grafting technique to graft watermelon onto Bottle gourd was the best method for improving most fruit quality parameters, i.e., fruit diameter, fruit length, average fruit weight, TSS and flavor.

Therfore, the present study was undertaken to determine the effect of different rootstocks and grafting methods on vegetative growth, fruit yield and quality of watermelon cv. Aswan F_1.

MATERIALS AND METHODS

The present study was carried out at a private nursery in Mansoura city and a private farm at Zayyan, Belqas district, Dakahlia Governorate during the two summer seasons of 2014 and 2015 to study the effects of different rootstocks and grafting methods on growth, yield and fruit quality of watermelon cv. Aswan F_1. The experiment included thirteen treatments resulted from the combinations of four rootstocks [Jumbo F_1 and Nun 6001 F_1 hybrids *(Cucurbita maxima* × *Cucurbita moshata*), Bottle gourd (*Lagenaria siceraria* Standl.*)* and Pumpkin *(Cucurbita moschata* L.)] and three grafting methods [Hole insertion (HIG), Splice (SG) and Tongue approach (TAG)] as well as non-grafted watermelons as control. The treatments were arranged in a randomized complete blocks design with three replicates. The field experimental plot consisting of one ridge with 20.0 m length, 3.0 m width with total area of 60.0 m^2. The distance between plants was 2.0 m apart. Each experimental plot contained ten plants.

Watermelon seeds were sown in seedling foam trays filled with a mixture of peatmoss: vermiculite (1:1 v/v) under plastic house on 1st February in the first season and 24th January in the second one. Rootstocks and control seeds were sown in seedling trays filled with the same batch after 15 days from scion seeds sowing because rootstocks seedlings growth is faster than that of watermelon. The grafting was performed after 20 days from rootstock seeds sowing. The grafting methods procedures were used according to vegetable grafting technique described by Kubota *et al.* (2010) with some modifications. Then, the grafted plants were transplanted into plastic cups of 7 cm diameter, containing BVB peatmoss consisting (90 % blackpeat, 10 % whitepeat and 1.2 – 1.7 kg /m³ fertilizer PG mix 12-14-24 + TE) with pH (5.5 – 6.0). Each combination contained 50 cups with one plant for each in both seasons. The cups of grafted plants by Tongue approach method were leaved in the greenhouse conditions and watered as needed. While, the cups of grafted plants by Splice and Hole insertion methods were placed into boxes and moved to the healing chamber for up to 9 days healing and rooting. The healing process was conducted according to Miles *et al.* (2013) with some modifications. After that, the hardening off process was started. The grafted plants were transplanted in the open field on 31st March in the first season and 25th March in the second one.

At soil preparation, chicken manure was applied at the rate of 8 m^3 per feddan mixed with chemical fertilizers of 25 kg calcium superphosphate (15.5 % P_2O_5), 12.5 kg ammonium sulphate (20.5% N) and 6 kg sulfur for each m^3 of chicken manure. The agricultural practices were performed as recommended for commercial watermelon production under drip irrigation system.

At 50 days after transplanting, three samples of plants were randomly chosen from each treatment to determine the number of lateral stems and leaves number in both seasons as well as foliage dry matter % (in the second season only). Number of female flowers were determined from the beginning of flowering until the end of season by choosing three plants randomly for each experimental plot. Then, sex ratio was calculated by dividing the number of male flowers on the number of female ones. Ripe fruits were harvested in two pickings. The first one was after 80 days from transplanting and 10 days later the second harvest was done. Number of fruits per plant, average fruit weight, early yield and total yield were estimated as fruit yield parameters. To study the effect of grafting on watermelon fruit quality, three fruits from each treatment were randomly taken in the first picking in both seasons. The values of TSS % were measured using Carl-Zeiss hand refractometer. Also, the reducing sugars percentage was determined according to the method described by Ranganna (1977). Vitamin C (ascorbic acid) as mg/100 gm fruit flesh was estimated according to A.O.A.C. (1996). In addition, lycopene content was determined according to the low-volume hexane extraction method described by Davis *et al.* (2007)

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) described by Gomez and Gomez (1984) using COSTAT computer software program. The differences between treatment means were compared by Duncan's multiple range test at probability of 0.05 according to Duncan (1955)

RESULTS AND DISSCUSSION

Effect of different rootstocks and grafting methods on vegetative growth characters:

Results presented in Table 1 show that vegetative growth parameters of watermelon cv. Aswan F_1 expressed as lateral stems number, leaves number and foliage dry matter percentage in all graft combinations were significantly increased compared to non-grafted plants (control).

The results proved that grafted plants onto Jumbo F_1 rootstock using Tongue approach followed by Splice and Hole insertion grafting methods significantly recorded superior values of vegetative growth parameters compared to other graft combinations and control in both seasons. While, grafting onto Pumpkin rootstock by Hole insertion method recorded the lowest values of vegetative growth parameters compared to other graft combinations in both seasons.

These results are supported by the findings of Yetisir *et al.* (2007) who reported that grafted watermelons gave a greater number of leaves as well as higher dry weight than the own rooted plants. Additionally, Mohamed *et al.* (2014) suggested that superior results of Tongue approach grafting technique may be due to promote the movement of water and nutrients from rootstock to scion as a result of the better development of vascular bundles which depends on the good adhesion between rootstock and scion. The more effectiveness of rootstocks than own rooted plants is related to its vigorous root system which is able to absorb water and nutrients more efficiently, as well as may serve as a supplier of extra

endogenous plant hormones (Lee, 1994; Pulgar *et al.*, 2000). Furthermore, rootstock can affect scion growth through mRNA and phloem proteins migration from the rootstock to the scion through phloem which accumulate in apical meristem tissues (Gomez *et al.*, 2005).

Effect of different rootstocks and grafting methods on flowering characters:

Data presented in Table 1 show that the greatest number of female flowers was observed in grafted watermelons onto Jumbo rootstock using Tongue approach grafting method and the least in non-grafted plants, while grafted plants onto Pumpkin rootstock by Hole insertion grafting method recorded the lowest means of female flowers among the tested grafting combinations in both seasons. With respect to sex ratio of watermelon, the obtained results state that there weren't significance differences between grafted and non-grafted plants in both seasons of study. Mohamed *et al.* (2012) found that the grafted and non-grafted watermelons didn't show any significant differences with respect to sex ratio. Sex expression in cucurbits may be affected by rootstock (Friedlander *et al.*, 1977; Takahashi *et al.*, 1982; Chailakhyan and Khrianin, 1987; Park, 1987). However, because cytokinins are the major hormones supplied by rootstock and gibberellins or internal ethylene are mostly the regulators for sex expression in cucurbits (Ying and Narayanan, 1991), the rootstock effect on sex expression is often not as significant as changes in other parameters.

Table 1: Effect of different rootstocks and grafting methods on vegetative growth and flowering parameters of watermelon cv. Aswan F_1 during 2014 and 2015 seasons.

Treatment	NO. of Lateral stems		NO. of Leaves		Dry matter (%)	NO. of female flowers		Sex ratio	
	2014	2015	2014	2015	2015	2014	2015	2014	2015
Jumbo × HIG	23.39 ab	22.24 ab	330.84 bc	308.27 b	12.85 c	87.00 b	61.23 c	10.19 a	10.71 a
Jumbo × SG	24.13 ab	23.19 a	344.98 ab	318.5 ab	12.75 b	88.83 b	63.09 b	10.55 a	10.92 a
Jumbo × TAG	24.54 a	23.5 a	361.53 a	336.63 a	13.02 a	92.67 a	68.00 a	10.55 a	10.18 a
Nun 6001 × HIG	18.94 f	18.53 d	253.39 f	228.20 f	10.21 h	70.67 fg	52.14 g	10.02 a	9.72 a
Nun 6001 × SG	20.02 ef	18.78 d	255.17 f	239.88 ef	10.29 h	72.00 f	52.81 g	10.02 a	9.91 a
Nun 6001 × TAG	20.81 de	18.84 d	281.78 e	246.00 ef	10.44 g	73.00 ef	54.72 f	10.11 a	10.19 a
Bottle gourd × HIG	21.62 cd	19.73 cd	293.95 de	259.56 de	10.89 f	76.67 de	56.02 e	10.38 a	10.43 a
Bottle gourd × SG	21.64 cd	19.78 cd	302.54 de	267.00 cd	11.21 e	78.67 cd	57.07 e	10.38 a	10.54 a
Bottle gourd × TAG	22.85 bc	21.11 bc	313.62 cd	280.83 c	12.45 d	82.33 c	59.08 d	10.22 a	10.31a
Pumpkin × HIG	17.12 g	15.83 e	171.84 h	151.80 h	9.35 k	57.00 i	45.63 j	9.58 a	9.58 a
Pumpkin × SG	17.39 g	16.36 e	177.87 gh	156.33 h	9.62 j	62.67 h	48.04 i	9.68 a	9.63 a
Pumpkin × TAG	17.42 g	16.56 e	196.04 g	177.16 g	10.08 i	67.00 g	50.04 h	9.43 a	9.54 a
Non-grafting (control)	14.83 h	13.67 f	128.45 i	109.00 i	9.19 l	50.33 j	35.71 k	9.62 a	9.60 a

HIG: Hole insertion grafting method, SG: Splice grafting method, TAG: Tongue approach grafting method

Effect of different rootstocks and grafting methods on fruit yield and its components:

The results in Table 2 show the effect of different rootstocks and grafting methods on number of fruits per plant, average fruit weight, early fruit yield and total fruit yield of watermelon cv. Aswan F_1.

Results in Table 2 prove that there were a balance between number of fruits per plant and average fruit weight which eventually lead to increase early and total fruit yield in both seasons. Concerning number of fruits per plant, results in the same table express that the highest values were resulted from grafted plants onto Jumbo rootstock using Splice grafting method in both seasons as well as grafted plants onto Bottle gourd using either Tongue approach or Splice grafting method in the first season only. In contrast, the lowest number of fruits per plant in the first season (3.06) were harvested from the own rooted plants, while grafted plants onto Pumpkin by Hole insertion grafting method produced the lowest value in the second season (4.06). Regarding average fruit weight, the highest average fruit weight were recorded when watermelons grafted onto Jumbo rootstock using Tongue approach and Hole insertion grafting method in the both seasons in addition to grafted plants onto Bottle gourd or Nun 6001 by Tongue approach grafting method in the second season.

The effect of different rootstocks and grafting methods on early and total yield of Aswan F1 during the two seasons of study is shown in Table 2. The obtained results show that the highest early fruit yield (16.35 and 15.12 ton/ feddan) and total fruit yield (24.39 and 23.360 ton/ feddan) were derived from grafted plants onto Jumbo rootstock by Tongue approach grafting method in the first and the second season, respectively. By contrast, the lowest values of early fruit yield (8.44, 7.65 ton/ feddan) and total fruit yield (11.48, 10.58 ton/ feddan) were produced by non-grafted plants in the first and the second season, respectively. Furthermore, it's worth to mention that grafted plants onto Bottle gourd occupied the second rank regardless the grafting method followed by Nun 6001, while the Pumpkin rootstock came in the last order with regard to early and total fruit yield.

The performance of grafting in early and total fruit yield increasing as shown in Tables 2 during both seasons may be due to the strong vegetative growth, higher female flowers, and higher average fruit weight in addition to number of fruits per plant comparing to non-grafted plants. In this concern, many authors proved that grafting affected fruit yield of watermelon (Alan *et al.*, 2007; Besri, 2008; Rouphael *et al.*, 2008). Islam *et al.* (2013) state that fruit yield of grafted watermelon was increased one and half times more than non-grafted plants. Sakata *et al.* (2005) reported that yield and fruit weight of grafted watermelons onto Shintosa rootstock were higher than those with other

rootstock. On the other hand, Yetisir *et al.* (2003) compared the effects of different rootstocks [squash interspecific hybrids (*Cucurbita moschata* × *Cucurbita maxima*) and bottle gourd (*Lagenaria siceraria*)] on fruit yield of watermelon. The results cleared the grafted plants onto bottle gourd produced 27–106% greater yield over control plants, but the *Cucurbita* sp. rootstock decreased yield by 127–240%. Colla *et al*. (2006) and Yetisir and Sari (2003) reported that the lowest yield recorded in own rooted watermelons associated with a decrease in both average fruit weight and the number of fruits per plant compared to grafted plants. Further, grafting can increase yield since grafted plants are resistant to soil-borne disease, have strong root systems, and increased photosynthesis (Xu *et al.*, 2005a; Qi *et al.*, 2006; Wu *et al.*, 2006).

Table 2: Effect of different rootstocks and grafting methods on number of fruits per plant, average fruit weight, early yield and total yield of watermelon cv. Aswan F_1 during 2014 and 2015 seasons.

Treatment	Number of fruits /plant		Average fruit weight (Kg)		Early yield (ton/fed)		Total yield (ton/fed)	
	2014	2015	2014	2015	2014	2015	2014	2015
Jumbo × HIG	5.03 b	5.23 cd	6.53 ab	5.97 a	15.54 b	14.48 c	23.01 c	21.88 c
Jumbo × SG	5.53 a	5.93 a	6.09 de	5.46 bc	15.67 b	14.73 b	23.60 b	22.68 b
Jumbo × TAG	5.13 b	5.60 b	6.79 a	5.96 a	16.35 a	15.12 a	24.39 a	23.36 a
Nun 6001 × HIG	4.00 d	4.46 fg	6.29 bcd	5.52 bc	13.51 e	12.17 g	17.63 h	17.26 g
Nun 6001 × SG	4.70 c	4.76 e	5.65 fgh	5.22 cd	13.66 e	12.86 f	18.59 g	17.43 g
Nun 6001 × TAG	4.76 c	4.70 ef	6.18 cd	5.67 ab	13.68 e	12.89 f	20.63 f	18.67 f
Bottle gourd × HIG	4.63 c	5.50 bc	6.44 bc	4.95 de	13.94 d	12.95 ef	20.87 f	19.05 ef
Bottle gourd × SG	5.5 a	5.43 bcd	5.51 fgh	5.10 d	14.95 c	13.11 e	21.21 e	19.39 e
Bottle gourd × TAG	5.53 a	5.20 d	5.81 ef	5.72 ab	15.09 c	13.47 d	22.51 d	20.81 d
Pumpkin × HIG	3.93 d	4.06 h	5.46 gh	4.92 de	9.96 h	9.23 i	15.04 j	14.01 i
Pumpkin × SG	3.90 d	4.36 g	5.60 fgh	7.70 e	11.19 g	10.66 h	15.27 j	14.34 i
Pumpkin × TAG	4.03 d	4.53 efg	5.77 fg	4.88 de	12.81 f	10.79 h	16.28 i	15.50 h
Non-grafting (control)	3.06 e	4.33 g	5.35 h	4.49 f	8.44 i	7.65 j	11.48 k	10.58

HIG: Hole insertion grafting method, SG: Splice grafting method, TAG: Tongue approach grafting method

Effect of different rootstocks and grafting methods on fruit quality parameters:

The results in Table 3 illustrate that the greatest values of TSS were recorded by watermelon grafting onto Jumbo rootstock regardless of grafting method in both seasons. While grafted plants onto Bottle gourd using different grafting methods gave the lowest values in both seasons. Furthermore, own rooted plants occupied intermediate rank among different treatments in both seasons. Also, the results show that the grafting methods had no significant effect on TSS.

For reducing sugars, the results in the same table show that the grafted plants onto Jumbo rootstock or Nun 6001 by the three grafting methods, Bottle gourd using Hole insertion or Splice grafting method gave the highest reducing sugars in the first season without significance among them. While in the second season, the highest values of reducing sugars were recorded by grafting onto Jumbo rootstock using the three grafting methods. In the contrary, non-grafted plants and grafted plants onto Pumpkin using different grafting methods showed the lowest values in both seasons without significance among them.

Table 3: Effect of different rootstocks and grafting methods on TSS, Reducing sugars, Vitamin C. and Lycopene of fruits of watermelon cv. Aswan F_1 during 2014 and 2015 seasons.

Treatment	TSS		Reducing sugars (%)		V.C (mg/ 100 g FW)		Lycopene (mg/ 100 g FW)	
	2014	2015	2014	2015	2014	2015	2014	2015
Jumbo × HIG	10.66 a	9.64 a	8.02 a	6.13 ab	10.83 ab	8.71 ab	9.00 a	7.13 a
Jumbo × SG	10.70 a	9.72 a	8.10 a	6.26 a	10.87 ab	9.00 ab	9.08 a	7.22 a
Jumbo × TAG	11.00 a	9.83 a	8.14 a	6.24 a	11.33 a	9.19 a	9.40 a	7.29 a
Nun 6001 × HIG	10.00 b	8.97 b	7.98 a	5.78 bc	8.40 fg	6.98 c	7.19 bc	5.77 bc
Nun 6001 × SG	10.00 b	9.01 b	7.72 a	5.80 bc	8.80 efg	7.18 c	7.36 bc	5.95 b
Nun 6001 × TAG	10.17 b	9.00 b	7.59 ab	5.82 bc	9.07 def	7.39 c	7.76 b	6.12 b
Bottle gourd × HIG	8.00 e	7.60 d	7.17 abc	4.71 f	9.47 cde	8.27 b	6.72 cd	5.23 cdef
Bottle gourd × SG	8.10 e	7.87 d	7.03 abc	4.85 ef	9.93 cd	8.28 b	6.81 cd	5.38 cde
Bottle gourd × TAG	8.30 e	7.90 d	6.62 bc	5.02 ef	10.00 bc	8.31 b	6.92 c	5.58 bcd
Pumpkin × HIG	9.00 d	8.40 c	6.53 bc	5.14 de	8.00 g	6.89 c	5.56 e	4.71 fg
Pumpkin × SG	9.10 cd	8.40 c	6.44 c	5.22 de	8.00 g	6.90 c	5.63 e	4.92 efg
Pumpkin × TAG	9.20 cd	8.47 c	6.14 c	5.27 de	8.27 fg	6.92 c	6.18 de	5.07 defg
Non-grafting (control)	9.50 c	9.00 b	6.07 c	5.46 cd	6.78 h	5.97 d	5.54 e	4.54 g

HIG: Hole insertion grafting method, SG: Splice grafting method, TAG: Tongue approach grafting method

Furthermore, the obtained results reveal that vitamin C was significantly influenced by grafting. Since, the greatest V.C values were observed in grafted watermelon fruits onto Jumbo using the three grafting methods followed by their counterparts grafted onto Bottle gourd using Tongue approach method in the first season as well as other two grafting methods in the second season. The greatest values of lycopene were estimated in the fruits of grafted plants onto Jumbo rootstock followed by Nun 6001 regardless of the

grafting methods in both seasons. In contrast, the least values were recorded in grafted plants onto Pumpkin rootstock using different grafting methods as well as control in both seasons.

Many investigators suggested that watermelon grafting greatly affected fruit quality (Davis and Perkins-Veazie, 2005; Salam *et al*., 2002; Yetisir *et al*., 2003). However, Miguel *et al.* (2004) cleared that grafting onto *C. maxim*× *C. moschata* hybrid didn't affect soluble solids concentration of watermelon fruits comparing to own-rooted plants. Mohamed *et al.* (2012) pointed out that grafting onto desirable rootstocks produced significant increase of lycopene pigment in watermelon fruits. Davis *et al.* (2008) reported that sugar contents can be affected by different rootstocks and grafting methods. Furthermore, Proietti *et al.* (2008) clarified that grafting would be an effective tool for improving the beneficial nutritional substances of watermelon fruits, particularly lycopene and vitamin C.

The positive obtained results may be due to that grafting influences absorption and translocation of phosphorus, nitrogen, magnesium and calcium and increase photosynthesis (Ikeda *et al.*, 1986; Kim and Lee, 1989; Ruiz *et al.*, 1997; Pulgar *et al.*, 2000; Hu *et al.*, 2005), thereby allow grafted plants ,sometimes, to improved fruit quality (Xu *et al.*, 2005b; Zhu *et al.*, 2006). On the other hand, the decrease in some fruit quality parameters in some combinations compared to control does not consider a general phenomenon but related to the specific scion–stock interaction in particular growing conditions (Crinò *et al.*, 2007)

CONCLUSION

According to the obtained results in this study, watermelon grafting onto Jumbo rootstock using Tongue approach grafting method was the best treatment that could be recommended to obtain the highest yield and improve fruit quality, especially lycopene and vitamin C of watermelon in Dakahlia province and other regions with similar agro-climate conditions. Also, these results showed that using specific rootstock and appropriate grafting method to graft watermelon influences growth, yield and, sometimes, fruit quality. Moreover, these results may be raise the awareness of Egyptian growers to use the grafted watermelons.

REFERENCES

A.O.A.C. (1996). Official Methods of Analysis, 12th ed. Washington, DC: AOAC.

Abd El-Wanis, M. M., A. A. S. A. El-Eslamboly and A. M. Salama (2013). Impact of different grafting methods on yield and quality of watermelon. Res. J. Agric. & Biol. Sci., 9(6): 330-340.

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

Alexopoulos, A. A., A. Kondylis and H. C. Passam (2007). Fruit yield and quality of watermelon in relation to grafting. Journal of Food, Agriculture and Environment, 5(1): 178-179.

Alkharpotly, A. A. A. E. (2009). Effect of grafting on yield and its components in watermelon. Ph.D.Thesis, Fac. Agric. (Saba Basha), Alex. Univ. Egypt, 247 pp.

Bekhradi, F., A. Kashi and M. Delshad (2011). Effect of three cucurbits rootstocks on vegetative and yield of 'Charleston Gray'watermelon. International Journal of Plant Production, 5(2): 105-110.

Besri, M. (2008). Cucurbits grafting as alternative to methyl bromide for cucurbits production in Morocco. Research Conference on Methyl Bromide Alternatives and Emissions Reduction Proceedings of the 14th International, Orlando: pp. 60-61.

Chailakhyan, M. K. and V. Khrianin (1987). Influence of environmental factors and nutrition on sex determination in plants (a review). Sexuality in Plants and Its Hormonal Regulation, Springer: 16-32.

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

Crinò, P., C. L. Bianco, Y. Rouphael, G. Colla, F. Saccardo and A. Paratore (2007). Evaluation of rootstock resistance to fusarium wilt and gummy stem blight and effect on yield and quality of a grafted 'Inodorus' melon. HortScience, 42(3): 521-525.

Davis, A., J. Collins, W. Fish, Y. Tadmor, C. Webber and P. Perkins- Veazie (2007). Rapid method for total carotenoid detection in canary yellow-fleshed watermelon. Journal of food science, 72(5): S319-S323.

Davis, A. R., P. Perkins-Veazie (2005).Rootstock effects on plant vigour and watermelon fruit quality. Cucurbit Genet. Coop. Rep, 28: 39-42.

Davis, A. R., P. Perkins-Veazie, R. Hassell, A. Levi, S. R. King and X. Zhang (2008). Grafting effects on vegetable quality. HortScience, 43(6): 1670-1672.

Duncan, B. D. (1955). Multiple range and multiple F-test. Biometrics, 11: 1-42.

El-Semellawy, E. M. H. (2005). Effect of grafting on growth and yield of watermelon plants grown under low plastic tunnels in Baltiem district. Ph.D.Thesis, Fac. Agric., Kafr Elsheikh, Tanta Univ., Egypt, 211p.

FAOSTAT (2013). Food and agrucultural organization of United Nations http://faostat.fao.org.

Friedlander, M., D. Atsmon and E. Galun (1977). The effect of grafting on sex expression in cucumber. Plant and Cell Physiology, 18(6): 1343-1350.

Gomez, G., H. Torres and V. Pallas (2005). Identification of translocatable RNA-binding phloem proteins from melon, potential components of the long-distance RNA transport system. The Plant Journal, 41(1): 107-116.

Gomez, K. A. and A. A. Gomez (1984). Statistical procedures for agricultural research 2 Ed. . John Wilely and Sons.Inc-New York.

Hu, C., Y. Zhu, L. Yang, S. Chen and Y. Huang (2005). Comparison of photosynthetic characteristics of grafted and ownroot seedlings of cucumber under low temperature circumstances. Acta Botanica Boreali-Occidentalia Sinica, 26(2): 247-253.

Ikeda, H., O. Shinji and A. Kazuo (1986). The comparison between soil and hydroponics in magnesium absorption of grafting cucumber and the effect of increased application of magnesium. Bull. Natl. Veg. Res. Ins. Japan, C9: 31-41.

Islam, M. S., H. Bashar, M. Howlader, J. Sarker and M. Al-Mamun (2013). Effect of grafting on watermelon growth and yield. Khon Kaen Agr. J., 41(1): 284-289.

Kim, S. and J. Lee (1989). Effect of rootstocks and fertilizers on the growth and leaf mineral contents in cucumber (Cucumis sativus L.). Research Collection-Kyung Hee University (Korea Republic).

Kubota, C., M. A. McClure, N. K. Burelle, M. G. Bausher, E. N. Rosskopf and D. O. Chellemi (2010). How to graft cucurbits. multi-state project 'Use of grafted seedlings for methyl bromide transition in U.S. open-field fresh vegetable production. Arizona University. Available at: http://cals. arizona.edu/ grafting/ howto/ cucurbits/ grafting_ methods.

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

Lee, J. M. and M. Oda (2003). Grafting of herbaceous vegetable and ornamental crops. Horticultural Reviews 28: 61-124.

Miguel, A., J. V. Maroto, A. San Bautista, C. Baixauli, V. Cebolla, B. Pascual, S. López and J. L. Guardiola (2004). The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of Fusarium wilt. Scientia Horticulturae, 103(1): 9-17.

Miles, C., L. Hesnault, S. Johnson and P. Kreider (2013). Vegetable Grafting (Watermelon). Washington state Univ. extension fact sheet. FS100E. Available at: http:// cru. cahe. wsu. edu/ CEPublications / FS100E/ FS100E. pdf.

Mohamed, F., K. Abd El-Hamed, M. Elwan and M.-A. Hussien (2012). Impact of grafting on watermelon growth, fruit Yield and quality. Vegetable Crops Research Bulletin, 76: 99-118.

Mohamed, F. H., K. E. Abd El-Hamed, M. W. M. Elwan and M. N. E. Hussien (2014). Evaluation of different grafting methods and rootstocks in watermelon grown in Egypt. Scientia Horticulturae, 168: 145-150.

Park, Y. (1987). Effect of fertilizer levels, growth regulators and salt treatment on the growth and sex expression in cucumbers grafted to different rootstocks. Thesis, MS thesis, Kyung Hee Univ., Suwon, Korea,

Proietti, S., Y. Rouphael, G. Colla, M. Cardarelli, M. De Agazio, M. Zacchini, E. Rea, S. Moscatello and A. Battistelli (2008). Fruit quality of mini- watermelon as affected by grafting and irrigation regimes. Journal of the Science of Food and Agriculture, 88(6): 1107-1114.

Pulgar, G., G. Villora, D. Moreno and L. Romero (2000). Improving the mineral nutrition in grafted watermelon plants: nitrogen metabolism. Biologia Plantarum, 43(4): 607-609.

Qi, H. Y., T. L. Li, Y. F. Liu and D. Li (2006). Effects of grafting on photosynthesis characteristics, yield and sugar content in melon. J. Shenyang Agri. Univ., 37(2): 155-158.

Ranganna, S. (1977). Manual of analysis of fruit and vegetable products. Tata Mcagaw hill Publishing Company Limited. New Delhi, India.

Rouphael, Y., M. Cardarelli, G. Colla and E. Rea (2008). Yield, mineral composition, water relations, and water use efficiency of grafted mini-watermelon plants under deficit irrigation. HortScience, 43(3): 730-736.

Rouphael, Y., D. Schwarz, A. Krumbein and G. Colla (2010). Impact of grafting on product quality of fruit vegetables. Scientia Horticulturae, 127(2): 172-179.

Ruiz, J., A. Belakbir, I. López-Cantarero and L. Romero (1997). Leaf-macronutrient content and yield in grafted melon plants. A model to evaluate the influence of rootstock genotype. Scientia Horticulturae, 71(3): 227-234.

Sakata, Y., T. Ohara and M. Sugiyama (2005). The history and present state of the grafting of cucurbitaceous vegetables in Japan. Proceedings of the IIIrd International Symposium on Cucurbits. R. McConchie and G. Rogers. Leuven 1, International Society Horticultural Science. 731: 159-170.

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

Takahashi, H., T. Saito and H. Suge (1982). Intergeneric translocation of floral stimulus across a graft in monoecious cucurbitaceae with special reference to the sex expression of flowers. Plant and Cell Physiology, 23(1): 1-9.

Turhan, A., N. Ozmen, H. Kuscu, M. S. Serbeci and V. Seniz (2012). Influence of rootstocks on yield and fruit characteristics and quality of watermelon. Horticulture, Environment, and Biotechnology, 53(4): 336-341.

Wu, Y., Y. Chen and Y. Zhao (2006). Effect of pumpkin stocks on growth, development, yield, and quality of grafted muskmelon. Fujian J. Agr. Sci, 21: 354-359.

Xu, C., T. Li, H. Qi and H. Wang (2005a). Effects of grafting on growth and development, yield, and quality of muskmelon. China Veg, 6: 12-14.

Xu, S., Q. Chen, S. Li, L. Zhang, J. Gao and H. Wang (2005b). Roles of sugar-metabolizing enzymes and GA3, ABA in sugars accumulation in grafted muskmelon fruit. J. Fruit Sci, 22: 514-518.

Yetisir, H. and N. Sari (2003). Effect of different rootstock on plant growth, yield and quality of watermelon. Animal Production Science, 43(10): 1269-1274.

Yetisir, H., N. Sari and S. Yücel (2003). Rootstock resistance to fusarium wilt and effect on watermelon fruit yield and quality. Phytoparasitica, 31(2): 1-7.

Yetisir, H., K. Şener and S. Nebahat (2007). Rootstock potential of Turkish Lagenaria siceraria germplasm for watermelon: plant growth, graft compatibility, and resistance to Fusarium. Turkish Journal of Agriculture and Forestry, 31(6): 381-388.

Ying, Z. and K. Narayanan (1991). Hormonal control in sex, expression in lagenaria. Plant Growth Regulator, 19(3): 165.

Zhu, J., Z. L. Bie, Y. Huang and X. Y. Han (2006). Effects of different grafting methods on the grafting work efficiency and growth of cucumber seedlings. China Veg., 9: 24-25.

تأثير الأصول وطرق التطعيم على إنتاج البطيخ *(Citrullus lanatus)*

طه محمد الجزار* ، كوثر كامل ضوه* ، إيهاب عوض الله إبراهيم ** و أحمد محمود العوضى**

***قسم الخضر والزينة، كلية الزراعة ، جامعة المنصورة، مصر.**

****قسم بحوث محاصيل الخضر خلطية التلقيح، معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر.**

أُجريت الدراسة الحالية بمشتل خاص فى مدينة المنصورة ومزرعة خاصة بمنطقة زيان، مركز بلقاس، محافظة الدقهلية خلال موسمى الزراعة الصيفى ٢٠١٤ و ٢٠١٥ لدراسة تأثير كلاً من طرق التطعيم والأصول المختلفة على النمو والمحصول وجودة الثمار فى البطيخ هجين Aswan. شملت التجربة ثلاثة عشر معاملة نتجت من توليفات أربعة أصول [هجن Jubmo و Nun 6001 (*Cucurbita maxima* × *Cucurbita moschata*)، اليقطين (*Lagenaria siceraria*) و القرع العسلى (*Cucurbita moschata*)] وثلاث طرق تطعيم (الإيلاج بالحفرة، اللصق و اللسانى) بالإضافة إلى النباتات غير المطعومة (الكنترول). رُتبت المعاملات فى تصميم قطاعة كاملة العشوائية بثلاث مكررات. أشارت النتائج إلى أن التطعيم، خاصة على أصل Jubmo بإستخدام طريقة التطعيم اللسانى، سجل أعلى قيم لقياسات النمو الخضرى (عدد السيقان الجانبية، عدد الأوراق و النسبة المئوية للمادة الجافة فى المجموع الخضرى)، عدد الأزهار المؤنثة ومحصول الثمار الكلى والمبكر مقارنة بالنباتات غير المطعومة فى كلا الموسمين. لم تسجل أى فروق معنوية بين المعاملات فيما يتعلق بصفة النسبة الجنسية. علاوة على ذلك, كان هناك توازن بين عدد الثمار للنبات ومتوسط وزن الثمرة والذى أدى فى النهاية إلى زيادة المحصول المبكر والكلى للفدان. قُدرت أعلى قيم لتركيزات (المواد الصلبة الذائبة الكلية (TSS)، السكريات المختزلة، فيتامين سى والليكوبين) فى ثمار النباتات المطعومة على أصل Jubmo مقارنة بالمعاملات الأخرى فى كلا الموسمين. وعلى الجانب الأخر، فإنه لم يكن لطرق التطعيم المدروسة تأثيرات معنوية على جودة الثمار فى كلا الموسمين. لذلك نوصى بتطعيم البطيخ هجين Aswanعلى أصل Jubmo بطريقة التطعيم اللسانى كإستراتيجية ناجحة لزيادة النموالخضرى، المحصول وجودة الثمار تحت ظروف التجربة و الظروف المشابهه لها.