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Grafting Can Modulate Watermelon Growth and Productivity under Egyptian Conditions

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ABSTRACT

This study was accomplished in a private farm at Al Salhia area, Sharqia Governorate, Egypt during the two successive spring-summer seasons of 2013 and 2014 to assess the effect of grafting methods and rootstocks on plant growth performance, fruit yield and fruit quality of watermelon (*Citrullus lanatus* [Thunb.] cv. Peacock wm60. Peacock wm60 plants were grafted onto five rootstocks (6001 F_1, Super Shintoza F_1, Ferro F_1, bottle gourd cv. Local, and Peacock wm60 as self-grafted) either by splice and tongue approach. Non-grafted plants of Peacock wm60 were used as control. Grafting methods pronounced non-significant impact on watermelon vegetative and root growth and fruit yield and quality after transplanting in the field (scope of our study). Based on the data, watermelon propagation via grafting on the rootstocks of 6001, Super Shintosa and Ferro positively impacted on plant growth attributes and fruit yield and quality (fruit weight, rind sickness and TSS content) compared to grafting on local rootstock, self-grafted or direct seed plants. Rootstock of 6001 appeared superior to others on enhancing the measured parameters of plant growth, yield and fruit quality as well as root growth (roots dry weight). Local rootstock of bottle gourd impacted poorly on plant growth, yield and fruit quality compared to other rootstocks but superior to self-grafted or direct seed plants. The data concluded that, choice grafting method either splice or tongue approach for production watermelon seedlings depends on their results in the nursery before planting the grafted seedlings in the field because of differences between the methods on the plant behavior after transplanting were absent.

KeyWords: Watermelon, Grafting, Grafting Methods, Rootstock, Scion, Seedling, Propagation, Yield, Fruit Quality.

INTRODUCTION

Potential of use grafting for vegetables propagation, as herbaceous plants, increased widely and become popular in agricultural systems (Besri, 2008) to overcome problems which arising and limiting vegetable production. On the other hand, increasing the demand for food make the growers do not follow the crop rotation which leads to continue to grow the same crop consecutively or repeating cultivation the same crop in the same growing season or area, these practices changed soil conditions that cause various physiological and pathological disorders leading to sever crop loss (Pavlou *et al*., 2002, Lee and Oda, 2003). In this case, grafting can play an appropriate role for alleviation the soil deleterious effects and protect the scions or crops from these adverse conditions (Mahdy *et al*., 2014). The grafted plant includes two parts, rootstock and scion, all of them supply the plant with certain and varied features wherever make it up fighter, healthy and can face numerous agricultural problems might be limit its growth and production. Moreover, grafting improves the nutritional status of the plant, so that the plant becomes more efficient uptake and use of water and plant nutrients and subsequently an increase in plant strength, an increase in the economic harvesting period and a parallel increase in yield, and a reduction in the use of agricultural chemicals (Santa Cruz et al, 2002, Yetişir *et al*, 2004, Abdelmageed and Gruda 2009). Also grafting has other advantage as it can solve many agricultural problems much faster than plant breeding programs which cost much money and need long time (Singh and Rao 2014). Production of vegetables via grafting in Egypt is still in the primary stage. Cucurbits mainly watermelon presents the common vegetables that were propagated through grafted transplants. Under Egyptian conditions, although the higher cost of propagation of watermelon through grafted transplants, the farmers resorted to grafting watermelon to face many problems may severely decline watermelon cultivation area. These problems varied between physiological phenomenon and soil borne diseases and pests. Many solutions were applied to face the mentioned problems i.e. soil fumigation, cultivate watermelon in virgin soils and propagation via grafted transplants. Increase chemical pollution of soil and water and scarcity of the displayed virgin soil orlimited availability of arable land attribute to increase the demand on grafted transplants for watermelon cultivation. Generally, apply grafting in vegetables cultivation in Egypt conceders a new and promising practice. So the number of interested nurseries in produce grafted vegetables transplants are little and face multiple choice between more than one of grafting method e.g. splice, approach, hole insertion and side graft (Lee 1994) as well as the multiplicity of rootstocks cultivar or hybrids belong genus *Cucurbita maxima*, *Cucurbita moschata* and *Lagenaria siceraria*. The numerous of rootstocks sources make it varied in its performance and subsequently scion or crop properties as growth yielding and fruit quality. Therefore, this study was conducted to evaluate the plant growth performance, fruit yield and fruit quality of watermelon (*Citrullus lanatus* [Thunb.] cv. Peacock wm60 grafted onto five rootstocks (6001 F_1, Super Shintoza F_1, Ferro F_1, bottle gourd cv. Local, and Peacock wm60 as self-grafted) either by splice and tongue approach as well as non-grafted plants.

MATERIALS AND METHODS

Plant material and experimental design

This study was carried out in a private farm at Al Salhia area, Sharqia Governorate, Egypt during the two successive spring-summer seasons of 2013 and 2014 to evaluate the plant growth performance, fruit yield and fruit quality of watermelon (*Citrullu slanatus* [Thunb.] cv. Peacock wm60 grafted onto five rootstocks

(6001 F_1, Super Shintoza F_1, Ferro F_1, bottle gourd cv. Local, and Peacock wm60 as self-grafted) either by splice (Fig. 1) and tongue approach (Fig. 2). Non-grafted plants of Peacock wm60 were used as control.

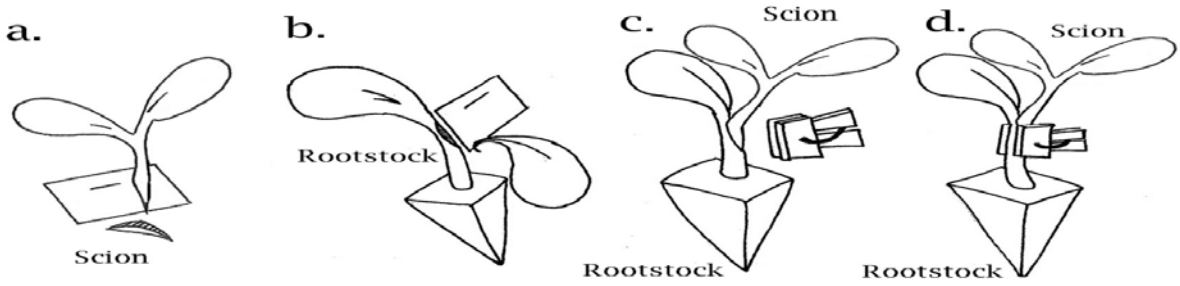

Fig. 1: The splice grafting method. Step a, preparing the scion; step b, preparing the rootstock; step c, joining the plants and step d, securing the joined region with a grafting clip. (Hassell *et. al.*, 2008).

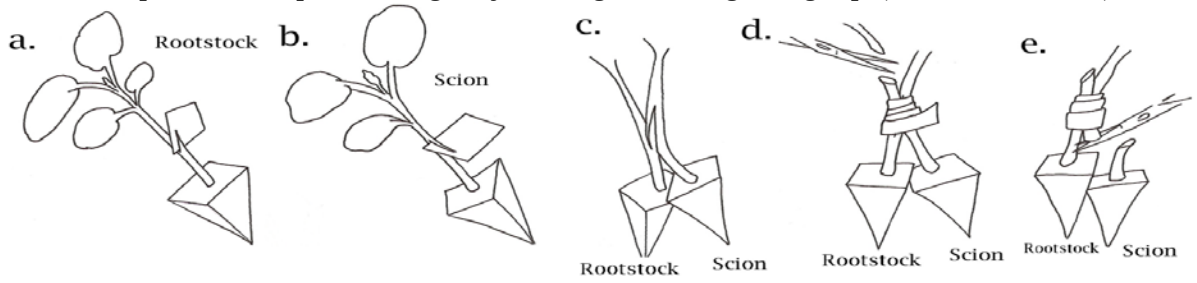

Fig. 2: The tongue approach grafting method. Step a, preparing the rootstock; step b, preparing the scion; step c, joining the scion to the rootstock; step d, securing the joining with a metal strip; and step e, removing the scion roots (Hassell*et. al.*, 2008).

The seeds of the scion were sown in the nursery 7-10 days earlier than the seeds of the rootstocks. Seeds were sown in 216-cell Styrofoam trays filled with a mixture of peat moss and perlit at the ratio of 7:3 (v: v) enriched by 1g potassium sulfate, 1 g calcium nitrate, 2 g mono potassium phosphate and 0.25 g fungicide for each 1 liter of the medium. Grafting was conducted when the rootstocks were ready to graft (15 days after sowing). The grafted seedlings were placed under shaded plastic tunnel completely closed under optimum temperature (24–26◦C) and humidity (>85%RH)for 7 days for healing and hardening which were the key factors for the survival of grafted plants. Tunnel was left completely closed for 3 days. After that, hardening process started in the fourth day by opening the tunnel for 2-3 hours followed by wetting the grafted plants with water before sealing the tunnel again. The tunnel was again opened for 6 hours in the fifth day and re-opened for half a day in the sixth day and the tunnel plastic cover was removed entirely in the seventh day of grafting.

For field evaluation, grafted and non-grafted seedlings were transplanted on 14th March 2013 and 10th March 2014 in rows 3.0 m in width, 9 m in length and spaced 1.0 m apart in the open field. The graft union of grafted seedlings was kept above the soil surface to avoid development of adventitious roots from the scion that connect the soil that may lead to infection and death of the entire plant. The experimental design was a randomized complete block with 11 treatments [(2 grafting methods x 5 rootstocks) + control without grafting] with 3 replicates and the plot area was 81 m2 included 27 plants. In both seasons, all cultural practices (irrigation, fertilization, weeding, and pest control) were performed according to the recommendations of the Egyptian Ministry of Agriculture for watermelon production.

Data recorded.

Vegetative growth characteristics

At 50 days after transplanting, a random sample of four plants from each experimental plot was chosen to record leaf chlorophyll as SPAD readings by Minolta chlorophyll meter. The same plant sample of four plants was rooted up and subjected to assess vegetative growth data e.g. plant length, stem diameter, number of leaves per plant, number of branches per plant, plant fresh weight and dry weight and roots dry weight.

Nitrogen, phosphorus and potassium content of leaves and plant.

Leaf samples from the fourth upper leaf of 6 plants were taken at 50 days from transplanting and oven-dried at 70 C° until constant weight and ground to pass a 1 mm sieve as well as the above mentioned plant sampls. 0.1 g of the dry samples was taken from leaves and plants separately and digested using a mixture of sulphuric acid (H_2SO_4 98 %) and hydrogen peroxide (H_2O_2 30 %) as described by Thomas et al. (1967). All the studied elements were assayed in the digest of the concerned plant samples. Total nitrogen was determined using micro-Kjeldahl apparatus as described by Pregl (1945). Phosphorus content was measured colorimetrically according to the method described by Murghy and Riley (1962) as modified by John (1970). Potassium was measured by flame photometer as described by Brown and Lilleland (1946).

Yield components.

Average fruits number per plant, average fruit yield per plant and estimated yield (ton/ feddan) were calculated within two harvest times, after 85 and 95 days from transplanting, respectively.

Fruit quality

Three ripen fruits were randomly collected from each experimental plots subsamples for fruit quality measurements. Average fruit weight, fruits of each plot were calculated and weighed. The average fruit weight was calculated by dividing fruits weight on fruits number per plot. Fruit peel thickness, three fruits of each plot concentric cut at the center point between stem and blossom ends and the fruit rind or peel thickness was measured by caliper. Soluble solid content (SSC or TSS) of fruit juice, obtained from the central endocarp, was determined using a hand refractomer.

Statistical analysis

All data were subjected to an analysis of variance using the Co-Stat package program (version 6.303; CoHort Software, USA).The differences among means were compared by Duncan's Multiple Range Test with a significance level at $p \leq 0.05$.

RESULTS AND DISCUSSION.

Response of watermelon plant Vegetative growth characteristics to grafting method and rootstock cultivar.

Data displayed in Tables 1, 2 and 3 shows the impact of grafting watermelon cultivar Peacock wm60 on three original rootstocks i.e. 6001, Super Shintoza and Ferro as well as local bottle gourd variety grafted and self grafted against direct seeded plants of watermelon (without grafting as a control) on the vegetative attributes e.g. main stem length and diameter, branches number, leaves number, leaves fresh and dry weight, leaf chlorophyll content, plant fresh and dry weight.The grafting technique was accomplished through two different methods of tongue approach and splice.The data clarify that grafting enhanced significantly all plant vegetative growth attributes compared to self grafted grafting or without grafting practice as a control. When comparing the domestic (local bottle gourd variety) and original (6001, Super Shintosa and Ferro) rootstocks, is clear that the original rootstocks were superior to the domestic one for enhancing rate of plant vegetative. Among the original rootstocks, it was obvious that rootstock 6001 exceeded Super Shintosa and ferro rootstocks. For the effect of grafting methods on plant growth behavior after transplanting in the field, it evident that grafting method effect was absentbecause of the effect of rootstocks on scion behaviorhas not changed as grafting method changed.Grafting methods, splice and tongue-approach,did not show significant effect on watermelon plant behavior under the field conditions while, Khankahdani*et al.,* (2012) reported that splice grafting technique was better than tongue-approachfor enhancing effect on watermelon plants. The data of the effect of propagation watermelon plants via grafting confirmsstrong impact on plant shoot and root systems growth features. According to many researchers,the promotion effect of grafting technique on watermelon plants performance may be attributed to one or more of grafting advantages e.g. mitigate the effect of inappropriate heat temperature (either low or high), increase plant tolerance to pests, soil born and aerial parts diseases, support the plants against nematodes, hold out plants from water or soil salinity stresses and efficient of absorption and movement of water and nutrients within plant (Imatsu, 1949, Barrett1 *et al.*, 2012, Mahdy *et al*., 2014, Singh and Rao, 2014). Also among the grafting benefits the effect on hormonal synthesis and kinetics (Toru and Huining, 1989). Our data is agreed with those of Yamasaki *et al.* (1994) who reported that grafting watermelon [*Citrullus lanatus* (Thunb.)] on inter specific hybrid of squash caused more vigorous growth than plants grafted on bottle gourd or non grafted plants. The data also in accordance with those of Alan *et al*., (2007), Bletsos (2005) and El-Eslamboly (2014) which proved that, grafting watermelon has affirmative effect on plant length, number of branches and leaves and stem diameter. Salam *et al*., (2002) stated that, both vine length and number of lateral branches formed from the grafted plants were greater than those formed of the un-grafted plants. Also Petropoulosa *et al*., (2012) found that grafted watermelon plants on pumpkin and bottle gourd rootstocks had better development as stem length, leaf area, leafs number and plant fresh weight than self-rooted plants

Table 1. effect of grafting methods and rootstocks on peacock wm60 watermelon plant stem length, branches number and leaves number during 2013 and 2014 growing seasons.

Treatments		Stem Length				Branches Number				Leaves Number			
		2013		2014		2013		2014		2013		2014	
Splice	6001	2.95	a	2.93	a	19.50	a	20.67	a	116.67	a	120.00	a
	Super Shintoza	2.45	b	2.45	b	17.33	ab	18.01	ab	108.33	ab	107.67	ab
	Ferro	2.10	c	2.20	b	16.67	ab	16.51	abc	101.67	bc	102.33	ab
	Local	1.53	d	1.61	c	10.33	c	12.33	cd	89.00	cd	88.67	bc
	Self-grafted	0.92	e	0.66	d	6.67	de	7.01	e	39.67	e	34.01	d
Tongue Approach	6001	2.64	ab	2.59	ab	18.00	ab	19.00	ab	111.00	ab	112.01	a
	Super Shintoza	2.23	bc	2.23	b	17.17	ab	17.01	ab	106.01	ab	104.33	ab
	Ferro	2.11	c	2.10	b	16.01	b	15.17	bc	101.67	bc	102.33	ab
	Local	1.38	d	1.42	c	9.67	cd	9.67	de	79.01	d	78.67	c
	Self-grafted	0.92	e	0.66	d	5.67	de	7.01	e	39.67	e	34.01	d
Without grafting		0.91	e	0.94	d	9.01	cd	8.33	de	53.01	E	54.00	d

Means followed by the same letter are statistically not significant according Duncan's multiple range test (*P*=0.05).

Table 2.effect of grafting methods and rootstocks on peacock wm60 watermelon plant stemdiameter, leaves chlorophyll and leaves fresh weightduring 2013 and 2014 growing seasons.

Treatments		Stem diameter				Leaf chlorophyll %				Leaves fresh weight			
		2013		2014		2013		2014		2013		2014	
Splice	6001	2.67	a	2.96	a	64.61	a	64.63	a	523.99	a	534.67	a
	Super Shintoza	2.17	ab	2.14	bc	56.65	ab	60.82	ab	389.39	b	397.33	b
	Ferro	1.86	bc	1.82	cd	49.41	abc	51.83	abc	366.84	b	375.67	b
	Local	1.40	cd	1.43	cde	47.58	bc	49.11	abc	245.62	c	250.67	c
	Self-grafted	1.07	d	0.97	e	40.33	c	40.35	c	129.05	d	119.05	d
Tongue Approach	6001	2.60	a	2.59	ab	59.85	ab	62.77	a	432.15	ab	441.00	ab
	Super Shintoza	1.95	bc	1.93	bcd	54.47	abc	55.30	abc	381.55	b	389.33	b
	Ferro	1.60	bcd	1.69	cde	49.40	abc	51.83	abc	364.63	b	368.67	b
	Local	1.34	cd	1.32	de	46.45	bc	48.38	abc	160.67	cd	160.33	cd
	Self-grafted	1.06	d	0.97	e	40.33	c	40.35	c	129.05	d	119.05	d
Without grafting		1.10	d	1.03	e	40.29	c	40.72	c	118.88	d	122.01	d

Means followed by the same letter are statistically not significant according Duncan's multiple range test (*P*=0.05).

According to data in table (3), leaf chlorophyll content of watermelon plants affected positively and significantly through grafting on the experimental rootstocks belonged pumpkins e.g. 6001, Super Shintosaand Ferro or belonged bottle gourd as the local variety compared to non grafted or grafted on self grafted plants. Results of Yi-Fei, *et al*., (2011) revealed that grafting muskmelon plants increased photosynthesis and carbohydrate metabolism in leaves because of improving leaves chlorophyll a + b content and area in middle and late growing stages of the plant. Abd El-Wanis *et al*., (2013) found that leaves chlorophyll content in grafted cucumber plants increased more than non-grafted others. For plant leaves properties Kudo and Harada (2007) stated that leaf morphology of potato scion was changed when grafted onto transgenic modified tomato rootstock

The tabulated data in table 3 involved the response of watermelon plant root behavior as dry weight tooriginal rootstocks (6001, Super Shintosa and ferro), rootstock of local bottle gourd varietyand the scion root used as rootstock or without grafting (direct seeded plant). For the data of roots dry weight, it could be classifiedto three groups, first group involved plants grafted on 6001, Super Shintosa and ferro which have the highest root dry weight, second group have plants grafted on local bottle gourd variety rootstock which conferred the medium root dry weight of watermelon plants and the third group which was self grafted or direct seeded plants, the plants of this group have the lowest root dry weight. For this regard, Kato and Lou, 1989 found that grafting eggplant led to increase in thick roots number significantly and often root fresh weight compared to own-root plants.

Table 3. Effect of grafting methods and rootstocks on peacock wm60 watermelon plantleaves dry weight andplant fresh and dry weight and plant root dry weightduring 2013 and 2014 growing seasons.

Treatments		Leaves Dry Weight				Plant Fresh Weight				Plant Dry Weight				Root Dry weight			
		2013		2014		2013		2014		2013		2014		2013		2014	
Splice	6001	34.22	a	34.18	a	4322.3	a	4236	a	135.77	a	135.44	a	12.69	a	13.23	a
	Super Shintoza	23.15	b	25.04	bc	3149.3	b	3086.3	bc	126.00	a	126.19	ab	11.84	ab	12.64	ab
	Ferro	23.11	b	23.14	bcd	2907.1	bc	2846.3	bc	117.01	ab	116.67	ab	11.46	abc	12.32	ab
	Local	19.50	bc	19.07	cd	2121.0	cd	2078.3	cd	103.33	ab	99.54	abc	9.79	bc	10.96	ab
	Self-grafted	16.73	c	16.73	cd	871.0	e	871.0	e	54.67	c	54.67	c	5.67	d	7.68	c
Tongue Approach	6001	29.67	a	29.12	ab	3323.7	ab	3257.0		129.01	a	128.54	ab	11.81	ab	12.84	ab
	Super Shintoza	23.10	b	24.27	bcd	2916.0	bc	2857.7	bc	118.67	ab	125.9	ab	11.47	abc	12.52	ab
	Ferro	22.92	b	22.93	bcd	2679.0	bcd	2679.0	bcd	116.30	ab	116.55	ab	11.48	abc	12.24	ab
	Local	17.27	bc	17.72	cd	1812.3	de	1769.3	de	80.67	bc	80.29	bc	9.36	c	10.64	b
	Self-grafted	16.73	c	16.73	cd	871.0	e	871.0	e	54.67	c	54.67	c	5.68	d	7.61	c
Without grafting		15.50	c	15.59	d	976.0	e	1016.3	e	56.33	c	58.51	c	6.78	d	8.26	c

Means followed by the same letter are statistically not significant according Duncan's multiple range test (*P*=0.05).

Response of nutrient content of watermelon plants and leaves to grafting method and rootstock cultivar:

Data in tables 4 and 5 approachingnitrogen, phosphorus and potassium content in watermelon plant and leavesaffected by planting grafted transplants in open field.The data proved to significant increase in leaves and plant content of the nutrients in plants grown from grafted transplants on all investigated rootstocks compared to non grafted or self grafted ones.Ferro rootstock recorded lesser values of N, P and K than those of Super Shintosa and 6001 rootstocks. For this part, the local rootstock of bottle gourd appeared less efficient in increasing the above mentioned nutrients level either in leaves or plants than the original three rootstocks. For the grafting methods, it was obvious that leaves or plant nutrients content did not significantlyvariedasgrafting methods of splice and tongue approachwasapplied for transplants production during 2013 and 2014 growing seasons.The data have the same trend over the growing seasons of 2013 and 2014. The variances in the minerals absorption could be related with the differences in the physical characteristics of rootstocks such as its biomass mainly

and vertical and horizontal growth which affect water and nutrient absorption from different soil layers (Colla*et al*., 2006 and Petropoulos *et al.*, 2014). Lee and Oda (2003) stated that the rootstocks own forceful root biomass which often able to absorbing water and nutrients more than scion roots. Our data is accordance of those by El-sayed *et al*., (2013) which confirm that nitrogen absorption was affected through different rootstocks in grafted cucumber during winter season. Our results were confirmed by those of Kim and Lee, 1989, Pulgar *et al*., 2000 and Ruiz *et al*., 1997 which evidenced that grafting influences absorption and translocation of phosphorus, nitrogen, calcium and magnesium.

Table 4. Effect of grafting methods and rootstocks on peacock wm60 watermelon plantleaves nitrogen, phosphorus and potassium content during 2013 and 2014 growing seasons.

Treatments		Leaves N Content				leaves P content				leaves K content			
		2013		2014		2013		2014		2013		2014	
Splice	6001	2.14	ab	2.11	a	1.09	a	1.07	a	2.41	a	2.29	a
	Super Shintoza	2.16	ab	2.10	a	0.92	abc	0.82	abc	2.21	ab	2.09	ab
	Ferro	1.92	abc	1.93	ab	0.92	abc	0.82	abc	2.01	abc	1.91	ab
	Local	1.74	bc	1.75	bc	0.87	abc	0.77	bc	1.89	bc	1.87	ab
	Self-grafted	1.21	d	1.21	d	0.65	c	0.55	c	0.31	e	0.31	d
Tongue Approach	6001	2.30	a	2.18	a	1.01	ab	1.05	ab	2.15	abc	2.13	ab
	Super Shintoza	2.07	ab	2.01	ab	0.92	abc	0.82	abc	2.01	abc	1.91	ab
	Ferro	1.92	abc	1.92	ab	0.91	abc	0.78	bc	1.85	bc	1.89	ab
	Local	1.91	abc	1.91	ab	0.81	abc	0.71	c	1.77	c	1.79	b
	Self-grafted	1.21	d	1.21	d	0.67	c	0.65	c	0.31	e	0.31	d
Without grafting		1.49	cd	1.49	cd	0.69	bc	0.58	c	0.91	d	0.91	c

Means followed by the same letter are statistically not significant according Duncan's multiple range test (*P*=0.05).

Table 5. Effect of grafting methods and rootstocks on peacock wm60 watermelon plant nitrogen, phosphorus and potassium contentduring 2013 and 2014growing seasons.

Treatments		Plant N Content				Plant P content				Plant K content			
		2013		2014		2013		2014		2013		2014	
Splice	6001	2.78	a	2.90	a	1.06	a	1.10	a	2.36	A	2.26	A
	Super Shintoza	2.16	ab	2.46	ab	0.95	ab	0.93	abc	2.01	Abc	2.09	Ab
	Ferro	1.95	abc	2.04	abc	0.74	abc	0.84	abc	1.72	Abc	1.87	Abc
	Local	1.53	bc	1.63	bc	0.61	bc	0.52	bc	1.61	Bc	1.71	Abc
	Self-grafted	1.10	c	1.10	c	0.55	c	0.42	c	1.35	C	1.35	Bc
Tongue Approach	6001	2.71	a	2.73	a	1.05	a	0.99	ab	2.21	Ab	2.24	A
	Super Shintoza	2.07	ab	2.55	ab	0.88	abc	0.98	ab	1.97	Abc	1.91	Abc
	Ferro	1.91	abc	1.95	abc	0.65	bc	0.94	abc	1.72	Abc	1.75	Abc
	Local	1.44	bc	1.64	bc	0.54	c	0.51	bc	1.61	bc	1.61	Abc
	Self-grafted	1.10	c	1.12	c	0.53	c	0.42	c	1.35	c	1.35	Bc
Without grafting		1.13	c	1.25	c	0.53	c	0.42	c	1.37	c	1.25	C

Means followed by the same letter are statistically not significant according Duncan's multiple range test (*P*=0.05).

Response of watermelon yield and its components to grafting method and rootstock cultivar:

Data in Table 6 illustrates the response of yield parameters e.g. average fruit weight, average fruits number per plant, average fruit yield per plant and estimated yield per feddan, to planting watermelon CV. Peacockwm60 via grafted transplants on three original rootstocks i.e. 6001, Super Shintosa and Ferro, as well as local bottle gourd variety and on the watermelon scion in addition to non grafted transplants (control).The data proved that plants grown from non grafted or watermelon grafted (self grafted) transplants produced minimal fruits number per plant and average fruit weight. Otherwise, the highest fruits number and average fruit weight were recorded by the plants grown from grafted transplants on 6001, Super Shintosa and ferro rootstocks. Grafting watermelon on local bottle gourd variety presented enhancer impact on average fruit weight and average fruits number per plant parameters than self or without grafting practices but less than that of the three original rootstocks. These results were confirmed over 2013 and 2014 growing seasons.Since the average plant yield and estimated yield per feddan were calculated by multiplying average fruit weight and average fruits number per plant and multiplying average fruit yield per plant and plants number per feddan, respectively so that these parameters were going in the same trend of plant fruit yield.Yield data as shown in table 6 confirmed the absence of significant differences of yield parameters affected by the grafting manner (splice and tongue-approach) of watermelon transplants. Similar result was obtained over the growing seasons of 2013 and 2014. The experiments of this study were implemented in fields have grown with watermelon several times without fumigation or other treatment to sterilizing the soil. Consequently, self grafted and direct seeded plants suffered from wiltingseverely in fruits bearing stage (data not shown) therefore the grafted plants on pumpkin or bottle gourd rootstocks differed widely in plant growth and yielding features than non grafted or grafted on same scion. Among the differenceshighly

increaseof branches and leaves number and plant length (table 1) which presented plant parts that bearing fruits (branches and nodes) and consequently increase fruits number which was the main parameter of increasing yield (table 6).Otherwise, increase root efficient of nutrients uptake and water absorption (Lee and Oda 2003, Leonardi and Giuffrida, 2006) parallel with leaves number and its chlorophyll content (tables 2, 3) furnished to increase net assimilates which contributed for improve fruit setting and growth as well as and consequently increase the yield. On the other hand increases fruit yield in substantial crops as tomato and watermelon are often a result of increased fruit size (Pogonyi *et al*. 2005).Our result agrees with those of Ozlem *et al.,* 2007, Howell *et al*., (2008) and El- sayed *et al*., (2013). Also Petropoulos *et al.,* (2012) stated that mean fruit weight at harvest was higher in grafted watermelon plants than in self-rooted others. Turhan *et al*., (2012) found that grafting watermelon on three squash hybrid rootstocks led to increase total and marketable yield than non-grafting.

Table. 6. effect of grafting methods and rootstocks on peacock wm60 watermelon fruit number, fruit weight,yield per plant and estimated yield per feddan during 2013 and 2014 growing seasons.

Treatments		Average fruits No/plant.				Average fruit weight kg				Average yield kg / Plant (kg)				Estimated yield ton / feddan			
		2013		2014		2013		2014		2013		2014		2013		2014	
Splice	6001	5.67	a	6.13	a	8.33	a	9.01	A	47.23	a	53.15	a	51.95	a	58.47	a
	Super Shintoza	5.24	a	5.26	ab	7.47	ab	7.13	ab	39.14	a	37.50	ab	43.05	a	41.25	ab
	Ferro	5.01	ab	5.01	b	7.01	ab	7.00	ab	35.01	ab	35.01	b	38.50	ab	38.50	b
	Local	3.83	bc	3.01	c	5.85	bc	5.87	bc	22.41	bc	17.61	c	24.65	bc	19.37	c
	Self-grafted	0.67	d	0.74	d	2.00	e	1.93	E	1.34	d	1.43	c	1.47	d	01.57	c
Tongue Approach	6001	5.24	a	5.42	ab	8.10	a	8.37	A	42.44	a	45.37	ab	46.68	a	49.91	ab
	Super Shintoza	5.12	a	5.21	ab	7.12	ab	7.07	ab	36.45	ab	36.83	ab	40.09	ab	40.51	ab
	Ferro	5.01	ab	5.00	b	7.00	ab	7.10	ab	35.00	ab	35.50	b	38.50	ab	39.50	b
	Local	3.69	c	2.68	c	4.67	cd	4.33	cd	17.23	c	11.60	c	18.95	c	12.76	c
	Self-grafted	0.67	d	0.71	d	2.01	e	1.83	e	1.34	d	1.30	c	1.47	d	1.43	c
Without grafting		1.00	d	0.67	d	2.60	de	2.07	de	2.60	d	1.39	c	2.86	d	1.53	c

Means followed by the same letter are statistically not significant according Duncan's multiple range test (*P*=0.05).

Response of watermelon fruit quality attributes to grafting method and rootstock cultivar.

Data in table 7 explains behavior of watermelon fruit features as shape, peel thickness and flesh total soluble content affected by planting watermelon of grafted and non grafted transplants (direct seeded transplants as control). It is pronounced that propagation of watermelon via grafted or non grafted transplants did not affect the fruit shape significantly. In terms of peel thickness, it is obvious that growing watermelon from grafted transplants on self grafted or direct seeded produced thinned fruit peel compared to that of grafted on original rootstocks e.g. 6001, Super Shintosa and ferro or local bottle gourd variety.Otherwise, grafting watermelon plants on local bottle gourd variety rootstock conferred the thickest fruit peel. Total soluble solids content (TSS) of watermelon fruit flesh recorded varied values depending on propagation method i.e. grafted and non grafted transplants, and on rootstock cultivar. The highest TSS values were obtained when planting watermelon via grafted transplants on 6001, Super Shintosa and ferro rootstocks but the lowest values were conferred by planting non grafted or self grafted transplants. Grafting on local variety bottle gourd rootstock enhanced the fruit TSS content moderately between grafting on original and self grafted rootstocks and non grafting (direct seeded transplants).The unchanged behavior of fruit quality features for all propagation treatments under the two grafting methods, splice and tongue approach, implies the absence their significant impact on fruits quality attributes.Same trend of data was obtained over the two growing seasons.It is well known that leaves are the main photosynthetic organ in plants, are the source of carbohydrates accumulation in fruits and other storage parts and supply carbon for synthesis of sugars and carbohydrate metabolism. Leaf photosynthesis is substantial for fruit growth and quality. The change in chlorophyll content (as shown in table(1), leaves number, and in table (2) chlorophyll content), photosynthetic rates and carbohydrate partitioning in source leaves can alter photoassimilates export rates, which are directly related to carbohydrate accumulation in fruits or storage parts that act as the sink (Robbins and Pharr1987, Madore 1990, Greutert and Keller 1993). Accordingly, the practice or treatment, which affects the leaves area or chlorophyll content, it will affect the yield and quality. Our results were in accordance with those of Salam *et al*., (2002) which reinforced a marked increase in watermelon fruit TSS content when grafted onto bottle gourd. Yetisir *et al* 2003 found that the soluble solids contents were affected significantly by the rootstock. Ozlem *et al.,* 2007stated that fruit rind thickness did not affectedby grafting watermelon on pumpkin and bottle gourd rootstocks under either open field or low tunnel growing conditions whoever, fruit total soluble content (TSS) was decreased by grafting compared to non grafting not for all rootstocks under open field conditions but under low tunnels TSS did not impacted by grafting or non grafting. On muskmelon, findings by Yi-Fei, *et al*., (2011) revealed that grafting muskmelon plants

enhanced the net photosynthesis rate, carbohydrates contents and translocation of sugars in muskmelon leaves.Otherwise, Miguel *et al*., (2004) did not find any difference in TSS of watermelon fruit from grafted and non- grafted others. Meanwhile Turhan *et al*., (2012) found that grafting watermelon on three squashhybrid rootstocksled to decrease total sugars and total soluble solids but increase rind thickness of fruits than non-grafting. Also Petropoulos *et al.,* (2012) stated thatin grafted watermelon,fruit sugar content varied with scion-rootstock combination.

Table 7: Effect of grafting methods and rootstocks on peacock wm60 watermelon fruit shape, fruit peel thickness and T.S.S. content during 2013 and 2014 growing seasons.

Treatments		Fruit Shape				Fruit peel thickness				T.S.S content.			
		2013		2014		2013		2014		2013		2014	
Splice	6001	1.38	a	1.38	a	37.63	a	37.33	a	10.97	a	10.33	a
	Super Shintoza	1.34	a	1.27	a	35.98	a	36.48	a	10.8	a	10.30	a
	Ferro	1.24	a	1.19	a	37.01	a	37.29	a	9.80	ab	9.83	ab
	Local	1.11	a	1.01	a	39.03	a	38.28	a	8.09	c	8.80	cd
	Self-grafted	1.17	a	1.19	a	15.01	b	15.60	b	6.33	de	5.67	e
Tongue Approach	6001	1.39	a	1.38	a	37.30	a	37.00	a	10.10	a	10.33	a
	Super Shintoza	1.30	a	1.27	a	36.73	a	37.17	a	9.80	ab	10.2	a
	Ferro	1.18	a	1.19	a	37.23	a	36.85	a	9.00	bc	9.07	bc
	Local	1.19	a	1.03	a	38.53	a	38.66	a	7.77	c	8.40	cd
	Self-grafted	1.16	a	1.17	a	15.60	b	15.28	b	6.00	e	5.67	e
Without grafting		1.13	a	1.13	a	15.01	b	15.01	b	7.67	cd	8.00	d

Means followed by the same letter are statistically not significant according Duncan's multiple range test (*P*=0.05).

CONCLUSION

Propagation watermelon Peacock wm60 cultivar via grafting improved plant performance within enhancing vegetative and root growth, yield and fruit quality compared to non-grafting or direct seed propagation. Use rootstocks breaded for grafting e.g. 6001, Super Shintoza and Ferro was superior to use unspecified rootstocks for grafting as local pumpkin cultivar or self-grafting. Grafting watermelon on the previous rootstocks via splices or tongue approach methods not impacted on plant growth or yield parameters in the field.

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تحسين نمو وإنتاجية البطيخ بالتطعيم تحت الظروف المصرية

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إجريت الدراسة في مزرعة خاصة بمحافظة الشرقية بمصر. خلال موسمي ٢٠١٣-٢٠١٤ لتقييم تأثير طرق التطعيم والأصول المختلفة علي صفات المجموع الخضري والإنتاج وجودة المحصول للبطيخ صنف(Pea cock Wm 60)المعروف محليا وتجاريا بالطاووس والذي تم تطعيمه علي خمس أصول مختلفة (هجين 6001 وسوبر شنتوزا و فيررو وبوتل جارد كأصل محلي و Pea cock Wm 60كأصل من نفس الصنف) وذلك بطريقتين تطعيم مختلفتين (لساني – جانبي بالإقتران) مقارنة بالنباتات الغير المطعومة من نفس الصنف .طرق التطعيم اظهرت عدم إختلاف في صفات المجموع الخضري وكذلك المحصول وجودته بعد الزراعة بالحقل في حين تطعيم بطيخ Pea cock Wm 60 علي أصول 6001 والسوبر شنتوزا والفيررو أدي الي زيادة في الصفات الخضرية والإنتاجية وجودة المحصول بصورة إيجابية عن التطعيم علي الأصل المحلي أو علي نفس الصنف , مقارنة بالنباتات الغير مطعومة .أصل هجين 6001 أظهر تفوق تأثيره علي المجموع الخضري والإنتاجية لقوة المجموع الجذري . في حين أظهر الأصل المحلي ضعف تأثيره علي المجموع الخضري والمحصول مقارنة بباقي الأصول ولكنه تفوق علي الأصل من نفس الصنف Pea cock Wm 60 والنباتات الغير مطعومة.