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Effect of grafting on the growth, yield, quality and storability of tomato (*Solanum esculentum* L.), grown in NFT system under plastic- house conditions.

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ABSTRACT

This study was carried out in the field experimental station of solar energy department of National Research Center, Egypt during autumn of the two successive seasons 2011-2012 and 2012-2013to study the effect of grafting on the vegetative growth, yield, and fruit quality characteristics i.e., fruit weight, length, diameter, total soluble solids (TSS) content and titrable acidity (TA) of tomato (*Solanum lycopersicum*). Tomato hybrid '.TM1000 F1 Sakata. Transplants were grafted onto 4 rootstocks namely *Solanum lycopersicum* cv. RX01660449(Sh) Hybrid Royal Sluis Comp., (*Solanum melongena*) cultivars (White eggplant (W.L), and Black eggplant (B.C)), *Datura stramonuim* (D.S) and ungrafted tomato hybrid transplants were used as a control .All transplants were grown in Nutrient Film Technique (NFT) system. Results showed that Vegetative growth *i.e.,* plant length, leaf number, and leaf area index (LAI) were increased when *Solanum lycopersicum* cv. RX01660449 (S.h) was used as a rootstock.The total yield of tomato plants grafted on *Solanum lycopersicum* cv. RX01660449 (S.h) rootstock was greater than the ungrafted ones without significant difference between them. On the other hand, the rest of grafted plants *i.e Solanum melongena* white eggplant (W.L), and Black eggplant (B.C), *and Datura stramonuim* (D.S) had a significant reduction in the total yield. At harvest, storage experiment was conducted in the Vegetable Handling Department laboratory, Horticulture Research Institute, Agriculture, Research Center, Giza to study the storage behavior of grafted and ungrafted tomato fruits at 10C° and 90% RH for 28 days. The obtained results indicated that, grafted fruits displayed less decrease in most studied quality parameters *i.e.,* weight loss percentage, lightness, firmness, and visual appearance as compared with ungrafted ones during the storage period. Tomato fruits produced from grafting Tomato hybrid '.TM1000 F1 Sakata on the rootstock of *Solanum lycopersicum* cv.RX01660449 Hybrid (S.h) maintained acceptable appearance, less weight loss percentage, shiny and firmer fruits comparing with fruits grafted on the other rootstocks or ungrafted fruits (control) during storage at 10C° and 90% RH for 28 days

Key words: Tomato, Grafting, NFT, Rootstocks, Storability, Plastic-house.

Introduction

In year 2010, 8.5 million metric ton (MT) of fresh tomato was produced in Egypt (FAO 2012). Under protective cultivation grafted seedling was used widely to overcome a wide range of stress. grafting have been used to induce resistance against low (Bulder *et al.,* 1990 and Jan *et al*., 2008) and high (Rivero *et al.,* 2003) temperatures; to enhance nutrient uptake (Ruiz *et al.,* 1997); to improve yield when plants are cultivated in infected soils (Bersi, 2002; Marsic and Osvald, 2004); to increase the synthesis of endogenous hormones (Proebsting *et al.,* 1992); to improve water use (Cohen and Naor, 2002); to increase flower and seed production (Lardizabal and Thompson, 1990); to enhance vegetable tolerance to drought, salinity and flooding (AVRDC, 2000; Maria *et al.,* 2004 and Estan *et al.,* 2005 and Cuartero *et al.,* 2006). Moreover, many researchers reported that an interaction between rootstocks and scions exists resulting in high vigor of the root system and greater water and mineral uptake leading to increased yield and fruit enhancement (Lee, 1994; Oda, 1995; Bersi, 2002; White, 1963; Leoni *et al*., 1990; Ioannou, *et al.,* 2002; Marsic and Osvald, 2004; Mona, 2008 and Lee, *et al.* 2010).Tomatoes, can be easily grafted onto eggplant, potato (*Solanum tuberosum* L.), or other species of the nightshade - Solanaceae - family (Lowman and Kelly, 1946; Matsuzoe *et al.,* 1991a). Previous studies on influence of grafting on fruit shelf life yielded mixed findings indicating either increased or decreased longevity of fruit depending upon the types of rootstocks and scion and their interactions. Grafting with resistant rootstocks may impact fruit quality and affected the fruit shelf life significantly (Davis *et al*., 2008a, b; Xin *et al*. 2011.

This work is aimed to study the effect of grafting on tomato fruit quality characters grown in Nutrient Film Technique (NFT) system under green house conditions.

Material and Methods

The first experiment:

This experiment was carried out in the field experimental station of solar energy department of National Research Center, Egypt during autumn of the two successive seasons 2011-2012 and 2012-2013. The tomato hybrid '.TM1000 F1 Sakata. ‘transplants were grafted onto 4 rootstocks namely Tomato(*Lycopersicum esculentum* cv.RX01660449 Hybrid (S.h)) Royal Sluis Comp. , Eggplant (*Solanum melongena*) cultivars (White eggplant (W.L), Black eggplant (B.C)) and *Datura stramonuim* (D.S) and self-grafted tomato hybrid transplants

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were used as control. Seeds of rootstocks were sown in Speedling trays (84 cells) filled with growing media consisting of peat moss and vermiculite 1:1 (V: V). Seeds of rootstocks *Datura stramonium* (D.S), white eggplant(W.L) and Black eggplant(B.C) were sown earlier, *i.e.* on 1/7, while Tomato *Lycopersicum esculentum* cv. RX01660449 Hybrid(S.H) was sown on 21/7. On the other hand, scion seeds tomato hybrid '.TM1000 F1Sakata were sown on 25/7 after 35 days on both seasons from sowing the stems of in both seasons, then rootstocks were cut at right angles leaving 2 to 3 leaves depending on temperature. The tapered stems of the scions were placed into the cleft of the cut-end of the rootstocks, followed by clipping. It was important during grafting to increase the chance for vascular bundles of the scion and rootstocks to come into contact. This was achieved by increasing the area of spliced cut surfaces and by appropriate pressure to the spliced cut surfaces together should not be dried (Oda *et al*., 1994). The seedlings were placed under a plastic tunnel for optimum temperature (25-30°C) and humidity (98%). After 10 days from grafting stage by watching the new growth on the scion. The plastic tunnel was gradually opened for adaptation and preparing the grafted seedlings for transplanting in the plastic house. Transplants were transplanted on 5th Oct. in the first season 2011 and 4th Oct. in Second season 2012 in Nutrient Film Technique (NFT) system .NFT gullies dimensions were 0.3 m wide, 5 m long and 6cm height. Plants were placed in the center of the gullies at a distance of 0.5 m between plants. Nutrient solution analysis of 60ppm.N; 30ppm.P; 280ppm. K^{+}; 26 ppm. Ca^{+2}; 11ppm. Mg^{+2}; 6 ppm; Fe 0.3ppm Mo; 0.5ppm Cu; 2 ppm Zn; was used. Electrical Conductivity (EC) of the solution tank was adjusted at 2.5ds/m (EC) and 5.8ph. Plants were trained and pruned by removing the side shoots. The complete random experimental design was used, where the treatments were arranged randomly in the plots

1-Vegetative growth:

A random sample of 3 plants from each replicate was taken and data was recorded as follows:

Plant height (cm) and number of leaf per plant was determined after 30, 90 and 120 days from transplanting.

Stem thickness***:*** was determined after 90 days from transplanting. leaf area (cm^2/plant) and leaf area index (LAI) was determined after 30 and 90 days from transplanting by measuring average leaf area**,** using Li. Cor. Portable area index meter model Li.3050 and then the leaf area per plant (cm^2) was divided on land area.

Dry matter percentage for plant was determined after 30 and 90 days from transplanting.

2 - Fruit quality characters:

A random sample of 10 fruits from each replicate were harvested at pink stage and examined for the following characters: average fruit weight (g), fruit length (cm) and fruit diameter (cm), and Total soluble solids percentage (TSS %). Titrable acidity (TA) was also determined using the titration method against 0.1 N of NaoH and phenol- phethaline as mentioned in the Association of Official Analytical Chemists, A.O.A.C. (1990).

3-Total yield:

All tomato fruits reached to the pink stage after six weeks from transplanting were picked weekly through the harvesting period and weighed.

The second experiment:

In this experiment, tomato fruits which obtained from the field experiment, harvested at the pink stage on January, transported to the Vegetable Handling Department laboratory, Horticulture Research Institute, Agriculture, Research Center to study the storage behavior of tomatoes fruits resulted from the grafting of tomato hybrid TM1000 F-1 Sakata, onto the four rootstocks. At harvest time pink fruit stage transported to the laboratory one day before storage, and kept overnight at 10C° and 90 % RH. In second day uniform fruits, free of physical defects and fungal infections, were selected and packed in polystyrene trays, each one contained about 500 g. of tomatoes. Each container was individually weighed, labeled, and placed in carton box, three containers for each. All containers were transferred to cold rooms at 10C° and 90 % RH. One carton box having three replicates (three polystyrene containers) of each treatment was examined following immediate after harvest and every 7 days intervals for the all treatments were stored at 10C and 90% RH for 28 days. Quality of harvested tomatoes fruits were measured at harvest and during storage as follows:-

1-Weight loss percentage:

Weight loss percentage of tomatoes fruits were estimated according to the following equation:

Weight loss % = ((Initial fruit weight – fruit weight of sampling date)/ Initial fruit weight) X 100

2- Fruit firmness:

Fruit firmness of each individual tomato fruits were measured at two points of the equatorial region by using a pressure tester 8-mm plunger. The firmness of the flesh was expressed as newton (N).

3- Surface color:

Surface color of 12 fruits from each treatment was measured using a colorimeter (CR400 Minolta) which provided L and a value. L refers to the lightness, ranging from 0 = black to 100 = white, higher positive a values refers to red color (Mc Guire, 1992).

4-Visual appearance:

Visual appearance was determined using score system of 9 = excellent, 7 = good, 5 = fair, 3 = poor, and 1 = unsalable. This scale depends on the morphological defects such as shriveling or sunken area on fruit surface.

Statistical analysis:

All data obtained were subjected to the proper statistical analysis using the MSTAT statistical software and the treatments means were compared by using the LSD at 0.05 level of probability as described by Senedecor and Cochran (1989).

Results and Discussion

The first experiment:

Effect of different rootstock on the vegetative growth, yield and quality characters of tomato fruit produced in NFT system:

Vegetative growth:

Data in Table 1, showed that grafted tomato plant on tomato cv. RXO1660449 (S.h) which used as rootstock increased their vegetative growth characters expressed as plant height and number of leaves / plant in all stages of growth with non-significant differences between them , this increase were very clear after 120 days from transplanting. On the other hand, the lowest recorded of these characters were resulted by using cv. White eggplant (W.L), *Datura stramonuim* (D.S) and cv. Black eggplant (B.C) as rootstocks. Concerning stem thickness, after 90 days from transplanting data show the same results. These results were agree with those obtained with Lee (1994) and Ioannou *et al.*, (2000) who found that grafted plants were taller and more vigorous than self-rooted ones and had a large central stem diameter this difference differ response of rootstock could be attributed to the analytical structure of the rootstock roots growing in the continuous running water in NFT system which may be not met the required conditions for roots growth of some rootstock genotype. It was observed that flowering began earlier in the grafted plants, probably due to the fact that grafting caused stress and delayed flower formation Chung *et a*l., (1997).

Data in Table 2, revealed that ungrafted treatment plants (control) gave the highest value of leaf area and leaf area index followed by grafted tomato onto cv. (S.h) after 90 days from transplanting. The results also showed that, a significant decrease in leaf area and leaf area index / plants when *Solanum melongena* cv. Black eggplant (B.C) was used as rootstocks. However concerning dry weight % / plant, data show that plants grafted on White eggplant (W.L) rootstock gave the highest value of dry weight % / plant from transplanting when compared with other treatments with significant differences between them after 90 days from transplanting.

Total yield:

Data in Table 2, showed that the highest values of total yield of tomato were recorded for tomato plants grafted on tomato (S.h) RX01660449 hybrid rootstock followed by ungrafted plants with non-significant differences between them, this results were in agree with the results of Lee (1994) found an increase in total yield without having significant effects in yield which was attributed to the vigor of the rootstock and the higher uptake of water and nutrients. Mona (2008) also found that eggplant grafted onto two tomato rootstocks gave a higher yield and bigger fruit size than those grafted onto two eggplant rootstocks. On the other hand, the rest of

grafted plants *i.e* cv. White eggplant (W.L), *Datura stramonium* (D.S) and cv. Black eggplant (B.C) had significant reduction in the yield. This negative effect of grafting has also been reported by other authors (Ginoux, 1974; Tsouvaltzis *et al*., 2004).

Table 1: The effect of different rootstocks on the plant height, leaf number and stem thickness of tomato grown in NFT system.

Treatments	plant height (cm)				leave number				stem thickness (cm)
	Days After Planting (DAP)				Days After Planting (DAP)				
	At trans-planting	30	90	120	At trans-planting	30	90	120	90 days
First season 2012-2013									
Cont.	7.5	61.3	135.3	270.6	2.0	15.5	25.6	38.5	1.47
W.L	5.5	45.3	91.9	139.5	2.0	6.8	14.9	18.6	0.92
S.h	9.6	53.3	143.6	289.9	3.0	14.3	26.0	41.0	1.48
D.S	10.7	50.3	109.8	159.4	3.0	7.8	15.3	19.2	1.32
B.C	6.2	46.5	100.4	148.2	2.0	7.8	13.6	17.0	1.13
LSD5%	1.48	9.4	21.5	33.8	0.45	2.02	3.62	5.26	0.23
Second season 2013-2014									
Cont.	8.2	67.4	148.9	297.7	2.20	17.1	28.2	42.4	1.62
W.L	6.0	49.3	100.1	152.1	2.18	7.4	16.2	20.3	1.00
S.h	10.5	58.4	157.2	317.4	3.29	15.7	28.5	44.9	1.62
D.S	10.2	47.8	104.3	151.4	2.85	7.4	14.6	18.2	1.25
B.C	6.9	51.2	114.8	163.0	2.20	8.5	15.0	18.7	1.24
LSD at 5%	1.55	10.1	23.2	41.7	0.44	2.18	3.91	5.70	0.25

Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena cv.* White eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* cv. Black eggplant

Table 2: The effect of different rootstocks on the Leaf area, Leaf Area Index, Dry matter (%) and total yield of tomato grown in NFT system.

Treatments	L. area (cm2/plant)		Leaf Area Index		Dry matter%		Total yield (Kg/Plant)
	30	90	30	90	30	90	
First season 2012							
cont.	469.4	1877.5	2.22	6.90	15.36	14.05	10.19
W.L	302.4	756.0	0.99	2.48	16.35	18.49	3.95
S.h	407.0	1628.0	1.56	6.25	13.96	12.80	11.33
D.S	274.3	685.6	1.03	2.58	14.66	14.55	4.41
B.C	263.8	659.6	0.98	2.45	14.84	14.50	3.64
LSD5%	64.2	165.43	0.26	0.84	2.45	2.76	1.36
Second season 2013							
cont.	516.3	2065.3	2.45	7.59	16.9	15.5	10.6
W.L	329.6	824.1	1.08	2.70	17.8	20.2	4.30
S.h	445.7	1782.7	1.71	6.85	15.3	14.0	11.30
D.S	260.5	651.3	0.98	2.45	13.9	13.8	4.19
B.C	290.2	725.5	1.08	2.70	16.3	16.0	3.92
LSD at 5%	69.4	245.3	0.28	0.91	2.93	3.0	1.39

Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena* cv.white eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* cv.Black eggplant

Fruit quality characters:

Data in Table (3) reveled that grafted tomato plants on tomato RX01660449 hybrid rootstock and ungrafted plant increased their fruit quality expressed as average fruit weight, fruit length and fruit diameter TSS and Titratable acidity with non- significant differences between them . On the other hand, the lowest recorded of these characters were resulted by grafted tomato plants on cv. White eggplant, *Datura stramonium* and cv. Black eggplant as rootstocks in the same seasons The above results in general agree with other researchers who found that fruit descriptive and qualitative characteristics were not affected by grafting. (Leoni *et al.*, 1990; Romano and Paratore, 2001).

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Table 3: Effect of different rootstocks on fruit characters, TSS and titratable acidity (TA) of tomato fruit grown in NFT system.

Treatments	First season 2012					Second season 2013				
	Fruit			TSS %	Titratable acidity (TA)	Fruit			TSS %	Titratable acidity (TA)
	Weight (g)	Length (cm)	Diameter (cm)			Weight (g)	Length (cm)	Diameter (cm)		
cont.	180.0	5.70	7.70	4.5	754	186.5	5.91	7.98	4.6	776
W.L	137.7	4.03	6.27	6.1	210	142.6	4.18	6.49	6.3	386
S.h	183.3	5.93	8.00	6.8	813	189.9	6.15	8.29	7	824
D.S	137.7	4.23	5.70	6.0	352	142.6	4.39	5.91	6.0	334
B.C	136.7	4.67	8.03	6.6	242	141.6	4.83	8.32	6.3	266
LSD at 5%	22.6	0.43	0.93	0.11	116	22.9	0.56	0.81	0.10	103

Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena* cv.White eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* cv.Black eggplant

The second experiment:

Effect of different rootstock on storability of tomato fruit produced in NFT system:

Weight loss percentage:

The effect of different rootstocks on tomato fruits grown in NFT system were summarized in Table 4. All grafted and ungrafted fruits showed a progressive loss of weight as the storage period was prolonged. This loss in weight is mainly associated with respiration and moisture evaporation. According rootstocks, different rootstocks appear to show different effects on fruit weight loss.ungrafted tomato fruits (control) showed significantly higher weight loss percentage as comparing with grafted fruits. The lowest weight loss percentage was observed in fruit grafted on (S.h) rootstock, followed by fruits grafted on (W.L) and (B.C) rootstocks without differences between them, and fruits grafted on (D.S) rootstock in both seasons of the study.

The interaction between rootstocks and storage period showed that weight loss percentage ungrafted fruits (Self-grafted tomato TM1000 F1 Hybrid') increased during all storage period compared to other grafted fruits.

Table 4: Effect of different rootstocks and storage period on weight loss percentage (%) of tomato fruit grown in NFT system:

Treatments	First season 2012					Second season 2013				
	Storage period (days)				Mean	Storage period (days)				Mean
	7	15	21	28		7	15	21	28	
Cont.	1.42	2.74	4.16	5.23	3.39	1.56	2.32	3.94	5.27	3.27
W.L	0.56	1.53	2.46	2.66	1.80	0.65	1.51	2.60	2.86	1.90
S.h	0.39	1.19	1.53	2.09	1.30	0.39	1.28	1.79	2.10	1.39
D.S	0.92	1.81	3.61	4.24	2.65	1.12	1.75	3.55	4.08	2.63
B.C	0.47	1.60	2.39	2.63	1.77	0.50	1.68	2.44	2.47	1.77
Mean	0.75	1.77	2.83	3.37		0.84	1.71	2.87	3.36	

LSD at 5% level for:

(A) Treatments =	0.19	0.31
(B) Storage period =	0.17	0.28
A X B =	0.37	0.62

Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena* cv.white eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* cv.Black eggplant

Lightness:

Table 5, shows obvious decrease in fruits lightness (L*) value as the storage period was increased. This decrement was significant after 7 days of storage at 10C º and 90% RH in both seasons in all grafted and ungrafted fruits. Such result may be contributed to the changes of fruit color from pink to light red color .Regarding rootstocks, the same table reveals that fruits grafted on (S.h) rootstock appeared to be shiny and lighter than ungrafted fruits (control). On the other hand, obvious darkness was noticed in ungrafted fruits (Self-grafted tomato TM1000 F1 Hybrid'). These results supported by Colla *et al*., (2006) who found that the L* value (brightness) measured on the surface of the external pulp of melon were significantly higher in graphted plants compared to ungraphted plants under green house conditions. The interaction between rootstocks and the storage period on fruit lightness was significant in both seasons. ungrafted fruits exhibited the darkest fruits in

the first season after 28 days of storage 10 C°, meanwhile ungrafted fruits and fruit grafted on (D.S) rootstock appeared to be the darker fruits without difference between them at the second season.

Table 5: Effect of different rootstocks and storage period on the lightness (L* value) of tomato fruit grown in NFT system:

Treatments	First season 2012						Second season 2013					
	Storage period (day)					Mean	Storage period (day)					Mean
	0	7	15	21	28		0	7	15	21	28	
Cont.	43.89	42.05	41.40	40.17	39.34	41.37	43.38	41.99	40.90	39.92	39.61	41.16
W.L	44.28	42.46	41.54	40.64	39.94	41.77	43.58	43.32	41.76	40.42	39.80	41.78
S.h	44.50	43.30	42.24	41.38	40.95	42.47	43.88	43.29	42.28	42.20	40.39	42.41
D.S	44.03	42.35	41.49	40.35	39.79	41.60	43.40	42.51	40.28	40.61	39.67	41.29
B.C	44.35	42.87	41.79	41.00	40.52	42.11	43.69	43.38	41.85	41.16	39.87	41.99
Mean	44.21	42.61	41.69	40.71	40.11		43.59	42.90	41.41	40.86	39.87	

LSD at 5% level for

(A) Treatments =	0.64	0.54
(B) Storage period =	0.64	0.54
A X B =	1.43	1.22

Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena* cv.White eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* cv.Black eggplant

Firmness:

Changes in tomato fruit firmness are tabulated in Table 6, a gradual and a significant reduction in fruit firmness had occurred by prolongation of the storage period. The decrease in fruit firmness may be due to gradual breakdown of protopectin to lower molecular weight fractions which are more soluble in water and this is directly correlated with the rate of softening of the fruits (Wills *et al*., 1981). As for rootstock, (S.h) was the most effective rootstock which exhibited higher firmer fruits comparing with fruits grafted on the other rootstocks or ungrafted fruits (control). No, significant differences were observed between fruit grafted on (W.L) and (D.s) rootstocks in the first season or fruits grafted on (W.L) and (B.C) rootstocks in the second season. On the other hand, ungrafted fruits (control) recorded the lowest firmer fruits in both season. Such results may be related to the variation on cellular morphology, cell turgor, the chemical and mechanical properties of cell walls of fruits as a result of increasing synthesis of endogenous hormones and changing water relationships and nutritional status of scion Rouphael *et al*., 2009). The interaction between rootstocks and the storage period on fruit firmness was significant, indicating (S.h) rootstock was the most effective rootstock introduced the firmer fruits in both seasons.

Table 6: Effect of different rootstocks and storage period on the firmness (Newton) of tomato fruit grown in NFT system:

Treatments	First season 2012						Second season 2013					
	Storage period (day)					Mean	Storage period (day)					Mean
	0	7	15	21	28		0	7	15	21	28	
Cont.	38.74	36.30	29.73	28.33	26.64	31.95	38.46	36.27	29.77	28.53	26.69	31.94
W.L	38.83	38.46	31.54	28.43	26.04	32.66	38.75	37.24	32.70	30.34	28.40	33.49
S.h	38.90	38.84	32.60	32.23	29.78	34.47	38.94	38.34	33.43	32.13	29.49	34.47
D.S	38.68	38.36	30.84	28.02	26.26	32.43	38.61	37.64	30.78	28.22	26.55	32.36
B.C	38.77	38.69	31.93	30.73	27.93	33.61	38.82	38.27	32.74	31.66	26.68	33.63
Mean	38.78	38.13	31.25	29.55	27.33		38.72	37.55	31.88	30.18	27.56	

LSD at 5% level for:

(A) Treatments =	0.24	0.34
(B) Storage period =	0.24	0.34
A X B =	0.81	0.77

Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena cv.* white eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* cv.Black eggplant

Redness:

As shown in Table 7, there was a pronounced increase in tomato fruits ripening (a*) value, however higher (a*) values indicated more red color or ripening as the storage was extended. This increase was significant after 7 days of storage. The lowest low (a*) was recorded in fruits grafted on (S.h) rootstock followed by fruits grafted on (B.C) rootstock in both seasons. No, significant differences were observes between fruit grafted on (W.L) and (D.S) rootstocks in the first season or fruits grafted on (D.S) and control in the second season. These results disagree with the finding of Colla et al., (2006) who found that redness/yellowness on the surface

of the external pulp of melon were significantly higher in grafted plants compared to ungrafted plants grown under greenhouse conditions.

The interaction between rootstocks and the storage period was significant. Ungrafted fruits (Self-grafted tomato TM1000 F1 Hybrid') showed the highest color change (the highest a* value) compared to grafted fruits during storage at 10°C for 28 days.

Table 7: Effect of different rootstocks and storage period on the redness (a* value) of tomato fruit grown in NFT system during 2012 and 2013 seasons:

Treatments	First season 2012						Second season 2013					
	Storage period (day)					Mean	Storage period (day)					Mean
	0	7	15	21	28		0	7	15	21	28	
Cont.	29.39	31.88	32.12	32.50	33.00	31.78	29.92	31.53	32.92	33.52	34.54	32.49
W.L	29.29	30.39	31.53	31.85	32.52	31.12	28.62	30.18	33.36	32.50	33.35	31.60
S.h	27.75	29.62	30.34	30.50	30.58	29.76	27.85	28.89	30.56	30.77	31.40	29.89
D.S	29.38	30.65	31.72	32.63	33.38	31.55	30.90	31.51	32.51	32.64	33.52	32.22
B.C	28.64	30.83	31.33	31.68	32.45	30.99	28.68	30.56	31.57	32.03	33.36	31.24
Mean	28.89	30.67	31.41	31.83	32.39		29.19	30.53	32.18	32.29	33.23	

LSD at 5% level for:

(A) Treatments =	0.67	0.33
(B) Storage period =	0.67	0.33
A X B =	1.50	0.75

Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena* White eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* Black eggplant

Visual appearance:

Table 8, showed that visual appearance score decreased with prolonging the storage period significantly and that was true for the two seasons. Such decrease in visual appearance, mostly may be due to a slight dryness of the surface, fruit darkening and ripening .Regarding rootstocks, the same table illustrate that (S.h) , (B.C),and (W.L)rootstocks showed a significant impact on tomato appearance as compared with fruits grafted on(D.S) rootstock or (Self-grafted tomato TM1000 F1 Hybrid'). These results are in harmony with Davis *et al* 2008 a,b who stated that grafting increase or decrease the longevity of fruits depending upon the types of rootstocks and scion and their interaction. No, marked decay was observed in all fruits under this study for 28 days.

The interaction between the rootstocks and the storage period was significant during storage. All grafted and ungrafted tomato fruits under this study maintained an excellent appearance during 15 days of storage. At the end of the storage grafted fruits exhibited acceptable appearance. On the other hand ungrafted fruits (Self-grafted tomato TM1000 F1 Hybrid') gave fruits with fair appearance during 28 days of storage at 10C° and 90% RH in both seasons.

Table 8: Effect of different rootstocks and storage period on the visual appearance score* of tomato fruit grown in NFT system:

Treatments	First season						Second season					
	Storage period (day)					Mean	Storage period (day)					Mean
	0	7	15	21	28		0	7	15	21	28	
Cont.	9.00	9.00	8.33	6.33	5.66	7.67	9.00	9.00	8.33	7.00	5.00	7.66
W.L	9.00	9.00	9.00	8.00	7.66	8.53	9.00	9.00	9.00	8.33	8.00	8.66
S.h	9.00	9.00	9.00	9.00	8.33	8.87	9.00	9.00	9.00	9.00	8.33	8.87
D.S	9.00	9.00	9.00	7.33	6.33	8.13	9.00	9.00	9.00	8.33	8.00	8.13
B.C	9.00	9.00	9.00	8.33	8.00	8.67	9.00	9.00	9.00	8.33	8.00	8.66
Mean	9.00	9.00	8.87	7.80	7.20		9.00	9.00	8.86	7.93	7.20	

LSD at 5% level for:

(A) Treatments =	0.56	0.40
(B) Storage period =	0.56	0.40
A X B =	1.25	0.90

* Score: 9= Excellent, 7= Good, 5= Fair, 3= Poor, 1= Unsalable.
Cont. =Self-grafted tomato TM1000 F1 Hybrid'
W.L=*Solanum melongena* White eggplant
S.h= *Solanum lycopersicum* cv.RX01660449 Hybrid
D.S= *Datura stramonuim*
B.C = *Solanum melongena* Black eggplant

Conclusion:

It could be concluded that grafted tomato plants on tomato cv. Rx01660449 hybrid rootstock grown under Nutrient Film Technique system improved vegetative growth of the plant, yield, fruit quality and storability of tomato fruits.

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