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Research Article

Effect of Grafting Technique on Productivity and Quality of Cantaloupe under Saline Irrigation Water

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Abstract

The high salinity of the irrigation water is the biggest challenge facing horizontal expansion of vegetable cultivation especially in the new reclaimed land. The high salinity of the irrigation water is of a deleterious effect on the cantaloupe production. Thus, this experiment was carried out under greenhouse conditions during 2015 and 2016 autumn seasons in Moshtohor, Kalyobiya Governorate, Egypt to investigate the possibility of using grafting technique to ameliorate the negative effects of high salinity of irrigation water on cantaloupe productivity and its quality. Two commercial cultivars "*Ideal and Veleta*" were used as scion while *Cobalt* and *Strong-Tosa* were used as rootstocks. A modified tongue approach grafting method was used, and then seedlings were exposed to four salinity levels [0.8 (non-saline control), 3.9, 7.1 and 10 dSm^{-1}]. The results showed that all investigated factors "salinity levels, cultivars and rootstocks" significantly affected cantaloupe productivity and quality. Where, the medium salinity level (3.9dS/m) resulted in the highest early yield, fruits number and total yield compared to all other salinity levels while the total yield decreased by 39.7% with increasing salinity levels up to 10dS/m. Whereas, graft combination of *Ideal*/*Strong-Tosa* increased the total yield by 53.1, 85.5, 43.8 and 1.4% at different salinity levels: control, 3.9, 7 and 10dS/m, respectively compared to the non-grafted plants of *Ideal* at non-saline control. This percentage was 38.4, 41.5, 19.3 and decline 13.1% with *Veleta*/*Cobalt* compared to the non-grafted plants of *Veleta* at non-saline control. Generally, when cantaloupe plants have to be irrigated with high salinity of irrigation water, it is recommended to cultivate grafted seedling resulted of *Veleta*/*Cobalt* and *Ideal*/*Strong-Tosa* where these plants resulted the highest benefit and income compared with those on its own roots (non-grafted plants) under saline conditions.

Keywords: Cucumis melo; Cantaloupe; Grafting; Rootstock; Scion; Irrigation water and salinity

Introduction

Cantaloupe (*Cucumis melo L.*) is a high economic vegetable crop in many countries including Egypt. It is grown in practically every country in the world under outdoor fields or greenhouses. The cultivated area of cantaloupe in Egypt is 66,434 feddan (4200m2) with total production of 846,936 tons and an average of 12.749 ton/fed. Ministry of Agric, Egypt, 2015. The most important problems facing horizontal expansion of cantaloupe in greenhouses or in open fields are the high salinity of the irrigation water or soil especially in the new reclaimed lands. As well as the recurrence of agriculture in greenhouses increases the soil salinity and thus reduces the vertical production of cantaloupe. In addition, cantaloupe is moderately salt tolerant, it has been determined that salinity causes several kinds of damage such as growth inhibition [1-3], yield and quality losses [4-6]. This leads us to use some newly trends to mitigate these negative impacts. The grafting technique is one of the most modern trends used to improve the productivity of vegetable plants, especially under adverse environmental conditions. Grafted vegetables onto resistant rootstocks offers numerous advantages on growth and yield, i.e., tolerance to salinity stress [7-10], increase yield and fruit quality in many crops such as melon [11] and watermelon [12,13]. Accordingly, the present study was conducted to investigate the possibility of using the grafting as a new promising technique for ameliorate the negative effects of the high salinity of the irrigation water on cantaloupe productivity and its quality.

Materials and Methods

This investigation was carried out in a private farm in Moshtohor village, Kalyobiya Governorate, Egypt during 2015 and 2016 autumn seasons to study the response of yield productivity and fruits quality of grafted and non-grafted cantaloupe plants to different irrigation water salinity levels. The soil was clay with pH of 8.0 and EC of 1.3dS/m. Two commercial cultivars *Veleta RZ* and *Ideal* (MG739) were grafted on the *Cobalt RZ* and *Strong-Tosa* rootstocks using modified tongue approach grafting method. The grafted and non-grafted seedlings were transplanted under net house condition, on the 21st of July in both investigation seasons. The plants were transplanted on one side of ridges 1.5m width, at 50cm apart. Four irrigation water salinity levels were applied [0.8, 3.9, 7.1 and 10 dSm^{-1}] by adding NaCl to the used underground water. A split split-plot designed was adopted, with three replicates where, salinity levels were placed in main plots, meanwhile cultivars "scions" in subplots and rootstocks in sub-subplot.

The yield of the first tow pickings was considered as early yield as well as number of fruits per plant and total yield per plant (g.) were calculated in the end of the growing season. The fruit length and diameter were measured to calculate fruit shape index (fruit length/fruit diameter) and. Finally, average fruit weight (g), flesh thickness of fruit (cm) and seed cavity diameter (cm) as well as total soluble solids percentage (AOAC, 1990) were measured. Data were subjected to the statistical analysis by the method of Duncan's multiple range tests as reported by Gomez [14]. Statistical analysis was performed with SAS computer software. Based on average of two seasons, the results of total yield were used to calculate the costs, benefits and saving of using grafted and non-grafted cantaloupe plants which grown under salinity irrigation water.

Table 1: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on fruit shape index of cantaloupe plants during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	0.98 A-E	0.95 DEF	0.98 A-E	0.97 B-E	0.97 b	0.97 A-D	0.95 A-E	0.96 A-D	0.96 A-E	0.96 a
	Strong-Tosa	1.0 A-D	0.99 A-E	1.0 A-D	1.04 A	1.0 a	0.96 A-D	0.97 A-D	0.96 A-E	1.00 A	0.97 a
	Non-grafted	1.01 A-D	0.97 B-E	1.02 ABC	1.03 AB	1.0 a	0.97 A-D	0.98 ABC	0.99 AB	1.00 A	0.99 a
	Mean	0.99 ab	0.97 bc	1.0 ab	1.0 a		0.97 a	0.96 a	0.97 a	0.99 a	
Mean Veleta		0.99 A					0.97 A				
Ideal	**Cobalt**	**0.94 DEF**	**0.94 DEF**	**0.93 EF**	**0.90 F**	**0.93 c**	**0.92 B-F**	**0.92 B-F**	**0.93 A-E**	**0.89 EF**	**0.92 bc**
	Strong-Tosa	0.92 EF	0.90 F	0.90 F	0.90 F	0.90 c	0.93 A-E	0.89 EF	0.90 DEF	0.85 F	0.89 c
	Non-grafted	0.95 C-F	0.90 F	0.93 EF	0.92 EF	0.93 c	0.94 A-E	0.94 A-E	0.91 C-F	0.93 A-E	0.93 b
	Mean	0.94 cd	0.91 d	0.92 d	0.91 d		0.93 b	0.91 cb	0.91 cb	0.89 c	
Mean Ideal		0.92 B					0.91 B				
Rootstocks and Salinity levels											
Cobalt		0.96 a	0.94 a	0.95 a	0.94 a	0.95 A	0.94 a	0.93 a	0.94 a	0.92 a	0.96 A
Strong-Tosa		0.96 a	0.94 a	0.95 a	0.97 a	0.95 A	0.95 a	0.93 a	0.93 a	0.93 a	0.93 A
Non- grafted		0.98 a	0.93 a	0.97 a	0.98 a	0.97 A	0.95 a	0.96 a	0.95 a	0.97 a	0.96 A
Mean salinity		0.97 A	0.94 A	0.96 A	0.96 A		0.95 A	0.94 A	0.94 A	0.94 A	

Results and Discussion

Effect of grafting technique (cultivars "scions" and rootstocks) under salinity levels of irrigation water on quality of cantaloupe fruits

Data presented in Tables 1-5 indicate the effect of salinity levels of irrigation water, cultivars, rootstocks and their interaction on fruit shape index, average fruit weight, flesh thickness of fruit, seed cavity diameter and T.S.S, respectively. Fruits quality expressed as average fruit weight, flesh thickness of fruit and T.S.S. were affected by salinity levels of irrigation water but fruit shape index was not affected in both seasons of study. Where, average fruit weight and flesh thickness of fruit were decreased by increasing salinity levels [15,16] and the opposite trend was observed with T.S.S which increased by increasing salinity levels [16,17]. Concerning the effect of cultivars on these traits of fruits quality, all fruit traits except T.S.S. were significantly affected by the used cultivars (*Veleta* and *Ideal*). In general, *Ideal* cultivar fruits were bigger and heavier than those of cv. *Veleta*. While *Veleta* fruits were the longer little than those of *Ideal* and the opposite trend at the fruit diameter all over the growing season, this reflected on the fruit shape index where cv. *Veleta* recorded the highest value compared with cv. *Ideal*. Moreover, results indicate that average fruit weight, flesh thickness and seed cavity diameter were positively affected by *Cobalt* rootstock while no significant effect could be detected regarding to fruit shape

index and T.S.S. The obtained results agreed with those stated by Colla [9] working on watermelon, [18] and Colla [8] working on cucumber who noticed that grafted plants produced fruits with highest average weight compared with of non-grafted plants.

Table 2: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on average fruit weight (g) of cantaloupe plants during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	1255 CDE	1314 BC	1249 CDE	1044 HI	1215 ab	1255 CDE	1294 B	1261B	973 FG	1202 b
	Strong-Tosa	1167 EFG	997 IJ	895 J	621 L	920 c	1032 EFG	1074 DEF	943 G	707 H	939 c
	Non-grafted	1200 DEF	1020 I	901 J	606 L	932 c	1131 CDE	1131 CDE	1003 FG	702 H	992 c
	Mean	1207 ab	1109 bc	1015 cd	757 e		1147 c	1166 bc	1069 c	794 d	
Mean Veleta		1022 B					1044 B				
Ideal	**Cobalt**	**1299 BCD**	**1312 BC**	**1263 CDE**	**1004 I**	**1220 ab**	**1296 B**	**1149 CD**	**1299 B**	**1004 I**	**1173 b**
	Strong-Tosa	1421 A	1463 A	1392 AB	1094 GHI	1342 a	1496 A	1523 A	1478 B	950 G	1381 a
	Non-grafted	1254 CDE	1272 CDE	1131 FGH	768 K	1106 b	1215 BC CDE	1218 BC	1143 CDE	774 H	1087 bc
	Mean	1324 a	1349 a	1262 a	955 d		1335 a	1296 ab	1306 ab	917 d	
Mean Ideal		1223 A					1214 A				
Rootstocks and Salinity levels											
Cobalt		1217 a	1313 a	1256 a	1024 bc	1217 A	1287 a	1221 ab	1280 ab	961 cd	1188 A
Strong-Tosa		1294 a	1229 a	1146 ab	857 cd	1131 B	1264 ab	1299 a	1210 ab	868 de	1144 B
Non- grafted		1227 a	1143 ab	1016 bc	687 d	1019 C	1173 ab	1174 ab	1073 bc	738 e	1039 C
Mean salinity		1266 A	1229 A	1138 B	856 C		1220 A	1231 A	1187 B	856 C	

Table 3: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on flesh thickness (cm) of cantaloupe fruit during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	4.0 CD	4.1 C	3.7 EFG	2.9 JK	3.7 ab	3.9 CD	4.1 CD	3.7 E	2.9 JKL	3.6 ab
	Strong-Tosa	2.9 JK	3.3 HI	2.8 JK	2.5 L	2.9 d	3.3 GHI	3.3 GH	3.8 DE	2.6 L	3.1 c
	Non-grafted	3.5 FGH	3.6 FGH	3.0 J	2.5 L	3.1 d	3.3 FG	3.6 EF	3.0 IJ	2.5 L	3.1 c
	Mean	3.5 cd	3.6 bc	3.1 de	2.7 f		3.5 cd	3.6 bc	3.2 d	2.7 e	
Mean Vleta		3.2 B					3.1 B				
Ideal	**Cobalt**	**3.9 CDE**	**4.2 BC**	**3.4 GH**	**2.9 JK**	**3.5 bc**	**3.9 CD**	**4.1 BC**	**3.0 IJ**	**2.7 KL**	**3.5 bc**
	Strong-Tosa	4.4 AB	4.6 A	3.9 CDE	3.1 IJ	4.0 a	4.3 B	4.5 A	3.8 DE	2.9 JKL	3.9 a
	Non-grafted	3.6 FGH	3.8 DEF	30 J	2.7 KL	3.3 cd	3.4 FG	3.6 EF	3.1 GHI	2.7 KL	3.2 c
	Mean	3.9 ab	4.2 a	3.4 cd	2.9 fe		3.9 ab	4.1 a	3.3 cd	2.8 e	
Mean Ideal		3.6 A					3.5 A				
Rootstocks and Salinity levels											
Cobalt		3.9 ab	4.1 a	3.0 de	2.9 de	3.6 A	3.9 ab	4.0 a	3.3 de	2.9 f	3.5 A
Strong-Tosa		3.6 abc	3.9 ab	3.4 cd	2.8 e	3.4 B	3.8 abcc	3.9 ab	3.4 cd	2.8 f	3.5 A
Non- grafted		3.5 bc	3.7 abc	3.0 de	2.6 e	3.2 C	3.3 de	3.6 bcd	3.0 ef	2.6 f	3.1 B
Mean salinity		3.7 B	3.9 A	3.3 C	2.7 D		3.7 B	3.9 A	3.2 C	2.7 D	

Table 4: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on diameter of seed cavity (cm) of cantaloupe fruit during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	3.8 DEF	4.8 ABC	4.9 ABC	5.1 ABC	4.7 a	4.7 A-E	5.2 ABC	5.6 A	5.5 A	5.2 a
	Strong-Tosa	4.9 ABC	3.7 DEF	3.4 FG	3.0 FG	3.8 b	5.2 ABC	5.2 ABC	3.5 E-H	3.1 H	4.3 bc
	Non- grafted	3.6 EF	3.4 FG	2.7 GH	2.1 H	3.0 c	5.0 A-D	3.8 E-H	4.2 B-H	3.5 E-H	4.1 c
	Mean	4.1 b	4.0 b	3.7 b	3.4 b		5.0 ab	4.7 ab	4.4 ab	4.0 b	
Mean Veleta		3.8 B					4.5 A				
Ideal	**Cobalt**	**4.5 BCD**	**3.9 DEF**	**5.4 AB**	**4.4 CDE**	**4.5 a**	**5.2 ABC**	**3.3 GH**	**5.5 A**	**4.0 C-H**	**4.5 abc**
	Strong-Tosa	3.6 EF	3.8 DEF	4.6 BCD	4.9 ABC	4.2 ab	4.2 B-H	3.8 E-H	4.4 A-G	4.7 A-F	4.3 bc
	Non- grafted	4.4 CDE	5.1 ABC	5.7 A	3.1 FG	4.6 a	5.7 A	5.3 AB	5.6 A	3.4 FGH	5.0 ab
	Mean	4.2 b	4.3 b	5.2 a	4.2 b		5.0 ab	4.1 b	5.2 a	4.1 b	
Mean Ideal		4.5 A					4.6 A				
Rootstocks and Salinity levels											
Cobalt		4.1 ab	4.4 ab	5.2 a	4.8 ab	4.6 A	4.9 abc	4.2 bcd	5.6 a	4.8 abc	4.9 A
Strong-Tosa		4.3 ab	3.8 b	4.0 ab	4.0 ab	4.0 B	4.7 abc	4.5 a-d	4.0 cd	3.9 cd	4.3 B
Non- grafted		4.0 b	4.3 ab	4.2 ab	2.6 c	3.8 B	5.4 ab	4.6 a-d	4.9 abc	3.5 d	4.6 B
Mean salinity		4.1 AB	4.1 AB	4.4 A	3.8 B		5.0 A	4.4 B	4.8 A	4.0 C	

Table 5: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on fruit T.S.S. of cantaloupe plants during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	9.3 FGH	10.5 DEF	10.8 CDE	12.0 ABC	10.7 a	8.7 HI	9.9 FG	11.1 DE	12.3 ABC	10.5 a
	Strong-Tosa	9.3 FGH	9.9 E-H	10.8 CDE	12.3 AB	10.6 a	8.4 I	9.6 FGH	11.4 CD	12.3 ABC	10.4 a
	Non- grafted	8.7H	9.0 GH	9.9 E-H	12.0 ABC	9.9 a	8.7 HI	9.6 FGH	11.1 DE	12.6 AB	10.5 a
	Mean	9.1 d	9.8 cd	10.5 bc	12.1 a		8.6 e	9.7 d	11.2 c	12.4 b	
Mean Vleta		10.4 A					10.5 A				
Ideal	**Cobalt**	**9.0 GH**	**9.9 E-H**	**10.8 CDE**	**12.3 AB**	**10.5 a**	**8.7 HI**	**9.9 FG**	**11.7 BCD**	**13.2 A**	**10.9 a**
	Strong-Tosa	9.6 E-H	10.2 D-G	11.4 BCD	13.2 A	11.1 a	9.0 GHI	10.2 EF	11.4 CD	13.2 A	11.0 a
	Non- grafted	8.7 H	9.6 E-H	10.2 D-G	12.3 AB	10.2 a	8.4 I	10.2 EF	11.1 DE	12.6 AB	10.6 a
	Mean	9.1 d	9.9 c	10.8 b	12.6 a		8.7 e	10.1 d	11.4 c	13.0 a	
Mean Ideal		10.6 A					10.8 A				
Rootstocks and Salinity levels											
Cobalt		9.2 f	10.2 cd	10.8 bc	12.2 a	10.6 A	8.7 d	9.9 c	11.4 b	12.8 a	10.7 A
Strong-Tosa		9.5 def	10.1 cde	11.1 b	12.8 a	10.8 A	8.7 d	9.9 c	11.4 b	12.8 a	10.7 A
Non- grafted		8.7 f	9.3 ef	10.1 cde	12.2 a	10.1 A	8.6 d	9.9 c	11.1 b	12.6 a	10.5 A
Mean salinity		9.1 D	9.9 C	10.7 B	12.4 A		8.7 D	9.9 C	11.3 B	12.7 A	

Most fruit quality parameters, i.e., fruit shape index, average fruit weight and T.S.S. were not significantly affected by various trials of the interaction between cultivars and salinity levels and the opposite trend was found with flesh thickness and seed cavity diameter in 2015 and 2016 seasons. However, average fruit weight, flesh thickness and seed cavity diameter as well as T.S.S were significantly affected by the interaction between rootstocks and salinity levels treatments where the highest values were represented in *Cobalt* rootstock when irrigated by salinity levels 3.9 and 7dS/m but increasing salinity up to 10 dS/m improved T.S.S. Meanwhile fruit shape index was not affected by this interaction. In connection with the interaction treatments between cultivars "scions" and rootstocks, the average fruit weight, flesh thickness and seed cavity diameter were positively significant affected by the grafting combinations of *Veleta/Cobalt*, *Ideal/Cobalt* and *Ideal/Strong-Tosa* compared with non-grafted plants (control) but T.S.S and fruit shape index were not affected by various trials of grafted plants in two seasons. Regarding to the effect of the

interaction treatments among salinity levels of irrigation water, cultivars and rootstocks, there were significant interaction effects on all fruits quality parameters except fruit shape index. Under all studied factors, the best interaction effects were found in the combination of the cvs. *Veleta* or *Ideal* grafted on *Cobalt* rootstock under all salinity levels except the highest one (10dS/m). Where, grafted plants of *Ideal*/*Strong-Tosa*, *Veleta*/*Cobalt* and *Ideal*/*Cobalt* produced the biggest and heaviest fruits with the biggest flesh thickness in a suitable contained of T.S.S when irrigated by 3.9dS/m level of salinity levels in both seasons.

Table 6: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on fruit number/plant of cantaloupe plants during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Vleta	Cobalt	4.0 AB	4.0 AB	3.3 BC	3.3 BC	3.7a	4.0 AB	4.0 AB	3.7 ABC	3.0 CD	3.7 ab
	Strong-Tosa	1.3 D	1.3 D	1.0 D	1.0 D	1.2 c	1.3 E	1.0 E	1.0 E	1.0 E	1.1 d
	Non-grafted	3.0 BC	3.3 BC	2.7 C	2.7 C	2.9 b	3.3 BCD	3.3 BCD	3.0 CD	2.7 D	3.1 c
	Mean	2.7 ab	2.9 ab	2.3 b	2.3 b		2.8 abc	2.7 abc	2.5 bc	2.2 c	
Mean Vleta		2.6 B					2.6 B				
Ideal	**Cobalt**	**3.0 BC**	**3.3 BC**	**3.7 ABC**	**233.33 CEF**	**3.2 b**	**3.3 BCD**	**3.7 ABC**	**3.3 BCD**	**3.0 CD**	**3.3 bc**
	Strong-Tosa	3.7 ABC	4.3 A	3.7 ABC	3.3 BC	3.7 a	4.0 A	4.3 A	3.3 BCD	3.3 BCD	3.7 a
	Non-grafted	2.7 C	2.7 C	2.7 C	190 GHI	2.8 b	3.0 CD	3.3 BCD	2.7 D	2.7 D	2.9 c
	Mean	3.1 ab	3.5 a	3.4 a	2.9 ab		3.4 ab	3.7 a	3.1 abc	3.0 abc	
Mean Ideal		3.2 A					3.3 A				
Rootstocks and Salinity levels											
Cobalt		3.5 ab	3.7 a	3.5 ab	3.0 abc	3.4 A	3.6 a	3.8 a	3.5 ab	3.0 ab	3.5 A
Strong-Tosa		2.5 abc	2.8 abc	2.3 bc	2.1 c	2.4 C	2.7 ab	2.6 ab	2.2 b	2.1 b	2.4 C
Non- grafted		2.8 abc	3.2 abc	2.8 abc	2.6 abc	2.8 B	3.1 ab	3.3 ab	2.8 ab	2.6 ab	3.0 B
Mean salinity		2.9 B	3.2 A	2.8 B	2.6 C		3.2 AB	3.3 A	2.8 BC	2.6 C	

Table 7: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on early yield (g /plant) of cantaloupe plants during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	1149 JK	1299 EFG	1644 A	1394 BCD	1371 a	1281 B	1283 B	1274 B	1016 FG	1213ab
	Strong-Tosa	1144 JK	307 O	12:00 PM	12:00 PM	363 c	323 L	0 M	0 M	0 M	81 d
	Non- grafted	1176 J	1333 D-G	1185 IJ	650 N	1086 b	1135 DE	1148 D	665 K	718 JK	916 c
	Mean	1156 a	980 ab	943 ab	681 b		913 abc	810 bc	646 bc	578 c	
Mean Vleta		940 B					737 B				
Ideal	Cobalt	1273 GH	1300 EFG	1259 GHI	994 L	1207ab	856 HI	1161 CD	1263 BC	942 GH	1055bc
	Strong-Tosa	1361 C-F	1449 B	1377 B-E	1426 BC	1403a	1007 FG	1517 A	1493 A	1047 EF	1266 a
	Non- grafted	1205 IJ	1286 FGH	1093 K	760 M	1086 b	1203 BCD	1230 BCD	1154 D	802 IJ	1097 b
	Mean	1280 a	1345 a	1243 a	1060 ab		913 abc	1302 a	1304 a	931 abc	
Mean Ideal		1232 A					1140 A				
Rootstocks and Salinity levels											
Cobalt		1211 ab	1210 ab	1452 a	1194 abc	1289 A	1069 abc	1222 a	1269 a	979 abc	1134 A
Strong-Tosa		1252 ab	878 bcd	689 d	713 cd	883 C	665 bc	758 abc	746 abc	524 c	673 C
Non- grafted		1191 abc	1309 ab	1139 a-d	705 cd	1086 B	1169 ab	1189 ab	910 abc	760 abc	1007 B
Mean salinity		1218 A	1162 B	1093 C	871 D		967 B	1056 A	975 B	754 C	

Effect of grafting technique (cultivars "scions" and rootstocks) under salinity levels of irrigation water on fruit yield and its components of cantaloupe plants.

Data presented in Tables 6- 8 shows the effect of salinity levels of irrigation water, cultivars, rootstocks, and their interaction on fruits number, early and total yield (g/plant), respectively. Yield production in terms of fruits number, early yield and total yield per plant were significantly affected by salinity levels during both seasons. Where, the medium salinity level (3.9dS/m) resulted in significantly the highest of early yield, fruits number and total yield than all other salinity levels while the total yield decreased by 39.7% (as average between two seasons) with increasing salinity levels up to 10dS/m. The obtained results are in the same line with those reported by [3,5,17,19-21] who showed that increasing salinity levels badly affected total melon yield. Also, early yield, fruits number and total yield per plant were affected by the used cultivars (*Veleta* and *Ideal*) where cv *Ideal* was higher than those of cv. *Veleta*. The effect of rootstocks was very clear where *Cobalt* rootstock produced significantly higher yield components than all other used rootstock and non-grafted plants, increased the total yield by 37.4% compare non-grafted plants, as average between two seasons. In the same context, [8] on melon as well as [22-26] on watermelon who noticed that grafted plants gave the highest fruit yields compared with non-grafted plants.

Table 8: Effect of salinity levels (dS/m), cultivars and rootstocks as well as their interaction on total fruit yield (g / plant) of cantaloupe plants during 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	5021 BC	5249 B	4165 DEF	3482 G	4479ab	5177 BC	5177 BC	4625 CD	2918 IJ	4495 b
	Strong-Tosa	1556 JK	1329 KL	894 LM	621 M	1100 c	1367 L	1074 LM	943 LM	708 M	1025 e
	Non- grafted	3600 G	3435 G	2409 HI	1636 J	2770 c	3767 FGH	3782 FGH	3007 IJ	1882 K	3110 d
	Mean	3392 bc	3337 bc	2489 cd	1913 d		3420 b	3344 b	2858 bc	1836 c	
Mean Veleta		2783 B					2865 B				
Ideal	Cobalt	3896 EFG	4379 DE	4630 CD	2678 H	3896 b	4319 DE	4213 DEF	4329 DE	2851 J	3928 bc
	Strong-Tosa	5212 B	6341 A	5102 BC	3647 FG	5075 a	5470 AB	6600 A	4928 BC	3427 HI	5106 a
	Non- grafted	3331 G	3815 EFG	3393 G	2038 IJ	3144 c	3645 GH	4060 EFG	3048 IJ	2063 K	3204 cd
	Mean	4150 ab	4845 a	4375 ab	2787 cd		4334 a	4958 a	4102 ab	2780 bc	
Mean Ideal		4039 A					4043 A				
Rootstocks and Salinity levels											
Cobalt		4459 ab	4814 a	4397 ab	3080 a-d	4187 A	4718 a	4695 a	4477 a	2885 ab	4140 A
Strong-Tosa		3384 a-d	3835 abc	2998 a-d	2134 cd	3088 B	3423 ab	3837 ab	2935 ab	2067 b	3066 B
Non- grafted		3465 a-d	3625 a-d	2901 bcd	1837 d	2958 B	3706 ab	3921 ab	3028 ab	1972 b	3157 B
Mean salinity		3772 B	4091 A	3432 C	2350 D		3878 B	4151 A	3480 C	2308 D	

Yield components except fruits number were significantly affected by the interaction treatments between cultivars and salinity levels, where the highest values were recorded when cv. *Ideal* was irrigated by salinity level 3.9dS/m compared with cv. *Veleta* which recorded the lowest values at 10dS/m level. Early yield and total yield per plant were significantly affected by the interaction treatments between rootstocks and salinity levels while fruits number was not significantly affected by this interaction. As for the early yield, the highest values were recorded by *Cobalt* rootstock when irrigated by salinity level 7 dS/m followed by 3.9dS/m. Meanwhile, the same rootstock resulted in the highest values of fruits number and total yield when irrigated by salinity level 3.9 dS/m followed by control level. Yield components were positively affected by graft combinations of *Ideal*/*Strong-Tosa* and *Veleta*/*Cobalt*, where the total yield was increased by 60.4 and 52.6%, respectively by these combinations compared with non-grafted of the same cultivar. Meanwhile, non-grafted plants especially *Veleta* cv. (control) recorded the lowest values of yield components.

The best interaction effects between the three studied factors were found in the combination of *Ideal*/*Strong-Tosa* and *Veleta*/*Cobalt* with the lowest (3.9dS/m) and control (non-saline) of salinity levels. While non-grafted plants of both cultivars (control) which irrigated by highest salinity level (10dS/m) recorded the lowest values. Generally all types of treatments interactions among the three studied factors were significantly higher compared to the control treatment. The interaction between cv. *Ideal* grafted on *Strong-Tosa* rootstock as well as *Veleta* on *Cobalt* with the non-saline level (control) and the lowest level (3.9dS/m) of salinity levels resulted in the best cantaloupe growth El-S Zaki 2018 and the yield. Whereas graft combination of *Ideal*/*Strong-Tosa* increased the total yield by 53.1, 85.5, 43.8 and 1.4% at salinity levels control, 3.9, 7 and 10dS/m, respectively compared to the general control (non-grafted plants of *Ideal* at control water). This percentage was 38.4, 41.5, 19.3 and decline 13.1% with *Veleta*/*Cobalt* compared to the general control (non-grafted plants of *Veleta* at control water). Generally, when cantaloupe plants have to be irrigated with high

salinity of irrigation water, it is recommended to cultivate grafted seedling resulted of *Veleta*/*Cobalt* and *Ideal*/*Strong-Tosa* where these plants resulted the highest benefit and income compared with those on its own roots (non-grafted plants) under each salinity level of irrigation water. Economically, it can be recommend under similar circumstances to use the water with moderate salinity (3.9 and 7dS/m) when combined with grafting seedling (*Veleta*/ *Cobalt* and *Ideal*/*Strong-Tosa*) in order to get optimum yield with using somewhat saline water.

Calculation of Costs and Benefits of Applied Treatments

This parameter is illustrative and is not reliable in order to differentiate between the costs of using grafted and non-grafted plants under salinity of irrigation water. Assuming that, the remaining costs such as rental costs, workers, fertilizers, etc., agree on all factors of the study. Costs and benefits of grafted and non-grafted plants which grown under salinity levels of irrigation water were calculated as average between both seasons. Where, the price of non-grafted seedlings is close to the price of the grafted seedlings because it required additional costs "the costs of controlling soil diseases (1.25LE) according to Hasan (2015)". The presented results in Table 9 show the costs (L.E) of the irrigation water was invariable with all salinity levels with average 2.22 L.E. /Plant. Where the highest benefits (10.30 and 9.56 L.E./Plant) and income (8.08 and 7.34 L.E./Plant) were obtained with irrigation by 3.9dS/m and non-saline level, respectively. While, the lowest benefits (5.82L.E./Plant) and income (3.60L.E./Plant) were obtained with cantaloupe plants which irrigated by highest salinity level (10dS/m). It is due to increasing the plants yield which irrigated by 3.9dS/m (4.121kg/Plant). Using of cv. *Ideal* obtained the highest benefit (10.10L.E./Plant) and income (7.83L.E./Plant) compare with those of *Veleta* plant which recorded the lowest benefit (7.06L.E./Plant) and income (4.89L.E./Plant). It is due to increasing the yield of *Ideal* cv. (4.042kg./Plant) compare with those of *Veleta* plants (2.824kg/plant). Also, the highest benefit (10.41L.E./Plant) and income (8.11L.E./Plant) were represented when both cantaloupe cultivars were grafted on rootstock *Cobalt* although grafted plants recorded the higher costs (2.30L.E/plant) compared with non-grafted plants (2.05 L.E/plant). It is due to increasing the yield of grafted plants on *Cobalt* rootstock (4.164kg/Plant) compare with those of non-grafted plants (3.058kg/plant).

Table 9: Effect of cultivars and rootstocks under salinity levels on costs and benefits of cantaloupe plants as average between 2015 and 2016 seasons.

cv.	Rootstock	First season (2015)					Second season (2016)				
		Control	3.9 dS/m	7 dS/m	10 dS/m	Mean	Control	3.9 dS/m	7 dS/m	10 dS/m	Mean
Veleta	Cobalt	5021 BC	5249 B	4165 DEF	3482 G	4479ab	5177 BC	5177 BC	4625 CD	2918 IJ	4495 b
	Strong-Tosa	1556 JK	1329 KL	894 LM	621 M	1100 c	1367 L	1074 LM	943 LM	708 M	1025 e
	Non- grafted	3600 G	3435 G	2409 HI	1636 J	2770 c	3767 FGH	3782 FGH	3007 IJ	1882 K	3110 d
	Mean	3392 bc	3337 bc	2489 cd	1913 d		3420 b	3344 b	2858 bc	1836 c	
Mean Veleta		2783 B					2865 B				
Ideal	Cobalt	3896 EFG	4379 DE	4630 CD	2678 H	3896 b	4319 DE	4213 DEF	4329 DE	2851 J	3928 bc
	Strong-Tosa	5212 B	6341 A	5102 BC	3647 FG	5075 a	5470 AB	6600 A	4928 BC	3427 HI	5106 a
	Non- grafted	3331 G	3815 EFG	3393 G	2038 IJ	3144 c	3645 GH	4060 EFG	3048 IJ	2063 K	3204 cd
	Mean	4150 ab	4845 a	4375 ab	2787 cd		4334 a	4958 a	4102 ab	2780 bc	
Mean Ideal		4039 A					4043 A				
Rootstocks and Salinity levels											
Cobalt		4459 ab	4814 a	4397 ab	3080 a-d	4187 A	4718 a	4695 a	4477 a	2885 ab	4140 A
Strong-Tosa		3384 a-d	3835 abc	2998 a-d	2134 cd	3088 B	3423 ab	3837 ab	2935 ab	2067 b	3066 B
Non- grafted		3465 a-d	3625 a-d	2901 bcd	1837 d	2958 B	3706 ab	3921 ab	3028 ab	1972 b	3157 B
Mean salinity		3772 B	4091 A	3432 C	2350 D		3878 B	4151 A	3480 C	2308 D	

When irrigated the plants by different salinity levels, the *Ideal* plants recorded the highest benefits (12.25L.E./Plant) and income (9.98L.E./Plant) at 3.9dS/m level, meanwhile the lower benefit (4.69L.E./Plant) and income (2.52L.E./Plant) were resulted with cv. *Veleta* at the highest salinity level (10dS/m). Also under different salinity levels, the highest benefits (11.20, 11.89 and 11.09L.E./Plant) and income (8.90, 9.59 and 8.79L.E./Plant) were represented in rootstock *Cobalt* and irrigated by non-saline level, 3.9dS/m and 7dS/m of salinity levels, respectively as compared with non-grafted plants which recorded the lowest benefits (8.97, 9.43 and 7.41L.E./Plant) and income (6.92, 7.38 and5.36 L.E./Plant) at the same salinity levels. This is due to increasing the yield of grafting plants on *Cobalt* rootstock (4.481, 4.755 and 4.437kg./Plant) as well as lower the yield of non-grafted plants (3.590, 3.773 and 2.965kg./ Plant). The grafting combinations *Ideal*/*Strong-Tosa* followed by *Veleta*/*Cobalt* then *Ideal*/*Cobalt* obtained the highest benefits (12.73, 11.17and 9.65 L.E./Plant) and income (10.38, 8.92 and 7.30 L.E./Plant) while the lowest benefits (2.66, 7.35 and 7.94 L.E./Plant) and income (0.44, 5.35 and 5.84 L.E./Plant) were obtained by *Veleta* /*Strong-Tosa* followed by *Veleta* and *Ideal*

plants on its own roots, respectively. Under all studied factors, the grafting combination *Ideal*/*Strong-Tosa* resulted the highest benefit (13.35, 16.18, 12.54 and 8.84L.E./Plant) and income (11.00, 13.83, 10.19 and 6.49L.E./Plant) at non-saline level, 3.9 dS/m, 7dS/m and 10dS/m of salinity, respectively compared with the same cv. on its roots also the graft combination *Veleta*/*Cobalt* showed the highest benefit (12.67, 13.03, 10.99 and 8.00L.E./Plant) and income (10.42, 10.78, 8.74 and 5.75 L.E./Plant) at the same salinity levels respectively compared with the same cv. on its roots. This is due to increasing the yield of these grafting plants compared with non-grafted plants of the same cv.

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