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 (3.9 dSm/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 10dSm/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 10dSm/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 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 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           | 0.99 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 |

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 seed cavity diameter were positively 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.
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 | 1261 B | 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 | | 1234 a | 1349 a | 1262 a | 955 d | 1335 a | 1296 ab | 1306 ab | 917 d |
| Mean Ideal | | 1223 A | 1214 A |

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 JK | 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 Veleta | | 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 JK | 3.9 a |
| Non-grafted | | 3.6 FGH | 3.8 DEF | 3.0 J | 2.7 KL | 3.3 cd | 3.4 FG | 3.6 EF | 3.1 GH | 2.7 KL | 3.2 c |
| Mean | | 3.9 ab | 4.2 a | 3.4 cd | 2.9 f | 3.9 ab | 4.1 a | 3.3 cd | 2.8 e |
| Mean Ideal | | 3.6 A | 3.5 A |

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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 BC | 5.2 BC | 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 | 3.0 | 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 |
| Mean Ideal | 4.5 A | 4.6 A |

Rootstocks and Salinity levels

| 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 | 12.3AB | 10.6 a | 8.4 I | 9.6 FGH | 11.4 CD | 12.3 ABC | 10.4 a |
| Non-grafted | 8.7 H | 9.0 GH | 9.9 E-H | 12.0 ABC | 10.9 a | 8.3 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 Veleta | 10.4 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 CDE | 13.2A | 11.1 a | 9.0 GH | 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 | 12.3AB | 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 |

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.

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

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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 |
| Vlete | Cobalt | 4.0 AB | 4.0 AB | 3.3 BC | 3.3 BC | 3.7 a | 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 Vlete | 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 | 3.7 a |
| Non-grafted | 2.7 C | 2.7 C | 2.7 C | 190 GH | 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**

| 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 |
| Vlete | Cobalt | 1149 JK | 1299 EFG | 1644 A | 1394 BCD | 1371 a | 1281 B | 1283 B | 1274 B | 1016 FG | 1213 ab |
| Strong-Tosa | 1144 JK | 307 O | 1200 PM | 1200 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 DF | 1148 DF | 665 K | 718 JK | 916 c |
| Mean | 1156 a | 980 ab | 943 ab | 681 b | 913 abc | 810 bc | 646 bc | 578 c |
| Mean Vlete | 940 B | 737 B |
| Ideal | Cobalt | 1273 GH | 1300 EFG | 1259 GH | 994 L | 1207ab | 856 HI | 1161 CD | 1263 BC | 942 GH | 1055bc |
| Strong-Tosa | 1361 C-F | 1449 B | 1377 B-E | 1426 BC | 1430a | 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 |

**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 |
| Vlete | Cobalt | 1149 JK | 1299 EFG | 1644 A | 1394 BCD | 1371 a | 1281 B | 1283 B | 1274 B | 1016 FG | 1213 ab |
| Strong-Tosa | 1144 JK | 307 O | 1200 PM | 1200 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 DF | 1148 DF | 665 K | 718 JK | 916 c |
| Mean | 1156 a | 980 ab | 943 ab | 681 b | 913 abc | 810 bc | 646 bc | 578 c |
| Mean Vlete | 940 B | 737 B |
| Ideal | Cobalt | 1273 GH | 1300 EFG | 1259 GH | 994 L | 1207ab | 856 HI | 1161 CD | 1263 BC | 942 GH | 1055bc |
| Strong-Tosa | 1361 C-F | 1449 B | 1377 B-E | 1426 BC | 1430a | 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**

| 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 |
| Vlete | Cobalt | 1121 ab | 1210 ab | 1452 a | 1194 ab | 1289 A | 1069 abc | 1222 a | 1269 a | 979 abc | 1134 A |
| Strong-Tosa | 1252 ab | 878 bc | 689 d | 713 cd | 883 C | 665 bc | 758 abc | 746 abc | 524 c | 673 C |
| Non-grafted | 1191 abc | 1309 ab | 1139 ad | 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 |

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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 (3.9 dS/m) resulted in significantly the highest of early yield, fruits number and total yield per 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 GH| 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 A  | 6600 A | 4928 BC | 3427 HI | 5106 a  |
|       | Non- grafted| 3331 G  | 3815 EFG| 3393 G  | 2038 B J| 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  |         |         |         |         |

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 3.9 dS/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-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 recommended 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 (1.25L.E) 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 (4.89L.E./Plant). It is due to increasing the yield of Ideal cv. (4.042kg/Plant) compare with those of Veleta plant which recorded the lowest benefit (7.06L.E./Plant) and income (4.89L.E./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      |
| Veleta      | 5021 BC    | 5249 B              | 4165 DEF  | 3482 G               | 4479ab    |
| Strong-Tosa | 1556 JK    | 1329 KL             | 894 LM    | 621 M                | 1100c     |
| Non-grafted | 3600 G     | 3435 G              | 2409 HI   | 1636 J               | 2770c     |
| Mean        | 3392 bc    | 3337 bc             | 2489 cd   | 1913 d               | 3420 b    |
| Mean Veleta | 2783 B     |                     |           |                      | 2865 B    |
| Ideal       | 3896 EFG   | 4379 DE             | 4630 CD   | 2678 H               | 3896 b    |
| Strong-Tosa | 5212 B     | 6341 A              | 5102 BC   | 3647 FG              | 5075a     |
| Non-grafted | 3331 G     | 3815 EFG            | 3393 G    | 2038 IJ              | 3144 c    |
| Mean        | 4150 ab    | 4845 a              | 4375 ab   | 2787 cd              | 4334 a    |
| Mean Ideal  | 4039 A     |                     |           |                      | 4043 A    |

**Rooftocks and Salinity levels**

| cv.         | Rootstock  | Salinity  | First season (2015) |           | Second season (2016) |           |
|-------------|------------|-----------|---------------------|-----------|----------------------|-----------|
|             | Cobalt     | 4459 ab   | 4814 a              | 4397 ab   | 3080 a-d             | 4187 A    |
|             | Strong-Tosa| 3384 a-d  | 3835 abc            | 2998 a-d  | 2134 cd              | 3088 B    |
| Non-grafted | 3465 a-d   | 3625 a-d  | 2901 bcd            | 1837 d    | 2958 B               | 3076 ab   |
| Mean        | 3772 B     | 4091 A    | 3432 C              | 2350 D    | 3878 B               | 4151 A    |

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 and 5.36 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 8.84 L.E./Plant) and income (11.00, 13.83, 10.19 and 6.49 L.E./Plant) at non-saline level, 3.9 dS/m, 7 dS/m and 10 dS/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 8.00 L.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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