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The Role of Grafting Tomato and Watermelon on Different Rootstocks on Their Chemical Contents

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Abstract: The objective of this study was to determine the impact of interaction between rootstocks and scions of watermelon and tomato on the chemical contents of their leaves and roots. The rootstock of local Syrian tomato produced the highest amount of total lipids, total fatty acids percentage and total unsaponated percentage of total lipids in root (0.69, 92.39, 3.34%) and leaf (0.73, 91.54, 4.02%) compared to Beaufort rootstock and He-man rootstock when grafted with Cecilia scion. With regard to watermelon grafts Samara on *C. pepo* excelled the two other watermelon grafts namely, Samara on Tetsukauto and Samara on *Lagenaria siceria* in its overall root contents of total fatty acids percentage of total lipids and total unsaponated percentage of total lipids. Samara on *C. pepo* excelled the other two watermelon grafts with regards to its significant leaves (0.1326, 18.73%) and root contents (0.1214, 15.33%) of phospholipids percentage and total unsaponoted phospholipids, respectively. Grafting increased indole-3-acetic acid (IAA) in seedlings of both tomato and watermelon. Cecilia on Beaufort (32.43 nm g^{-1}) and Cecilia on Syria (36.71 nm g^{-1}) had significantly greater contents of Indole-3-acetic acid in their roots whereas, only Samara on *C. pepo* watermelon grafts (98.27 nm g^{-1}) had significant greater contents of IAA in its roots. Clear effects of grafting watermelon and tomato on their lipids and IAA contents were concluded in this study.

Key words: *Lycopersicon esculentum*, *Lycopersicon hirsutum*, grafting, rootstock, scion, tomato, watermelon, total fatty acids, total unsaturated fatty acids

INTRODUCTION

The production of grafted plants first began in Japan and Korea in late 1920, with watermelon grafted on gourd rootstock. There were many grafting methods for different types of fruit-bearing vegetables, which have been used in greenhouses as well as in the open-field agriculture (Khah *et al*., 2006; Pogonyi *et al*., 2005; Augustin *et al*., 2002; Mohammed *et al*., 2009). In addition to the many advantages indicated for grafting in the previous references, enhancement of nutrient uptake is one of the preferable advantage of this technique (Takacs *et al*., 2005). Good combination between rootstocks and scions results in increase of fruit yield and quality (Romano and Paratore, 2001).

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Chemical analysis of leaves and roots of tomato and watermelon for lipids and hormones plays an important role for determination of the quality of some scions on different rootstocks. Many scientists found an increase in the concentration of fatty acids and some changes in lipids during the growth periods of different plants (De La Roche *et al*., 1972; Gerloff *et al*., 1967; Smith, 1968; Willemot, 1975). Roberts *et al*. (2005) stated that using grafting technique led to improve the vegetative and root growth of watermelon.

The objective of this study was to investigate the effect of different rootstock/scion combinations of tomato and watermelon on the chemical contents of leaves and roots of each of these two plant species.

MATERIALS AND METHODS

Tomato (*Lycopersicon esculentum* Mill.) var. Cecilia F1 was grafted on three rootstocks, Beaufort, He-man and local Syrian tomato using tube grafting method. Watermelon (*Citrullus lanatus* [thomb.]) var. Samara F1 was grafted on Tetsukabuto squash, *Lagenaria siceraria* Standl. and local Syrian squash *Cucurbita pepo* L. by tongue approach grafting method. Twenty grafts of each of tomato and watermelon were prepared. Seeds of three rootstocks of tomato plants were sown 10 days before the planting of the scion, Cecilia F1. The three rootstocks used in this study were Beaufort (*Lycopersicon esculentum* × *Lycopersicon hirsutum*) from De Ruiter seeds, He-man (*L. esculentum* × *L. hirsutum*) from Syngenta seeds B.V. and local Syrian seeds from Syrian farmers. Cecilia F1 seeds were obtained from GSN French Company. All scion seeds were sown on 02/05/2007 in 96 holes trays filled with peat moss substrate inside a fiberglass greenhouse in ASTRA Farms in Tabuk, Kingdom of Saudi Arabia. Grafting was done 18 days after planting of the scion using tube grafting technique. The grafted plants were maintained under transparent plastic cover at 28°C and around 90% humidity. Excellent union of scion with each of the three rootstocks was established 9 days after grafting.

Seeds for the scion, Samara F1 from SAKATA Vegetables Europe French Company, were sown 10 days before seeding of the watermelon rootstocks on 22/04/2007. The three rootstocks used were Tetsukabuto (*C. maxima* × *C. moschata*) from Takii Japanese Company, bottle gourd Lagenaria *ciceraria* and local Syrian squash *Cucurbita pepo*. Tongue approach grafting method was used.

Five homogeneous grafts were statistically analyzed for each of tomato and watermelon. Following recording of measurements, lipids were analyzed using Sokslet apparatus according to AOAC technique (1995). The percentage of total saturated and unsaturated fatty acids were determined in roots and leaves of both tomato and watermelon seedlings using lead-Salt-ether method. Saponification was performed for oil samples and then percentage of unsaponified substances and total fatty acids were calculated by weight according to Farag *et al*. (1986). Being an important natural auxin which has several different effects such as induction of cell elongation and cell division, indole-3-acetic acid (IAA) was extracted by 80% methanol according to Zaffase *et al*. (2002).

Descriptive statistics for the studied characteristics were expressed as percentage. Pooled data were analyzed using the statistical analysis SPSS 13. One-way ANOVA was used to determine differences between treatments. Duncan's multiple range test and LSD. ($p = 0.05$) were utilized to distinguish between means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Significantly, greater amounts of total lipids, total fatty acids percentage of total lipids and total unsaponated substances percentage of total lipids were found in roots of the tomato grafts, Cecilia on Beaufort and Cecilia on Syria (Table 1, Fig. 1). No such significant increase in any of these three substances was found in the roots of Cecilia on He-man. This increase in the level of lipids percentage is attributed to grafting, since, the lipids percentage in both Cecilia hybrid (0.53%) and in Beaufort without grafting (0.51%) was lower than the lipids percentage in grafts Cecilia on Beaufort (0.63%).

In watermelon, roots of grafts Samara on *Lageneria siceria* and Samara on *C. pepo* showed significantly greater increase in total fatty acids percentage of total lipids (Table 1, Fig. 2), however, root of graft Samara on Testukabuto and Samara on *C. pepo* showed significantly greater increase in total unsaponated substances percentage of total

Table 1: Root content of total lipids, total fatty acids of total lipids and total unsap percentage of total lipids in tomato and watermelon seedling

Treatments	Total lipids (%)	Total fatty acids % of total lipids	Total unsap % of total lipids
Tomato			
Cecilia F1	0.53^{c}	90.74^{c}	1.65^{a}
Cecilia on He-man	0.50^{a}	91.54^{d}	2.25^{d}
Cecilia on Beaufort	0.63^{e}	91.87^{e}	3.01^{e}
Cecilia on Syrian	0.69^{f}	92.39^{g}	3.34^{f}
He-man rootstock	0.57^{d}	91.95^{f}	3.25^{g}
Beaufort rootstock	0.51^{b}	90.43^{b}	2.24^{c}
Syrian rootstock	0.50^{a}	90.12^{a}	2.16^{b}
Watermelon			
Samar F1	0.51^{a}	91.56^{a}	1.12^{a}
Samara on Tetsukabuto	0.74^{e}	92.45^{d}	2.15^{f}
Samara on *Lagenaria siceraria*	0.66^{c}	93.78^{f}	1.96^{c}
Samara on *C. pepo*	0.61^{b}	93.98^{g}	2.30^{g}
Tetsukabuto	0.81^{f}	93.67^{e}	2.13^{e}
Lagenaria siceraria	0.74^{e}	92.34^{c}	2.04^{d}
Syrian squash *C. pepo*	0.68^{d}	91.69^{b}	1.72^{b}

Means in the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test

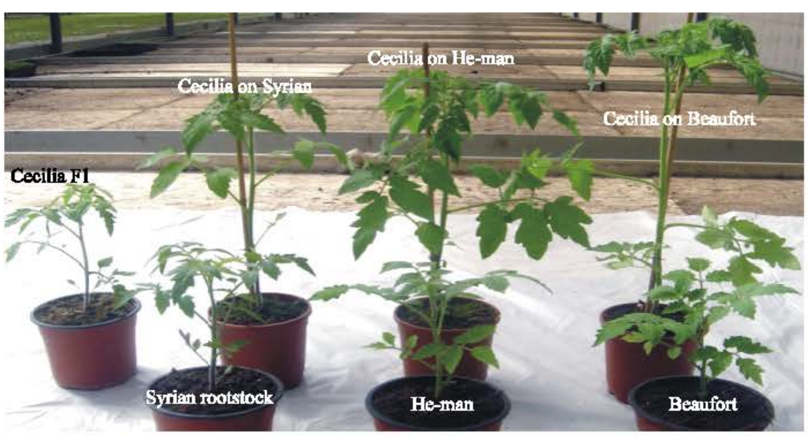

Fig. 1: Grafting of Cecilia F1 tomato on three different rootstocks (Syrian tomato , He-man and Beaufort)

Fig. 2: Grafting of Samara F1 watermelon on three different rootstocks (Tetsukabuto, *Lagenaria siceraria* and *C. pepo*)

Table 2: Leaves content of total lipids percentage, total fatty acids percentage of total unsap. percentage of total lipids in tomato and watermelon seedlings

Treatments	Total lipids	Total fatty acids	Total unsap.
	----------	(%)	----------
Tomato			
Cecilia F1	0.58^{c}	89.97^{b}	2.10^{a}
Cecilia on He-man	0.59^{d}	90.45^{c}	2.34^{b}
Cecilia on Beaufort	0.71^{f}	91.03^{e}	3.95^{f}
Cecilia on Syrian	0.73^{g}	91.54^{f}	4.02^{g}
He-man rootstock	0.66^{e}	90.67^{d}	3.76^{e}
Beaufort rootstock	0.56^{b}	89.78^{a}	2.54^{d}
Syrian rootstock	0.53^{a}	98.89^{g}	2.35^{c}
Watermelon			
Samar F1	0.65^{a}	90.42^{a}	2.76^{b}
Samara on Tetsukabuto	0.86^{b}	91.10^{b}	3.53^{g}
Samara on *Lagenaria siceraria*	0.89^{e}	92.96^{e}	3.19^{f}
Samara on *C. pepo*	0.88^{d}	92.67^{d}	2.81^{c}
Tetsukabuto	0.90^{f}	93.69^{f}	3.17^{e}
Lagenaria siceraria	0.95^{g}	94.14^{g}	2.87^{d}
Syrian Squash *C. pepo*	0.87^{c}	91.69^{c}	2.12^{a}

Means in the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test

lipids. These results agreed with Horvath *et al.* (1980) and Bulder *et al.* (1991). However, Ruiz *et al.* (2005) stated that grafting gives lowest lipid peroxidation (which it most often affects polyunsaturated fatty acids) in tobacco plants and Li *et al.* (2008) reported that upon exposure to chilling stress, the malondialdehyde (MDA) content, which reflects the degree of lipid peroxidation, increased markedly in the own-rooted seedling roots and leaves and kept stable in the grafted cucumber seedlings.

Leaves of all three tomatoes and watermelon grafts revealed significant increase in total lipids, total fatty acids percentage and total unsaponated substances compared to the control (Table 2).

Significant increase in phospholipids and total unsaponated percentage of phospholipids was detected in leaves and roots of all tomato and watermelon grafts (Table 3, 4).

The highest phospholipids percentage and total unsaponated percentage of phospholipids was found in tomato plants grafted on local Syrian tomato (0.104 and 22.27%,

Table 3: Total phospholipids % and unsap. of phospholipids in leaves of tomato and watermelon seedlings

Treatments	Phospholipids (%)	Total unsap % of phospho lipids
Tomato		
Cecilia F1	0.087^{c}	14.03^{a}
Cecilia on He-man	0.0885^{d}	15.63^{b}
Cecilia on Beaufort	0.1065^{f}	26.35^{f}
Cecilia on Syrian tomato	0.1095^{g}	26.83^{g}
He-man rootstock	0.0993^{e}	25.06^{e}
Beaufort rootstock	0.0842^{b}	16.94^{d}
Syrian rootstock	0.0795^{a}	15.67^{c}
Watermelon		
Samar F1	0.0975^{a}	18.40^{b}
Samara on Tetsukabuto	0.1294^{b}	23.53^{g}
Samara on *Lagenaria siceraria*	0.1335^{e}	21.27^{f}
Samara on *C. pepo*	0.1326^{d}	18.73^{c}
Tetsukabuto	0.1357^{f}	21.14^{e}
Lagenaria siceraria	0.1425^{g}	19.13^{d}
Syrian squash *C. pepo*	0.1306^{c}	14.13^{a}

Means in the same column followed by the same letter(s) are not significantly different ($p \le 0.05$) according to Duncan's multiple range test

Table 4: Total phospholipids percentage and unsap. of phospholipids in roots of tomato and watermelon seedlings

Treatments	Phospholipids (%)	Total unsap % of phospho lipids
Tomato		
Cecilia F1	0.0795^{d}	11.00^{a}
Cecilia on He-man	0.0755^{a}	15.00^{d}
Cecilia on Beaufort	0.0945^{f}	20.07^{e}
Cecilia on Syrian	0.1035^{g}	22.27^{g}
He-man rootstock	0.0855^{e}	21.67^{f}
Beaufort rootstock	0.0765^{c}	14.93^{c}
Syrian rootstock	0.0756^{b}	14.40^{b}
Watermelon		
Samar F1	0.0762^{a}	7.467^{a}
Samara on Tetsukabuto	0.1113^{d}	14.33^{f}
Samara on *Lagenaria siceraria*	0.0992^{b}	13.07^{c}
Samara on *C. pepo*	0.1214^{e}	15.33^{g}
Tetsukabuto	0.1125^{f}	14.30^{e}
Lagenaria siceraria	0.1113^{d}	13.60^{d}
Syrian Squash *C. pepo*	0.1034^{c}	11.47^{b}

Means in the same column followed by the same letter(s) are not significantly different ($p \le 0.05$) according to Duncan's multiple range test

respectively) as shown in Table 4. Phospholipids are considered very vital in cellular structure especially in cellular membranes. Phospholipids and total unsaponated percentage of phospholipids significantly increased in the root of all watermelon grafts (Table 4) however, Samara on *C. pepo* showed the highest level of increase in both phospholipids percentage and total unsaponated percentage of phospholipids (0.121 and 15.33%, respectively).

Significant increase of total unsaturated fatty acids % of total lipids was detected in leaves of the tomato grafted Cecilia on Beaufort and Cecilia on Syria whereas, significant increase of total saturated fatty acids % of total lipids was detected in the leaves of Cecilia on He-man compared with the other two grafts (Table 5). However, significant decrease of the later was observed in the leaves of all watermelon grafts compared with the control (Table 5).

Total Unsaturated fatty acids of total lipids significantly increased in the roots of the tomato grafts Cecilia on Beafourt and Cecilia on Syria (77.44 and 80.57%, respectively), whereas, total saturated fatty acids % of total lipids significantly increased in the roots of Cecilia on He-man only 25.31% (Table 6). Significant increase of total unsaturated fatty acids

Table 5: Total saturated and unsaturated fatty acids % in leaves of tomato and watermelon plants

Treatments	Total saturated fatty acids % of total lipids	Total unsaturated fatty acids % of total lipids
Tomato		
Cecilia F1	18.94[f]	81.06[b]
Cecilia on He-man	16.87[d]	83.13[d]
Cecilia on Beaufort	15.65[b]	84.35[g]
Cecilia on Syrian	15.33[a]	84.67[f]
He-man rootstock	16.43[c]	83.57[e]
Beaufort rootstock	17.06[e]	82.94[c]
Syrian rootstock	19.72[g]	80.28[a]
Watermelon		
Samar F1	20.19[g]	79.81[a]
Samara on Tetsukabuto	19.65[f]	80.35[b]
Samara on *Lagenaria siceraria*	18.88[d]	81.12[d]
Samara on *C. pepo*	17.94[b]	82.06[f]
Tetsukabuto	18.54[c]	81.46[e]
Lagenaria siceraria	16.32[a]	83.68[g]
Syrian squash *C. pepo*	19.05[e]	80.95[c]

Means in the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test

Table 6: Total saturated and unsaturated fatty acids % in roots of tomato and watermelon plants

Treatments	Total saturated fatty acids % of total lipids	Total unsaturated fatty acids % of total lipids
Tomato		
Cecilia F1	24.54[e]	75.46[c]
Cecilia on He-man	25.31[g]	74.69[a]
Cecilia on Beaufort	22.56[b]	77.44[f]
Cecilia on Syrian	19.43[a]	80.57[g]
He-man rootstock	22.57[c]	77.43[e]
Beaufort rootstock	23.43[d]	76.57[d]
Syrian rootstock	24.97[f]	75.03[b]
Watermelon		
Samar F1	27.25[g]	72.75[a]
Samara on Tetsukabuto	23.78[b]	76.22[f]
Samara on *Lagenaria siceraria*	25.82[e]	74.18[c]
Samara on *C. pepo*	26.88[f]	73.12[b]
Tetsukabuto	22.43[a]	77.57[g]
Lagenaria siceraria	24.52[c]	75.48[e]
Syrian Squash *C. pepo*	25.17[d]	74.83[d]

Means in the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test

% of total lipids occurred in the roots of Cecilia on Beaufort and Cecilia on local Syrian tomato but not in roots of Cecilia on He-man, however, the reverse is true in the case of total saturated fatty acids % of total lipids. These results agreed with Markhart-III *et al.* (1980), Horvath *et al.* (1980) and Bulder *et al.* (1991). Although, it seems clearly that scion/rootstock relationship had a role in total saturated and unsaturated fatty acids % of total lipids contents, its affect on the later is considered more important since, it is reported to be involved in cold resistance.

Significantly greater increase of indole-3-acetic acid occurred in the roots of the tomato grafts Cecilia on Beaufort and Cecilia on local Syrian tomato (32.43 and 36.71%, respectively). Although, the hormone amount in these two rootstocks was less than in the scion (Cecilia F1) and high in the grafts, this may be attributed to the interaction between the rootstock and the scion of these grafts. The IAA hormone is the only natural product that promotes or inhibits the growth of roots, buds and stems depending on its concentration,

Table 7: The roots content of Indo-3-acetic acid (IAA) in seedlings of tomato and watermelon

Treatments	Indol-3-acetic acid (nanomol g^{-1}) fresh wight
Tomato	
Cecilia F1	30.03[d]
Cecilia on He-man	27.54[a]
Cecilia on Beaufort	32.43[e]
Cecilia on Syrian	36.71[g]
He-man rootstock	34.92[f]
Beaufort rootstock	29.68[c]
Syrian rootstock	28.77[b]
Watermelon	
Samar F1	27.26[a]
Samara on Tetsukabuto	33.21[d]
Samara on *Lagenaria siceraria*	29.31[c]
Samara on *C. pepo*	98.27[b]
Tetsukabuto	71.39[g]
Lagenaria siceraria	92.37[f]
Syrian Squash *C. pepo*	02.36[e]

Means in the same column followed by the same letter are not significantly different (P=0.05) according to Duncan's multiple range test

where, the roots are sensitive to its high concentration and in all three watermelon grafts compared to their control treatments (Table 7). Graft Samara on *C. pepo* revealed a remarkably higher value of IAA content compared to the other two grafts.

CONCLUSION

From the previous results, it can be concluded that chemical evaluation is considered one of the important factors in evaluating success of the grafting process in tomato and watermelon plants. Thus, this will probably make rootstocks selection for vegetables grafting much easier in the future. To improve the application of grafting, farmers and agricultural specialists should always be careful in selecting suitable rootstocks.

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