Effect of salinity on grafted and ungrafted watermelon

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Summary
The aim of our study was to examine watermelon cultivar 'Esmeralda' grafted onto 2 different types of rootstocks (Lagenaria and interspecific squash hybrid) under saline conditions. For control, non-grafted watermelon, and even self-grafted plants were used. Plants were planted in 12 l container filled with peat on 23rd May. Salt applications were started after a month. The treatments consisted of 3 levels (control, 100 mmol, 150 mmol) for 10 days, using sodium chloride (NaCl). At the end of the treatments shoots of plants were sampled. The shoots, leaves and roots fresh weights were measured. The fresh shoot and leaves weight were significantly higher in case of watermelon grafted onto interspecific squash rootstock in every treatment. There weren't any differences in shoot and leaves fresh weight between the self-rooted self-grafted and Lagenaria-grafted plants. No significant difference were observed in fresh root weight between the Lagenaria/watermelon and squash/watermelon combinations, but compared to the non-grafted and self-grafted ones, they showed significantly better growth in every treatments. The roots of Lagenaria-grafted plants were particularly strong at control treatments. Based on the aspects studied interspecific squash hybrid is the most suitable rootstock for watermelon under saline conditions.

Key words: watermelon, salt stress, grafting, Lagenaria, interspecific squash hybrid

Introduction
Grafting vegetables onto compatible rootstocks offers a number of advantages and therefore many experiments have been published on the subject in the recent years. Grafts have been used to induce resistance against low (Bulder et al., 1990) and high (Rivero et al., 2003) temperatures and against iron chlorosis in calcareous soils (Romera et al., 1991) and to enhance nutrient uptake and mineral nutrition (Pulgar et al., 2000; Ruizet al., 1997), increase synthesis of endogenous hormones (Proebsting et al., 1992), reduce uptake of persistent organic pollutants from agricultural soils (Otani and Seike, 2006), raise salt and flooding tolerance (Estan et al., 2005; Yetisir et al., 2006), and limit the negative effect of boron and copper toxicity (Edelstein et al., 2005, 2007; Rouphael et al., 2007). Salinity is one of the major abiotic stresses that could reduce plant growth. It can be a serious problem in arid and semi-arid regions where the area is prone to salinity due to irrigation. Moreover in many irrigated areas of the arid and semi-arid regions, farmers are forced to use saline water to irrigate their crops due to an inadequate supply of fresh water. Using rootstocks capable of ameliorating salt-induced damage to the shoot can be a solution to avoid yield loss in salt sensitive genotypes belonging to Cucurbitaceae family (Uygur and Yetisir, 2009).

The use of grafted seedlings in vegetable growing, particularly in watermelon has also increased dramatically in Hungary. The size of grafted watermelon area has grown from 200-300 hectare to 1000-1500 hectare in the last 5 years.
Material and methods
The experiment was carried out at the Experimental and Training Farm of the Faculty of Horticulture, Corvinus University of Budapest in 2012. Watermelon variety 'Esmeralda' in 3 grafting combination (grafted on itself, Lagenaria siceraria and interspecific squash rootstock) and self-rooted plant for control were used. Seeds of the scion and the Lagenaria rootstock were sown a week before the interspecific and the self-rooted watermelon plants (27th April). Grafting was carried out on the 4th May. The one cotyledon grafting technique was used. 324 plants (including border plants) were planted out in 12 l containers filled with peat on 23rd May. The peat did not contain any nutrients. Containers were arranged in twin rows 100+300x50 cm plant spacing. The experiment was conducted in a completely randomized design, with four replicates in each treatment group and six plants in each replicate. The fertigation solutions were prepared by the use of commercial water-soluble fertilizer containing macro- and micro-nutrients (YaraLiva N:P:K 15:30:15 for 2 weeks and N:P:K 14:11:25 later). The fertigation solution were complemented with Calcinit (0,2 v/v%).

The fertilizer was applied via drip irrigation system, with a concentration in the irrigation water of 0.2% (v/v). Furthermore plants got foliar fertilizer (Agroleaf N:P:K 31:11:11) 2 times 2 following days in the end of July. A preventive plant protection was used against eventual infection by aphids, trips, mite and powdery mildew. The area was hoed by hand 2 times in June. After a month from planting, salt application was begun. The salinity treatments consisted of 3 levels (control, 100 mmol, 150 mmol) for 10 days, using sodium chloride (NaCl). The two higher salinity levels were achieved by adding NaCl to the fertilizer solution used for control. Plants were irrigated with equal volume (2l/plants/day) for 10 days, while the control plants were irrigated with the same fertilizer solution without salt. One treatment was one twin row because of the build-up of the irrigation system. The drip lines for each row were equipped with a valve at the header line. This allowed fertilizer/salt solution to be directed to selected rows during application. Excess of irrigation water was allowed to freely drain from the bottom of the pots for avoiding excessive accumulation of salt in root zone. At the end of the treatments shoots of plants were sampled from top of growth medium. In the 150 mmol salt treatment the self-rooted and self-grafted plants all died. Supposedly it was due to the additionally effect of the salt treatment and the extreme weather condition: low temperature after planting and extremely high temperature during the treatments (Graph 1).

Graph 1. Air temperature during the experiment
If it was possible (there were enough live plants) 3 plants were collected in each treatment and grafting combinations. The shoots and leaves fresh weight was measured. The live and dead leaves were separately measured in case of each plant. An average weight per plant was calculated from 3 plants. The roots of one plant were washed out in every combination and in all four replicates. The roots fresh weights were also measured.

The results were statistically analysed with multivariate analysis of variance (ANOVA), IBM SPSS Statistics 20.0 software.

**Results and discussion**

The growth vigour was significantly affected by rootstocks. However there were big differences between the *Lagenaria* and the interspecific squash rootstock. The fresh shoot weights were significantly higher in case of watermelon grafted onto interspecific squash rootstock in every treatments. There were no statistically significant differences in shoot weight between the self-rooted self-grafted and *Lagenaria*-grafted plants. However the *Lagenaria*-grafted plants resulted the lowest shoot weight in every treatment, including control. In spite of this it showed better salt tolerance because at the 150 mmol salt concentration all the self-rooted and self-grafted plants died while plants grafted onto interspecific squash and *Lagenaria* rootstock survived. Besides at 100 mmol salt concentration the interspecific squash-grafted plants resulted bigger shoot weight than non-grafted control. Although at the 150 mmol salt doses some of the *Lagenaria*-grafted plants died, those that survived had the same fresh shoot weight than those treated lower salt doses. The fresh shoot weight of interspecific squash-grafted plants showed continuous decrease by increasing salt doses.

An increase of salinity in the irrigation water significantly decreased the leaves fresh weight of both grafted and non-grafted watermelon but the decrease in the squash-grafted ones was not detrimental by 100 mmol salt concentration (32 % loss). The average leaves fresh weight per plant was statistically similar for non-grafted, self-grafted and *Lagenaria*-grafted plants both in control and 100 mmol treatment.

Root systems are the most critical part of the plant facing with the soil related stress factors such as salinity. In the control treatment all grafted combination showed better root growth. From all combinations *Lagenaria* grafted plants resulted statistically significant root weight (373% compared to non-grafted plants). The fact that the self-grafted plants produced bigger roots (173% compared to non-grafted), indicates that grafting per se could affect some growing parameters positively. At 100 mmol salt treatment the root growth of non-grafted and self-grafted plants decreased to equal weight (4.23 g, 4.4 g). The same can be stated to *Lagenaria*-grafted and interspecific-grafted plants (12.15 g; 12.56 g) There were no significant difference observed in fresh root weight between the *Lagenaria*/watermelon and squash/watermelon combinations, but compared to the non-grafted and self-grafted ones they showed significantly better growth. Moreover by 150 mmol salt concentration these rootstocks produced the same amount of roots as the non-grafted plants by the control treatment.
Table 1. The effect of salt treatments and grafting combinations to some growing parameters

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grafting combination</th>
<th>Shoot fresh weight (g/plant)</th>
<th>Decrease/Increase (from non-grafted control)</th>
<th>Leaves fresh weight (g/plant)</th>
<th>Decrease/Increase (from non-grafted control)</th>
<th>Root fresh weight (g/plant)</th>
<th>Decrease/Increase (from non-grafted control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td>non-grafted</td>
<td>306.75</td>
<td>100%</td>
<td>189.96</td>
<td>100%</td>
<td>8.12</td>
<td>100%</td>
</tr>
<tr>
<td>control</td>
<td>self-grafted</td>
<td>306.00</td>
<td>100%</td>
<td>182.34</td>
<td>96%</td>
<td>14.15</td>
<td>174%</td>
</tr>
<tr>
<td>control</td>
<td>Lagenaria/watermelon</td>
<td>244.25</td>
<td>80%</td>
<td>167.30</td>
<td>88%</td>
<td>30.27</td>
<td>373%</td>
</tr>
<tr>
<td>control</td>
<td>Interspecific/watermelon</td>
<td>492.00</td>
<td>160%</td>
<td>277.29</td>
<td>146%</td>
<td>18.07</td>
<td>223%</td>
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<tr>
<td>100 Mmol</td>
<td>non-grafted</td>
<td>231.00</td>
<td>75%</td>
<td>75.04</td>
<td>40%</td>
<td>4.23</td>
<td>52%</td>
</tr>
<tr>
<td>100 Mmol</td>
<td>self-grafted</td>
<td>207.25</td>
<td>68%</td>
<td>77.56</td>
<td>41%</td>
<td>4.40</td>
<td>54%</td>
</tr>
<tr>
<td>100 Mmol</td>
<td>Lagenaria/watermelon</td>
<td>156.33</td>
<td>51%</td>
<td>37.63</td>
<td>20%</td>
<td>12.15</td>
<td>150%</td>
</tr>
<tr>
<td>100 Mmol</td>
<td>Interspecific/watermelon</td>
<td>405.00</td>
<td>132%</td>
<td>187.70</td>
<td>99%</td>
<td>12.56</td>
<td>155%</td>
</tr>
<tr>
<td>150 Mmol</td>
<td>Lagenaria/watermelon</td>
<td>157.00</td>
<td>51%</td>
<td>35.15</td>
<td>19%</td>
<td>7.70</td>
<td>95%</td>
</tr>
<tr>
<td>150 Mmol</td>
<td>Interspecific/watermelon</td>
<td>258.25</td>
<td>84%</td>
<td>69.35</td>
<td>37%</td>
<td>6.89</td>
<td>85%</td>
</tr>
</tbody>
</table>

Conclusions
An increase of salinity in the irrigation water significantly decreased vegetative shoot mass, leaf and root fresh weight of both grafted and non-grafted watermelon, but the decrease was significantly lower in the watermelon/Interspecific squash combination. Although the watermelon/Lagenaria combination showed growth parameters closest to non-grafted plants it can be declare salt tolerant, because in contrast to non-grafted and self-grafted ones a number of plants survived the 150 mmol concentration salt treatment. Moreover on the score of root fresh weight this combination showed the best results. The rootstock-mediated enhancement of salt tolerance undoubtedly provides an additional motivation for watermelon grafting in modern horticulture.

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References


