Grafting *Capsicum* to Tomato Rootstocks

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ABSTRACT

Grafting to control soilborne diseases and nematodes is common in many horticultural crops. Vegetable grafting has become standard procedure for many greenhouse operations, and is gaining importance in field production. The grafting of Capsicum annuum L. seedlings (‘Early Jalapeno,’ ‘Keystone,’ and ‘NuMex Joe E. Parker’) by hand onto ‘Celebrity’ tomato (Solanum lycopersicon L.) seedlings was evaluated. The apical wedge graft and tube graft were both successful. The success of grafting was not significantly affected by the size of the grafting tube clips. Both sizes of clips for the tube graft gave similar results, 58% and 54% survival for the 1.2 mm and 2.0 mm tube clips, respectively. However, the apical wedge graft had the highest percentage of success, with a survival rate of 100%. In conclusion, grafting of C. annuum onto tomato is feasible, and may provide a mechanism for control of soilborne diseases and nematodes that adversely affect C. annuum cultivars.

INTRODUCTION

Grafting of vegetables is a common practice to control soilborne diseases and nematodes, for both field and greenhouse grown crops (King, et al. 2008). In addition, grafted vegetables can produce higher yields and have improved tolerance to environmental stresses, soil salinity, and low soil temperatures (Edelstein 2004). Currently, more than 40 million grafted tomato seedlings are estimated to be used annually in North American greenhouses (Kubota, 2007). Grafting of chile peppers (Capsicum annuum L.) is a recent practice where C. annuum scions are grafted onto C. annuum rootstocks that have soilborne disease and nematode resistance (Morra and Biloto 2006).

Intergeneric grafting of herbaceous crops is an old art, and became standard practice in Japan and Korea in the late 1920s for introducing disease resistance to watermelons (Citrullus lanatus Matsum. et Nakai). Watermelons were grafted to bottle gourd (Lagenaria siceraria Standl.), and melon (Cucumis melo L.) onto wax gourd (Benicasa hispida Cogn.) rootstocks for disease resistance (Lee and Oda 2003). Because grafting can give increased disease and pest resistance and vigor to some herbaceous crops, it is useful in low-input sustainable horticulture (King, et al. 2008). Furthermore, because soil sterilization can never be complete, grafting has become an essential technique for the continuous cropping of fruit-bearing vegetables grown in greenhouses.

Despite the widespread use of grafting, information about scion and rootstock compatibility for some horticultural crops is still lacking. As a rootstock for Solanaceous crops, tomato cultivars can provide a broad range of disease resistance to soilborne diseases and nematodes (Rivard and Louws 2008). Several tomato cultivars, e.g., Celebrity, have a wide range of resistance to soilborne diseases, as well as southern root-knot nematode (Meloidogyne incognita (Kofoid and White) Chitwood). If tomato could be used as a rootstock for Capsicum, it would add another avenue in the production strategy for providing soilborne disease and nematode resistance.

Two grafting methods common with
fruit-bearing vegetables are the apical wedge graft (cleft) and the tube graft (Japanese top graft). The apical wedge graft is commonly used to propagate herbaceous stems (Garner 2003). The stem of the scion is cut in a wedge, and the tapered end fitted into a cleft cut in the end of the rootstock. The tube graft in which a silicon tube is used to hold the scion and rootstock together during healing is especially popular for tomato grafting. The process is fast and large numbers of grafted seedlings can be managed easily throughout the healing process. Tube grafting makes it possible to graft small plants grown in plug trays. This is an advantage because the smaller the plants, the more plants that can be fitted into healing chambers or acclimation rooms. For this reason, tube grafting is popular among commercial vegetable grafting operations.

With vegetable grafting few experiments have been done to determine optimal grafting procedures and production practices. In fact, no published data is available on Capsicum/Tomato grafting. Therefore, the objective of this study was to conduct greenhouse experiments using the tube graft and the apical wedge graft to evaluate the compatibility of tomato as a rootstock for C. annuum.

MATERIALS AND METHODS

The C. annuum cultivars, Early Jalapeno, Keystone Resistant Giant (bell), and NuMex Joe E. Parker (New Mexican), were selected. Each cultivar represented a distinct pod type. The tomato cultivar, Celebrity, was chosen because of its availability and its multiple resistance to several soilborne diseases and the southern root-knot nematode. Because of their slower germination and growth, seeds of the Capsicum cultivars were sown 10 to 14 days before the sowing date of the tomato seeds. The best time for tube grafting is when the rootstock and scion stems have the same diameter. This occurred approximately 21 days after sowing the Capsicum cultivars.

Seedlings for the scion and the rootstock were grown as described in Votava, et al., (2005). In general, planting trays composed of 96 cells divided into eight 12-celled containers (#TOD 1804, T. O. Plastics, Clearwater, MN) were filled with a commercially prepared peat moss-vermiculite soil mixture (Sun Gro Redi-earth plug & seedling mix, Sun Gro Horticulture, WA, U.S.A.). Seeds were sown and after germination each cell was thinned to one plant. Trays were watered as needed, normally twice a day.

Grafting experiments were performed over a nine month period from January to September. Each grafting attempt consisted of three to four plants for each cultivar. The grafting was done on a greenhouse bench in the morning. The tube graft method used two sizes of silicon tube-clips, 1.5 mm and 2.0 mm (Hydro-Gardens, Colorado Springs, CO). To increase the likelihood of vascular bundles of the herbaceous scion and rootstock to come into contact, the exposed area was maximized by cutting the scion and rootstock at a 45-degree angle. The rootstock was cut at a 45-degree angle below the cotyledons, making sure that the scion and rootstock stem were of a similar diameter. The grafting tube was then placed on the cut rootstock. The cut end (45-degree angle) of the scion was placed in the tube clip of the prepared rootstock, and pushed to make complete contact with the rootstock (Fig. 1).

![Fig. 1. Capsicum scion joined to Celebrity tomato rootstock using a silicon tube clip.](image)
Healing and acclimatization are very important at the union for grafted plants to survive. High humidity and low light levels aid in the healing process. A temporary mist chamber was constructed with PVC piping and shade cloth (Fig. 2).

![Fig. 2](image)

The PVC structure is covered with a nylon fabric material to reduce light and increase relative humidity.

To reduce the light intensity, the mist bench was covered with a shade (50%) cloth. The chamber was about one meter high and had propagation mats to maintain warmth (~28C) within the rootstock media.

After grafting, the plants were placed in the mist chamber to facilitate the healing process. The mist chamber had intermittent mist applied to the grafted plants every 10 min for 30 sec for 12 h. Grafted plants were maintained in the mist chamber for 7 to 14 days before moving them onto a greenhouse bench with air temperatures between 24 and 32C during the 24-hour cycle. The grafting clips were left on the plants throughout this process. As the diameter of the stems increased, the clips fell off.

For apical wedge grafting the seeds were started as for the tube graft method. However, once seedlings reached grafting size the tomato rootstock was cut at a 90-degree angle just below the cotyledons instead of at a 45-degree angle. The stem of the scion was cut in a wedge, V-shaped, and the tapered end fitted into a vertical cut into the top of the rootstock. Stems were similar in diameter which was in the range of 1.5 to 2.0 mm diameter. The graft was then held firm with parafilm wrapped around the cut to prevent the graft union from drying out (Fig. 3).

![Fig. 3](image)

a) Apical wedge graft with parafilm wrapping. b) Apical wedge graft after healing.

To test the skill of the grafted and the suitability of the post-grafting environment, *Capsicum* to *Capsicum* grafts were completed using the same three cultivars. The same cultivar was used for both the scion and the rootstock and the 1.5 mm grafting clips were used. After grafting, the seedlings were placed in the same mist chamber as the intergeneric grafts.

**RESULTS**

On the basis of the high percentage of successful grafting obtained with the apical wedge graft (100%) it is possible to graft *Capsicum* onto tomato rootstocks (Table 1).

| Table 1. The percentage and number of successful grafts with C. annuum cultivar scion onto "Celebrity" tomato rootstock. |
|---|---|---|
| Early Jalapeno | 100% (27/27) | 66% (17/26) | 56% (17/31) |
| Keystone | 100% (32/32) | 50% (15/30) | 49% (15/31) |
| NuMex Joe E. Parker | 100% (33/33) | 52% (16/31) | 58% (16/28) |
| Overall Mean | 100% (22/22) | 58% (12/21) | 54% (17/32) |

*Size of silicon tube-clip used to make the graft.

Means between the two silicon tube-clip sizes, and the means among the cultivars were not significantly different by least significant difference (LSD) test at *P* ≤ 0.05.
successful grafts with *C. annuum* cultivar scion onto ‘Celebrity’ tomato rootstock.

2 Size of silicon tube-clip used to make the graft.

3 Means between the two silicon tube-clip sizes, and the means among the cultivars were not significantly different by least significant difference (LSD) test at $P \leq 0.05$.

The tube graft, which is the standard commercial grafting technique for vegetables, was also successful. This technique had a success rates ranging from 49% to 66% (Table 1). With the cultivars tested, there was no cultivar effect on grafting success. Both the 1.5 mm and the 2.0 mm grafting tubes had similar success.

In the self-grafted tests, which functioned as a positive control for the effect of the grafting procedure and the post-grafting environment, the success rate was in the range of the intergeneric grafts, about 60% (Table 2).

Table 2. The percentage and number of successful grafts with *C. annuum* cultivar scion grafted onto the same cultivar rootstock using 1.5 mm tube clips.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>% Success</th>
<th>Number of Successful Grafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Jalapeno</td>
<td>50%a (48/96)</td>
<td></td>
</tr>
<tr>
<td>Keystone Resistant Giant/KRG</td>
<td>63%ab (38/62)</td>
<td></td>
</tr>
<tr>
<td>NuMex Joe E. Parker/JEP</td>
<td>79%bc (31/41)</td>
<td></td>
</tr>
<tr>
<td>Overall mean</td>
<td>59% (117/199)</td>
<td></td>
</tr>
</tbody>
</table>

There appeared to be a cultivar difference with ‘NuMex Joe E. Parker’ (76%) with success rates that were higher than ‘Early Jalapeno’ (50%) for healing response.

**DISCUSSION**

Grafting vegetables has become increasingly more common to supplement soilborne disease and nematode resistance through the use of resistant rootstocks. Tomatoes offer enhanced disease resistance to many soilborne diseases and nematodes, thus providing a source of resistant rootstocks that can be used for grafting. The ability to graft *Capsicum* onto a resistant tomato cultivar, e.g., Celebrity, opens new avenues for *Capsicum* production, whether growing in the greenhouse or the field. In addition, this provides a valuable tool to the choices *Capsicum* growers have in sustainable (organic) and standard production systems.

Silicon tube-clips are becoming the vegetable grafting industry standard in Europe and Asia. Tube grafting is quicker and less complicated than apical wedge grafting because tube grafting only requires a single cut on both the root and shoot portions of the graft. Because fewer intricate cuts are involved, this technique can be used on very small seedlings. In this study, the tube graft was successful, producing an efficacy of 50% to 70% very easily. Commercial vegetable tube grafters are able to make approximately 800 to 1000 grafts per day (Lee and Oda 2003).

Morra and Bilotto (2006) did not observe graft incompatibility for *Capsicum* to *Capsicum*. In this study, however, graft incompatibility was observed. This could be from grafted’s inexperience or technique. It could also be associated with the post-grafting environment. Dessication could be associated with the lower success of the tube grafts, so a misting chamber that maintains a high relative humidity and with low ambient light-level could increase the survival rate (Itagi et al. 1990).

Greenhouse and field trials are needed to determine whether grafting *C. annuum* onto tomato rootstock increases the ability to withstand soilborne pests and to determine if the crop performance will be commercially acceptable (e.g., yield, anchorage, fruit shape, etc.). Nevertheless, grafting *C. annuum* to tomato is feasible and should be investigated further.
REFERENCES


