Effect of grafting on watermelon growth and yield

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ABSTRACT: Wilt of watermelon especially caused by \textit{Fusarium} is a common and serious problem all over the world. Grafting with bottle gourd is a unique solution to control wilt of watermelon. The experiment was conducted in the coastal region of Bangladesh with the direct involvement of the farmers. All the grafted watermelon plants remain alive up to harvesting while more than one-third non-grafted plants died from vegetative to fruiting stage. Fruit yield was observed one and half times higher in grafted fields as compared to non-grafted counterparts.

Keywords: watermelon, \textit{Fusarium} wilt, grafting, bottle gourd

Introduction

Grafting watermelon onto other Cucurbitaceous crops tends to reduce damage caused by soil-borne pathogens, such as \textit{Fusarium}, \textit{Verticillium}, \textit{Phytophthora}, \textit{Pseudomonas}, \textit{Didymella bryoniae}, \textit{Monosporascus cannonballus}, and nematodes (Louws et al., 2010), and boots up plant growth and development controlling wilt caused pathogens and to increase the tolerance to biotic stress such as viral, fungal and bacterial infection (Rivero et al., 2003; Edelstein et al., 2004; Cohen et al., 2007). Providing resistant rootstock to susceptible scions prevents primary sources of infection, resulting in reduced disease incidence (Davis et al., 2008). Historically, \textit{Fusarium} wilt has been the greatest yield-limiting disease of watermelon worldwide (Taylor et al., 2008). Among many vegetable crops grafting was initially introduced to control \textit{Fusarium} wilt in watermelon (King et al., 2008).

It has been routinely utilized in Japan and Korea since the late 1920s for the control of \textit{Fusarium} wilt (Lee, 1994). Grafting provides complete protection from the wilt disease with no reduction in fruit quality and quantity (Cohen et al., 2002). It is an advantageous alternative to soil fumigation by methyl bromide for the control of \textit{Fusarium} wilt in watermelon production (Miguel et al., 2004, Yetisir et al., 2007). In most cases of an outbreak of \textit{Fusarium} wilt, the plants begin to decline late in the production season after virtually all production costs have been spent (Taylor et al., 2008).

Besides wilt control grafting has many other advantages. It can provide resistance against low (Bulder et al., 1990) and high (Rivero et al., 2003) temperatures, against iron chlorosis in calcareous soils (Romero et al., 1997), to improve salt tolerance of plant (Colla et al., 2006), to enhance nutrient absorption (Ruiz et al., 1997), and to improve water use (Cohen and Naor, 2002) and

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nutrient uptake (Pulgar et al., 2000), leads to vigorous plant growth with higher yield (Tarchoun et al., 2005).

Crinò et al. (2007) used different Cucurbita spp. and Mohamed et al. (2012) used hybrids between Cucurbita maxima and Cucurbita moschata as rootstocks for watermelon grafting and observed 100 per cent protection against Fusarium wilt. Karaca et al. (2012) evaluated 21 bottle gourds (Lagenaria siceraria) as rootstocks for grafting with watermelon and found 83 to 100 per cent protection against wilt of watermelon.

In Bangladesh watermelon is a very popular fruit crop. It is a cash crop to the farmers with high cost involvements. Like other parts of the world wilt especially caused by Fusarium is severe sometimes. Research on grafting watermelon with bottle gourd has proven complete protection against Fusarium wilt. Most of the researches were based on on-station trials with grafting in the field lab. But farmers need to test the technology in their field with their direct involvement. With this point of view, the present study was undertaken to evaluate the growth and yield performances of watermelon grafted with bottle gourd as rootstock with the direct involvement of the end users of the technology.

Materials and Methods

The study was conducted at multi-location testing (MLT) site, Mohipur-Kuakata, Patuakhali, Bangladesh (21°49’58.30” N latitude and 90°8’35.92” E longitude) under farmers’ field condition. The experimental plots were slightly salinity affected. At the time of planting soil salinity was 1.4 desi-Simens m² that rose up to 4.8 dS m² at harvesting stage. Watermelon (Citrullus lanatus) variety, Glory (hybrid- F₁ seeds) was grafted with white flowered bottle gourd (Lagenaria siceraria) variety, BARI (Bangladesh Agricultural Research Institute) lau-2 using as rootstock to control wilt disease of watermelon. Performance of grafted watermelon plants were evaluated against non-grafted counterparts. The experiment was laid out in a complete randomized block design with six dispersed replications having unit plot size of 6x6 m². Watermelon seeds were planted on 24 December 2009 in a well prepared field in pit system with spacing of two meters from pit to pit. 3-4 watermelon seeds were planted in each pit to have at least two plants. After 15 days of watermelon seeds planting same number of bottle gourd seeds were planted side by side of watermelon seeds, because bottle gourd seedlings growth is faster than that of watermelon. Two watermelon and two bottle gourd seedlings were allowed to grow in each pit. When both watermelon and bottle gourd vines attained to a length of 20-25 cm with similar vine diameter tongue approach grafting (Nelson, 2007; Hassell and Memmott, 2008) was done. One watermelon vine and one bottle gourd vine were brought close and at the point where the union was to occur, a slice of bark three to four centimeters long was peeled, the same size on each, from both the stems. The two peeled surfaces were then bound tightly together with polythene tape wrapping completely with two complete covers around the area where the two peeled areas were in contact. Top foliar portion of bottle gourd vine above 12 to 15 cm of grafting point was removed to encourage a more rapid healing of the grafted union. After four days of grafting 50 percent of the watermelon vine five cm below the grafting point and similar portion of bottle gourd vine above five cm of the
grafting point were cut. After three days of the first cut rest of the above mentioned vines were cut. By this time grafting union was completed and the watermelon scions were able to get water and nutrients through bottle gourd rootstocks. The crop was fertilized with 10000, 250,100 and 200 kg/ha cowdung, urea, triple super phosphate and muriate of potash, respectively (Salam et al., 2002). All fertilizers were applied in the pits. Urea was top dressed into three equal installments: first- 15 days of germination, second-after completion of the union of grafting and third-first appearance of the male flower. Irrigation, weeding and other intercultural operation was done as and when necessary. Cucurbit fruit f...ly trap. Data on different growth and yield parameters were recorded and analyzed statistically.

Results and Discussion

Growth attributes and survival results were presented in Table 1. The result of the study revealed that among growth parameters only length of the main vine was significantly higher in grafted plants than that of non-grafted plants. Vigorous plant growth in grafted watermelon was observed in several studies (e.g., Mohammed et al., 2012; Tarchoun et al., 2005; Yetisir et al., 2007; Boughalleb et al., 2008). Promoted watermelon plant growth in the grafted plants can be explained by the interaction of some or all of the following phenomena: increased water and plant nutrient uptake (Pulgar et al., 2000), due to stronger and more extensive root growth of the rootstock (bottle gourd), augmented endogenous hormone production (Zijlstra et al., 1994), enhanced scion vigor (Leoni et al., 1990) and tolerance salinity (Zerki and Parson, 1992; Colla et al., 2006). Lee (1994) and Ioannou (2001) found that grafted watermelon plants were more vigorous than self-rooted ones and had a larger central stem diameter. Additional effects of other processes could also play a role in explaining the enhancement in plant growth (Yetisir et al., 2007). Salam et al. (2002) observed 32 per cent higher main vine length in grafted plant than that of non-grafted counterpart. There was no significant difference in terms of number of lateral stems, number of male and female flowers, and days to 1st male and female flower appearances. Mohammed et al. (2012) also did not found any significance difference in number of male and female flowers between grafted and non-grafted watermelon. No significance difference was observed in days to 1st male and female flower appearances (Salam et al., 2002) but grafted plants showed seven to ten days delay in flowering than non-grafted plants due to having stress during grafting union process in the grafted plants. Though number of male and female flowers did not differ significantly sex ratio (male/female) was found significantly higher in non-grafted plants. Grafted water-melon plants tend to give higher female flowers and lower male flowers comparing to non-grafted plants which affected the sex ratio in favor of non-grafted plant and this is also associated with the higher fruit yield resulted from grafted plants (Mohammed et al., 2012). Sex expression and flowering are controlled by plant hormones. It was reported that the plant hormones are important endogenous factors which regulate all aspects of plant vegetative and reproductive development and thus are believed to be important player in root-shoot communication (Aloni et al., 2010).
All grafted plants showed complete survival (Table 1) whereas 28.95 per cent non-grafted plants were died due to wilt at different stages of their life, mostly at vegetative and fruiting stages. Wilted plants were tested randomly in the laboratory and causal organism was found *Fusarium* spp. Salam et al. (2002), Yetisir et al. (2007), Taylor et al. (2008) and Mohammed et al. (2012) also observed all grafted watermelon plants were alive up to harvesting. The method of disease control afforded by grafting is not well understood. It is presumed that the primary method is by avoidance when the rootstock is resistant to the pathogen (Boughalleb et al., 2008; King et al., 2008). Substances associated with *Fusarium* tolerance are synthesized in the root and translocated to the scion through the xylem system (Biles et al., 1989) and the activity of the substances released to disease resistance may vary during the development stages of the grafted plants (Heo, 1991).

Fruit and fruit yield attributes were presented in Table 2. No yield attributes differed significantly. Only total yield (ton/hectare) was found significantly higher in grafted plots as compared to non-grafted plots. The yield contributing characters were somehow higher in grafted plants, though not significant. Plants with vigorous root systems release more cytokinins into the ascending xylem sap resulting in increased yield due to growth promotion (Aloni et al. 2010). But significantly higher fruit yield in grafted plots were mainly due to the higher survival of grafted plants. This result was supported by the previous study (Salam et al., 2002; Colla et al., 2008; Huitrón et al., 2011; Mohammed et al., 2012). Rouphael et al. (2008) obtained both total fruit yield and marketable fruit yield significantly higher in grafted watermelon than non-grafted.

### Table 1 Growth and flowering behavior of watermelon as influenced by grafting with bottle gourd

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Length of main stem (m)</th>
<th>No. of lateral stems</th>
<th>No. of male flowers</th>
<th>No. of female flowers</th>
<th>Sex ratio</th>
<th>Days to 1st male flower</th>
<th>Days to 1st female flower</th>
<th>Survival %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grafted</td>
<td>2.89</td>
<td>15.2</td>
<td>45.2</td>
<td>26.8</td>
<td>1.69</td>
<td>49.8</td>
<td>56.5</td>
<td>100</td>
</tr>
<tr>
<td>Non-grafted</td>
<td>1.88</td>
<td>12.8</td>
<td>50.6</td>
<td>21.8</td>
<td>2.32</td>
<td>43.4</td>
<td>49.9</td>
<td>71.05</td>
</tr>
<tr>
<td>T-test</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>**</td>
</tr>
</tbody>
</table>

NS= non significant  
* P<0.05  
** P<0.01

### Table 2 Yield and yield attributes of watermelon as influenced by grafting with bottle gourd

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of fruits plant-1</th>
<th>Individual fruit wt. (kg)</th>
<th>Fruit length (cm)</th>
<th>Fruit circumference (cm)</th>
<th>Total fruit yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grafted</td>
<td>3.5</td>
<td>4.11</td>
<td>32.4</td>
<td>58.7</td>
<td>42.01</td>
</tr>
<tr>
<td>Non-grafted</td>
<td>2.8</td>
<td>3.80</td>
<td>29.3</td>
<td>54.3</td>
<td>28.25</td>
</tr>
<tr>
<td>T-test</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>**</td>
</tr>
</tbody>
</table>

NS= non significant  
** P<0.01
Conclusions

Wilt disease is the main problem in watermelon cultivation worldwide and it is well known that grafting watermelon with some inter specific species can provide the best solution for the disease. Yield as well as farmer’s income can be increased by using this technology. But most of the watermelon growing farmers in Bangladesh are far away of the technology due to proper extension work. They are using a lot of chemicals to control wilt but it does not work. Increasing farmer’s awareness and providing training how to use the technology by themselves are the most important.

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References


