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Grafting to Control Bacterial Wilt and Root-Knot Diseases for Production of Healthy Eggplant and Tomato Crops

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Eggplant and tomato are two of the most popular and important vegetables in Bangladesh. They are grown widely throughout the country. Unfortunately, satisfactory production of eggplant and tomato is seriously constrained due to severe attacks of bacterial wilt disease caused by a bacterium (Ralstonia solanacearum) and root-knot disease caused by a root-knot nematode (Meloidogyne incognita). Both of these pathogens are soil-borne and can cause 30-50% yield losses. In severe attacks, the entire crop may be damaged. Generally, chemical control of soil borne diseases is difficult and expensive. Moreover, it causes environmental pollution and health hazards to the producers as well as consumers.

The scientists of the Bangladesh Agricultural Research Institute (BARI) have identified two wild eggplant species, Solanum sisymbriifolium and Solanum torvum that possess high resistance to bacterial wilt and root-knot diseases. They proved through research that grafting commercial eggplant and tomato varieties on these wild eggplants as rootstocks protects them from these diseases. This technique is known as ‘cleft grafting’. These wild eggplants are widely available throughout the country and can be utilized effectively to control the above diseases and to greatly improve productions of eggplant and tomato.

How to Identify Bacterial Wilt and Root-Knot Diseases in Eggplant and Tomato

Bacterial wilt or root-knot diseases may attack eggplant and tomato at any stages of their growth. These diseases are particularly prevalent during periods of high temperature (25°C – 35°C) and moisture and in fields where eggplants and tomatoes are cultivated year after year. Bacterial wilt disease spreads out quickly throughout the field and also to adjacent fields when the infested fields are irrigated. The leaves of infected eggplant or tomato first start to wilt
partially and then wilt completely and the plants die in 3-4 days (Picture-1). Eggplants or tomato may die without bearing any flowers or fruit if they are attacked at early growth stages.

In the case of root-knot disease, the nematode infects the roots of plants and produces small knots of tissue in the infected parts (Picture-2). Diseased plants gradually become weak and eventually die. Moreover, various bacterial and fungal pathogens enter the plants through the wounds created by the nematode infection, causing different diseases.

**Purpose of Grafting**

- Cultivation of grafted eggplant and tomato can reduce the incidence of bacterial wilt and root-knot diseases by 90-95%.
- Grafting allows the production of early crops of tomato and eggplant, protecting them from bacterial wilt and root-knot diseases, which are prevalent during the summer period.
- Roots of the wild eggplant are strong and healthy and help grafted plants take up adequate amounts of nutrients from the soil, resulting in much improved yield and 1-1.5 months longer harvesting period than that of the non-grafted plants.
- Results of field trials and demonstrations in different locations have shown that farmers can produce 1.5 - 2 times higher yields and earn higher profits through cultivation of grafted eggplant and tomato.

**Development of Grafting Technique and Its Spread**

Japanese scientists were the first to innovate the technique of cutt grafting in eggplant and were successful in controlling bacterial wilt disease in eggplant and tomato. By 1930, about 95% eggplant farmers in Japan cultivated eggplant by using grafted eggplant seedlings. Presently, the grafting technique is widely used to produce eggplant and tomato crops in several southeast Asian countries. BARI scientists initiated research and use of eggplant grafting in 1982 through the Japanese project CVSR. Later on, the practice of eggplant grafting was started at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). In 1998, BARI scientists through the IPM CRS project started field trials and demonstrations of eggplant and tomato grafting in farmers’ fields at Kashimpur village of Gazipur district. Later on, the technique was continually demonstrated for three years in Keo village in Sripur Upazila of Gazipur and Naodaagaram and Gaitgihat villages of Jessore. As a result of the widespread incidence of bacterial wilt and root-knot diseases in farmers’ fields and farmers’ interest to adopt the technique, demonstrations on cultivation of grafted eggplant and tomato crops have been ongoing in several locations of Gazipur, Narsingdi, Comilla, Bogra and Jessore districts.

**Brief Description of Wild Eggplant Species**

In Bangladesh six wild eggplant species are available. Of these, Solanum sisymbriifolium and Solanum torvum have been shown to possess high resistance to bacterial wilt disease caused by Ralstonia solanacearum and root-knot disease caused by the nematode Meloidogyne incognita. Cultivated eggplant and tomato grafted onto these two wild eggplant species (as rootstocks) are protected from bacterial wilt and root-knot diseases. However, Solanum sisymbriifolium is presently being used as rootstock in eggplant and tomato grafting because of several advantages. The shape and size of the leaves of S. sisymbriifolium are similar to that of cultivated tomato plants and are dark green in color. There are many thorns on the surface of the leaves.
as well as on the stalks of leaves and fruits. The flowers are white in color and grow in bunches having identical size of cultivated eggplant. The ripe fruits appear yellow in color and then turn red when mature. For preservation of seeds, the collected seeds should first be washed with clean water and spread out in shade for a couple of days and then dried in the sun to preserve in an airtight polythene bag. Seeds should be preserved no more than 6-12 months for optimal germination rates.

**Raising Seedlings of Rootstock and Scion**

The plant on which the graft is made is called the "rootstock", and the plant that is grafted onto the rootstock is called the "scion". In eggplant or tomato grafting, the wild eggplant, **S. suisbrutifolium**, is the rootstock, and the cultivated eggplant or tomato used for grafting is the scion. Firstly, seeds of the rootstock should be sown, preferably in line, in a well prepared small seedbed. The seeds usually germinate in 10-15 days depending on the prevailing air temperature. After germination, about 10-day old seedlings of the rootstock having 2-3 leaves should be planted in polyethylene bags (measuring 18cm x 13cm) filled with soil having a mixture of 50:50 decomposed cowdung and loam soil (Picture-3). The seedlings in the polyethylene bags should be watered regularly. The seeds of the scion (eggplant or tomato) should be sown in seedbed, preferably thinly in lines, 7-10 days after sowing the seeds of the rootstock. For the purpose of grafting, the age of the rootstock should be between 40-50 days and that of the scion 30-35 days. Successful grafting depends on raising healthy seedlings of rootstock and scion.

**Grafting Procedure**

Eggplant and tomato grafting is done by using "cleft grafting" method. "Cleft" means a slit or a longitudinal opening. Cleft grafting, therefore, means setting or inserting the shoot of the scion into the slit made on the rootstock to make a union of the two plants. Cleft grafting is done by following the procedure:

- Select a shaded place on a small table, or even a flat surface for the grafting procedure.
- At the time of grafting, the age of the rootstock grown in polybags should be between 40-50 days and that of the scion (eggplant or tomato seedlings) should be 30-35 days. Gently uproot the seedlings of the scion, wash the roots in clean water and place the seedlings in a container with the roots dipped in a small amount of water so that the seedlings of the scion do not dry up. Keep the seedlings of the rootstock as well as the scion in the shaded place where the grafting work will be done.
- Cut off the stem of rootstock 5-6.5cm (2-2.5 inches) from the soil level using a clean, sharp razor blade (Picture-4). Then make a one-cm deep longitudinal slit or opening in the top of the cut stem of rootstock so that it is divided into two equal halves (Picture-5). Cut the scion 4-5cm from the top and make two angular cuts about 1 cm long on opposite sides at the bottom end of the scion so that bottom end takes a "V" shape (Picture-6). After removing the large leaves from the shoot, insert the "V" shaped end of the scion into the slit made on the stem of the rootstock (Picture-7). Close the cut edges using a small plastic clip (Picture-8).
- Water the grafted plants by means of a small hand sprayer so that the point of grafting is not drenched.
- A person can make 400-500 grafts a day and more than 95% grafts can survive when proper care is ensured.
Management of Grafted Seedlings

- The grafted seedlings require suitable climatic conditions of 25°C to 30°C temperature, relative humidity of not less than 85% and very low direct sunlight during healing of the grafted union.
- To obtain this kind of environment, immediately transfer the grafted seedlings to a 1.8-2 meter (6-7 feet) high arch-like grafting house or chamber made of bamboo sticks as frames and with the top covered with jute cloth or sacks and transparent polyethylene sheets. The length of the grafting house may be 3-4.5 meter (10-15 feet) and the width 1.8-2 meter (6-7 feet) (Picture-9). The covers with jute cloth or sack and polyethylene sheet (0.1 mm thick) will cut down the direct sunlight substantially by about 75%. The floor of the grafting house may be covered with black polyethylene (0.1 mm thick) sheet with wet straw mulch on it and the grafted seedlings can be placed on the mulch (Picture-10).

- Spray the grafted seedlings with water 4-5 times a day for 7-10 days by using a hand sprayer, which will help maintain 85%-100% humidity within the grafting house.
- After 7-10 days, take the grafted seedlings out of the grafting house and place them in a safe, shady place for 7-10 days for acclimatization or hardening.
- The grafted seedlings will be ready for transplantation in the main field in 15-20 days.
- Observe the grafted seedlings regularly and clip off the suckers coming out at the base of the grafted seedlings.
- The plastic clip used for grafting can be removed after transplanting the grafted seedlings in the main field. Wash the clips thoroughly in hot soapy water, rinse them in hot water and allow them to dry thoroughly before storing them in a cool, dry place.

Transplanting Grafted Seedlings in the Main Field

The main field for transplanting the grafted seedlings should be prepared by following the standard practices and planting distances used for cultivating a normal crop of eggplant or tomato. The soil of the grafted seedlings in the polybags should be adequately watered 3-4 hours before transplanting them in the main field. The polybags should be removed before transplanting and discarded properly. Care should be taken on the following aspects:

- Remove the plastic clips attached to the grafted seedlings after transplanting, otherwise the grafted joint may be damaged or break while carrying the grafted seedlings to the field.
Remove the suckers of the rootstock (wild eggplant) that may appear at the base of the grafted seedlings before transplanting.

Most important, the point of the grafting union must be at least 5cm (2 inches) above the ground level after transplanting so that the graft union does not come in contact with the soil. The grafted plant may be attacked by bacterial wilt or other seed-borne diseases if the grafting point comes in contact with the soil.

After transplanting the grafted plants may be supported with a bamboo stick to prevent it from falling down.

Field trials and demonstrations in different locations have shown that grafting of eggplant and tomato is highly effective to control bacterial wilt and root-knot diseases. This technique is also effective in controlling a number of other soil-borne diseases. By adopting this practice, the farmers are expected to produce healthy crops of eggplant and tomato with much higher yield and economic returns. This practice is particularly rewarding for producing early season eggplant and tomato crops. Grafting is a simple method and with training, the grafting technology has the potential to become a successful cottage industry for the nurserymen as well as for the progressive farmers that will provide employment and income. The performance of eggplant and tomato grafting practiced by farmers in two locations are illustrated in Tables 1 & 2.

Table 1. Performance of grafted eggplant crop in farmers’ fields in Gaibandha village of Bagherpara upazila in Jessore (eggplant variety “Choka” grafted on Solanum asymbotroides rootstock).

<table>
<thead>
<tr>
<th>Results</th>
<th>Fields of grafted eggplant</th>
<th>Fields of non-grafted eggplant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant mortality from bacterial wilt disease</td>
<td>5.4% (16% lower mortality)</td>
<td>25.4%</td>
</tr>
<tr>
<td>Total No. of fruits per plant</td>
<td>52 (16 more fruits)</td>
<td>36</td>
</tr>
<tr>
<td>Yield of eggplant per ha</td>
<td>64 tons (36 tons more yield)</td>
<td>28 tons</td>
</tr>
<tr>
<td>Farmer’s net income per ha</td>
<td>Tk 3,19,580 (Tk 1,91,052 additional income)</td>
<td>Tk 1,28,528</td>
</tr>
</tbody>
</table>

Table 2. Performance of grafted tomato crop in farmers’ fields in Keona village of Sripur upazila in Gazipur (Variety BARI Tomato-3 grafted on Solanum asymbotroides rootstock).

<table>
<thead>
<tr>
<th>Results</th>
<th>Grailed BARI Tomato-3</th>
<th>Non-grafted BARI Tomato-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant mortality from bacterial wilt disease</td>
<td>0%</td>
<td>23%</td>
</tr>
<tr>
<td>Total No. of fruits per plant</td>
<td>39 (10 more fruits)</td>
<td>29</td>
</tr>
<tr>
<td>Yield of tomato per ha</td>
<td>38 tons (18 tons more yield)</td>
<td>20 tons</td>
</tr>
<tr>
<td>Farmer’s net income per ha</td>
<td>Tk 3,07,960 (Tk 1,44,826 additional income)</td>
<td>Tk 1,63,154</td>
</tr>
</tbody>
</table>

The results given in the above tables amply show that the cultivation of grafted eggplant and tomato is a highly effective technology to manage bacterial wilt and root-knot diseases and farmers can produce healthy crops of these vegetables with high yields as well as high economic returns. Funded by USAID and coordinated by the Bangladesh Agricultural Research Council, cultivation of grafted eggplant and tomato is presently being demonstrated in farmers’ fields of Jessore, Comilla, Narsingdi and Bogra districts through the collaboration of the Department of Agricultural Extension and Bangladesh Agricultural Research Institute. Moreover, four NGOs, such as Menonite Central Committee (MCC), CARE-Bangladesh, ActionAid-Bangladesh, and Practical Action-Bangladesh have started demonstrations of cultivation of grafted eggplant in a number of districts for quick dissemination of the technology.