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Guide
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Grafting Sweet Peppers for Production in the Hot-Wet Season

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Introduction

Sweet peppers are difficult to grow during the hot-wet season. High rainfall, flooding, waterlogged soils, diseases and high temperatures can significantly reduce yields.

Grafting sweet pepper scions onto selected rootstocks of sweet pepper and chili (hot) pepper can minimize problems caused by flooding and soil-borne diseases including bacterial wilt and Phytophthora blight. Sometimes the use of grafted pepper plants can make the difference between harvesting a good crop and harvesting no crop at all (Fig. 1).

Grafting options

Producing grafted sweet peppers is more expensive than non-grafted pepper production. Use grafting only when there is a risk of flooding or soil-borne diseases such as bacterial wilt and Phytophthora blight.

Chili pepper rootstocks

Use chili pepper rootstocks when flooding or waterlogged soils are expected. Chili roots can tolerate waterlogging and survive for days under water.

Most chili lines will graft successfully with sweet pepper lines. The key is to identify chili rootstocks that will maintain high yields and fruit quality of the scion variety. The lines should be resistant to bacterial wilt (caused by *Ralstonia solanacearum*) and other soil-borne diseases. AVRDC recommends chili accessions PP0237-7502, 0242-62, and Lee B. They are resistant to damage caused by flooding, bacterial wilt, and

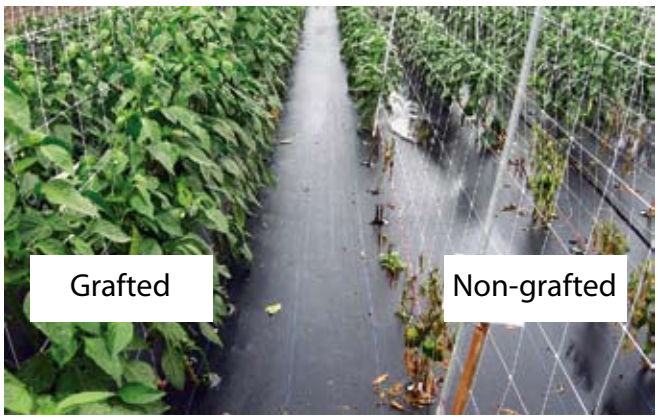

Figure 1. Grafted sweet pepper plants (left bed) are growing vigorously while non-grafted plants (right bed) are dead.

Phytophthora blight (caused by *Phytophthora capsici*). Field observations indicate these lines show tolerance to both diseases.

Sweet pepper rootstocks

Most sweet pepper varieties are susceptible to damage by soil-borne diseases and flooding. Therefore, it is not advisable to use sweet pepper rootstocks until resistant or tolerant lines are identified. So far, no resistant lines have been developed at AVRDC or other research institutions. Breeding for disease resistance and flood tolerance is in progress.

Facilities

Two types of facilities are generally needed to produce grafted sweet pepper seedlings. A screenhouse (Figs. 2, 4) is used for growing seedlings prior to grafting and for hardening of grafted plants prior to transplanting.

Immediately after grafting, a grafting chamber (Figs. 3, 5) is used for about one week to provide high humidity and reduced light intensity during development of the graft union. The chamber can be built at low cost and is recommended for small-scale farmers or community nurseries. If necessary, the grafting chamber alone can be used to raise grafted seedlings. The chamber's shade nets are removed to grow seedlings prior to grafting. Immediately after grafting, shade nets are layered over the chamber to facilitate healing. Plants are cared for in a similar manner as stated in steps 10 and 11 on page 7. Then, rather than moving plants back into the screenhouse (as stated in step 12), simply peel off the remaining (black) shade net layer on the chamber and harden the plants until ready for transplanting.

Screenhouse

The screenhouse should be constructed of 60-mesh nylon netting to exclude virus-transmitting insects such as aphids and whiteflies (standard 32-mesh will not exclude whiteflies). The double door reduces the chance for entry of insects as workers enter or leave the structure. If insects are detected in the screenhouse, they should be immediately killed.

The upper half of the structure should be covered with a separate layer of transparent, UV-resistant polyethylene to prevent rain penetration. A 50% shade net should be placed about 30 cm above the highest point of the house to reduce light intensity and temperature. Additional shading inside the screenhouse may be needed for plants during the first two or three days after they are returned from the grafting chamber for hardening. A screened ventilation ridge along the top of the house is recommended for houses 6 m or more in width. This vent reduces the heat that accumulates in large screenhouses.

Grafting chamber

This facility is designed to maintain high humidity and reduce light intensity to minimize heat build-up. The polyethylene cover retains moisture that evaporates from a water-filled floor pan. The chamber is covered with shade nets to reduce light penetration. The over-the-top shade nets further reduce light penetration and allow good air circulation to minimize heat build-up. Light intensity can be controlled as needed by addition or removal of shade nets. The structure, as shown, is suited for open air, full sun conditions. Placing the shelter under natural shade can reduce the need for shade netting. Select a flat site that is elevated and not subject to flooding. Bamboo stakes or pipes (30 cm in length, inner diameter of 1.5-1.8 cm) are driven 15 cm into the ground. Space the stakes every 50 cm along the length of the chamber. To construct the arched frame of the chamber, bend PVC pipes and insert each end into the bamboo stakes on either side. The tunnel floor is covered with a black polyethylene film (0.15 mm thickness). The edges of the film are turned up and fastened to the tunnel skeleton so it will hold water. Bricks are placed in rows on the floor to hold plant trays above the water line.

A transparent, 0.1-mm-thick, UV-resistant polyethylene sheet is used as the first covering. This serves to maintain a high level of humidity inside the house and to prevent rainwater penetration. Two layers of shade nets, with the silver reflective net being the outermost covering, are placed over this sheet during the

Figure 2. Screenhouse

Figure 3. Grafting chamber

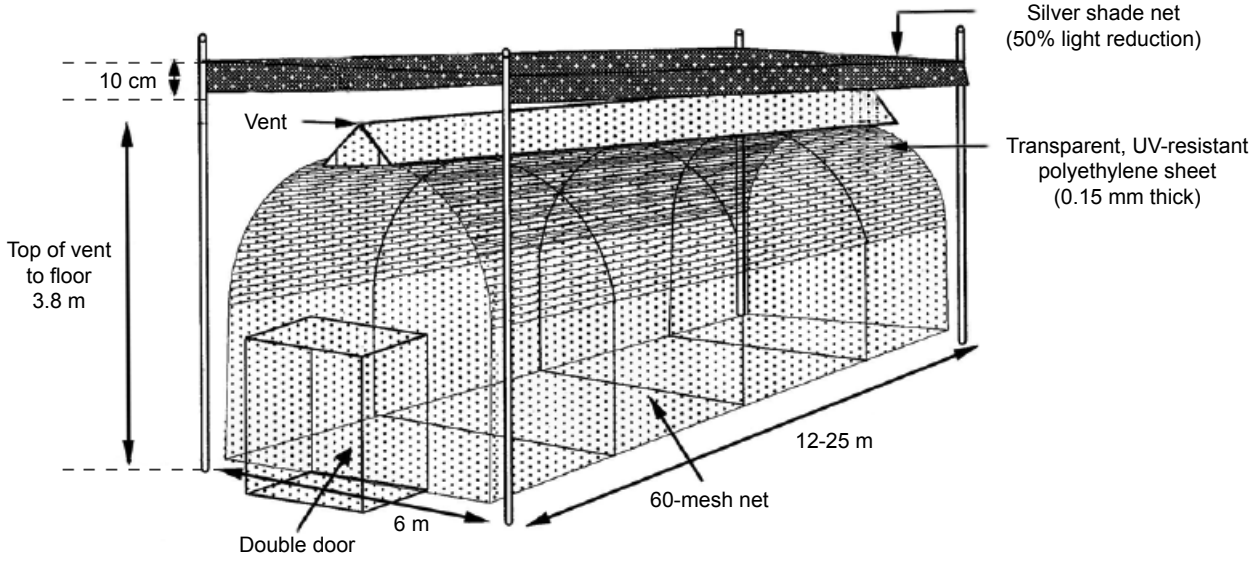

Figure 4. Screenhouse

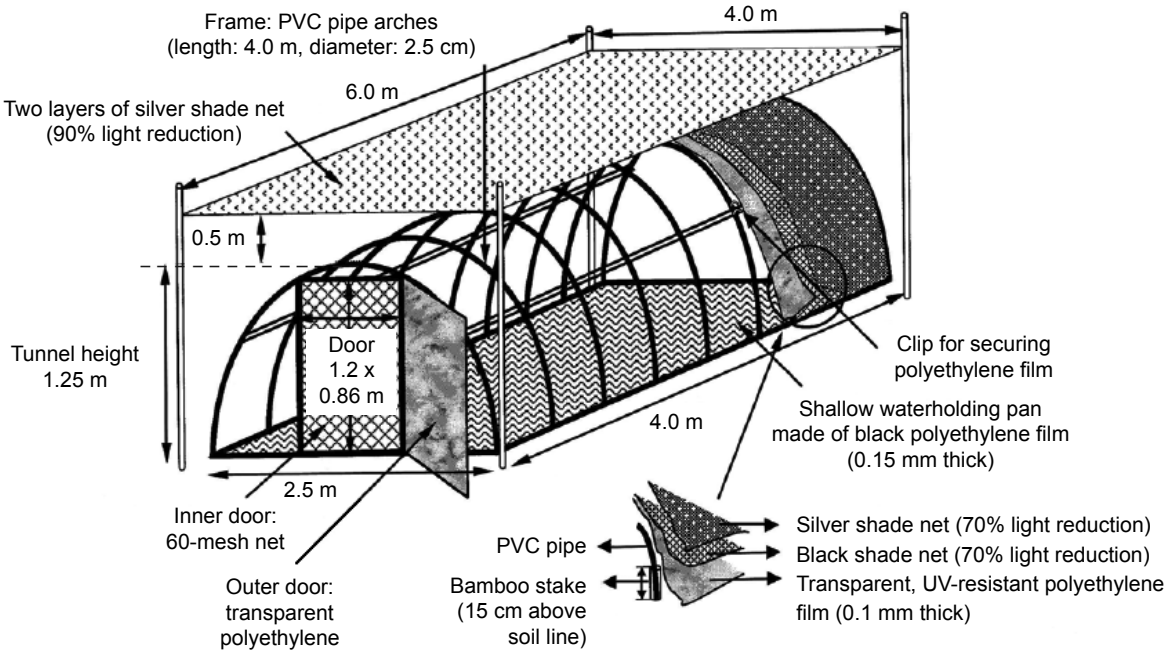

Figure 5. Grafting chamber

healing phase. Fasten the sheet and nets onto the skeleton using plastic clips. The inner door is covered with transparent polyethylene.

The use of this tunnel as a grafting chamber is illustrated on page 7 of this guide. The 2.5 x 4 m tunnel chamber shown in Fig. 5 will accommodate 30 trays (40 x 60 cm), each holding 40 plants using 6-cm-diameter pots. Thus, the tunnel chamber capacity is 1,200 seedlings.

Growing seedlings for grafting

Sowing schedule

NOTE: The stem diameters of the rootstock and scion must be similar for successful grafting.

The first factor to consider when deciding sowing dates is the **germination period**. Most fresh market pepper lines germinate in two to three days, as do chili pepper lines used as rootstocks.

The second factor to consider is the **growth rate**. Seedlings of large-fruited pepper varieties grow faster than chili seedlings.

Taking all factors into account, chili seeds for rootstocks are sown 5 to 6 days before sowing sweet pepper seeds for scions. However, seeds of some varieties of chili and sweet pepper germinate at the same time. In this case, seeds of sweet pepper scions should be sown 5-6 days after the chili rootstock seeds. This is because the stem diameter of chili pepper develops more slowly than the stem diameter of sweet pepper, especially if the air temperature is below 25°C, which leads to a short node distance between cotyledon and true leaves.

The growth rate of both scion and rootstock seedlings varies from season to season and variety to variety. Growers must adjust their sowing times according to their own specific conditions.

Raising seedlings

Commercial potting mixes are recommended. Their quality, consistency, and freedom from plant pathogens allow for the development of uniform, healthy seedlings.

If commercial mixes are not available, prepare a lightweight, well-drained, pasteurized soil mix. One example is the AVRDC standard mix consisting of field soil, well-decomposed compost, rice husk, and river sand in a 2:3:1:1 ratio. If compost is not available, add 30 g of nitrogen (e.g., 65 g of urea (46% N) per 100 liters of soil mix for pepper seedlings, or 50 g of nitrogen for chili seedlings). If a field soil mix is used, cover seeds with fine compost to prevent crusting.

Rootstock seedlings: Grow in individual pots, 5 cm high x 6 cm in diameter. Sow two seeds per pot and thin to one seedling.

Scion seedlings: Raise in individual pots or in open flats. If using open flats, space seeds at least 4 cm apart to prevent seedlings from becoming tall and spindly.

Seedlings may be grafted after developing 2 to 3 true leaves. The stem diameter of scions and rootstocks should be 1.6 – 1.8 mm at this point. This stage of development typically requires 35 to 40 days.

Figure 6. Pepper plants grown under shelter

Grafting and managing seedlings

This section illustrates how to graft pepper scions onto chili rootstocks

1. Select scion and rootstock with the same diameter. Your sweet pepper scion and chili rootstock stems must be the same diameter, 1.6-1.8 mm. To achieve this, sow the chili approximately 5 to 6 days before sweet pepper.

2. Cut the chili stem at a 30° angle, 1.5 cm above the cotyledon, or first true leaf.

3. Cut sweet pepper stem at a 30° angle, slightly above the cotyledon. It is critical that the sweet pepper scion stem diameter matches the chili stem diameter. Select a place on the stem to cut the pepper scion to achieve the proper diameter.

4. Slide a 10-mm long latex tube (2-mm inner diameter, cut at a 30° angle) over the scion stem. Make sure that the cut angles of the tube and scion are parallel.

5. Push the scion about halfway into the tube (you must leave room in the tube for the chili rootstock stem).

6. Slide the scion (now fitted with the latex tube) over the chili seedling stem. Again, make sure that the cut angles of the tube and rootstock stem are parallel.

7. Gently push the scion and rootstock together. If you have kept all of the cuts parallel, then you can be certain that the scion and rootstock are in complete contact with one another. The tube will stay on the seedling until it naturally hardens, splits, and falls off in the field.

8. Grafted pepper seedling showing latex tube fitted to scion and rootstock.

9. Grafted pepper seedlings in trays ready for moving to grafting chamber.

10. Move the grafted seedlings immediately into the shaded chamber. Recommended temperatures are 25–32°C. Keep a shallow layer of water in the polyethylene floor liner and keep the doors closed to maintain high humidity (>85% RH). Place seedling trays on bricks to support the plants above the water line. The grafted seedlings may wilt initially but will become upright within three days.

11. Four to five days after grafting, begin the hardening process by peeling away the top (silver) layer of shade net material. Drain the water out of the floor pan. Open the chamber's plastic-covered door, but keep the screen door closed to prevent insect infestation. Maintain these conditions for two to three days.

12. Move the grafted plants out of the chamber and place them into a screenhouse. Nine days after grafting, apply a foliar application of 0.3–0.4% urea solution, or 1 g per liter of BASF foliar Nitrophoska (20N–19P_2O_5–19K_2O), or the equivalent of a similar soluble fertilizer. Hold the plants in the screenhouse for seven to eight days for further development and hardening. The entire process takes 50 to 55 days from sowing.

Field management

The field management of grafted plants is generally similar to the management of non-grafted plants. However, a few specific practices for off-season production should be noted:

Raised beds and shelters

Because grafted plants are recommended only for planting during the hot-wet season, raised beds are highly recommended to minimize flooding. Clear polyethylene-covered rain shelters can be used to shield plants from direct impact of heavy rainfall and provide some shade (Fig. 6). Rain shelters have been shown to increase summer yields when used in combination with grafted plants.

Transplanting depth

The graft union must be kept above the soil line (Fig. 7). The closer the graft union is to the soil line, the more likely adventitious roots from the scion will develop and grow into the soil. If this occurs, disease can bypass the resistant rootstock and may lead to infection and death of the entire plant.

Sucker and adventitious root removal

Remove suckers that develop on the chili rootstocks near the cotyledons. Remove adventitious roots that develop on the scion before they reach the soil. To prevent infection from soil-borne diseases, the scion tissue must not come into contact with the soil.

Figure 7. Transplant set with graft union above soil line

Staking and pruning

Grafted plants should be staked two to three weeks after transplanting. Indeterminate pepper plants should be pruned to allow two main stems to develop. It is very important that plants be tied securely to stakes. This will prevent vines from sliding down and the scion stem contacting the soil.

Pest management

Common diseases during the hot-wet season include bacterial wilt, Phytophthora blight, bacterial spot, and whitefly-transmitted geminivirus. Commonly observed insects are fruitworm, whitefly, aphids, mites, thrips and root knot nematode. Monitor your crops closely and take appropriate control measures.

Water management

Plants with chili rootstocks require higher soil moisture than non-grafted pepper plants. Adjust your irrigation accordingly. Sweet peppers on chili rootstocks are more likely to develop blossom end rot; this can be minimized by maintaining high soil moisture.

Fruit setting

High temperatures during the off-season can reduce fruit yields. The use of heat-tolerant varieties plus applications of a commercial fruit-set hormone are recommended.

For more information on growing peppers, consult AVRDC International Cooperators' Guide: *Suggested Cultural Practices for Chili and Sweet Peppers*.

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