Grafting Tomatoes to Improve Plant Health

Tomatoes are an important crop to backyard gardeners and commercial producers. Ideal tomato plants have excellent foliage, robust production, marketable fruit characteristics and disease resistance. Thousands of tomato varieties are available for planting. Narrowing down which varieties to plant can be challenging. Even more challenging is finding a tomato variety that meets the needs of the local market and is resistant to disease. One way to meet that need is to graft your favorite variety onto a disease-resistant rootstock. Grafted tomato plants are sold at local nurseries and online plant stores. Grafted plants range in price from less $1 per plant to $20 per plant, depending on the type and quantity purchased. Before purchasing grafted plants or grafting your own, it is very important to understand why you are grafting the plant, what disease you are trying to protect against and what varieties and rootstocks are compatible. The main reason to plant grafted tomato plants is to protect the plants from soil-borne diseases such as bacterial wilt, root knot nematode, and Fusarium wilt. Additional benefits of grafted plants may include increased yield and plant vigor.

Disease Prevention

Soil-borne diseases can result in severe losses to tomato growers in Louisiana. Soil fumigation is not effective, and a four- to five-year crop rotation cycle is needed to see noteworthy drops in pathogen populations in the soil. Furthermore, there are no commercially resistant tomato varieties available for many soil-borne diseases, and some resistant varieties lack durability and have unfavorable horticultural traits. Grafting with resistant rootstocks has shown to be an effective strategy for managing bacterial wilt, Fusarium wilt, southern blight and root knot nematodes in the southeastern U.S.

Common Soil-borne Diseases and Symptoms

Bacterial Wilt *(Ralstonia solanacearum):* Wilting is observed during the hottest parts of the day. The entire plant wilts (but does not turn yellow) and dies almost overnight, even in the presence of moist soils.

Fusarium Wilt *(Fusarium spp.):* Lower leaves on one side of the plant or one side of a branch turn yellow followed by leaf and stem wilting.

Southern Blight *(Sclerotium rolfsii):* Tomato plants begin to wilt during the hottest part of the day and show some recovery in the evening when temperatures drop. This pattern continues for a few days until the entire plant wilts and dies. White fungal strands can be seen at the base of the plant as well as on the soil surrounding the plant. Small mustard seed-like structures form over the fungal strands. These are overwintering structures of the fungus that allow the fungus to survive in the soil for many years.

Root Knot Nematodes *(Meloidogyne spp.):* Nematodes are microscopic parasitic worms that live in soil. Root knot nematodes steal nutrients from the plant by feeding directly on the roots. They form galls on the roots that prevent the movement of nutrients to the foliage. Plants turn yellow and are often stunted.

Photo by Charles Overstreet, LSU AgCenter

Grafting Guidelines

GRAFTING TERMINOLOGY

- **Rootstock:** The plant that is the source of resistance onto which another plant is grafted.
- **Scion:** The shoot portion of the grafted plant that has favorable fruiting characteristics.
- **Graft union:** The point on the plant where the scion and rootstock are joined.
- **Compatible:** A successful graft union.
- **Healing chamber:** A modified environment in which temperature and humidity are controlled to promote a successful graft union.
- **Sanitation:** Practices that promote a healthy, pathogen-free environment.

Table 1. Reported disease resistance available in Louisiana commercial tomato rootstock varieties. International codes for seed distribution for each disease are provided in brackets

Rootstock	Fusarium Wilt (Fol:1 or 2)		Verticillium Wilt (Vd)	Bacterial Wilt (Rs)	Nematodes (Mj, Mi or Ma)
	Race 1	Race 2			
Maxifort	HR	HR	HR	S	MR
Beaufort	HR	HR	HR	S	MR
Anchor-T	HR	HR	HR	MR	MR
Survivor	HR	HR	HR	MR	HR
Asahi	HR	S	HR	MR	HR
RST-04-105	HR	HR	HR	HR	HR
Big Power	HR	HR	HR	S	HR
Robusta	S	HR	HR	S	S
HR = highly resistant, MR = moderately resistant, S = susceptible					

Rootstock Selection

Rootstock selection (Figure 1) is the most important step in grafting tomatoes. Rootstocks are selected based on the predominate diseases affecting your tomato crop. Knowing the disease history in your field is important because no one rootstock variety has resistance to all the common soil-borne diseases. In Louisiana, the major soil-borne diseases are bacterial wilt, root knot nematode, Southern blight and Fusarium wilt. When selecting a rootstock, other solanaceaous crops such as eggplant and pepper can be considered. Eggplant rootstocks are preferred when flooding or waterlogged soils are common, as they can survive for several days under water. However, many types of pepper are incompatible with tomato, thus the graft survival rate will probably be low. Commercially available tomato rootstocks with reported disease resistance are listed in Table 1. Two eggplant varieties, MM152 and EG203, are resistant to some strains of *R. solanacearum* strains from Louisiana that cause bacterial wilt. Additionally, variety EG195 had shown to provide substantive protection from root knot nematode, tomato Fusarium wilt and damage caused by flooding.

Fig. 1. Rootstock and scion wood.

Grafting Timeline

The timeline for grafting will depend on the desired final planting date into the field. In southern Louisiana, spring planting dates range from March 15 to late May, and in northern Louisiana, from April 1 to late May. For both regions, fall planting occurs between late June and late July. Depending on the rootstock and scion varieties, the entire process (from sowing of the seed to transplanting in the field) generally takes seven to nine weeks. Typically, the grafting process and the subsequent healing time require that seeds be sown two weeks before non-grafted transplant production begins.

Seed sowing schedule

To make sure the scion and the rootstock are at similar growth stages (i.e. similar stem diameters), sowing dates are usually staggered. However, growth rates vary from season to season and from variety to variety, so growers will have to adjust their sowing dates based on their specific growing conditions and the type and variety of seed they are sowing. Most fresh market tomato varieties germinate in two to three days, while eggplants and peppers germinate in six to seven days. For grafting tomato onto tomato, seeding should be staggered two to five days, with seeding of the rootstock occurring first. For grafting tomato onto pepper or eggplant, seed sowing should be staggered six or seven days, with seeding of the rootstock occurring first. Always sow about 20 percent more seed than needed so you have a greater number of plants to select from for matching stem diameters.

Potting mix (germinating mixes)

Commercial potting mixes are recommended, as quality is consistent and mixes are often sterilized to kill plant pathogens that cause seedling damping-off. A lightweight mixture that promotes water drainage is recommended.

Pots or flats

Scion and rootstock seedlings should be planted in the same size pots or flats to promote even growth. Always purchase new pots or flats. Reusing pots or flats will increase the chances of disease caused by damping-off pathogens. If reusing pots or flats is the only option, first sterilize them with a 10 percent bleach solution.

Grafting timing

Grafting is done when the stem diameter of the seedlings is 1.5 to 2 millimeters (for Japanese tube grafting or Japanese top grafting) at the point where the cut will be made, and the seedlings have two to three true leaves. This stage of development usually occurs seven to 10 days after the seeds germinate or 14 to 16 days after sowing. Seedlings should be watered 12 to 24 hours before grafting. Avoid watering the seedlings immediately prior to grafting. Graft early in the morning or just after dark. At these times the seedlings are typically transpiring slowly. Ideally, the grafting process should take place indoors. If conducted outdoors, graft under in the shade and when temperatures are moderate (between 50 and 80 degrees Fahrenheit) and it is not windy. If the cut surface of the scion or rootstock dries out, the graft will fail.

Fig. 2. Japanese tube (or top) grafting. Photo by Mary Sexton, LSU AgCenter

The Grafting Process

There are a number of different methods for grafting tomatoes and other vegetable crops. However, Japanese tube (or top) grafting (Figure 2) is the most popular method for tomatoes. The success rate for this method under optimal graft conditions is greater than 90 percent.

- Cut the rootstock at a 45-degree angle below the cotyledons to prevent it from producing new shoot growth. Make the cut with a sterile sharp blade or knife. If the blade or knife is used multiple times, it should be disinfected with 70 percent isopropanol.
- Select a scion with a stem diameter that matches the diameter of the rootstock and cut it at a 45-degree angle above the cotyledons using a sharp, sterile knife or blade.
- Align the vascular tissue of the scion and rootstock and join them with a 1.5- to 2-millimeter rubber or silicon clip. Place the clip on the rootstock, then slide the scion into the clip. Immediately move the grafted seedlings to a healing chamber. The grafted seedlings can be spritzed with water every five to 10 minutes until they are moved to the healing chamber.

The Healing Process

Once the seedlings are grafted, they require several days to heal and form a strong union. Immediately after grafting takes place, the seedlings need to quickly reform vascular bundles and form callus tissue around the union to provide the scion with nutrients and water. The purpose of a healing chamber is to keep the scion from experiencing water stress while this process occurs. In addition, any activity that causes the union to separate will cause the graft to fail. Grafted seedlings should be carefully placed into the chamber to prevent mechanical injury and inspected daily to be sure the scion has not fallen away from the rootstock. Newly grafted transplants will look like they are wilting. This is normal. They will regain turgidity once the graft union heals. Depending on the environmental conditions, grafted seedlings should remain in the healing chamber for 10 to 14 days.

Healing chambers can be large or small. Smaller chambers can be assembled to fit a single tray of tomatoes. Larger chambers may be assembled to cover an entire bench in a greenhouse. All healing chambers, no matter what size, have similar and mandatory features. Step by step instructions for building a healing chamber are provided at the end of the document.

1. The chamber must retain high relative humidity around the healing seedlings. Chambers are encased with clear plastic so that the top, sides and bottom are covered. In large chambers, misting heads can be secured to the structure to maintain a relative humidity of 80 to 95 percent. In smaller, single tray-sized chambers, seedlings should be misted with water using a spray bottle at least two to three times daily. Both small and large chambers also can be equipped with cool-water vaporizers or humidifiers. (Figure 3)

Fig. 3. Automatic irrigation inside the healing chamber, especially on larger models, is essential to maintaining high humidity.

Fig. 4. Larger healing chambers are used in commercial production. Pipes are constructed in a frame above the bench and covered in plastic. Notice the dark shade cloth on the left. Remember the healing process requires a few days without light.

2. The seedlings should not be exposed to any light for the first three to five days. Three to five layers of 30 to 50 percent shade cloth is placed over the clear plastic layer, which is then encased with a solid dark colored tarp. After five days, the dark tarp can be removed along with one or two layers of the shade cloth. The remaining layers of shade cloth should be removed one day at a time. After all cloth is removed, expose seedlings to full sunlight inside the chamber (Figure 4).

3. The temperature in the chamber must be maintained between 70 and 80 F, and should not fluctuate. Temperature fluctuations result in dew formation on the leaves, which is detrimental to the healing process.

4. Open smaller chambers at least twice a day for two to three minutes to replenish carbon dioxide levels in the chamber. Re-mist plants before closing.

Field Management

The field management of grafted plants is generally similar to the management of non-grafted plants. However, plant placement and depth is very specific for grafted plants. It is critical that the graft union is above the soil or mulch line. The closer the union is to the soil, the more likely the scion will extend adventitious roots into the soil. If this occurs, disease can bypass the resistant rootstock, resulting in disease. Suckers on the rootstock and adventitious roots on the scion should be removed. Many gardeners and growers plant a portion of the stem under the soil to encourage the production of a large root ball that protects the stems from breaking in strong winds. This practice must not occur with grafted plants. Grafted plants should be staked to provide support against strong winds and to prevent the plant from falling and coming into direct contact with the soil.

Step by Step Instructions on Constructing a Small Healing Chamber (Figure 5)

Supplies for Chamber A

- 2 plain end PVC pipes (1 inch x 10 feet)
- 4 plain end PVC tees (1-inch diameter)
- 2 plain end PVC elbows (1-inch diameter)
- 1 black garbage bag (3 mil thickness, 33- to 42-gallon size)
- 1 clear plastic garbage bag (3 mil thickness, 33- to 42-gallon size)
- 1 spray bottle
- 1 hacksaw or PVC cutting tool

1. Cut the PVC pipe into four 24-inch lengths, three 12-inch lengths and four 6-inch lengths using a hacksaw. Alternatively, many stores that sell PVC pipe will cut it for you.

2. Construct a rectangle using two of the 24-inch lengths and two of the 12-inch lengths. Join each corner with a plain end tee. The tee should be placed so that the joint faces downward.

3. Connect a 6-inch (or longer) length of pipe to the downward joint of each tee. The height of the chamber will depend on the pot or flat size and the final height of the grafted transplant. Build the chamber so that a 3- to 12-inch space is left between the final transplant height and the top of the chamber.

4. Construct a three-sided triangle using two of the 24-inch lengths of PVC pipe and one of the 12-inch lengths of pipe. Join them to the downward 6-inch pipes (step 3) using two plain end tees (back) and two elbows (front).

5. Do not glue the joints together. This way the chamber can be disassembled for convenient storage.

6. Place the chamber in a clear plastic bag, then place the covered chamber in a black plastic bag.

Supplies for Chamber B

- 2 plain end PVC pipes (1 inch x 10 feet)
- 8 plain end PVC elbows (1-inch diameter)
- 4 plain end PVC tees (1-inch diameter)
- 1 black garbage bag (3 mil thickness, 33- to 42-gallon size)
- 1 clear plastic garbage bag (3 mil thickness, 33- to 42-gallon size)
- 1 spray bottle
- 1 hacksaw or PVC cutting tool

1. Cut the PVC into twelve 12-inch lengths and two 6-inch lengths. Use a PVC cutting tool or hacksaw for best results.

2. Connect two 12-inch lengths with a plain end tee. Repeat. Use these connected pieces plus an additional two 12-inch lengths to construct a rectangle. A plain end elbow will connect all four corners.

3. Replicate steps 1 and 2. Now you should have a top rectangle and a bottom rectangle.

4. Place a 6-inch length into both tees on one rectangle. Then connect the top rectangle to each 6-inch length. Doing so will elevate the top section from the bottom section.

5. The chamber is complete and ready to house grafted cuttings. This chamber will fit one standard-sized greenhouse tray.

6. Do not glue the PVC joints so the chamber can be taken apart for storage.

7. Place the chamber in a clear plastic bag, then

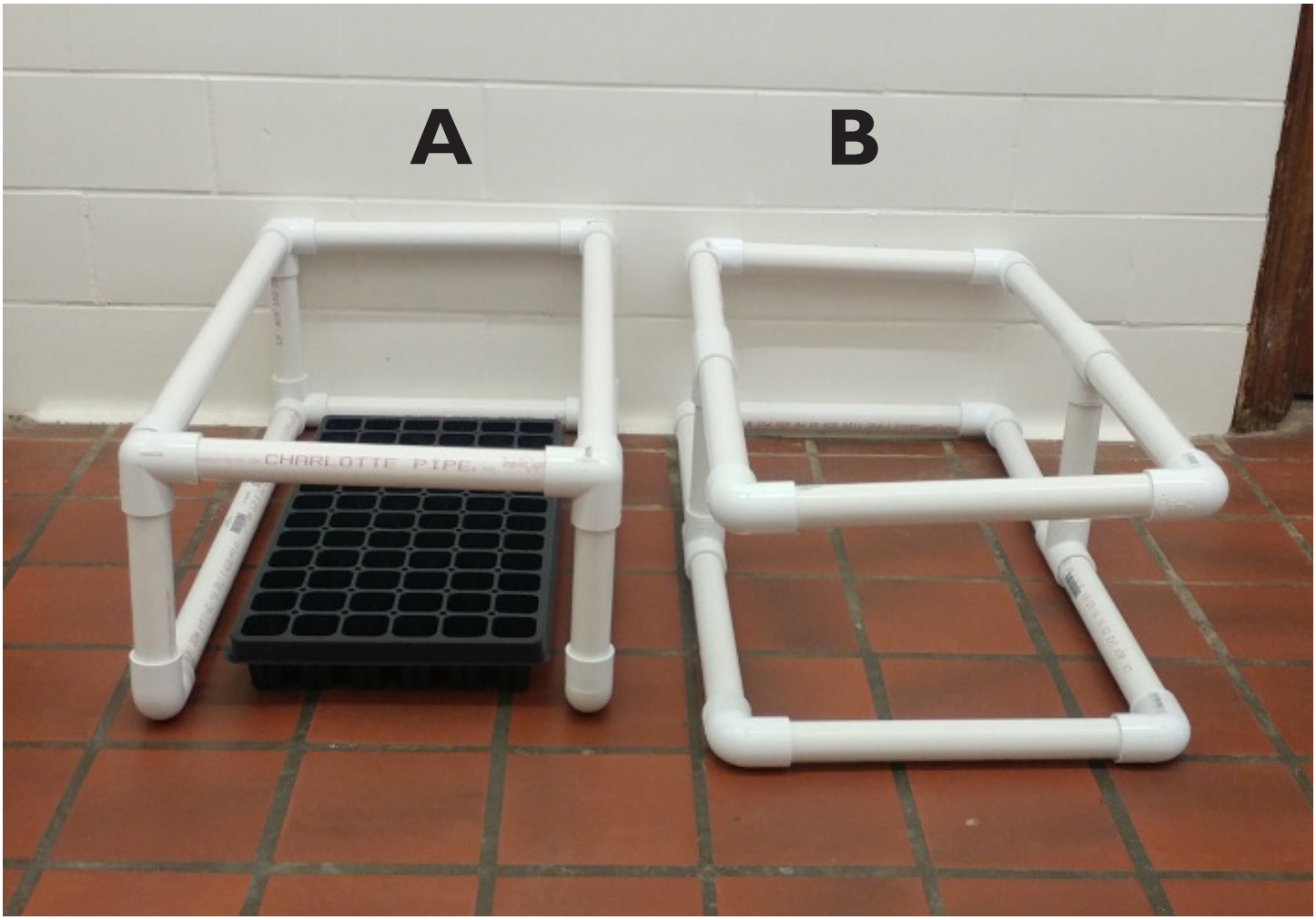

Fig. 5. Small healing chambers are ideal for home garden production. They can be created from PVC pipe to fit a single standard-sized greenhouse tray.

Additional Resources: Rivard C. and Louws F. 2006. Department of Plant Pathology. North Carolina Cooperative Extension Service. E07 45829 9/06—1M—BS

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