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Grafting desirable fruiting varieties to vigorous, disease-resistant tomato rootstocks has become a cost-effective method for growers to overcome many disease and production related issues. Grafting tomatoes can improve production, overall crop health; reduce or eliminate the need for pesticide use; lengthen harvest duration; and significantly increase net income. The entire process from sowing of rootstock and scion varieties to final transplanting of grafted plants into greenhouse soil or soilless media normally takes 6–8 weeks.

## Materials:

- Seeds of a rootstock variety.
- Seeds of a scion variety.
- Your preferred growing medium.
- Plug trays of your desired cell size.
- Shallow leakproof trays.
- A disinfectant, such as Virkon® or a 1:10 bleach solution.
- An old-fashioned, double-edged razor blade, the Miter-Cut Grafting Knife, or a spare blade of the Miter-Cut Grafting Knife.
- Silicone top-grafting clips.
- A spray bottle.
- Humidity domes or a humidifier.



The 4 sizes of silicone top-grafting clips Johnny's offers will accommodate stem diameters from as small as 1.5 mm to as large as 3.0 mm. The best strategy is to have clips of various sizes on hand in case the stems of your plants grow larger than you intend them to.

## CHOOSING THE RIGHT ROOTSTOCK

Rootstocks fall into 2 broad categories: generative and vegetative. Generative rootstocks are less vigorous than vegetative rootstocks, but they devote a higher proportion of their energy to the reproductive parts of the plant, which means they put more of their energy into flowers and fruit. Vegetative rootstocks put more of their energy into the leaves and stems.

Ideally, tomato plants are balanced, putting energy into growing the plant and the fruits at the same time. Picking the right rootstock means choosing the one that is most likely to balance the plant under the anticipated growing conditions. A well-balanced plant means that energy is going to sizing up fruits while also continuing to grow the vine.

A plant that is too generative is putting too much energy into growing and ripening fruits at the expense of plant growth. A plant that is unbalanced in a generative direction has a thin, weak head (top of the plant), and the developing flower trusses can be small and curled. You may notice that the vegetative parts of the plant don't seem to be growing very fast. Internodes tend to be shorter so the top flower cluster is closer to the head.

Overly generative plants tend to peter out, as too much energy is going to fruits and not enough is going to build the vine for future growth.

A plant that is too vigorous will tend to have a relatively thick stem at the head, which may be oval instead of round. The developing flower cluster stem may be thin and held nearly vertical, instead of arching out from the vine. Overly vegetative plants tend to grow very fast, with longer distances between nodes, so the head is far above the highest truss. Tomato crops tend to start out very vegetative at the beginning of the season, before there is any fruit load to balance the plant, but it is desirable to balance the crop as soon as possible. A plant that stays overly vegetative may get large with relatively few fruits in proportion to the size of the plant, and the fruits may be slow to ripen.

Using any of the rootstocks we carry will add vigor to any scion variety to which it is grafted. Choosing the combination that will promote balanced growth is a matter of taking into account the type of fruit to be produced and the conditions under which the plants are grown.

## ROOTSTOCKS

Vigorous, vegetative rootstocks are most appropriate for large-fruited (over 100 gm./fruit) varieties that will be in cultivation for over 6 months with 16 or more clusters picked. A vegetative rootstock will also help with crops that will be grown in hot areas. The hotter the 24-hour average temperature, the more vigor is needed to keep the plant growing well. The extremely high level of vigor imparted by rootstocks like Maxifort are useful to keep plants vigorous in long-season crops with above average temperatures.

Generative rootstocks are more appropriate for crops that will be growing for 6 months or less, with 15 or fewer clusters harvested, as with most crops in the field and unheated greenhouses. Generative rootstocks also work well with small-fruited (less than 100 gm./fruit) varieties in long-term cultivation.

Fruit Size	Crop Cycle Length	Rootstock Characteristics	Rootstock Variety
<b>Large fruited</b> (>100 gm./4 oz.)	Long cropping cycle, hot conditions expected.	Vigorous, vegetative rootstock.	#3195 DRO141TX #2700 Maxifort
<b>Small fruited</b> (<100 gm./4 oz.)	Any cropping cycle.	Generative rootstock.	#3088G Estamino
<b>Large fruited</b> (>100 gm./4 oz.)	Short cropping cycle.	Generative rootstock.	#3088G Estamino

## PLANTING

### Germination testing:

Do a germination test on each variety you plan to graft, to observe the speed of germination and growth of the rootstock compared to the scion in your particular growing environment. Sometimes the rate of growth varies between rootstock and scion depending on growing conditions. The stems of rootstock and scion need to be as close as possible to the same diameter for successful grafting.

Sow seed 6–8 weeks before your desired transplant date. Grafted tomato plants take 1–2 weeks longer to reach the transplant stage because they stop growing during the healing process. Overseed by at least 25% more than the number of plants you plan to transplant. Since most tomato rootstocks are interspecific crosses (the product of traditional plant breeding crossing a *Solanum lycopersicum* domesticated tomato with a wild variety), this wide cross increases hybrid vigor but decreases germination percentage and uniformity. Your goal is to match the stem size of rootstock to scion variety so you want plenty of plants to choose from when it comes time to graft.

If you test the varieties you will be growing for germination and growth rate, slower germinating or slow-growing varieties can be planted earlier, and faster growing varieties can be planted a day or two later so the diameter of the stalks match up at grafting time. If this is not possible, most rootstock and scion varieties can be planted on the same day.

Place the seeded flats into leakproof trays. These will provide extra support for when you are moving the flats from one location to another. Additionally, the trays will allow for bottom watering of the rootstock varieties both prior to and following grafting.

The best germination is ensured by creating an environment with a steady 80°F/27°C temperature. Use a germination chamber or heat mats with a soil probe to achieve this. Water the flats, cover them to conserve moisture, and germination should begin to occur within 3–4 days. To avoid leggy seedlings, move the trays to an environment with the same temperature and good light as soon as germination begins.

Once the seeds have germinated, after about 10 days, you can reduce the temperature to 64–66°F/18–19°C to encourage a stocky growth habit. Make sure plants have plenty of direct light and keep close track of their progress because they are growing quickly and will exceed the optimal size to graft in a very short time.

## GRAFTING

Plants will be ready to graft approximately 17–21 days after sowing. The best way to tell if your plants are the right size is to put a grafting clip on the stem of a seedling. When it fits snugly, it is time.

You will need to prepare a clean area, such as a work bench, with no direct sunlight to do the cutting. An indoor area works well because the climate is more controllable, but an area in a greenhouse that is shaded and not too hot, 70–74°F/21–23°C, will work. Do not graft near a fan or draft.

Hygiene is very important during grafting because if you pick up a pathogen on your hands or equipment, you may transfer it to all of your plants. Do not smoke during grafting or near recently grafted plants due to risk of Tobacco Mosaic Virus. Wash your work area down with a disinfectant before grafting. Always start with new blades and grafting clips.

You will need a healing chamber to protect the plants until the graft has taken. A healing chamber keeps newly grafted plants in a high-humidity, low-light environment so they do not respire too much and dry out before the vascular structure is reconnected. This can be as simple as plastic domes placed over individual flats to keep the humidity high, a plastic tent or tunnel suspended over a group of plants, or any structure to keep the humidity at 80–90% during the healing process. A healing chamber near the grafting area is ideal, so the plants are moved around as little as possible. Any setup that maintains the plants in a humid environment, out of direct sunlight, at 80–82°F/26–27°C will work.

Give your plants a normal watering the day before, but not the day of grafting. Roots that are really wet will have too much moisture going up the stem, which can push the scion off and reduce the percentage of successful grafts. On the other hand, if you realize that the rootstocks are really dry as you are grafting them, stop grafting, water them, and resume grafting the next day because dry rootstocks will not survive.

### Practicing grafting:

If you have never grafted tomatoes before, or need to get back in practice, the best way to succeed is to plant some old tomato seeds and practice the following techniques with expendable plants. That way if the grafts don't take, you can analyze your technique and make improvements without setback. If you have never grafted before, even grafting the top back on to the stalk it came from is good practice and will show you what the perfect graft would look like.



When you are ready to graft, take an old-fashioned double-edged razor blade and snap it in half lengthwise while it is still in its paper cover, being very careful not to cut yourself. It is important to use this type of blade because they are thinner and sharper than other types of razors.

Take a plant of your rootstock variety with stem diameter that matches your clips and sever the top just below the cotyledons at a 45° or greater angle. An angle greater than 45° — up to 60–70° — is better because it creates more cut surface area to reconnect. Discard the top. Find a scion whose stem diameter matches the rootstock you cut, and sever the top below the cotyledons in the same manner, at a matching angle. Discard the root ball from the scion.

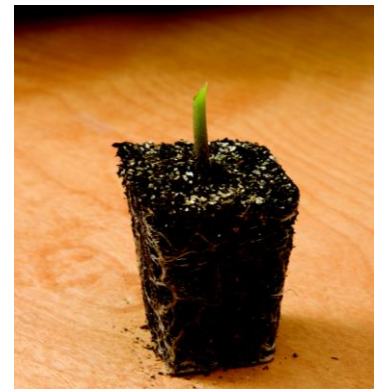
**Miter-Cut Grafting Knife:**  
 This tool uses a preset blade to reduce human error and makes a cut at the same angle every time. The blade opposes a stem holder, which has two pre-cut grooves for the stem. When the stem is placed in either groove and the cut is made it is automatically at the correct angle every time. A blank stem guide is also provided to make cuts at other angles. It can be used in place of a razor blade.



A plant ready to graft.



Cutting.



With the top severed.

At this point, some people like to cut all the leaves off the scion except the leaf at the growing point. If you decide to defoliate the plants, you will also need additional razor blades, or a spare blade of the grafting knife. This is to reduce respiration and the amount of leaf area for the healing plant to support. Some people prefer not to defoliate, and it's certainly faster without this extra step. Experiment and see which method you prefer, but either method can work well. Defoliated plants can be easier to handle if the scion seedling is very leafy.



Defoliating.



Defoliated.



Place a grafting clip half way over one of the cut stems; then join to the other stem so the cuts match up. One advantage of the silicone clip is that you can see through it to make sure the cut surfaces match up. Air or dirt between the cut surfaces will prevent the graft from healing.

Once the grafting clip is in place, return the plant to the plug flat it grew in or place it in an unused flat.



Making the connection.



Finished graft

If the scion has grown larger than the rootstock, you can move up above the cotyledon on the scion to acquire a smaller, matching cut surface. Likewise, if the rootstock is larger than the scion, you can move up above the cotyledons on the rootstock for a smaller stem diameter. If you have to move up above the cotyledons on the rootstock, the rootstock may resprout from latent buds, which will have to be pruned off later.

Once you feel proficient at this, the fastest way to graft many plants is to have the plants graded by size, so you have whole flats of rootstocks and scions that match each other. Cut an entire flat of rootstocks and put grafting clips on all the rootstock stubs. Then cut an entire flat of scions, putting them in a small container of sterile water to keep them

moist while you are cutting, and then attach all the tops to the prepared rootstocks at once. Change blades each time you begin a new session, or when they become dull.

If it is hotter or dryer than ideal in your grafting environment, you may want to mist the plants with a spray bottle. Be gentle — a powerful spray can knock the tops of the grafted plants off. As soon as you are done grafting a tray, you can either mist the plants and the inside of the healing chamber with a spray bottle to raise the humidity, or use a cool mist humidifier to put humidity right into your chamber. A humidifier is preferred for healing chambers larger than a single dome because they produce more mist than a spray bottle.

## HEALING

Once you have put the plants in the healing chamber, keep the tunnel closed for three days and maintain it at 80–95% humidity, at 80–82°F/26–27°C, and in the dark for 24 hours. After 24 hours, use soft light equivalent to 540–740 foot candles, which is equivalent to using a grow light with four T12 fluorescent grow tubes with two of the tubes removed (half power). Indirect sunlight (light shining in a window of the same room, as long as it does not fall directly on the plants) or artificial lighting is fine. Direct sunlight or strong indirect sunlight may cause the healing chamber to heat up excessively, or cause the grafted plants to lean towards the light, pulling the graft apart. Check the plants from the outside of the tunnel. If they are wilting, raise the humidity level and reclose the chamber.

On the fourth day, open the tunnel and check to see if the plants are still moist. The plants will not use much water during this time and should not need watering yet. Close the tunnel once you are done.

On the fifth day, make a small opening in the tunnel so that some of the humidity can start to escape, and check the plants frequently. If they wilt, close the tunnel back up, re-elevate the humidity, and try ventilating again the next day. If the plants did not wilt when ventilated on day five, make the opening a little larger on day six. Gradually increase ventilation until you can take the plastic off completely without the plants wilting.

The key is to gradually bring the grafted plants to normal greenhouse temperature and humidity, but return to the previous conditions if they start to wilt. High humidity conditions cannot be maintained indefinitely, or the scion may grow adventitious roots of its own and not fuse with the rootstock.

If flats need to be watered during the healing process, bottom water. Flood the bench they are on for a few minutes, or place flats in an inch of water so they can absorb it from the bottom. If you placed the seeding flats into shallow leakproof trays, you can bottom water by filling the trays. Top watering before the plants are healed may knock the tops off. Eventually, the seedlings will be strong enough to top water again. After the plants have re-acclimated to greenhouse conditions for a few days they are ready for normal handling.

Silicone clips will expand with the growth of the plant and eventually fall off by themselves.

At transplanting, make sure the graft union is above the soil line, or the scion variety may root into the ground and negate the benefits of the rootstock. Prune off any suckers that develop below the graft union, as these are from the rootstock. Otherwise, manage the plant as you would normally.



A photo from the Johnny's trial greenhouse. Two tomato plants grafted to Maxifort are on the left, 2 ungrafted plants of the same variety are on the right. It is easy to see that the vigor of the grafted plants is much greater.

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