

Grafting techniques for greenhouse tomatoes
Richard McAvoy
Professor & Extension Specialist – Greenhouse Crops.

Grafting is widely used in horticulture for a variety of reasons. In fruit trees like apple, dwarfing rootstock are used to control the size and vigor of the tree. With field grown vegetables, grafting is used to increase resistance to soil-borne diseases. Increasingly greenhouse tomato growers are using grafting to both decrease susceptibility to root diseases and to increase fruit production through increased plant vigor.

Grafting involves splicing the fruit-producing shoot (called the 'scion') of a desirable cultivar onto the disease resistant rootstock from of another cultivar. For instance, if you generally grow the cultivar 'Trust' for fruit production, you would graft the top part of a 'Trust' seedling onto the root-portion of a more vigorous or more disease resistant cultivar. The two cultivars most widely used for rootstock in the greenhouse are 'Maxifort' and 'Beaufort'. Both cultivars offer enhanced disease resistance to *Pyrenochaeta lycopersici* (Corky Root), most common species of nematodes, *Verticillium* sp, *Fusarium oxysporum* races 1 and 2, and *Fusarium oxysporum* fsp and *Radicis-lycopersici* (crown rot). In addition, 'Maxifort' confers a very vigorous growth habit while 'Beaufort' confers moderate plant vigor.

There are three primary techniques used for grafting, tongue approach grafting, cleft grafting and tube grafting. Cleft grafting and tube grafting are very similar in that the shoot of the fruit producing variety (e.g. 'Trust') is completely cut off from it's own roots and attached to the severed stem of the rootstock plant (for instance ' Maxifort'). [The name 'Tube Grafting' originated because when the technique was first developed a tube was used to attach the shoot to the root. Clips are now used to make this graft.] Tube grafting is quicker and less complicated to do than cleft grafting because it only requires a single straight cut on both the root and shoot portions of the graft. Also, because fewer intricate cuts are involved, this technique can be used on very small seedlings. With both cleft and tube grafting, the newly grafted plants must be protected from drying out until the graft union has healed. This usually involves covering the plants with a plastic cover to reduce light and retain moisture, and then misting the grafted plants periodically during the day. Tomato grafts heal quickly and the plants can begin to be acclimated back into the greenhouse after 4-5 days, and usually plants are fully set and in the greenhouse 7-8 days after the initial graft.

With both cleft grafting and tube grafting it is vitally important that the diameter of the cut ends (of the shoot and the rootstock) match up perfectly. If the diameter does not match, the graft takes longer to heal and the rootstock will slowly starve to death (more about this latter). Because the cultivars used for rootstock tend to have a 'weedy' growth habit (long thin stems), we generally sow seeds for the rootstock earlier than seed for the scion.

For Cleft Grafting sow seed for the rootstock 5-7 days prior to seed for the shoot. When the plants reach the four- to five-leaf stage, cut the stem for both the shoot and the rootstock at right angles, each with 2-3 leaves remaining on the stem (see Figure 1 below). Next the stem of the shoot (scion) is cut in a wedge, and the tapered end fitted into a cleft cut in the end of the rootstock. The graft is then held firm with a plastic clip (Figure 2) .

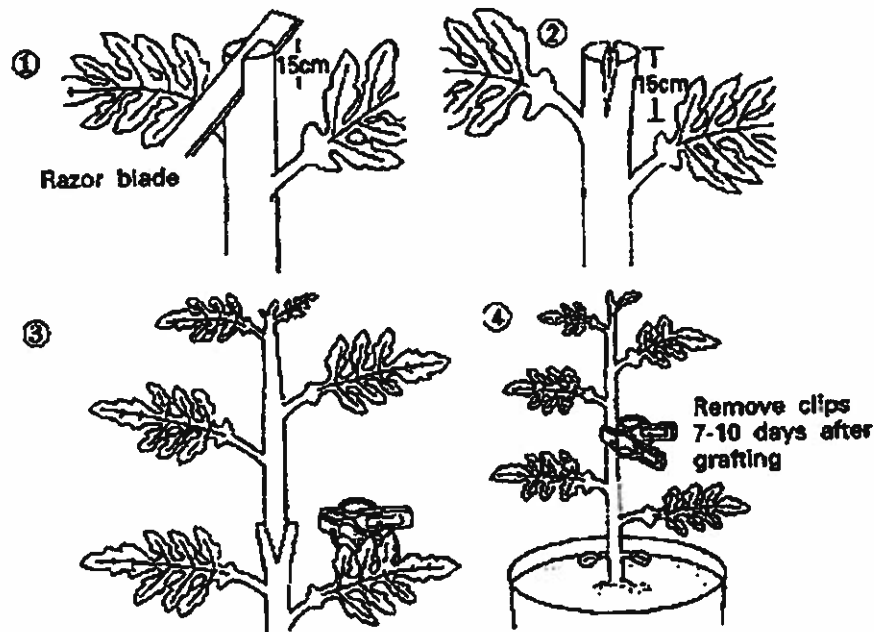


Figure 1. Schematic of the technique used for cleft grafting (schematic diagrams from GRAFTING OF VEGETABLES TO IMPROVE GREENHOUSE PRODUCTION Masayuki Oda College of Agriculture, Osaka Prefecture University, Sakai Osaka 5998531, Japan 1999-12-01 (<http://www.agnet.org/library/article/eb480.html>)).

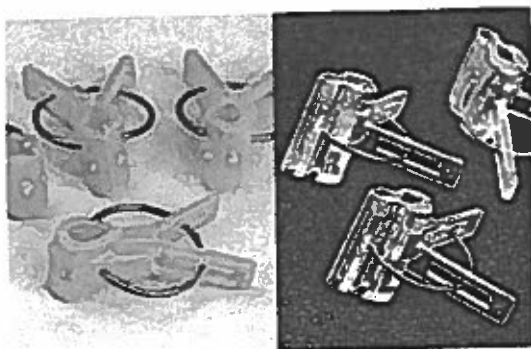


Figure 2. Grafting clips used for greenhouse tomatoes and other vegetable. The larger, more robust clips (left) are best for the tongue approach and cleft grafting techniques (stems 1/8-1/4" diameter), while the smaller grafting clips (right) are best for the tube grafting and similar techniques that use younger plants (stems 1/16 to 1/8" diameter).

For Tube Grafting sow seed for the rootstock 1-2 days prior to seed for the shoot. Because smaller plants are used in tube grafting, you should be able to graft plants two or three times faster than with the more conventional cleft method. Also, the smaller plants take up less room during the healing and acclimation process. The optimum growth stage for grafting varies according to the kind of plug tray used and your ability to handle the small plants. [Because of limits to my manual dexterity, I find it hard to handle plants smaller than about 4" in height and 1/8" stem diameter. However, you can graft smaller plants as long as you can physically work with them]. Also note that plants in small cells must be grafted at an earlier growth stage, and require tubes with a smaller inside diameter.

The steps in Figure 3 are used for tube grafting. First, the rootstock is cut at a slant (you can also use a blunt cut but the slant allows more surface contact on the graft). The shoot is cut in the same way. Place the two cut ends in direct contact and use a small clip to hold the cut surfaces together. If you plan to have the rootstock support a double leader in the production house (Figure 6), the graft **MUST** be made below the cotyledons or seed leaves on both the rootstock and the shoot or scion. With a double leader, the top of the plant is pinched soon after the graft heals and two equal-sized leaders are produced from the buds at the base of the seed leaves. With the cultivar 'Maxifort' as the rootstock a double leader is generally recommended because of the enhanced vigor produced by this cultivar. 'Beaufort' is a good rootstock for a single leader plant.

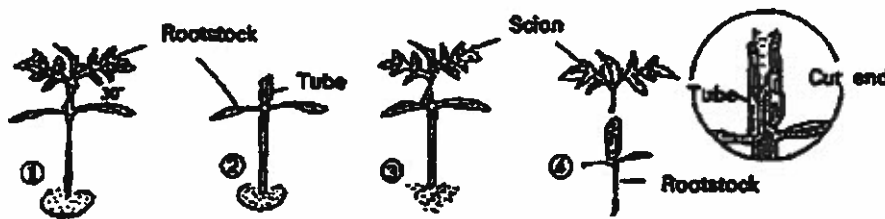


Figure 3. Schematic of the steps used for tube grafting. Note: if you plan to have the rootstock support a double leader in the production house, the graft **MUST** be made below the cotyledons or seed leaves on both the rootstock and the scion.

Tongue Approach Grafting is a technique that allows the scion donor-plant to remain on its own rootstock until the graft heals (Figure 4). This method is commonly used on members of the *Cucurbitaceae* family (melons, cucumbers) because it produces a higher survival (success) rate. Some growers also prefer the technique for tomato, especially when greenhouse conditions for healing and acclimation are less than ideal for successful tube grafting. This is because the root-portion of the scion plant remains intact until the graft union has healed. With this method, larger plants are used (seedlings 14 to 21 days old for tomato, 10 - 13 days for cucumber, seeds 7 - 10 days for pumpkin) to ensure sufficient stem diameter to perform the graft. First, the top of the rootstock is removed so that the shoot cannot grow. Next, the stems of both the scion and rootstock are cut in such a way that they tongue into each other (Figure 4), and the graft is secured with the larger clips (Figure 2). The roots of the scion are left intact for 3 - 4 days while the graft union heals and then the stem of the scion-donor is crushed between the fingers or partially cut

below the graft. This step is used when the scion is cut off its own roots. Finally, the stem is completely cut off with a razor blade three or four days after being crushed (see photo of grafted cucumber plant in Figure 5).

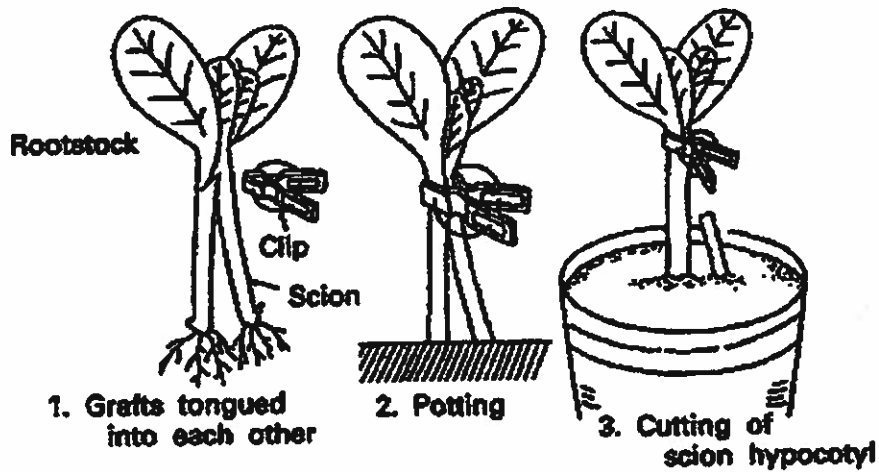


Figure 4. Tongue approach grafting (demonstrated on young cucumber seedlings). With this technique the graft union is allowed to heal while the shoot donor (the scion) plant is still attached to its own roots. After several days the shoot is severed from the root. This method tends to produce a high success rate especially when healing & acclimation conditions are less than ideal.



Figure 5. Cucumber plant successfully grafted using the tongue approach method.



Figure 6. Grafted greenhouse tomato plant trained to produce a double leader. If you plan to use a double leader the graft union must be made below the seed leaves (cotyledons) of both the scion and the rootstock.

General Grafting Tips: Expose plants to full sun and some water stress in the days before grafting to keep the plants short and to increase tolerance to water stress. Immediately before starting to graft, make sure plants have been watered and are turgid (not wilted). If you do your grafting in the greenhouse, do it early or late in the day to avoid undue water stress and drying of the cut plants. Ideally, grafting should be done in a shady place, such as a work area out of the greenhouse that is sheltered from the wind and bright sun.

When grafting, cut both the shoots (scion) donor plants and the rootstock plants on the same angle with a razor. Do not cut more plants than you can graft together in a few minutes since it is very important that you do not let the cut surfaces dry out or the scion wilt. Next match the scion with a rootstock of equal stem diameter and place the cut surfaces together in tight contact before clipping in place. The objective is to maximize the chances for the vascular bundles of the scion come into contact with the respective vascular tissues of the rootstock. [Since the stem has a few different types of specialized tissues arranged in concentric circles (when the stem is viewed in cross section), it is important that the cut surfaces match in diameter (Figure 7) and have sufficient surface area at the splice.]

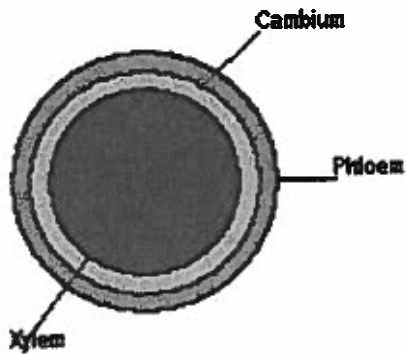


Figure 7. A schematic representation of the cut stem viewed in cross section. The tissue in the center of the stem (the xylem colored blue) conducts water and nutrients from the roots to the top of the plant. The tissue of the outer ring (the phloem colored green) nourishes the roots with sugars and hormones from the leaves. The middle layer (the cambium colored brown) allows the stem to increase in diameter and makes new xylem and phloem tissue. All three of these layers must match up when grafting the scion to the rootstock in order to make a successful graft.

Healing & Acclimatization: Proper healing and acclimatization are very important for grafted plants to survive. After the grafts are made, the plants must be protected from wilting until the cut ends knit together (heal). Keep the grafted plants at about 86°F and with more than 95% relative humidity for 3-5 days while the cut ends heal together. This can be accomplished by placing the grafted plants under a heavily shaded area with fog or mist. Alternatively for small scale operations, the newly grafted plants can be placed under an opaque plastic tent or a humidity dome covered with an opaque plastic or even newspaper to reduce light levels (Figure 8). Plants under the tent or dome should be misted once or twice a day during this period. A small hand-held pressurized sprayer works well for small scale misting.



Figure 7. (Top) Grafted plants need to be protected from bright sun and wilting until the graft union has healed. On a small scale, flats of grafted plants can be placed under a humidity dome to retain moisture and covered with an opaque plastic sheeting to reduce light levels. Mist plants once or twice a day to keep the humidity high and to prevent the scion from drying out. Tomatoes grafts typically heal in about 5 days. (Bottom) A small (1/2 gallon) pressurized hand sprayer is convenient for misting grafted plants during the healing and acclimatization process.

After healing, the plants must be re-acclimated to the full-sun conditions of the greenhouse environment. Do this gradually over a period of 3 to 4 days. Start increasing the light exposure by removing the opaque plastic sheeting (if using humidity domes). Start by cracking open the tent or domes a few hours in the early or late part of the day and increase the interval each day. Continue to mist as needed to avoid wilting. After a few days, move the plants completely into the house but continue to mist as needed to avoid wilt.

Finally, when you plant the grafted plants into the production house it is important to keep the graft union above the soil line. Tomatoes tend to root easily and if the scion roots into the soil, the plant will be susceptible to soil-borne diseases and you will lose some of the benefits of the graft.

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