How to Splice Graft Cucumber Plants

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Grafting cucumber with squash rootstock (*Cucurbita maxima*, *C. moschata* and *C. maxima X C. moschata*) has proven to be an effective approach to improving cucumber's cold tolerance (Guan et al., 2018). Vegetable growers are likely to benefit from this technique for extended early season cucumber production under protected cultural systems. Grafted cucumber plants are not readily available in the market now. However, it is possible for growers who are interested in this technique to graft cucumbers on their own.

Three methods are commonly used to graft cucumbers: splice, hole insertion and tongue approach grafting techniques (Guan and Zhao, 2014). Compared to the hole insertion and tongue approach grafting methods, splice grafting is simpler, and therefore it is more likely to be adopted by beginning grafters. This publication introduces a systematic guide on how to splice graft cucumber plants.

Sizes of rootstock and scion plants at grafting

Although splice grafting works best when the rootstock and scion have similar hypocotyl diameters, the genetic difference between cucumber and squash plants makes a complete match of the cutting surfaces almost impossible. The ideal stage of grafting rootstock and scion plants is when the sizes of their stem diameters have the smallest difference (Figure 2, page 3).

Cucumber scion: During seed germination, two cotyledons gradually unfold and expand. Meanwhile, the hypocotyl accumulates carbohydrate and becomes thicker. About 5-7 days after the plant emerges, the first true leaf starts to grow and then expand. The ideal size of the scion plant at grafting is when the true leaf starts to emerge. The reason to graft the scion plant before the first true leaf is fully expanded is to minimize the leaf surface area and reduce water loss after grafting. At this point, hypocotyl has accumulated enough carbohydrate to support graft healing.

Squash rootstock: The ideal time to graft the rootstock is after the cotyledons are fully expanded and the first true leaf starts to emerge. It is important to graft the rootstock at the young stage because cucurbits develop hollow hypocotyls (Figure 3, page 3). The central cavity expands as the hypocotyl becomes thicker. If the central cavity on the squash rootstock is larger than the stem diameter of the scion, graft failure may be caused by the lack of tissue attachment between the rootstock and the scion plants.

Most squash seeds take longer to germinate than cucumber seeds, so rootstocks should be planted 2-3 days earlier than the scion seeds.

Three steps of splice grafting

- **First step:** cut off one of the cotyledons of the rootstock, as well as emerging true leaf. Cut it at an angle so there is at least 1/4 inch of cut surface.

- **Second step:** cut the hypocotyl of the scion plant with the similar angle as the cut of the rootstock plant, and create at least 1/4 inch of cut surface.

- **Third step:** put the two cut surfaces together and hold them in place with a side grafting clip.

Figure 1. *Three steps of splice grafting technique. A cucumber scion is grafted onto a squash rootstock.*

Figure 2. *Scion (left) and rootstock (right) plants at grafting.*

Remove apical meristem tissue on rootstock plants

It is important to remove apical meristem tissue of the rootstock plant. This meristem tissue is made of undifferentiated cells located at the base of the cotyledon. If it is not completely removed, the rootstock shoot will grow and compete for resources with the scion (Figure 4).

Figure 5 (page 5) illustrates three cuts made on rootstock plants. The rootstock on the left shows meristem tissue that has not been fully removed. Shoots of the rootstock plants will grow out here. The rootstock in the middle does not clearly show any meristem tissue, but there is a chance for regrowth of the rootstock plant. Meristem tissue is completely removed on the rootstock on the right, and there will be no rootstock regrowth. Note that the cut on the rootstock on the right begins at the base of the rootstock cotyledon. This will assure the complete removal of meristem tissue. Cutting rootstock in a way to completely remove meristem tissue requires practice. If this is difficult to achieve, rootstock regrowth can be pinched with fingers after graft healing and before transplanting.

Attach rootstock and scion cut surfaces

If grafting is conducted when the central hollow in the rootstock hypocotyl is larger than the diameter of the scion stem, attach the cut surface of the scion plant to one side of the cut surface of the rootstock plant in order to ensure plant tissues are in contact with each other (Figure 6, page 4). The cut surfaces of the rootstock and scion plants should be attached shortly after the cuts are made. Do not cut multiple rootstock and scion plants and then attach them together later.

Side grafting clips are used for grafting cucumbers. Different designs of side grafting clips are available for grafting a variety of plant types and sizes. The clip's capability to hold the graft union tightly, but not too

Figure 3. *A squash rootstock develops a hollow hypocotyl. The central cavity will expand as the hypocotyl become thicker.*

Figure 4. *A grafted cucumber plant with regrowth from the rootstock at grafting union.*

Figure 5. *Different levels of removing meristem tissue on the rootstock plant. Left: meristem tissue is not fully removed. Middle: no visible meristem tissue, but there is still chance for rootstock regrowth. Right: meristem tissue is completely removed.*

Figure 6. *Attach the cut surface of the scion plant to one side of the cut surface of the rootstock plant.*

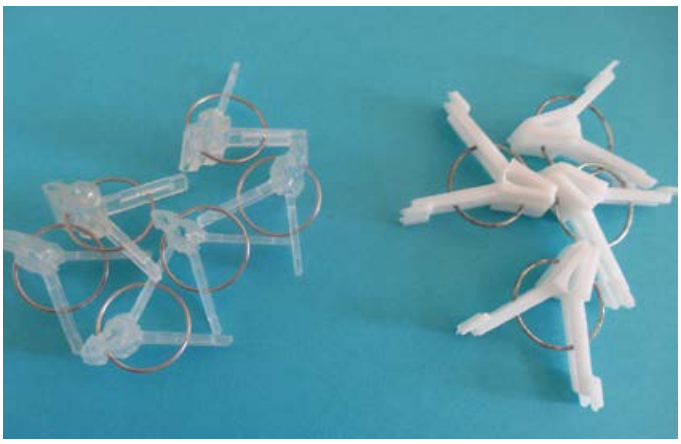

Figure 7. *The side grafting clips on the left have two holes that are about 2 mm and 4 mm in diameter. The smaller hole is ideal for grafting young cucumber plants. The side grafting clips on the right are suitable for grafting plants with a wider range of sizes.*

tight to limit the growth of the stem, is the key to choosing the right grafting clips. Because cucumbers are grafted at a young stage, choose grafting clips that are designed to clip small-size stems, such as the ones shown in Figure 7.

Post-grafting healing

As important as the grafting procedure itself, post-grafting healing is critical in achieving grafting success. Newly grafted cucumber plants should be healed in an environment with 100% relative humidity and temperatures ranging from 77 to 89°F. The most critical period for graft healing is the first three days after grafting. Gradually reduce temperatures and relative humidity in the following days until they reach typical greenhouse conditions. The entire process takes about 6-7 days.

Post-grafting healing could take place in a greenhouse with a self-built healing chamber (Figure 8, page 5) as long as the greenhouse temperatures can be maintained above 75°F at night. In the winter, grafting is best conducted during sunny days to ensure that temperatures reach the desirable range during the daytime. Temperature inside the healing chamber should be closely monitored to avoid rising above 95°F. If temperature is above 90°F, shade cloth should be used. Humidifiers can be placed inside the healing chamber to maintain 100% relative humidity. Humidifiers that generate a strong visible mist are the most desirable in this case, as they increase relative humidity in a short period of time (Figure 9, page 5).

An alternative way to create 100% relative humidity is to cover the newly grafted plants with a thin layer of plastic and seal the edges. Plant transpiration

Figure 8. *A graft healing chamber built on a greenhouse bench. The healing chamber is made with PVC pipes and covered with plastic film and two layers of 30% shade cloth. As plant heal, the plastic is gradually opened to reduce humidity. When plastic is opened, shade cloth is no longer needed to prevent temperature from rising above the optimal level.*

Figure 9. *A humidifier that generates strong visible mist is desirable to increase relative humidity in the healing chamber.*

generates moisture that create the high humidity condition (Figure 10). If this technique is used to maintain high relative humidity in a greenhouse, at least 60% shade cloth should be used since temperatures under the plastic can easily rise above the optimal level after the sun rises. If you are familiar with tomato grafting, you may notice that post-graft healing cucumbers require higher temperature and higher relative humidity than healing tomato plants.

Humidity should be gradually reduced on the third day after grafting. If humidity is kept high for too long, it encourages development of adventitious roots (Figure 11, page 6). Relative humidity can be reduced by adjusting output of humidifiers. If a plastic covering was used to maintain high relative humidity, humidity can be reduced by removing the plastic, waiting until the inner side of the plastic and leaves dry, and then covering the plants again. The process can be conducted once on Day 3 after grafting, and more frequently on the following days. Making openings on top of the plastic can also be used to reduce humidity.

Post-grafting healing can also be conducted in a growth chamber (Figure 12, page 6) or a seedling room. The advantage of using an indoor growing environment is the relative ease of maintaining temperatures in the desirable range in the winter compared to a greenhouse. Since high relative humidity can cause damage to electrical wires inside

Figure 10. *A thin layer of plastic is covering the grafted plants to create a 100% relative humidity condition.*

Figure 11. *Adventitious roots developed on grafted plants.*

of the chamber, covering the newly grafted plants with plastic is better than using humidifiers in these cases.

Completely dark conditions delay the graft healing process and should be avoided. Using fluorescent lights with 200-400 µmol $m^{-2}s^{-1}$ light intensity is sufficient during the graft healing process.

References

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Figure 12. *Grafted cucumber plants were healed in a growth chamber with temperature set at 85°F and relative humidity set at 60%. Plants were covered with plastic to maintain 100% relative humidity around the plants. Humidity has started to be reduced on Day 3 in the picture. Lights are turned on for 14 hours per day at 300 µmol $m^{-2}s^{-1}$ intensity.*

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