Grafting is a technique where tissue from one plant is combined with another by aligning their vascular pathways so that they heal together. In tomato grafting, one plant acts as the roots and one or more as the shoots. It can be natural or human made.

Grafting by humans can be traced back as far as 2000 years by people in central Asia. Some say even more than 3000 years ago!

It is estimated that Europe produces around 100 million grafted tomatoes per year. Asia produces over 1 billion grafted vegetables per year! In the United States, grafted tomatoes are just now catching on in the past 5 years or so as new regulations go into effect for treating soil for commercial growers and home gardeners are discovering their benefits.

Who has tried grafting? Anyone tried grafting tomatoes? Success?

With tomatoes, the three most commonly employed grafting techniques are Tube, Approach, and Cleft. Today we will be discussing Tube Grafting.
Vascular Pathways - Grafting is a technique where tissue from one plant is combined with another by aligning their vascular pathways so that they heal together.

**Xylem** and **phloem** are the conducting elements of vascular plants. They function in the transport of water, nutrients, sugars, proteins and RNA throughout the plant. The xylem and phloem are generally found together in vascular bundles and can lie in various positions relative to each other.

While we can not always perfectly line up these tissues, that is exactly what we are going for in grafting tomatoes. Think of it like connecting water pipes.
Definitions

- **Rootstock** – the plant that functions as the root system and receives the scion. All commercially available rootstocks are hybrids and will not grow out an edible tomato. Also known as stock.

- **Scion** – the plant that will function as the top or shoot.

- **Callus** – the hardened tissue that forms over a wound and at the graft site. Prolific callusing helps graft union success. Root and shoot differentiation occurs from callus.
Definitions

- **Cotyledons or Seed Leaves** – embryonic leaves that appear after a seed germinates. These are not considered “true leaves”
- **True Leaves** – The leaves that appear after the cotyledons and are the first leaves that have vascular tissue.
- **Hypocotyl** – the segment of stem between the cotyledons and the soil surface
Advantages of grafting

- Resistance to soilborne disease and insect pressure
  - ‘Estamino’ Rootstock that we will be discussing – Tomato Mosaic virus, Leaf Mold 1-5, Verticillium Wilt (Verticillium albo-atrum, Verticillium dahlia), Fusarium Wilt 0-2, Fusarium Crown and Root Rot. Intermediate resistance: Root knot nematodes (Meloidogyne arenaria, Meloidogyne incognita, Meloidogyne javanica), Tomato Spotted Wilt virus.”
  - ‘Supernatural’ Rootstock - Verticillium Wilt, Corky Root Rot, Fusarium Crown and Root Rot, Nematodes, Tobacco Mosiac Virus
  - In Alaska, soilborne disease is not much of a concern. However, with increased high tunnel usage, issues could arise. Especially if proper crop rotational practices are not used. You are required to purchase a phytosanitary certificate to bring live tomato plants into Alaska as they are carriers for important diseases affecting Solanaceous crops.
Advantages of grafting

- Taking cold-tolerant, short season varieties and utilizing a more vigorous rootstock is a new way of jumpstarting heirloom and open pollinated production.
  - Successful pairing of rootstock with scion accompanied by proper growing environment can extend harvest season and increases yield.
  - Larger root system means more water and nutrient uptake – twice the rootmass of ungrafted heirlooms is normal. In containers, it is best to give more soil space – Around 7-10 gallons of soil for each indeterminate variety in Alaska. Determinate and more compact varieties can be planted in 5 gallons of soil or 2 plants in a whiskey barrel size pot.
Advantages of grafting

- Higher resistance to a multitude of abiotic stresses
  - Drought, cold, heat, soil contaminates

- Combined all of these factors increase production and vigor. You still have to grow it correctly and ensure pollination. The closer you can get to 78 degrees air temp and 70 degrees soil temperature, the more they will thrive.
Potential downfalls in grafting

- Expensive –
  - Average cost of one rootstock seed is about $0.25
  - On a larger scale, materials and high labor costs lessen the motivation to graft for commercial tomato production. The EPA is phasing out methyl bromide for using on soil infected with diseases and grafting is a viable option as a result. Robots are also viable solution for taking cuttings, grafting, and planting and are used frequently and successfully in other countries. A well-practiced human tube/splice grafter can hand graft 1000 combinations in an 8 hour day. It is tedious.
  - Only 7 out of every 10 plants make it to marketability on average, so costs for high failure need to be absorbed. General rule of thumb is 90% germination and 80% graft “take”. 3-5% of the grafts that take will not be saleable.
Potential pitfalls

- Wrong pairing of rootstock with scion – Generative vs. Vegetative
  - If a rootstock is considered Generative, it is known to put more energy into producing fruit. This is an advantage in a short season of production. The two I mainly use are considered more generative.
  - If a rootstock is Vegetative, it is known to put more energy in producing leafy growth and fruits later.
  - Nutrition and environment may play a larger role than roots alone.
  - Some variety combinations just don’t work as well. Poor grafting technique, stress during the graft healing and acclimation process, and other factors play a role.

- Knowledge gap – Consumer is often intimidated to learn about the processes as the necessary amount of information has not always been accessible. However, understanding the principles of grafting opens the door to many possible gardening and farming techniques and so education and research are very important.
Common types of grafts used on tomatoes

Tube/Splice Grafting
## Process

### Schedule for Tube Grafting

<table>
<thead>
<tr>
<th>Variety and number of seeds</th>
<th>Day 1 Sew Rootstock seeds</th>
<th>Day 3-4 Sow Scion Seeds</th>
<th>Grafting Start ~ Day 11</th>
<th>Exits Healing ~ Day 21</th>
<th>Transplanted</th>
<th>% Success</th>
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The two rootstocks I use are Estamino (EST) and Supernatural (SUPER). They are both considered more generative. Both are non-GMO and both are available as Certified Organic seed. They are hybrids and will not produce edible tomatoes if allowed to fruit.

Desirable qualities of a rootstock:

- **Even germination period** – Rootstocks are not always even germinators. For this reason, we sow rootstock seeds 3-4 days before sowing scions. The scions will eventually catch up. Germination percentage is usually around 90-95%. EST not even, SUPER more even

- **Stretched hypocotyl allows for easier grafting** – The distance between the graft union and the soil line is important for many reasons. A short hypocotyl can lead to graft failure when the scion roots into the soil before the graft heals. EST is Short, SUPER is longer
Desirable qualities of a rootstock cont.

**Fast establishment** – roots out quickly when young, allowing it to be transplanted/moved for grafting sooner. EST=faster SUPER=Slower

**Hypocotyl stays narrow until grafting** – allows a wider window of time to graft in order to match stem size. Both EST and SUPER have a 7-10 day window for me.

**Abiotic/biotic stress tolerance** – Cold, heat, drought, salinity tolerance and degrees of resistance to soilborne diseases and nematodes.
Desirable qualities of a Scion for tube grafting

**Predictable germination period** – Usually shorter than rootstock if seed is fresh

**Average growth once germinated** - Grafting occurs around 2-3 true leaf stage = some varieties take a while to get their first true leaves

**Doesn’t gain stem girth fast** – allows for a wider window of grafting

**Short time to first fruits & cold tolerance** – 75 days or less is desirable here in AK.
Process

**Tools**

- **Germination**: Seedling heat mat, soilless potting media like Pro-Mix or a seedling mix, light source, container – I prefer starting in plug sizes.

- **Grafting**: 70% Isopropyl (Rubbing) alcohol, razor blade or Japanese grafting tool, Silicone Grafting Tubes = 1.5 mm and 2mm sizes, caliper tool to measure stem diameter, spray mist bottle with clean water, good lighting, pencil and labels.

- **Healing Chamber**: Different ways to accomplish this. Constructing a chamber that can be used to hold humidity is necessary. A grow tent or portable mini greenhouse with shelves and a modified humidifier on a timer works well. Rubbermaid-type storage containers that are opaque on bottom work well. I’ve even seen a plastic bag work. Dark Fabric/black plastic cover, Always have a Mist bottle handy, Heat source enough to keep the chamber at 70-75F constantly. Light source - T8 or T5 flurorescent.
Process - Tools

Caliper tool and Silicone Grafting Tubes in Sizes 1.5mm & 2mm

Japanese Grafting Tool
Process - Germination

- Day 1 – Plant rootstock seed. Germinate 75F
- Day 2-3 Plant scion seed ½ one day and ½ next day. Germinate 75F
- Day 9 start evaluating whether rootstock or scion needs to be “push/pulled”
- Day 11-14 - Begin evaluating stem size for grafting and start grafting. Around the time the first rootstock stems just below the cotyledons reach 2 mm wide is usually a good time to start grafting.
Process – Grafting - Rootstock

- **Day 11-14 or so** - The day of grafting, make sure the rootstocks are not overly watered. About 3/5 in wetness.

- Soak cutting tools in 70% alcohol for 15 minutes. Mist scion leaves with clean water.

- Grade rootstocks that are to be grafted.

- Make cuts to rootstock below cotyledons at a 45 degree angle. Use a guide like an exacto knife pad, grid paper, brown paper towels with diamond shapes imprinted. A grafting tool makes it much simpler. *Try to keep cut up high above soil (~1” is desirable) to lessen scion rooting in, causing the graft not to heal correctly. ** Do not leave rootstock to sit for more than a minute after you cut it.

- Slip tube over rootstock cut end about ½ way. Orient your tubes and cuts the same if you are doing multiples.
Process – Grafting - Rootstock

Cut is made to Rootstock at a 45 degree angle

Silicone grafting tube slips over cut end of Rootstock so stem fills about $\frac{1}{2}$ of tube and tube does not slip down easily.
Process – Grafting - Scion

- Day 11-14 or so: Keep Scion plants turgid by keeping them at a 3/5 wetness. Mist them frequently before and after they are cut. Ensure no water or soil gets in grafting tube.

- Cut scion at same angle and trim off excess foliage to reduce transpiration.

- Orient cut scion to match with the rootstock cut and slide into tube until the two cut surfaces match up. Do not push too hard and visually verify that cuts are matching by looking through the tube. A magnifying lens may help when you are first starting.

- Place graft(s) into healing chamber in Darkness.
Process – Grafting - Scion
Process – Healing Chamber

- **Day 1 in Healing Chamber** - Keep humidity at 80-95%. It is beneficial to get everything set up and running and tested before you need it.

- Keep temperature at 70 – 80F constantly for proper callousing and healing. Yes, 68F will slow down the process and allow for more complications. I shoot for 70-75F.

- Get new grafts into healing chamber right after grafting. Give 72 hours of darkness. Check humidity and temp frequently – you may need to mist.

- **Day 4 in Healing Chamber** – Introduce light – Keep T5’s minimum 1.5’ and T8’s 1’ at this point – Inspect several times for hard wilt and adjust distance to light.

- **Day 5-7 in Healing Chamber** – gradually increase light. On day 7 start decreasing humidity.
Day 7-10 in Healing Chamber – Continue reducing humidity by about 15% a day. Day 10 at the latest, they should be in normal humidity, but may still benefit from some shading. Some grafts may need watering during this time. Take care to water gently without disturbing the graft or water from the bottom.

Transplant, making sure to not disturb the graft union until it is sufficiently healed and the plant is rooted. REMEMBER: DON’T BURY THE GRAFT! And check for scion rooting during the season.

Graft tube will pop off as stem gains caliper.
Sources for supplies

- Johnny’s Seeds = www.johnnyseeds.com – Grafting tool, Silicone grafting tubes, Rootstock seeds
- Osborne Seed = www.osborneseed.com – Rootstock seeds
- Alaska Mill & Feed – Carries exclusive “Alaska Grown” grafted tomatoes
- South Anchorage Farmer’s Market – Flattop Farm booth May 6 – end of June
- www.flattoptfarmak.wordpress.com for this presentation and variety information