COOPERATIVE EXTENSION PUBLICATIONS

College of Tropical Agriculture and Human Resources
University of Hawai'i at Manoa

Grafting Cacao

The Purpose of Grafting Cacao Trees

Tropical fruit trees are typically propagated through vegetative cloning, a method that ensures the desired genetics of the clonal plant are identical to those of the parent plant. Vegetative cloning allows the grower to perpetuate specific traits such as fruit quality, disease resistance, and high yield.

Grafting is the preferred method of vegetative propagation for cacao (*Theobroma cacao*). Grafting skill allows farmers to choose the qualities they want in their trees and reduce expenses related to sourcing cacao trees.

This publication serves as a step-by-step guide to grafting cacao. The graft performed in this tutorial is called a top wedge or cleft graft. While there are multiple grafting techniques, this is the most widely used and accepted method for cacao grafting.

This technique and others can be viewed as a video at UH CTAHR Cacao Grafting Video [youtube.com/watch?v=KXF_LHwIvLc]. For more information on propagation of tropical fruit trees, please refer to the UH CTAHR Tropical Fruit Tree Propagation Guide [ctahr.hawaii.edu/oc/freepubs/pdf/F_N-49.pdf].

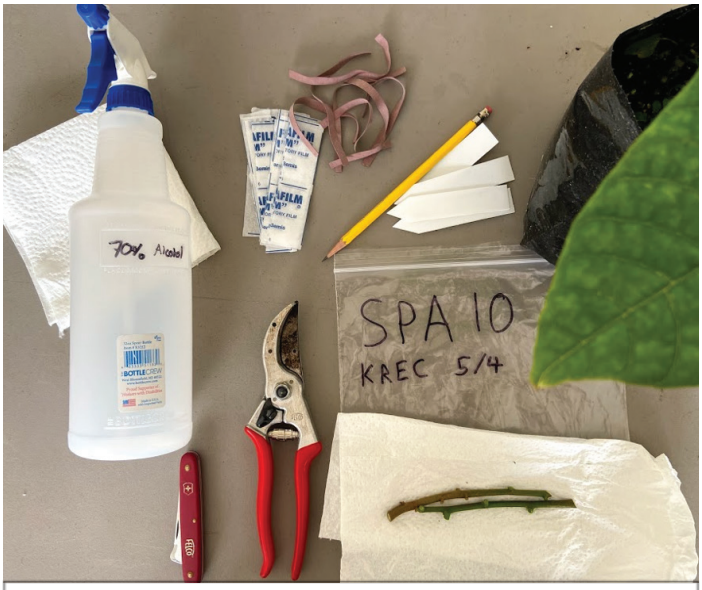

Figure 1. Supplies needed for grafting.

Supplies Needed for Grafting (Figure 1)

- Parafilm for sealing graft. Parafilm is a flexible self-sealing film and is the preferred grafting tape for cacao.
- Sharp, clean, and sterile grafting knife. Having a grafting knife that is sharp and clean will improve the success of grafting attempts. It is also possible to graft with single-edged razor blades, which are inexpensive and easy to use. This guide describes the cutting technique used with a grafting knife.
- Label and pencil. Graphite pencil marks do not wash off of rough-surfaced plastic labels and are more durable than permanent markers.
- 70% isopropyl alcohol in a spray bottle. Isopropyl alcohol is a disinfectant and necessary for keeping tools sterile during the grafting process. Isopropyl alcohol is not an oxidizer and will not rust metal tools.
- Grafting rubbers. Grafting rubber strips are essentially cut rubber bands; in fact, you can substitute large rubber bands. Experienced grafters often do not use grafting rubbers, relying only on parafilm to hold the graft union.
- Pruning clippers
- Cacao rootstock tree (Figure 2)
- Cacao scion (from a known plant)

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Elihu Isele
Maxwell Breen
Russell Galanti

Department of Tropical Plant and Soil Sciences
rgalanti@hawaii.edu, (808) 746-0910

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Terminology, Selection, and Preparation of Ideal Rootstock and Scion Material

Rootstock

The rootstock (Figure 2) provides the rooting system of the tree and is the part that receives the grafted scion. In Hawai'i and virtually all cacao-growing regions, seedling rootstock is used. Currently in Hawai'i, HSCT 4 seedlings are the preferred rootstock (Bittenbender 2019, personal communication). In other cacao-producing areas, seedling rootstock from varieties such as IMC 67, TSH 1188, and EET 400 is the preferred choice.

Figure 2. Example of an ideal cacao rootstock. Cacao rootstocks are typically grown from seed.

Seedling rootstock varieties are generally chosen for their availability, early vigor, and resistance to soil-borne diseases (Sodre 2019), all of which make for more efficient propagation and long-term health of trees in the field. Preliminary research to produce and study the potential of clonal rootstock from rooted cuttings is in progress at CTAHR (Breen 2020, personal communication).

How to grow rootstock

Mature cacao pods from trees that produce desirable rootstock are cracked open and the seeds are planted on their sides, directly into a sterile media in poly bags or tree pots (tree pots that are 4"x4"x8" work very well). The rootstock should be top-dressed with ½ teaspoon of a balanced slow-release fertilizer at first leaf hardening, which will occur about 30–45 days after planting. Osmocote [ICL Specialty Fertilizers, Summerville, SC] and Nutricote (American Horticultural Supply, Oxnard, CA] fertilizer brands work well.

About four to five months after planting, rootstock should be larger in diameter than a pencil (around ¼ inch), at which point it will be ready to be grafted onto.

Scion

The scion will form the canopy and bear the fruit of the grafted tree. Scion pieces of the desired variety will be harvested from stock plants or trees in the field. When selecting cacao scion, it is important to be aware of cacao's two distinct types of growth. The choice of *plagiotropic* or *orthotropic* material for the scion will determine the architecture of the resulting plant (Sena Gomes 2015).

Plagiotropic ("fan branch") material makes up the vast majority of growth on most cacao trees, so it is more readily available for use as scion. Plagiotropic material is characterized by alternate leaves on a single plane (Figure 3) and generally lateral to moderately upright growth.

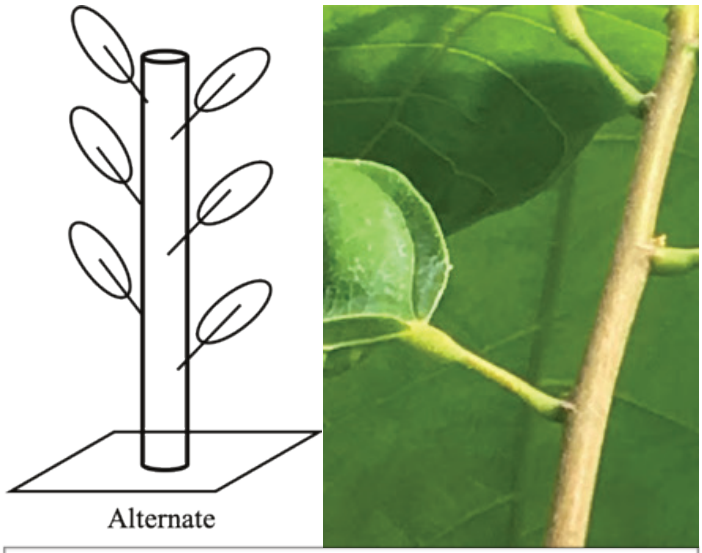

Figure 3. (Left) The alternate leaf arrangement of plagiotropic growth. (B) Plagiotropic growth on a cacao tree.

Orthotropic ("chupon") growth most often comes off of the trunk of mature cacao trees but occasionally will emerge out of mature fan branches. Orthotropic material is characterized by leaves in a spiral pattern on all planes (Figure 4) and directly upright growth.

A cacao plant grafted with plagiotropic scion will require more formative pruning and ultimately gives the grower more control over the tree's architecture. A cacao plant

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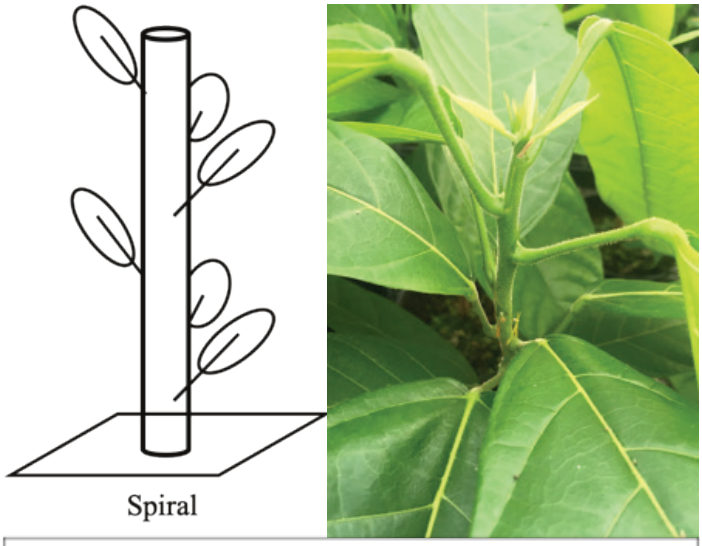

Figure 4. (Left) The spiral leaf arrangement of orthotropic growth. (Right) Orthotropic growth on a cacao tree.

grafted with orthotropic scion will behave like a seedling tree and produce a "jorquette," a cluster of fan branches, at an indeterminate height (Umaharan 2018).

This guide shows the use of plagiotropic scion material for grafting due to its agronomic advantage and its greater availability relative to orthotropic material.

The best material for scion is found on the distal ends (close to the branch tips) of the canopy where fan branches receive the most sun. Scion should be the same diameter as or slightly smaller than the rootstock stem. Scion should be recently matured; a mix of green and brown stem color is a good indicator that it is the right age (Figure 5).

Figure 5. The ideal scion material to use for the rootstock shown in Figure 2. Size is about the same diameter as a pencil or slightly smaller and color is mixture of green and brown.

Scion material taken from mother trees should have 3 or more buds; ideally, the buds should be swollen but not yet open (Figure 6). The length of scion cuttings should be less than 10 inches so they can easily be wrapped in paper towels and stored in a plastic bag. Cuttings will be cut into two bud scion pieces for grafting.

Scion cuttings should be fresh and used as quickly as possible. As soon as cuttings are taken from a tree, they begin to lose moisture and lose their viability as

Figure 6. (Left) An ideal candidate for scion material. Note the slightly swollen buds. (Middle) A stem with buds that have extended, not ideal for scion material. (Right) An over-matured branch with dormant buds, not an ideal candidate for scion material.

scion (Purdy 1989). After cutting the scion from the mother tree, remove the leaves by cutting the petioles close to the stem without damaging the buds, then wrap a bundle of scion cuttings in dry paper towels and place the bundle in a sealed plastic bag with the scion variety clearly labeled. Please collect and label with precision and care, as mislabeled germplasm is a serious issue in the cacao industry worldwide (Motilol & Butler 2003).

Scion cuttings can be stored in a cooler or other insulated container, with ice or an ice pack if conditions are extremely hot. If ice is used, be sure to separate it from bags of scion with thick material like a cloth towel. Scions can be viable for four or more days, but we have achieved best grafting results with scions less than 48 hours from harvest.

During grafting, scions will be selected from the harvested cuttings to match the rootstock diameter for each graft. The scion and rootstock diameters should be as similar as possible—the scion can be smaller in diameter than the rootstock, but never larger.

Step-by-step Instructions to Grafting Cacao

Step 1: Grow or acquire rootstock of the correct diameter.

Step 2: Harvest or acquire high-quality scionwood.

Step 3: Sterilize all tools with 70% alcohol solution between every few grafts and when changing scion varieties. Wipe the tools clean to remove plant tissue and sap before sterilizing with alcohol.

Step 4: Before performing the graft, you will need to remove the apical (top) end of the rootstock (Figure 7) by clipping the end of the rootstock at the graft site (Figure 8, left) to prepare it to receive the scion. Match the scion and rootstock diameters to determine where to cut, making sure to leave 1½ inches below the cut as a grafting area. Leave three or more leaves below that, so that the plant can continue to photosynthesize (Figure 8, right).

Figure 7. Step 4: Determining if the scion is the same size or smaller than the rootstock.

Step 5: Trim your scion to two buds and wrap with parafilm, leaving the area to be cut unwrapped but completely covering the rest of the scion to reduce moisture loss (Figure 9).

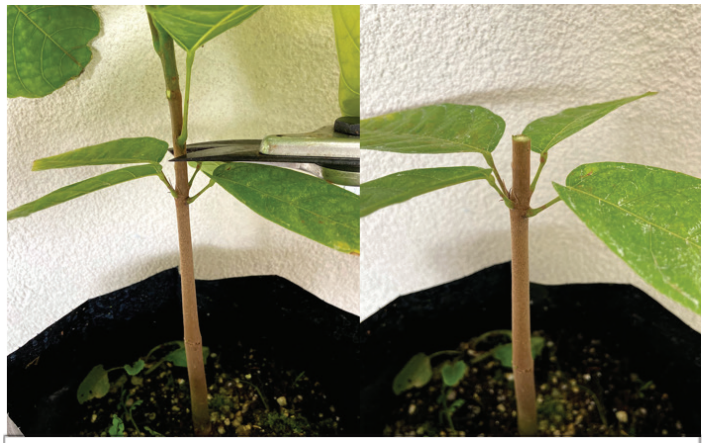

Figure 8. Step 4: (Left) Using pruning clippers to remove top of rootstock. (Right) An ideal rootstock prune, with several leaves below the graft point with about 1 inch for the grafting area.

Step 6: Carefully make a vertical cut in the top of the rootstock and rock the knife back and forth to make the cut up to twice as deep as the width of the blade (about 1½ inches) based on the length of the bottom of your scion (Figure 10).

Figure 9. Step 5: Preparation of scion; pruning to two buds and wrapping with parafilm. Be sure to wrap parafilm from the bottom moving toward the top.

Step 7: Hold the grafting knife in a fixed position close to your body. The sharp side should be facing away from your body, with the slanted bevel facing downwards. To make the cut, pull the scion towards your body and over the knife blade. Only the scion should move, while the knife remains still. Keeping the knife still and flat as you make the cut helps you avoid any curving or turning of the cut. The angle of the scion resting against the blade should be as narrow as possible while still cutting through the wood of the scion. The idea is to make the cut as long as possible, in order to maximize the surface area that will be in contact with the cambium and wood of the rootstock (Figure 11).

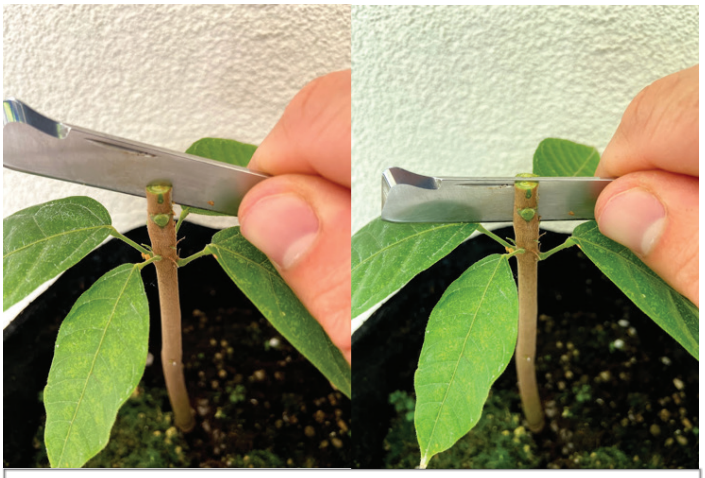

Figure 10. Step 6: (Left) Making the rootstock cut by carefully rocking the knife blade into the cut stem. (Right) Stopping the cut at a depth equal to one or two blade widths, depending on the length available at the bottom of your prepared scion piece.

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Figure 11. Step 7: Creating the proper wedge shape on the scion that will be attached to the rootstock.

Rotate the scion 180 degrees and make an identical cut on the other side, forming a wedge shape. Strive to make flat cuts the first time, but if necessary, redo each cut as needed to create flat surfaces on the wedge shape. With practice you will find you only need to make the initial two cuts.

Step 8: Now slide the wedge into the rootstock (Figure 12) and match the cambium layers of the rootstock and scion. This can be done by feeling whether the bark of the rootstock and scion are flush while running your finger over the side. If the scion is smaller than the rootstock, only one side will be lined up.

Figure 12. Step 8: Creating the proper wedge shape on the scion that will be attached to the rootstock.

Step 9: If there is poor matching of surfaces and you can see light in between the rootstock and scion, you will need to tighten the union with a grafting rubber. Wrap slowly and tightly from the bottom up over the union without disturbing the scion location (Figure 13).

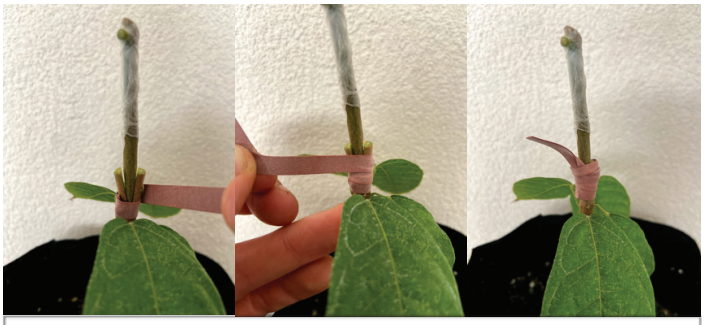
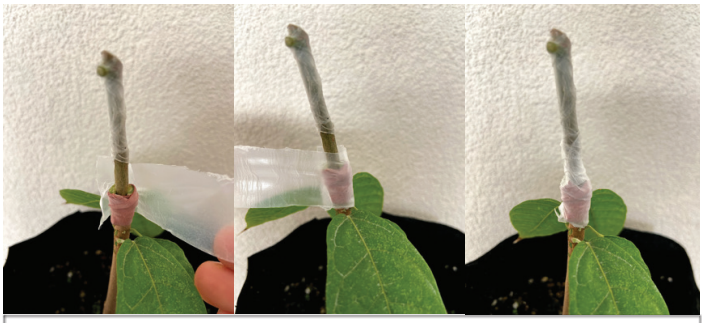


Figure 13. Step 9: Wrapping the scion and rootstock union with grafting rubbers.

Step 10: Then wrap parafilm from below the graft union, up around the union and any uncovered part of the scion. The parafilm will stretch and make a watertight and breathable seal (Figure 14).



Figures 14. Step 10: Wrapping the graft union with parafilm over the grafting rubber.

Step 11: Write a plant label with a pencil that includes the following information: date, scion variety, and rootstock variety, plus the grafter's name or initials if grafters are to be evaluated (Figure 15).

Step 12: *Take care while watering, moving plants, and transplanting to the field so as not to disturb the scion and rootstock, as this will break the graft union.* After grafting, it is important to keep the tree under substantial (50%+) shade and to keep the union dry. Do not wet the graft union with overhead irrigation; use drip irrigation instead.

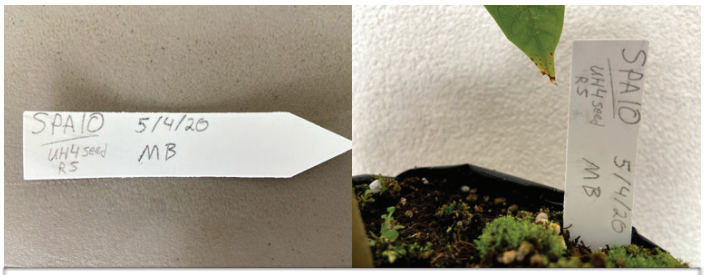


Figure 15. Step 11: Preparing the plant label for record keeping, an important but often overlooked step. Written on the tags above: "SPA10" = Scion Variety "UH4 seed RS" = Root stock variety & propagation method ("seed RS" = seedling rootstock) 5/4/20 = date of grafting MB = Grafters initials

Within 2–4 weeks, the buds on the scion of a successful graft should push through the parafilm. It is important to not move or disturb the grafted plant for 2 months after grafting, as the union is quite weak. After 5 weeks you need to carefully cut the rubber band and remove it, but the parafilm can be left in place, since it will decay. The

Figures 16 Grafted Cacao. (Left) A properly completed grafting of a cacao scion and rootstock. (B) A grafted tree after one week has 'taken', showing bud break.

successfully grafted trees can be under more light (~30% shade) when the rubber bands are cut. The grafted tree can be fertilized again when flushes from the scion harden and turn dark green.

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