



Grafting Macadamia Trees in Hawai'i*

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Macadamia nut (*Macadamia integrifolia*) is one of the most important tree crops in the state of Hawai'i. Macadamia does not grow true to seed, and therefore clonal propagation is required in order to maintain the quality and productivity of our macadamia trees. To do this, we must use recognized varieties and clone them by grafting. Grafting macadamia can be difficult for a beginner because the wood is hard, and a successful graft takes skill. However, the process can be broken down into three stages: 1) preparing and growing the rootstock,¹ 2) preparing the scion wood,² and 3) successfully fusing the scion and rootstock together. With careful planning and execution, your grafted tree could be ready to transplant in two years!



Figure 1. Seedlings after being thinned to one per pot, approximately three months after planting.

Tools and Supplies

Macadamia seeds
Mature macadamia trees of known and preferred variety
Potting media
Polybags (18x6 inch)
Channellock pliers
Flagging tape
Hand pruners
Loppers or small hand saw
Grafting knife
Rubber strips for budding and grafting
Parafilm or nursery grafting tape

Preparing and Growing the Rootstock

There is currently no standard rootstock recommended for macadamia nut in Hawai'i, though most growers prefer to use '660'. Seeds for rootstocks are collected from selections based on grower's preference for varieties that make a strong rootstock, including climate and

¹ **The Rootstock:** The rootstock, also called "stock" or "understock," is the lower portion of the grafted plant onto which the scion is grafted. The rootstock produces the grafted plant's roots.

² **The Scion:** The scion is the part of the grafted plant that will produce the plant's shoots. Typically trimmed from a mother tree, the scion will, in the future, give rise to all of the plant's leaves, stems, flowers, and, in this case, nuts. The scion is usually considered the top part of the grafted plant.

*Amended from AEC-58 "Grafting and topworking the macadamia" by Edward T. Fukunaga (1951)

pest/disease tolerance. It is important to not cross rough shell (*M. tetraphylla*) and smooth shell (*M. integrifolia*) macadamia for grafting. If you are planning to use a smooth shell variety for the scion wood, you should also use a smooth shell variety for the rootstock.

1. Remove husks and soak seeds in water for two days.
2. Dry the seeds in the sun for one to two days, or until the shell cracks.
3. Fill the polybags with media. Do not use soil, to avoid unwanted pests and diseases.

Note: Use a combination of cinder, macadamia compost, or other types of well-drained media.

4. Plant seeds 1 inch below the media surface, with the cracked side of the seed facing upwards up to facilitate germination. Up to three seeds may be planted per pot.
5. Thin seedlings to one plant per pot once established. Extra seedlings can be transplanted into other pots or removed completely (Fig. 1).

Note: Only keep strong, healthy rootstock seedlings and discard all others.

6. Allow seedlings to grow for about one year, or until the stem reaches approximately 0.5–0.75 inches in diameter.

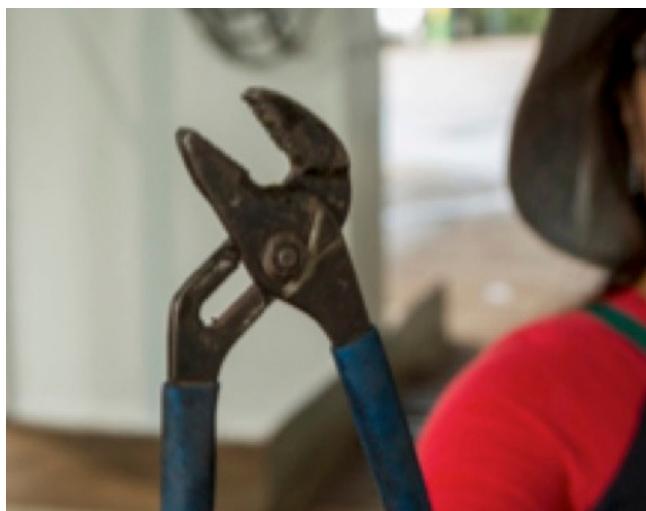


Figure 2. An example of pliers used to girdle a macadamia tree branch for scion wood.

7. Fertilize seedlings 3 months after planting with a slow-release complete fertilizer.
8. Provide adequate and consistent water to the seedlings. Avoid over-watering, but do not allow the pots to dry out. Over- and under-watering are detrimental to the growth and health of your seedlings.

Preparing the Scion Wood

Select your scion wood based on the variety of macadamia that you want to produce. This decision will be based on your location and personal preference and on availability of mature trees. Remember that this wood will be the variety of macadamia nut that your tree will produce.

1. Scion selections should be from older wood that is straight, healthy, and about 0.5–0.75 inches in diameter. These branches may be ones you plan to prune off or simply based on availability.
2. Use pliers or a similar tool (Fig. 2) to remove about 1 inch (in length) of the outer layer of bark on the branch. Be sure to girdle completely by removing the bark deep enough that you see white wood (Fig. 3). Girdle far enough back on the branch to achieve several pieces of scion wood, but not so far that the diameter of the branch exceeds 1 inch.

Note: Girdling the branch prevents the movement of carbohydrates, which are formed in the leaves



Figure 3. Girdling a branch selected for scion wood in the field.

of the girdled branch, from flowing back into the tree. A build-up of these carbohydrates in the scion is necessary for increased take and survival of the graft union.

3. Use flagging tape to mark the branch. Log the date and variety on the tape with a permanent marker and also note them on a calendar, including the location in the field, to refer back to when the scion wood is ready (Fig. 4).
4. Harvest your scion branches no sooner than 6 weeks after girdling. Depending on your location, scions can take up to 6 months to be ready for grafting. The girdled branch should remain free of flowers and nuts to accumulate the most carbohydrates and have the best chance at a successful graft; if it produces buds, they should be removed.

Note: An iodine dip test can be useful in determining starch build-up. If the scion wood turns blue when dipped, then the branch has had enough time to accumulate starch and is ready for use in grafting.³

5. Cut the scion branch below the girdle with clippers. For best results, perform the graft on the same day that the scion is removed from the mother tree. If you are not grafting immediately, be sure to keep



Figure 4. Completed girdling of macadamia tree branch for scion wood; branch flagged with the date for future harvesting of scion wood.

the scion wood cool and in a humid environment to prevent it from drying out. Avoid waterlogging the scion, and maintain awareness of the scion's polarity (top and bottom) (Fig. 5).

Note: The “top” of the scion will be closer to the bud, or growing point, which can be found above the leaf or leaf scar on the branch.

6. Remove all leaves from the scion wood.
7. Cut the scion wood into pieces that are approximately 5 inches long and, more importantly, have at least 3 buds on each piece (Fig. 5).



Figure 5. Example of a scion wood piece that could be used for grafting. Note the direction of the buds, which are facing upwards.

³ See Shigeura and Ooka (1984) for more information: <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/RES-039.pdf>

Grafting the macadamia

1. Using your shears or loppers, remove the top portion of the rootstock by cutting straight across about 15 inches above the media surface. Remove a few of the top leaves for ease of grafting and to provide room for the scion.
2. Select a scion piece about the same diameter as the rootstock.
3. Hold the scion wood firmly, ensuring that the buds are facing upwards and away from the end that you will slice into a wedge (Fig. 5).
4. Using your grafting knife, carefully slice away wood with a quick, smooth, diagonal motion to cut the scion wood into a V-shaped point. Maneuver the blade angle to slice thin pieces away until you reach the appropriate shape and angle (Fig. 6).

Note: To gauge the flatness of your slices, lay your knife blade on each side of the wedge. There should be no space between the blade and wood.

5. Using the scion, locate a place where the diameter of the scion piece is as closely matched to the diameter of the rootstock (Fig. 7), as this will provide the best contact with the cambium.⁴

Note: It is not necessary for the cut to be located in the middle of the rootstock as long as at least one side of the scion cambium is in direct contact with the rootstock cambium. It is difficult to see the cambium with the naked eye, so line up the edges of the scion cut with the edge of the rootstock after making the cut (step 6), as this is where the cambium layer is located.

6. Place your grafting knife blade on this location on the top of the rootstock (Fig. 8). Insert the middle of your knife blade into the outer edge of the rootstock. Using your palm, gently rock the knife until you make a straight, downward cut about 1 inch into the rootstock (Fig. 9).



Figure 6. Making the cut into the scion wood.



Figure 7. Matching the diameter of the scion with the rootstock.



Figure 8. Inserting the grafting knife into the rootstock.

⁴ **The Cambium:** The cambium is a single layer of cells found near the bark of woody plants. These cells actively divide to produce xylem (wood tissue that transports water and minerals from the root system and up the plant) and phloem (bast tissue, or fiber, that transports sugars from the leaves to other plant parts). The cambium of the scion and rootstock must be connected and fused together for graft success.



Figure 9. Completing the cut into the rootstock.



Figure 10. This scion is thinner than the rootstock. Notice that the cut made into the rootstock is off-centered but provides the best cambium contact between scion and rootstock.



Figure 11. Wrapping the graft with a rubber band strip while retaining pressure on the graft union and while connecting scion and rootstock cambiums.

7. Insert the wedge side of the scion into the rootstock, being careful to not force the wedge or split the rootstock.

Note: If your wedge angle is too wide, causing the rootstock to split, cut off the part of the rootstock that split, and repeat from step 1. Re-slice the scion piece to create a narrower (longer) wedge.

8. Match the edges of the scion and rootstock to ensure the greatest amount of cambial contact (Fig. 10).
9. Use a rubber strip to tightly bind and stabilize the graft (Fig. 11). Ensure that contact between the scion and rootstock cambiums remains intact.
10. Cover the entire scion, including the graft union, with one layer of parafilm or nursery grafting tape (Figure 12a–c).
11. Water the grafted tree and be sure that the media does not dry out.
12. In a few weeks you may see young vegetative shoots forming under and pushing through the parafilm. Typically, this indicates a successful graft (Fig. 13).
13. Fertilize the tree with a complete fertilizer once the graft is successful, approximately 1 year after planting the rootstock seed.
14. Once the graft is well established, remove any shoots and suckers that emerge below the graft. Allow the grafted portion to grow for an additional 8–12 months before planting into the field. It is important to maintain good nursery practices to minimize broken roots and pot binding in the nursery.

Note: You should get your first macadamia nuts approximately 4 years after planting your grafted tree in the field!

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Figure 12a. Beginning to wrap the scion with parafilm from the graft union and upward.



Figure 12b. Complete coverage of the scion wood is important to reduce water loss and potential entry of pathogens into the graft.



Figure 12c. A completed graft with parafilm covering the union and entire scion.

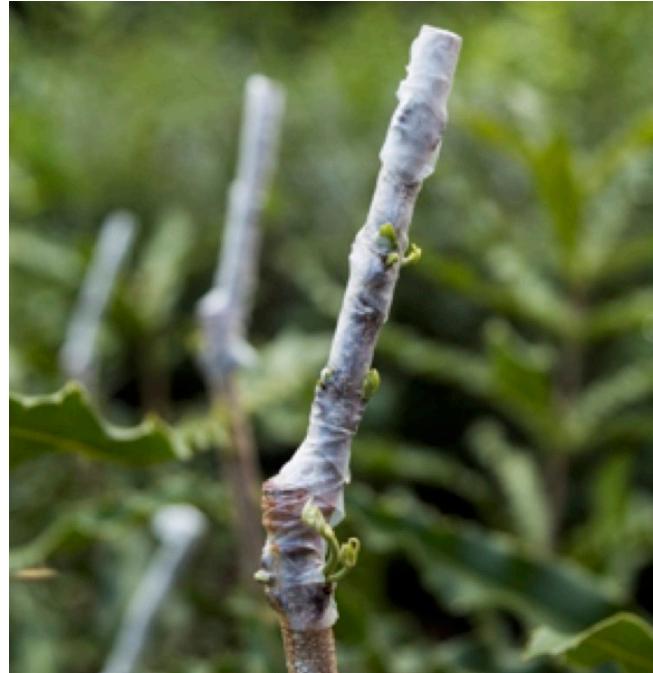


Figure 13. Buds breaking through the parafilm, indicating a successful graft. Leaves below the graft should be removed before planting into the field.

if the intended use site is included on the label. **READ AND FOLLOW LABEL INSTRUCTIONS BEFORE PURCHASING AND USING ANY PESTICIDE PRODUCT.**

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