How to Propagate Hybrid Hazelnuts from Hardwood Stem Cuttings

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Introduction: Why Propagate from Hardwood Stem Cuttings?

There are four basic methods of vegetative propagation that are used with hazelnuts: mound layering, micropropagation, grafting, and stem cuttings. Methods for mound layering are well developed and low-tech. (See www.midwesthazelnuts.org, under "Growing Hazelnuts" for a guide to mound layering.) However, only a limited number of new plants can be produced from each mother plant with layering. Micropropagation, by contrast, can produce millions of clones from one mother plant, but it requires specialized indoor facilities, with sterile conditions and controlled temperature and light, so it is not easily applied by most people. Although European hazelnuts are commonly micropropagated in Oregon, researchers are still working to optimize the protocol for micropropagation of the hybrid hazelnuts we have in the Midwest. Grafting is used for many species of tree fruits, but grafting is pointless with multi-stemmed bushes such as hybrid hazelnuts because they keep sending up new suckers which would overwhelm the grafted part of the plant. Grafting has been used successfully with European hazelnuts, which are grown as trees, but even with them it requires constantly pruning back any new suckers that grow from the roots, because they will have the genotype of the root stock, not of the desired scion wood.

Stem cutting propagation from hardwood stems is a method that is intermediate between mound layering and micropropagation. Whereas mound layering can only produce as many new plants as the mother plant produces new shoots, with hardwood stem cuttings that number can theoretically be doubled, since some of the stems can be cut into two or three sections, all of which can be rooted. In reality, however, only about 30 to 40% of the sections root, so the yield of viable new plants may be no higher than for mound layering. Also, since hardwood cutting propagation is best done in a greenhouse with good temperature controls and supplemental lighting, it is not accessible to everyone. Although the work is less strenuous than for layering, it requires more management, and is ultimately slower. (It can take from four to eight months for rooting to occur.) Moreover, the method has not yet been fully developed, especially concerning the optimal temperature and humidity levels. However, even at its rudimentary state, stem cutting propagation may have utility to nursery producers and researchers who need to propagate small numbers of plants in situations where mound layering is not feasible, such as where the mother plant is located too far from a road to haul sufficient sawdust to make a mound.

Quick Outline of Steps:

1. Coppice bushes in the late spring as for mound layering. That is, cut them down to the ground.
2. Let the new suckers regrow through the entire following year. In the fall, after they have gone dormant, cut them off at ground level and keep them cool until preparation for rooting.
3. Prepare the humidity tents.
4. Cut the stems to appropriate lengths, dip their ends in IBA solution, stick them in the peat/perlite in the humidity tents, water them well and close the plastic sheeting tight over the top to maintain humidity.
5. Two to three months later check them for rooting. Transplant those that have rooted into pots and harden them off. Return the rest to the humidity tents and check again a month later.

Supplies needed:

For coppicing

- Heavy duty loppers or other tool

For collecting and storing the stems

- Pruning shears.
- Twine for bundling the stems.
- Large trash bags.
- A cooler, preferably a large walk-in cooler kept at high humidity.

For the humidity tents (prepare at least two, with one for hardening off potted cuttings)

- A greenhouse kept at 65 to 70^0 F, with supplemental lights on a 16 hour timer
- 36" x 22.5" x 8.5" molded plastic utility tubs or similar
- Three 6 foot long PVC pipes for arches per tub
- Six plummers U clamps per tub and nuts and bolts to go with them
- A power drill
- Plastic sheeting cut to 6' x 7.5' rectangles *(70% shade plastic, available from greenhouse supply stores, is best. Clear plastic can be used but may fall apart over time if not UV resistant.)*
- Six to eight 2-inch paper clamps to fasten the plastic sheeting to the tubs
- A hygrometer/thermometer for measuring humidity
- Peat moss
- Perlite
- A humidification system, possibly fed by a drip irrigation system (optional)
  Watering can or hose with fan sprayer

For preparing the cuttings

- Pruning sheers
- IBA
- Ethanol
- DI water

For potting the rooted cuttings

- Potting mix
- Osmocote 15-9-12 + micronutrients
- 3 or 4 inch pots
- Plant labels
- 30 inch long bamboo stakes and twist-ties
- An additional humidity tent to use as a hardening off chamber

Before you start

Select your best hazelnut bush or bushes. These should be bushes that have performed well over several seasons, not just one. Ideally, they should also be bushes in good health. For more information about screening your plantings for high-performing plants, see the Hazelnut Improvement Program at www.midwesthazelnuts.org.

Step 1: Coppicing the bushes.

The first step is to induce the mother plant to produce lots of young new stems, called "collar suckers", from the ground level. Although it is sometimes possible to find collar suckers from bushes which have not been coppiced, they are not abundant. If you want many suckers you have to coppice the mother plant, that is, cut the bush down to the ground, in the late fall or early spring. Then you have to wait until the next fall to harvest the new shoots that grow in response to the coppicing **(Fig. 1)**. These are the same shoots that would have been used for mound layering during the summer if you had chosen to layer, in which case you would have been

harvesting rooted layers about the same time. So propagating from stem cuttings by this method is actually slower than by layering if you count from the time of coppicing.

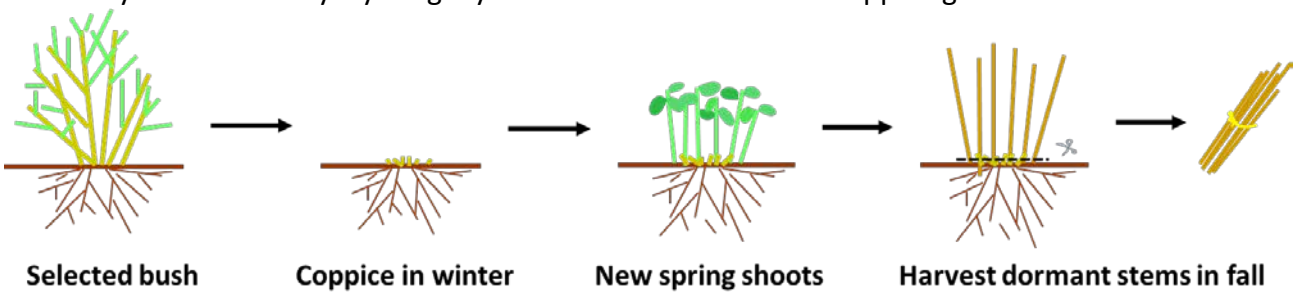

Fig. 1. Timeline for coppicing and harvesting stems.

Coppicing can be done any time that the bush is dormant, when most of the nutrients and energy of the plant are stored underground in the roots. You can still coppice in early spring, after buds have begun to break, but if you do it this late repetitively you'll weaken the plant. For more instructions on coppicing, see the bulletin on mound layering.

Step 2: Harvesting the stems.

Stems should be harvested in the fall soon after they have gone dormant. That is usually November in the Upper Midwest. They may still have leaves adhering to them, but an abscission layer should have formed between the leaves and the stem such that they can be pulled off easily. If there are still leaves, they should be removed to prevent rotting in storage.

Collect only first year stems **(Fig. 2)**. You can distinguish first year from older stems because they have a slightly reddish tinge, whereas older stems tend to have a more greyish color. First year stems are usually straight and unbranched, though they may be branched if they were injured. If they are highly branched or have catkins attached they are probably two year old stems.

Fig. 2. Crown suckers ready to harvest in November after coppicing the previous spring.

Stems may vary in length from 1 ½ to 4 feet, and in basal width from 1/8 to 3/4 inch. The best stems are the longest and skinniest stems, but since stems tend to grow wider at the same time as they grow longer, there is a trade-off between these two factors. Unless space for rooting them is limiting, you might as well use all the stems that the mother plant provides. If space is limiting, select stems that are about the thickness of a pencil.

Collect the stems by cutting them with sharp pruning shears as close to ground level as possible. Bundle and label them, then keep them in a cool place where they will not dry out until you can get them into cold storage. If it will be for only a few weeks, they can be kept in a large plastic trash bag to keep them from drying out in a shady place outdoors.

Hazelnuts, like most woody plants, require a period of winter chilling at temperatures that are below about 38^0F, but above freezing, before they will break bud in the spring. This is called "vernalization". Even dormant stems collected for rooting need to be vernalized, so you should store them in a place where they will be subjected to temperatures in the range of 32 to 38^0F for at least three weeks before starting them in the humidity tents. (Three weeks may be more than is necessary, but that is the shortest period we have tested.) A walk-in cooler or root cellar that is kept at high humidity for other plants or root vegetables is ideal. Periodically misting them off with a hose helps keep them from dehydrating. If the stems are not too long, they can be kept in a loose plastic bag in a refrigerator; make sure it is not airtight or they might rot. Keeping them outdoors, in a trash bag in a shady place, could also work during mild November weather, but note that the vernalization clock stops when the temperature dips below freezing, so keeping them outdoors is not recommended for long-term storage.

Step 3. Constructing the humidity tents.
There are many ways to build humidity tents. Below are the steps for making ones like ours.

- Purchase 36" x 22.5" x 8.5" molded plastic utility tubs, available from hardware stores.
- Drill ¼ inch drainage holes around the perimeters near the bottom for drainage.
- Bend three 6' x ½" PVC pipes into arches, one at each end and a third in the middle, to be a framework for the plastic sheeting. **(Fig. 3)**
- Use U-clamps on the insides of the tubs, just below the rims, to hold the arches in place.
- Fill the tubs to the brim with a 1:4 mixture of peat and perlite and drench it with water until the water runs out the holes in the bottom.
- Drape 70% white shade plastic over the top.

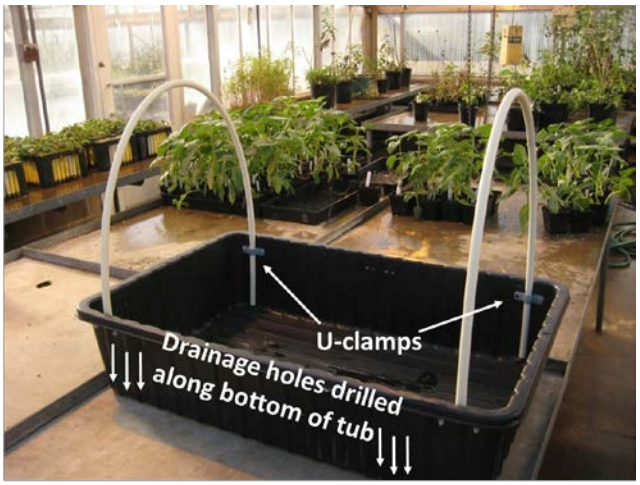

Fig. 3. A tub with arches made of two 5-foot PVC pipes. We recommend using three 6-foot PVC pipes.

We will discuss later whether to fold the plastic like bedsheets on each end, and clamp it to the sides and ends of the tubs with two 2-inch paper clamps on each side to form a moderately tight seal as in **Fig. 4**, or to leave it unfastened.

Note: before re-using a tub, sanitize it and other components of the system, including the PVC hoops and the plastic sheet, by wiping them down with a 1% solution of bleach or other sanitizer to prevent the growth of algae and fungi, then allow them to air dry.


Fig. 4. A finished humidity tent with the plastic sealed at the sides and ends with 2 inch paper clamps.

Step 4. Preparing the stems.
We have successfully rooted stems started in the humidity tents as early as the last week of November and as late as the middle of March but recommend starting in November. The stems started in November had three weeks of vernalization, which seemed to be enough, though they did not break bud or grow roots as quickly as stems started later. The problem with starting later is that, because the majority of stems take three to six months to form roots, with some not rooting until after 8 months, stems started in late winter must be managed in the greenhouse through the hot summer months, when it is more challenging to keep the humidity tents from overheating.

Before you proceed, prepare the rooting compound, which you should prepare fresh each time. (It can be kept in a refrigerator for a few days.) We recommend a solution of 2,000 ppm Indole-3-Butyric Acid (IBA) in a 1:1 solution of ethanol and de-ionized water. That is 2 g of IBA powder per liter of liquid, or 1/32 oz per pint, which is all you will need. Alternatively, the rooting powders sold at garden centers, such as Dip N Grow, Hormodin, Root-One, or Rhizopon) can be used. We have not tested these powdered formulations in stem cutting trials, but based on trials with layering assume that 8000 ppm, the concentration listed for "hard-to-root" plants, would be about right, because absorption of the IBA from talc is not as good as from ethanol. Higher concentrations are not necessarily better: in layering trials we found that concentrations higher than 2000 ppm in ethanol or 8000 ppm in talc resulted in excessively profuse but weak roots.

After retrieving the stems from cold storage, keep their bases in a bucket of water to keep them from dehydrating while you work with them. However, because these dormant stems have no leaves from which to lose moisture, it is not necessary to keep the tops wet while working with them. The first step is to trim about ½ an inch off the bottom of each stem to expose fresh vascular tissues in the stems, which may enhance water up-take.

The next step is to cut them to appropriate lengths **(Fig. 5)**. The centers of the humidity tents can accommodate stems that are up to 30 inches tall, but at the sides the stems need to be a bit shorter than that. Stems that are less than 30 inches long will fit under the plastic of the humidity tent just as they are, but stems that are longer than 30 inches will need to be cut into segments that are short enough to fit. Strive to keep them as long as will still fit. Rather than trying to make the two halves of divided stems the same length, try to make them the same weight. That is, the apical segment should be a little longer than the basal segment. That way both halves have a chance to root, as explained below.

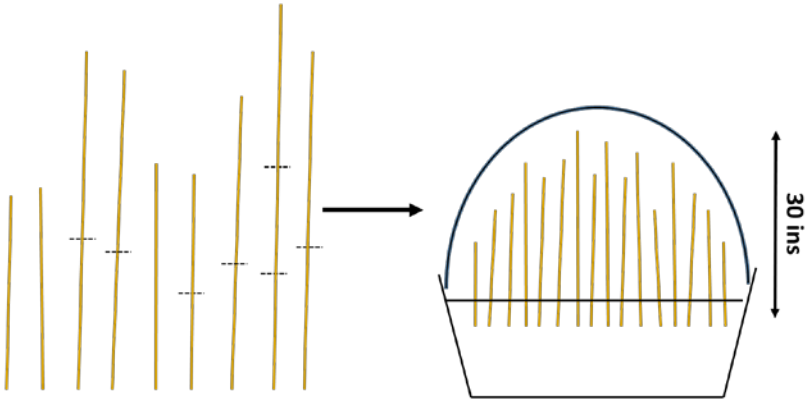

Fig. 5. Cut stems only as short as they need to be to fit into the humidity tents.

The reason for keeping stems as long as possible is that rooting success depends partly on how much stored carbohydrate they have stored in their stems, which is proportional to their length and their thickness. Carbohydrate provides the energy that the stems need for respiration until they develop new leaves for photosynthesizing, and also provides the building blocks for growing new roots. If they run out of carbohydrate before both leaves and roots are developed they will die. Conversely, the thicker the stems are, the tougher their outer layers are, which can present an obstacle for emergence of the new roots. That is why thin stems tend to root better than thicker ones, though we have seen stems of a wide range of sizes successfully produce roots. (Wounding the surface bark may enhance rooting, partly for this reason, though we have not yet tested this.)

Discard any cuttings that lack healthy looking buds. Having buds that break and produce new shoots and leaves appears to be a requirement for producing roots and for survival after rooting.

Now you are ready to dip the ends of the cuttings into the rooting compound. If using a liquid IBA solution, only the basal inch or so needs to be dipped in the solution for about 10 seconds, then insert the base of the cutting into the peat/perlite in the rooting tub, only as deeply as needed so that it will stand vertically. If using a talc formulation, the powder will stick to the wet stem end. To avoid brushing off the IBA as you insert the stem, use a dibble to make a hole slightly larger than the stem, insert the stem in the hole and firm the rooting medium around it so it will stand up.

Place the cuttings about 2 inches apart in rows that are about 3 inches apart. They will break bud, with the most vigorous producing shoots that can be up to 4 inches long, so placing them closer will crowd them too much. Also if they are too close it is difficult to harvest rooted cuttings without damaging the roots. It is okay to space them further apart if you have enough space.

After you have prepared all the stems, water it one more time with a hose with a soft spray head to settle the rooting medium around the stems. Then close the plastic over the top and seal it with paper clamps—or not, depending on conditions, as explained below.

A Challenge: Managing the Right Humidity and Temperature

When we first started rooting stem cuttings in humidity tents we assumed that it was essential to maintain humidity at very high levels, as close as possible to 100%, which is possible when the plastic is sealed tightly at the sides. Because stem cuttings have no roots with which to replace moisture lost through leaves—and because these cuttings will break dormancy and produce leaves within a week to a month of being set (depending on how much vernalization they have had)—reducing moisture loss is a major concern. Research with many other species of plants supports this idea. However, as good as sealed humidity tents are at maintaining humidity, they also tend to overheat. We observed temperatures inside the tents up to 105^0F in May and 125^0F in July, even though they were kept in a greenhouse with a cooling system. Use of shade cloth to keep temperatures down did not help but rather reduced rooting, possibly because light may be important for photosynthesis to maintain a positive carbohydrate balance in the cuttings. Likewise, rooting in greenhouses kept cooler than 65^0F did not work.

So in winter 2013 we started experimenting with keeping the plastic unclamped to allow a little ventilation while using ordinary household humidifiers to keep the humidity up. We found this approach to be successful even if humidity was allowed to decline to as low as 20% for short periods of time. However, using humidifiers required much more management than was needed for the sealed tents, which could be completely ignored for the first two months. Keeping the humidifier tanks full would have been a full time job if we had not hooked them up to a drip irrigation system, and even so it required regular monitoring because the drip irrigation system frequently malfunctioned. The vented tents with humidifiers probably worked only because we checked on them daily, and watered them by hand every time we found humidity to be below 60%. However, in the same experiment we also learned that not only is high humidity not necessary for survival and rooting of cuttings, but that extremely high humidity, such as is found when tents are sealed tightly, actually increased mortality of cuttings within the first two months, possibly because of waterlogging of the rooting medium and oxygen starvation of the basal portion of the stems.

In conclusion, we still do not know what exactly what levels of humidity and temperature are ideal. We hope to do further experiments to figure this out, and to figure out how best to maintain them at the ideal levels. We will add that information to this bulletin when we know.

Until we know better, the following is what we recommend. First, start the cuttings in November, to avoid having to keep them going when the temperatures start to rise in the late spring. Keep the tents tightly sealed during the coldest winter months, which also tend to have the lowest ambient humidity, but make sure that the medium is not saturated. If the medium is too wet, open the plastic slightly until it dries out. Aim for a humidity level between 50 and 70% during the warmest and driest hours of the day, but water if humidity declines below 50%. There should be a little condensation on the underside of the plastic, but not so much that it drips. As ambient air temperatures rise in the spring vent the tents more, and add humidifiers if it becomes too difficult to maintain humidity with watering alone.

Step 5. Evaluation of Rooting, Potting, and Care of Potted Rooted Cuttings

If the cuttings were started in November, the first stems will probably have rooted in about three months; if they were started in January it may take only two months. Because the cuttings should have leafed out by this time **(Fig. 6)**, and because their leaves will be adapted to the relatively high humidity conditions within the tents, it is important to avoid subjecting them to moisture stress during evaluation. It is thus best to do evaluations on overcast or rainy days, or early in the morning when ambient humidity is high. Spray over the tops of the leaves as soon as you open the plastic, and again whenever the leaf surfaces dry out, to prevent moisture loss.

Fig. 6. Cuttings breaking bud within two weeks of being placed in humidity tent. Note that these cuttings are shorter than we now recommend.

First, discard any cuttings that look dead—do not be alarmed if many are. If they produced leaves that then died, consider the stem dead **(Fig. 7)**. Also remove any leaves that have dropped, which may contribute to rotting. To evaluate for rooting, gently pull the cuttings out of the medium one at a time. If a cutting has not rooted, return it to the same position in the medium and evaluate it again in about three weeks. If it resists pulling, it likely means that it has either produced a large callous, in which case return it to the medium, or it has rooted. In either case, gently dig it out from the underside with your hands, taking care not to tear roots. If several cuttings have rooted adjacent to each other it is best to extricate them as a group and gently separate their roots in a bucket of water.

Fig. 7. Some cuttings started in Nov., 3 ½ months later, ready to be evaluated. Some have healthy leaves and have likely formed roots while others are dead and should be discarded.

Pot rooted cuttings **(Fig. 8)** immediately, to avoid allowing their tender roots to dehydrate. Use pots that are large enough to accommodate the root balls, but not much larger--3 to 4 inch cubic pots or tree bands are usually big enough—using a well-drained potting mix. We recommend a commercial bark-based potting mix plus perlite to enhance drainage. Use a 1:5 ratio of perlite to potting mix for pots; slightly less perlite for bands. To each gallon of mix also add about ¾ oz Osmocote ™ 15-9-12 + micronutrients. The slow release fertilizer is important because the plants did not receive any fertility from the rooting medium and thus will be starved for nutrients at this time. The nutrients will help them maintain shoot growth, which is important for survival.

Fig. 8. A well-rooted cutting.

Be sure to label the new plant to keep track of its genetic source. If the plant is top heavy it may need to be staked to keep it from falling over. Water each new plant immediately to settle the medium around its roots and immediately place it in a hardening-off chamber. The hardening-off chamber will maintain high humidity because of all the moisture in the potting mix if it is full of plants, but if it is not full it can be helpful to place a tub of water inside it to help keep humidity up.

The hardening-off chamber is an additional humidity tent set up like the rooting chamber but without the rooting medium. Because the leaves on the rooted cuttings emerged and grew under conditions of relatively high humidity they likely lack some of the mechanisms that leaves normally

use to control moisture loss, such as being able to control stomatal opening and closing, and having a waxy cuticle. So it is important to allow them to adapt to drier air conditions gradually. This is accomplished by keeping the hardening off chamber closed for the first two or three days but starting to open the plastic it for a few hours at a time after that, incrementally opening the plastic wider or for more hours each day. After about two weeks the potted cuttings should be ready to be moved out onto a greenhouse bench. The same process can be used to acclimate them to outdoor conditions when the weather allows.

Fig. 9. An exceptionally good looking rooted cutting which was up-potted to a larger pot in mid-summer. We wish they all looked this good!

We have obtained up to 90% survival of rooted cuttings managed this way, though sometimes it is only 50%. The cuttings most likely to survive are those with healthy new shoots that continue to grow after rooting. The rooted cuttings should be up-potted to larger pots **(Fig. 9)** if roots are observed to start growing out the holes in the bottoms of the pots. They should not be transplanted to the field until the fall, to avoid summer heat stress. Early September is best, but they can be planted any time until the ground freezes. Setting new buds before winter is essential for overwinter survival.