

## Fact Sheet #2—Planting and Establishment

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### Introduction

This fact sheet provides practical advice on cost-effective planting and establishment methods for hazelnuts that are based on grower experience and university research. For growers new to establishing woody plants, it is a good idea to plant a small number of hazelnut plants the first year, to gain experience before establishing a large-scale planting. Growing hazelnuts for profit is a challenge, given the long pre-production phase and a break-even timeline that can be as long as 10 years. Most growers can't afford either the lost time or money of a failed planting. Perhaps the biggest contributor to failure is "February blight", where growers learn about hazelnuts in January, order plants in February, and plant them in the spring without having done adequate planning or site-preparation. Planning ahead is the very best way to ensure establishment success.



**Photo 1.** Hazelnuts are slow to establish and require careful planning and management in the early years, but the payoff is decades of low-input nut production.

### Site Selection

The two hazelnut species native to the Upper Midwest, American hazelnut (*Corylus americana*) and beaked hazelnut (*Corylus cornuta*), are both widely adapted across the Upper Midwest and will do well on sandy soils, heavier clay soils, and everything in between. However, as with most plants, hazelnuts are most vigorous on well-drained loamy soils with high fertility. Optimal soil pH is not known, but as with soil types, hazelnuts are widely adapted and occur on a range of pH from 4.5 up to 7.5. Both native species are hardy to Zone 3. As such, American hazelnut or beaked hazelnut can be grown pretty much anywhere in the Upper Midwest.

The two native species are generally not productive enough for commercial production, so most growers are planting hybrid hazelnuts that originated from interspecific crosses between American hazelnut and European hazelnut (*Corylus avellana*). (See Fact Sheet 1 in this series for more information about choosing hazelnut plants.) The hybrids also perform well across a broad range of soil types, but because European hazelnut is only hardy to USDA Zone 7, the hardiness of the hybrids will vary based on their parentage. The hybrid cultivars being released by the Upper Midwest Hazelnut Development Initiative have all been tested in the Upper Midwest and are hardy to USDA Zone 3. Hybrid cultivars from other regions are only now being tested in the Upper Midwest, so winter hardiness is not fully known.

## Timeline of Establishment

### Year 0—Preparation Year

- Order plants
- Eliminate perennial weeds
- Eliminate compaction
- Soil sample, and address any deficiencies of P, K, and non-leachable micronutrients
- Lime if needed to raise the pH to 6.0
- Build soil organic matter with compost, manure and/or cover crops
- Establish permanent vegetation in alleys
- Till the planting strip in the summer or fall, especially if planting the following spring

### Year 1—Establishment Year

- Transplant
- Water as needed
- Protect from herbivores
- Implement weed control system
- Install tree tubes

### Years 2 and 3

- Continue watering, maintaining weed control, and protection from herbivores as needed, gradually tapering off as plants get established
- Remove tree tubes in the spring of the 2nd year
- Keep alleys mowed

## Field Selection

Hazelnuts can be grown just about anywhere except for poorly drained soils that experience waterlogging. Hazelnuts grown in hedgerows are a good option for sloped fields, where their deep roots together with the roots of other perennial vegetation in the alleys can help hold soil and prevent erosion. However, if the hazelnuts are to be harvested with straddle-type harvesters, the slopes should not be too steep. In general, if a slope is not too steep for a tractor, it will not be too steep for mechanical harvesters as long as the harvesters have hydraulic leveling capability.

Hazelnuts (and catkins) are a food source for a range of wildlife, including jays, squirrels, deer, and turkeys. Hazelnut plantings located adjacent to woodlots or other wild areas are likely to experience significant browse and nut loss. If maximizing nut production is the goal, the planting should be located as far from wild areas as possible, and vegetation around the planting should be kept short. If grower objectives include improving ecological services from the land, then locating plantings along waterways in riparian buffers, in windbreaks, or adjacent to woodlands as early-successional shrubland can provide a wide range of ecological benefits along with a hazelnut crop. However, some nut loss will have to be accepted.

## Planting Layout

### Whole-Field or Strip Preparation?

Once a field is chosen, the first decision is whether to prepare the entire field or to prepare just the planting strips. This decision is based in part on existing vegetation and in part on available equipment. Strip preparation works well if the existing vegetation is desirable and if equipment is available to manage strips that are 3-4 feet wide. By preparing only strips, soil disturbance is minimized, which helps preserve soil ecology and prevent soil erosion, especially on slopes. This also eliminates the need to establish new cover in

the alleys. However, if the field is dominated by rhizomatous or other difficult-to kill perennial weeds it is generally best to do whole-field preparation, because these weeds are much easier to eliminate before planting than afterwards, and because these weeds are likely to reinvade the planting strip if left in the alleys.

If there is slope to the field, orient the strips along the contour such that the strips are perpendicular to the slope. Keyline design can be effective at slowing and capturing rainwater and snowmelt, which is especially desirable on erodible soils or drought-prone soils. More information about this site layout technique can be found at [Keyline Water Management](#).

### Row and Plant Spacing

At this time, there are no definitive recommendations for between-row and in-row plant spacing for the hedgerow hazelnut system, though research is underway to develop such recommendations. Optimal spacing will depend on soil type, the genotypes being grown, and the equipment used for plant size management, alley management, and harvest. For now, most growers are using a 15 ft between-row spacing and a 6 ft in-row plant spacing. On more marginal sandy or heavy clay soils, especially in Northern Minnesota and Wisconsin, a tighter spacing of 12 ft between-rows and 4 ft between plants is recommended. Hazelnuts can also be grown in diversified systems with other crops, in which case, more space between rows may be necessary to accommodate the other crops. The Savanna Institute's [Planting Tree Crops](#) book is a great resource for anyone interested in multi-species agroforestry plantings.

### **Site Preparation– Year 0**

“Year 0” is a term used to describe site preparation that is done before planting, including controlling weeds, testing and amending soil, and cover cropping. If planting into a former row crop field, not much preparation may be needed, but if planting into sod, an entire year may be needed. In that case, Year 0 would be the year before a spring planting or the spring and summer before a fall planting.

### Spring or Fall Planting?

Like most woody deciduous plants, hazelnuts can suffer from transplant shock when transplanted in full leaf. In response, they may drop their leaves and go into premature dormancy, which weakens them. Although this can be mitigated somewhat by using tree tubes, it is better either to wait until early fall to plant leaf-on containerized plants, or to plant them when they are dormant, either in the spring or fall. Bare-root dormant plants are generally planted in the spring whereas containerized plants are generally planted in early fall.

### Control Perennial Weeds

Like all plants, hazelnuts establish best with minimal competition from weeds. Perennial rhizomatous weeds, such as quackgrass and thistles, can be the most problematic. Options for removing these weeds in year 0 include applications of systemic herbicides like glyphosate (Round-Up® ), tillage, and/or smothering.

- Applying glyphosate or other broad spectrum herbicide in year 0 is referred to as a “burn-down” treatment. It is intended to kill all vegetation to enable starting over with more desirable vegetation, like a cover crop. To be most effective, the herbicide must be applied on photosynthetically active weeds that are 6” tall or less. If the weeds are too tall, mow them first, wait for regrowth, and then spray.



**Photo 2.** The goal of the establishment phase of a new hazelnut planting is to provide optimal growing conditions within the planting strip while establishing a perennial crop between the strips.

- Tillage or clean cultivation can also be effective, but it may need to be repeated several times (whenever regrowth is observed), and it will reduce organic matter and soil quality.
- Landscape fabric, black plastic, or other heavy duty barrier installed in the spring and left there all year can be effective in smothering out weeds, but is too expensive to be practical on a large scale.
- Cover cropping is an effective way to suppress annual weeds, but cover crops are not effective at suppressing already established perennial weeds. Therefore, it is necessary to remove any perennial weeds with other methods before establishing a cover crop.

However it is done, the goal is to remove perennial weeds at least from the planting rows and ideally from the entire field in year 0. Because every situation is different, a site visit with a county Extension agent or agronomist is recommended to develop a weed removal program specific to your soils, weed complex, and willingness to use herbicides.

### Test and Amend the Soil Fertility

Improving soil quality is challenging and making large improvements takes many years. For the most part, the soil is what it is. One thing that should be done regardless of soil type is to take a soil sample and amend any nutrient deficiencies, particularly for immobile nutrients such as phosphorus (P) and potassium (K), that are best incorporated into the soil prior to planting.

To take a soil sample use a soil probe or shovel and pull a minimum of 10 samples evenly distributed across the field. If there are distinct differences in soil color or texture between different parts of the field, sample them separately because they may have different requirements. Testing the soil to a depth of 10-12 inches is recommended for woody crops. Crumble and stir the sub-samples together in a five gallon bucket, put 2 cups of soil in a plastic bag, and bring the bag to your local Extension office to be tested for pH, P and K, and whatever other nutrients have been found to be limiting in your local area for your soil type. Your Extension office or testing lab can tell you what those are.

Although the optimal pH for hybrid hazelnuts in the Midwest is not known, and although wild hazelnuts have been observed to grow on soils with pH as low as 4.5, if your soil pH is less than 5.6 it would be advisable to lime it, as recommended in your soil test report. If your soil is also low in Magnesium (Mg), use dolomitic lime.

Fertilization recommendations for phosphorus and potassium have not been developed for hazelnuts in the Upper Midwest. Generally, soil test P levels for woody crops should be between 18-25ppm and soil test K levels should be between 110-140ppm. Your local extension agent can give you recommendations for how much fertilizer to apply and what kind, based on your soil test levels.

Deficiencies of secondary macronutrients, such as calcium, magnesium and sulfur, and micronutrients, such as boron, copper, iron, manganese and zinc, are also possible but unlikely. Micronutrient deficiencies are most likely with soil that is very sandy, exceptionally low or exceptionally high in organic matter, or exceptionally acidic or alkaline. Again, consult your local Extension office for recommendations, because for some of these nutrients, over-application can cause as much harm as good. Adding compost is a way to add micronutrients without risk of overapplication.

If fertilizer or lime is needed, it can be applied any time before planting to the entire field or just to the planting strip, but it should be incorporated with tillage equipment.

### Remove Soil Compaction

Any legacy subsurface compaction should be removed. Such compaction is most common in fields with clayey soils, but can occur in any field that has been plowed, even if the plowing was last done decades ago. The preferred method to remove compaction is deep ripping. Such ripping requires an implement that can get into the soil at the depth of the compaction, and enough horsepower to pull it. Ripping can be done any

**There are many ways to establish hazelnuts. The key is to find a system that works for your soil, weed complex, equipment, and budget.** Landscape fabric (top left) is very effective at suppressing weeds, as is a combination of wood chips and spot herbicide applications (top right). Drip irrigation in combination with woodchips (middle left) is helpful on especially droughty soils. Tree tubes help protect young transplants from herbicide drift and mower blight, which is especially important if the weeds get out of control (middle right). Mowing alone (bottom left) is rarely sufficient weed control because it is difficult to mow close enough to the plants. Planting hazelnuts on mounded windrows built from topsoil and compost is an option for wet or clay soils (bottom right).



time before planting, when the soil is neither too dry nor too wet. If done when the soil is too wet it can cause more damage than it solves. After ripping a field, avoid heavy vehicle traffic, especially when wet, to avoid re-compaction. In lieu of ripping, some growers have used oilseed radish as a cover crop, with their deep taproots creating channels through the compacted soil.

### Add Organic Matter

It is always beneficial to add organic matter to soil. The ideal would be to apply a 4-6" layer of well-rotted compost to the planting strip and incorporate it, but doing so at any sort of scale is likely cost-prohibitive. An alternative is to add a shovel-full or two to each planting hole and mix it with the soil immediately before planting. If compost or other decomposed organic matter isn't available, using cover crops as green manure is a good option, though growing high-volume green manure crops such as winter rye or vetch requires effective equipment and good planning to grow and incorporate the crop into the soil.

### Consider Cover Cropping

Once the perennial weeds are removed in Year 0, a leguminous cover crop, such as clover, alfalfa, or trefoil can be seeded and allowed to grow all year. The cover crop reduces weed growth and will improve soil quality. Then, in the planting year (year 1), the cover crop can be killed within the planting rows or suppressed long enough to get the hazelnuts established and growing. A good resource for those new to cover cropping is the [Midwest Cover Crop Council](#).

A key decision when including cover crops in your hazelnut establishment plan is whether the intent is to use the cover crop temporarily as a tool to hold the site and build soil (green manure) or whether the intent is to establish a crop that will continue growing long after the hazelnuts are planted. If the intent is to grow it, kill it, and plow it in before planting the hazelnuts, then the full range of cover crop options would be available. If the intent is to keep the cover crop growing after planting, then a low-growing perennial crop should be used to avoid shading the hazelnuts. White clover or the creeping grasses would work. Or, if taller-growing crops are grown, plans need to be in place to control the cover crop growth around the hazelnut plants to limit competition.

### Rototill the Planting Strips

Although it is possible to transplant into ground that has not been tilled, tilling makes transplanting much easier, no matter what planting method is used. A variety of tillage implements may be used, but the final result should be a friable loose soil, which will enable good root to soil contact at planting. Rototilling works well, but if the soil is coming out of sod, a heavier implement may be needed to break up the sod first, and multiple passes may be needed, with enough time between them for the sod to decay. If fall planting is planned, the strips can be plowed in the summer preceding planting. But if planning to plant in the spring, strips should be tilled the previous summer or fall to avoid having to till when the soil is too wet. The higher the clay content of the soil the more important it is to work the soil only when it is dry. This will also leave the planting strip bare so that it will dry out faster in the spring. This creates a larger planting window, making it more likely the ground will be ready when the bare-root dormant plants need to go in.

### Why Can't I Just Plant Into My Field, As Is?

Early advocates of planting hazelnuts recommended planting directly into hay fields or other established vegetation and letting the hazelnuts "work it out". The theory was that it forced the hazelnut to grow bigger root systems and because hazelnuts evolved in the savanna ecosystem they are adapted to competition with grasses. Grower experience has demonstrated over and over again that planting hazelnuts directly into vegetation and doing no weed control is a great way to kill hazelnut plants. This advice has cost growers money and has set the industry back, so it is not advised. University of Minnesota research has shown not only increased mortality and slowed early growth with lack of weed control, but reduced vigor and delayed nut production for years afterwards. Certainly, maintaining biodiversity and vegetative cover is a good idea,

	Bare-root dormant	Containerized
<b>Pros</b>	Easy to produce in outdoor nurseries and thus usually less expensive Less expensive to ship Can be mechanically planted	Can be planted any time the soil is workable. Can be held until planting conditions are right. High transplant survival if good quality plants to start with and if well cared for.
<b>Cons</b>	Must be planted soon after receipt Usually available in early spring when soil conditions may be too wet. Must be kept cool and moist while handling Require a loose soil to ensure good root to soil contact.	More labor intensive to produce at the nursery and thus generally more expensive. More expensive to ship Encircling roots can compromise longevity. Harder to transplant mechanically

but use weed control to establish the hazelnuts first. Once established, then a biodiverse mixture of vegetation can be established and maintained for years to come.

### Year 1—Establishment Year

#### Plant Material Options

There are two kinds of hazelnut transplants: bare-root dormant and containerized. Both have their advantages and disadvantages, but transplant survival can be equally good with both if plants are healthy to begin with and if they are handled correctly.

#### Pre-Plant Handling

*Bare-root dormant* plants, such as in Photo 3 (right), can be more challenging to plant because the root systems are larger and require a loose soil to ensure good soil-root contact. But, because the plants are dormant at planting, there is less transplant shock. If something goes wrong with bare-root dormant plants it is usually due to poor storage and handling prior to or during planting. The plants are usually shipped from the nursery in a plastic bag in a box with wet newspaper or peat moss covering the roots. The ideal is to plant the day the plants arrive, but that is not always possible, especially in the spring due to wet soils. So, before the plants arrive it is essential to have a plan for how to store them until you can plant. The cooler the storage conditions (but above freezing) the better, to keep them from breaking dormancy. Keeping them in their packing material is okay, but make sure the roots never dry out, and that the shoots can breathe, especially if they start to break dormancy. On planting day, remove the plants from storage only as needed and place their roots into a container full of water. Keep the roots in the water as you move down the row doing the planting. It is a bad idea to move the box of plants around the field all day, even if kept in the plastic bag liner. It does not take much to dry out and kill the root hairs!

*Containerized plants* are just that, grown in a container or pot. The larger the container, usually the more expensive the plant. Containerized plants are expensive to ship, but because the roots are in soil, they are more resilient in storage as



**Photo 3.** Containerized (left) and bareroot dormant (right) planting stock are both viable options for hazelnuts, but each has different needs for storage and planting.

long as they are kept watered. That is a big advantage for spring transplanting, when spring rains and muddy soils often delay planting. The downside is that transplanting leafed-out deciduous plants of any kind are susceptible to transplant shock, and hazelnuts are especially so. Thus, it is recommended that containerized hazelnuts be transplanted either when they are dormant, such as first thing in the spring, or in the fall after summer heat has passed. September is best because it gives roots time to grow into the soil before winter, but anytime before the ground freezes can work. If you have no choice but to transplant leafed-out plants in late spring or summer (such as if wet soil prevents planting earlier), grow tubes are essential to reduce transplant shock.

### Planting the Hazelnuts

#### *The Best Way*

The transplanting method described below is the most likely to ensure high survival, but not all steps are practical for large-scale plantings. With a little experience, you will learn which steps are critical and which can be skipped in your situation.

The first step to planting is to dig holes. The size of the holes depends on the size of the root systems. They should be about four to six inches wider and at least 2 inches deeper than the width and depth of the root system. Roots of bare-root dormant plants are flexible and can be spread horizontally, so their holes generally need to be wider than deep. Digging holes with a shovel requires almost no effort with sandy soils, and isn't very hard in loamy soils that have recently been rototilled and are at the optimal moisture content. But, it can be a chore for heavy clays, in which case a power auger might be easier. The excavated soil should be thoroughly broken up to look like coffee grounds, so it will be easy to use for backfill. For both clayey and sandy soils, it is a good idea to mix in compost or organic matter with the excavated soil at a 1:1 ratio. Never place granular fertilizer or fresh manure where it will come into direct contact with the roots.

The next step is to place the plants in the holes. A common planting mistake is to plant too deeply. The correct depth is the same depth as the plant was in the nursery or the pot. The crown (the point at which the roots connect to the stem) should be no more than one inch below the soil surface. Adjust this depth, if needed, by adding some of the excavated soil back into the planting hole.

For bare-root plants, spread the roots out in the hole, taking care that they don't criss-cross or point upwards at the side of the hole. Carefully cover them with the excavated soil and tamp it down lightly. The perfectionistic way to plant bare-root plants is to make a mound of soil in the center of the hole and drape the roots over it. If a few roots are so long that it is impractical to make a hole wide enough for them, it is better to trim them with sharp shears than to bend them.

For containerized plants, if the root ball is overly dense, or has circling roots, tease some of the roots loose before planting. If the roots are extremely dense, this may require some force or a sharp tool. Do not be afraid to cut them! They will be healthier for it in the end! Point the loosened roots towards the outside of the hole to train them to grow into the soil before backfilling the hole and tamping it down. It is crucial to cover the root ball of a containerized plant with a thin layer of soil or mulch soon after planting, as the potting mix will dry much faster than the surrounding soil if exposed to the air.



**Photo 4.** Using a tree planter to plant directly into sod or a perennial cover crop is a fast establishment method, but is risky. When it works it can save significant expense, but the weed competition alone can result in complete failure, not a risk most growers are willing to take. If attempted, it requires a dry soil with excellent tilth and a good weed control program in the planting year and year after planting.

Ideally, water when the hole is half-filled, to settle the soil and ensure good root to soil contact, and then add the rest of the soil and water again. However, it is more practical to water all plants at once after finishing planting. Lightly tamping down the backfilled soil with your hand or foot and then watering is usually good enough to ensure good root to soil contact. It is helpful to shape the soil into a shallow basin, about one inch deep, to keep the water from running off. Water deeply, but not with so much force that it washes soil away from roots.

### *A Faster Method*

Planting hazelnut plants by hand is the ideal, but is incredibly labor intensive, especially with bare-root plants. The use of an auger to dig the holes saves considerable effort. The auger should be at least as wide as the root system and preferably 6" wider or more. The soil should come out of the ground loose and friable. If not, it is probably too wet for planting. Either stop and wait for drier conditions or use compost to amend the excavated soil before backfilling. Once the hole is dug, adjust the depth and while holding the plant, backfill with the excavated soil.

### *Speed At All Costs*

It is possible to plant large acreages with an auger. Thousands of acres are planted that way in Oregon every year. However, for large scale plantings when labor is hard to find, a tractor pulled tree planter can be used, but the soils need to be loose and friable and it only works for bare-root dormant plants or small containerized plants. Many local DNR offices own a tree planter and will loan it out at nominal cost. The problem with the tree planter is all the roots get forced into a narrow planting slit and root to soil contact is not ideal, so survival is reduced. However, the method is very fast.

### **Watering**

Once they are established, hazelnuts are very drought tolerant, due to their deep fibrous root systems. However, watering is essential during the planting year as the root systems are still small. How much water they need will vary depending on precipitation, soil type, size of plant, stage of plant growth and level of weed control. Plantings on clayey or loam soils with good weed control that receive a few timely rains after planting might never need to be watered during the establishment phase, except immediately after planting, especially if they are mulched with a thick layer of woodchips. However, if the planting is on sandy low-organic matter soils that dry out quickly, growers will need to make plans for providing water before the need becomes critical. The general rule of thumb is to provide 1" of water per week over the entire rooting area, whether from rain or irrigation. A more precise method is to use soil moisture meters or evapotranspiration models to determine when and how much supplemental water is needed. For more information see the [Methods to Monitor Soil Moisture](#) guide published by UW-Extension.

One option for watering during establishment is a water tank pulled through the planting, with someone walking behind using a hose or buckets to deliver water to each plant. Drip irrigation is a much less labor-intensive option. A single half inch poly line in each row with two half gallon per hour emitters at each plant is sufficient. How long the rows can be and how many rows can be watered at a time depends on the volume of water delivered by the well or pump, slope, and the distance from the source to the plants. With minimal maintenance, drip irrigation lines can last multiple years. The [Basics of Drip Irrigation](#) report published by the University of Wisconsin is a great resource for anyone new to drip irrigation.

The need for irrigation after the establishment phase has not yet been determined for hazelnuts in the Upper Midwest. Although the bushes themselves are extremely drought tolerant, kernel yield may be adversely impacted by even a short duration summer drought that occurs during the critical three-week period when nuts are filling in July or August. So investment in drip irrigation may pay off with improved nut quality, even on good soils.

## Weed Control

### The Importance of Weed Control

The importance of good weed control during establishment cannot be overemphasized. Weed competition for soil moisture, nutrients and sunlight can significantly reduce growth and even survival.

#### [Options for Weed Control in Hazelnut Plantings](#)

describes preliminary results from a University of Minnesota weed control experiment established in spring 2013. By fall 2015, bushes with good weed control were significantly larger than bushes with no weed control. The more effective the weed control, the larger the plants. However, there were no differences between the different methods of weed control, as long as the method was applied to a strip that was at least three feet wide. By contrast, growth when weed control was applied only to a small 1.5-foot wide ring around each plant was only slightly better than no weed control. By fall 2019, yield

suggested that good weed control in the first three years pays off with earlier and higher yields, even when there is no additional weed control other than mowing after the first three years: four-year cumulative yields were on average four times greater for plants with the best combination of treatments than yields from plants that had only been mowed.

### Weed Control Methods

It is important to have a weed control plan in place before planting, as growers are often surprised at how fast weeds can move in and quickly overwhelm a hazelnut plant. As any grower will attest, it is much easier to prevent a weed problem than to fix one. Weed control practices for hazelnuts (and all perennial shrubs) fall into four main categories: mowing (by machine or animal), weed barriers (biomass mulches or plastic), cultivation (by hand or machine), and herbicides.

#### *Mowing*

Mowing with a lawn mower, weed whip, or other tool is an important part of a weed control strategy, but by itself does not provide the level of control needed during the establishment phase. Regular mowing is effective at preventing competition by shading, but is not effective at preventing competition for moisture. The reality is that most growers get behind on mowing and the hazelnut plants suffer. Once the weeds get taller than the plants, it can be difficult to see them and the chance of accidentally mowing them increases. If mowing is going to be the primary weed control strategy, then 15" grow tubes are highly recommended, because they make it easier to see the plants and they allow for rescue herbicide applications, if necessary.

Using livestock for weed control is the dream of many growers, as the animals do all the work. Goats, which are browsers, are not recommended, but growers have tried horses, cows, sheep, and poultry, with varied levels of success. During the establishment year the room for error is minimal, so the risks of browse or trampling may not be worth it. Well-anchored tree tubes or cages can be used to protect the hazelnut plants, but larger animals will sometimes use the tubes or cages for scratching. For this reason, larger livestock are best used in a flash grazing situation, where they are in the planting only for short periods of time when the herbaceous vegetation is abundant and more attractive to them than the hazelnuts. Do not let them linger or stay in the planting overnight. In contrast, poultry work very well at eating and trampling weeds and pose



**Photo 5.** The University of Minnesota has been conducting weed management trials since 2013. Results to-date suggest that a combination of weed control treatments is the most effective at controlling weeds and will result in better early growth. The goal of the trials is to determine whether any increase in nut yields is worth the economic costs of the various weed control treatment.

less of a risk to the hazelnuts, but tubes or cages are still recommended while the hazelnuts are still small.

### *Organic Mulches*

Wood chip mulch can be a very effective method of weed control. It also adds organic matter to the soil as it breaks down, and conserves soil moisture, thus reducing (or eliminating entirely) the need for irrigation. Wood chips need to be thick enough to completely block out sunlight in order to prevent annual weeds from germinating. Three inches is a minimum, but thicker layers will provide longer lasting control, provided they are not so thick as to smother the young plant. Woodchips also need to cover an area at least three feet in diameter to be effective. Apply them as a donut rather than a volcano, with only a very shallow layer immediately adjacent to the plant.

Wood chips can also be expensive and hard to find, especially the volumes needed to apply them thickly enough, so this option is best for those with a ready source of free or low cost chips, such as from a utility or municipality. Be careful not to use chips that contain weed tree seeds, as these will germinate and become a weed problem themselves. Spreading woodchips on a large scale can be done with a mulch spreader made for the purpose, or with a silage wagon with a side chute. Other sources of organic matter, such as straw, grass clippings, or leaves, can also be effective as a mulch, but they tend to break down quickly and lose effectiveness within one growing season.

Although they are very good for controlling annual weeds, organic mulches are worthless in suppressing perennial weeds, especially quackgrass and other rhizomatous grasses. Hand-pulling grasses from woodchips in particular is not easy, so spraying with a contact herbicide such as glyphosate (Round-Up®) is about the only viable option if quackgrass grows into your woodchips. That is why it is best to eliminate rhizomatous grasses entirely before planting.

### *Weed Barriers*

Another form of weed barrier is landscape fabric. Fabric is extremely effective at suppressing weeds, with the exception of the weeds that grow up through the planting hole, which should be removed by hand because they can smother the hazelnut. Up-front costs for landscape fabric may be higher than for other methods of weed control, especially for good quality fabrics, but since woven polypropylene fabrics will last well beyond the establishment period when weed control is critical, they might be cost-effective in the long run. However, eventually even the best landscape fabric will fail. Either holes will develop in it, or debris that supports weed growth will collect on top of it. When this happens, the weeds that grow through it, especially rhizomatous grasses and weed trees, will be even more difficult to remove than they would have been without it, as will the fabric itself. Even the thin plastic mulches used by vegetable growers, which can be effective but generally last only a year, are a pain to remove. Use of biodegradable or photodegradable barriers, would eliminate this problem, but they may not last for the three years recommended for good hazelnut establishment.

### *Cultivation*

Mechanical cultivation is an effective and fast method of weed control. Several types of cultivation tools designed specifically for weed control in woody crops are available, such as the eco-weeder (Photo 6) and the



**Photo 6.** Specialized equipment for cultivating in shrub and tree plantings should be considered for larger-scale plantings. Equipment such as the Eco-Weeder™ shown here or the weed badger allow the operator to cultivate weeds between the plants.

weed badger, which can move in and out between woody plants in a row. These tools are worth consideration for growers establishing big plantings. Repeated shallow cultivation when weeds are still small is most effective, as it does not bring new weed seeds to the soil surface to germinate. Shallow cultivation—less than one inch—also limits damage to hazelnut roots, which is a concern about cultivation. Other concerns about cultivation are that repeated disturbance of the soil is likely to reduce soil quality and contribute to erosion. However, erosion can be limited by laying rows out on the contour, with perennial vegetation in the alleys, and the damage to soil quality over three years of cultivation are likely to be more than offset by the gains in soil quality from planting a long-lived perennial crop.

### *Herbicides*

Herbicides are a fast and effective weed control option, but if not done correctly can cause significant harm to the applicator, the hazelnut plants, and the environment. If growers decide to use herbicides, it is recommended to meet with a local Extension agent or agronomist to develop a specific herbicide use plan and to confirm the herbicide is labeled for use with hazelnuts.

There are four general herbicide options. 1) Pre-emergent herbicides that prevent weeds seeds from germinating. Pre-emergent herbicides such as oryzalin (Surflan®) will prevent weeds from germinating for two to three months, and will not damage hazelnuts, making them easy to apply. However, pre-emergent herbicides are not effective against already-established perennial weeds like quackgrass or thistles. 2) Contact burn-down herbicides, such as acetic acid, that kill whatever green tissue the herbicide touches. 3) Non-selective systemic herbicides like glyphosate (Round-Up®) that are translocated throughout the plant, including to the roots. 4) Selective post-emergent herbicides to kill grasses.

More care is needed in applying non-selective contact or translocated herbicides because they can damage hazelnuts. A common approach is to use these herbicides for secondary weed control, via spot applications to kill weeds that have escaped primary weed control. By using a backpack sprayer and a shielded nozzle, the herbicide can be applied very close to the hazelnut plant without the herbicide contacting the plant, but it needs to be done carefully and in low wind conditions. A safer (and faster) approach is to protect the hazelnut plants from the herbicide with tree tubes. If the main weed is grass, then a selective post-emergent herbicide like sethoxydim (Poast®) can be sprayed in the planting strip to kill the grasses without damaging the hazelnut plants, but must be done when the grass is less than 6" tall.

### **To Tube or Not To Tube**

A University of Wisconsin-Extension study comparing the survival and growth of hazelnuts grown in 15" and 30" tree tubes, to plants grown with no tube, found that tree tubes increased both survival and growth. (See [Effect of Tree Tubes on Hazelnut Establishment and Growth.](#))

However, the 30" tubes resulted in tall plants that were prone to blowing over in the wind once loaded with nuts (Photo 7), though this was a temporary problem, because stems growing outside of the tubes eventually overtook the spindly stems and provided stability. In the long-run, tree tubes had no significant effect on either bush size or nut yield, but they did make it easier to establish the plants, by providing protection against



**Photo 7.** Tree tubes are effective at hastening hazelnut growth and do a great job protecting the plants from herbivory, wind, and mower/herbicide damage, but a 30" tube shown here results in top heavy stems that can lodge once they start producing nuts. For this reason, 15" tubes are recommended instead, and for the planting year only.

herbivory, mowing, cultivation and herbicides. Whether they are worth the additional cost and labor for installing them will depend on your unique situation. If you do use them, we recommend 15 inch tall tubes secured with one, and preferably, two stakes.

### **Nitrogen Fertilization**

Fertilization is not something that growers should need to worry about during the first two or three years, especially not if the soil was tested and amended before planting as recommended, with the exception of nitrogen (N). Although most soils in the Upper Midwest have enough organic matter to supply the needs of hazelnuts during their establishment phase, sandy and other low organic matter soils may not. Suspect N deficiency if your hazelnut plants are growing slowly or have a pale leaf color, and there is no other plausible cause. Nitrogen recommendations for hazelnuts in Oregon are based partly on leaf analysis. The more deficient the plant, as determined by leaf analysis, the more N is needed.

To do leaf nutrient analysis, collect leaf samples in late July or early August. Recommendations are calibrated to this time frame, so samples collected at other times are not useful. Pick the 1<sup>st</sup>, 2<sup>nd</sup> or 3<sup>rd</sup> fully developed leaf from the terminal end of a stem. That is, ignore all the immature leaves that have a brighter green color on the stem tip, and collect the next leaf, one per stem. Collect 20 to 40 leaves from different parts of the plant or plants you are concerned about, collecting only leaves that look typical of those plants. As with soil sampling, if there are distinct parts of the planting that appear to be performing differently, sample them separately. Do not include leaves that are damaged, or dirty, or from stems that bear a developing nut cluster. Dry the leaves (a food drier works well, as does a sunny window), then send them to a lab or your county agent for analysis.

Research at the University of Minnesota suggests that the leaf N deficiency-sufficiency thresholds for hybrid hazelnuts in the Upper Midwest are roughly the same as those defined for European hazelnuts in Oregon. The more deficient the plant, the more N is needed, and the larger the plant, the more N is needed to address a given level of deficiency. Not only do larger plants need more, but they are also capable of taking up more. Fertilizing a small plant the same as a large plant is like feeding a baby like an adult: most ends up on the floor. Wasted fertilizer is polluting. The recommendations in Table 1 are tentative until further research is completed.

Plants take up N fertilizer most efficiently when they are fully leafed out and conditions are optimal for plant growth. This is because N uptake requires plant energy, which is most available when plants are photosynthesizing. Optimal conditions for plant growth are most likely to occur in mid-May through mid-July in the Upper Midwest, as long as soil moisture is optimal. The earlier N is applied in this window, the more time plants have to take it up before winter. Conversely, heavy rains in this period may leach N fertilizer out of reach of plant roots, contributing to N contamination of groundwater. The best way to avoid this is to use slow release or stabilized forms of N, such as polymer-coated urea, or urease and nitrification inhibitor-treated urea. These release N slowly over a period of months, matching the plants' ability to take it up, so little is wasted. Although these fertilizers are



**Photo 8.** Nitrogen applied without good weed control often ends up fertilizing the competition, in this case, the darker-colored grass near the hazelnuts. University of Minnesota research suggests that good weed control may be more important than fertilization, at least during establishment.

**Table 2.** Tentative nitrogen recommendations based on leaf analysis and plant size.

Leaf N Analysis (%)		Apply this much N	
		Oz per cubic yard of plant volume <sup>1</sup> (g per cu m)	Lbs per acre <sup>2</sup> (Kg per Ha)
< 1.8	Severe Deficiency	2 (74)	76 (84)
1.8 – 2.2	Deficiency	1 (37)	38 (42)
2.2 – 2.5	Sufficient	None until nut bearing, and then apply N based on amount of N exported with harvest. <sup>3</sup>	
>2.5	Excess	None	

<sup>1</sup> Plant canopy volume is calculated as plant canopy area times plant height, where canopy area is calculated as a circle based on plant width. Use the average size of plants in your planting. Note that plants are not likely to reach 1 cubic yard in canopy volume until three or four years after planting. So until then the amounts of N needed per plant will likely be fractions of ounces. One ounce is about 1/3 cup of 46-0-0 granular fertilizer.

<sup>2</sup> Lbs per acre are calculated assuming 12 by 6 foot plant spacing, for 605 plants per acre, and an average plant canopy size of one cubic yard, and thus will need to be adjusted depending on your plant density and plant sizes. Based on this calculation, the amount of N actually applied will increase as the plants grow. However, in no case should more than 100 lbs N per acre be applied.

<sup>3</sup> Recommendations for applying N based on harvest exports will be discussed in Fact Sheet 3.

more expensive, they are worth it.

After applying N, watch to see if there is a response. The most immediate response is likely to be in a darker green leaf color but it may take more than a year for this to be translated into a growth response. Collect leaf samples again the July/August following application, to determine if more N is needed.

Fertilization becomes more important as nuts are harvested from the plants. The higher the yield, the more nutrients are removed. Although woody plants cycle nutrients tightly, sustaining yields over time will require adding back the nutrients that are removed with harvest. If husks are removed along with the kernels and shells, then the nutrients contained in the husks will also need to be returned in fertilizer. Nitrogen, which is abundant in the protein of hazelnut kernels, and potassium, which is abundant in hazelnut shells and husks, will both need to be returned in proportion to yield. Fertilization for the production phase of hazelnut culture will be discussed in greater detail in a subsequent hazelnut bulletin.

The Upper Midwest Hazelnut Development Initiative is a collaboration of the University of Wisconsin, University of Minnesota, and early-adopter hazelnuts growers across the Upper Midwest. For more information about the UMHDI visit [www.midwesthazelnuts.org](http://www.midwesthazelnuts.org). For questions about this Fact Sheet contact [jason.fischbach@ces.uwex.edu](mailto:jason.fischbach@ces.uwex.edu).

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