Planting and Care of Fine Hardwood Seedlings

Hardwood Tree Improvement and Regeneration Center
Northern Research Station
USDA Forest Service
Department of Forestry and Natural Resources
Purdue University

# Weed Competition Control in Hardwood Plantations

***John R. Seifert,*** *Division of Forestry, Indiana Department of Natural Resources*
***Marcus F. Selig and Robert C. Morrissey****, Department of Forestry and Natural Resources, Purdue University*



## Introduction

Controlling or eliminating weed competition is an essential component of hardwood plantation establishment (Bey et al. 1976). Plantations are commonly established on abandoned agricultural fields with an existing seed bed and rootstock of undesired plants. Fast-growing herbaceous weeds such as grasses, sedges, and broad-leaved plants or undesired woody perennials such as trees, shrubs, and vines will out-compete slow-growing hardwood seedlings.

The specific weed species present will be dependent upon past land uses as well as surrounding land uses and species. Landowners will likely encounter several species of native weeds, as well as invasive woody species such as multiflora rose (*Rosa multiflora* Thunb.)*, ailanthus (Ailanthus altissima* (P. Mill.) Swingle)*, autumn olive* (*Elaeagnus umbellata* Thunb.), or honeysuckle (*Lonicera* L. spp.) (Fig. 1). Regardless of the origin or species of weeds, they will provide competition with planted seedlings for nutrients, moisture, and light. If weed competition is un-managed, it will result in reduced seedling growth, vigor, andsurvival. High densities of weeds may also provide food and habitat for mammals that will damage or destroy seedlings through girdling and browse (Erdmann 1967).

In order to manage competition efficiently and economically, a land manager must first consider the weed species present, their stage of growth, the crop trees being managed, and existing site characteristics. When determining the optimal weed management strategy, it is also important to consider the landowner's projected economic and time inputs, as well as final objectives. The three general approaches for controlling weed competition are mechanical, chemical, or physical systems. All methods require varying amounts of time and economic inputs, and may differ in effectiveness dependent upon site conditions and competition with undesirable species. Regardless of which system or combination of systems is implemented, weed control should be applied for the first 2 to 3 years of plantation establishment, or when the trees have reached a height that will allow them to grow free of competing vegetation (Fig. 2).

***Figure 1.*** *Clockwise beginning from top left: Amur honeysuckle (Lonicera maackii (Rupr.) Herder); ailanthus (Ailanthus altissima (P. Mill.) Swingle); autumn olive (Elaeagnus umbellata Thunb.); and multiflora rose (Rosa multiflora Thunb.).All are aggressive non-native invasive species commonly encountered in Indiana.*
*(Photos courtesy of Zach Lowe)*

***Figure 2.*** *Two mixed hardwood plantations after 3 years with no weed competition control (left) and frequent mowing to control competition (right).( Photos courtesy of Nathan King)*

***Figure 3.*** *Frequent mowing between planted rows can be a simple, effective means to reduce competition for seedlings. (Photo courtesy of Francis K. Salifu)*



## Mechanical

Mechanical weed control involves either mowing or cultivating around planted seedlings. Both mowing and tilling have been found to be beneficial to plantation establishment, increasing growth, survival, and nutrient uptake (Kennedy 1984). While often successful, the effects of mechanical weed controls are short-lived and may need to be repeated five to six times per growing season. Mechanical cultivation is very effective for removing existing vegetation; however, it also creates favorable growth conditions for existing seed beds of undesired vegetation and may increase future growth of competition. Hansen et al. (1984) found it necessary to cultivate planted areas every 10 days in order to receive complete weed control. For this reason, it is common to use mechanical weed controls in combination with longer-lasting chemical treatments. Land managers who are planning to use any type of mechanical weed control after planting should consider this when designing the planting area. It is important to create enough distance between planting rows to allow for disking or mowing between seedlings. One-way mowing or tilling (between rows) is most common in hardwood plantations, as cross-tilling (between and across rows) requires planting on a near perfect grid. When tilling after planting it is beneficial to leave a buffer for root growth of at least 6 inches (Seifert 1993). Hansen et al. (1984) found that cultivation decreased survival when compared to herbicides alone. This was likely a result of the disk plows cutting and damaging seedling roots near the surface of the soil (Zutter et al. 1987). Controlling weed competition becomes unprofitable when crop trees are mowed down. It may be advisable to define planting rows with tall markers at regular intervals. This will serve to limit unintentional mechanical damage to planted seedlings in cases where an inattentive landowner allows competing vegetation to take over planted seedlings.

**Mowing.** Mowing is most often the easiest form of weed control to implement. Consistent and careful mowing allows planting rows to remain clearly defined, facilitating subsequent weed control systems and other plantation operations (Fig. 3). When a landowner intends to maintain a plantation with frequent mowing, it is wise to consider the size of the mower- or bush-hog-deck when designing the plantation layout. Mowing will also benefit crop trees by reducing light competition, but will not likely reduce nutrient and moisture competition. On moist, fertile sites where these resources are not limiting factors, mowing alone may be a satisfactory weed control method if done frequently, although these types of sites are atypical. Conversely, on more nutrient deficient or drier sites, the benefits realized from mowing may be minimal or non-existent. In these situations it would be advisable to combine mowing with another form of weed control.

**Tilling.** Soil tillage, before and after planting, is commonly an effective means for improving soil characteristics and reducing vegetative competition (Fig. 4). In most soil types, tilling prior to planting serves to eliminate existing weed competition and also creates favorable conditions for planting operations, so long as the site is well-drained. Zutter et al. (1987) found tilling to be more effective than herbicides when competition was composed of mainly woody or semi-woody species. Tillage provides elimination of perennial competitors while enhancing the growth of herbaceous weeds. Rotary


***Figure 4.*** *Tilling can improve soil characteristics and reduce vegetative competition on a site both before and after planting.*

tillers or disc harrows are most common in plantation settings and should be set to a depth just deep enough to uproot vegetative competition. Again, it is important to consider the width of the tiller to be used when designing the plantation layout.

## Chemical

Chemical application is often the most efficient method of weed control, but requires knowledge and skill to use safely and effectively. Herbicide use and registration is controlled by Federal and State agencies. Unfamiliar users should contact local agencies or professional foresters to determine any restrictions in their area. Herbicide labels are legal documents that provide necessary warnings, precautions, and acceptable application methods. Users should always read and comply with these instructions. It is unlawful to use herbicides for plantation establishment that are not labeled for "forest sites," "non-crop areas", or "tree farms". Many land owners are unfamiliar with herbicide labels and use, and may find it useful to hire a forest consultant with an herbicide applicators license to perform the herbicide application to their tree plantations.

Chemical weed control requires planning and preparation. A land manager must consider the species to be controlled, as well as the crop trees. Herbicides are designed to eliminate undesirable or problematic species through various modes of action. It is often necessary to apply several different herbicides in one application to eliminate all weed species present. Further, the common practice of mixed species plantings requires that herbicide selection be precise as various crop tree species may have different susceptibility levels to herbicides. By selecting the proper herbicide, application rate, and application time, the difficulty of herbicide application can be overcome. When planning a chemical weed control system it is also important for a land manager to consider the size of the area requiring weed control and the available application equipment.

**Pre-emergent herbicides.** Pre-emergent herbicides are designed to eliminate weeds before they are established. These herbicides are soil-active and must be incorporated into the soil through rainfall. Pre-emergent herbicides are most commonly applied prior to planting or before foliar emergence in the early spring (Fig. 5). Pre-emergent herbicides can provide effective weed control throughout the growing season, but the length of efficacy is dependent upon the rate of application, soil properties, and climatic factors. Control may sometimes be difficult when using only soil-active herbicides because the rates necessary to control perennial competitors may also be injurious to tree seedlings. However, when applied properly, Hansen et al. (1984) found that pre-emergent herbicides gave superior weed control when compared to post-emergent herbicides, cultivation, and the planting of cover crops.


***Figure 5.*** *Black walnut (Juglans nigra L.) plantation treated with pre-emergent herbicide before bud-break in spring. (Photo courtesy of Douglass .F. Jacobs)*

Common pre-emergent herbicides used for establishing hardwood plantations include simazine (Princep®) and sulfometuron (Oust®). These herbicides are regulated for general use, but must still be used with caution and in accordance with the products' label. Simazine is used to control broad-leaved weeds and annual grasses. At higher rates it may be used for non-selective weed control, but this will commonly have detrimental effects upon crop trees. Sulfometuron is a broad-spectrum urea herbicide that may be applied as a pre- or post-emergent, but is most commonly applied as a pre-emergent for hardwood plantation establishment. It is used to control broad-leaved weeds, and annual and perennial grasses. Sulfometuron may inhibit growth of woody species; therefore extra care should be taken not to harm crop trees through its application.

Pre-emergent herbicides are best applied late winter to early spring. This will allow the herbicide to become incorporated into the soil prior to the growing season, preventing weed establishment prior to planting. Efficacy, soil type, and rate of application of the soil-active herbicide will influence the length of time that should be observed between application and planting.

**Post-emergent herbicides.** Post-emergent herbicides are used after weed competition is established and actively growing. These herbicides are applied directly to the green foliage of existing weeds, and the chemical is then absorbed and translocated into the root systems of weeds. Post-

***Figure 6.*** *Post-emergent herbicides are applied directly to the vegetative foliage of actively growing weed competition. A properly timed application prior to bud-break of crop trees, but while competitors are actively growing, can be very effective in controlling competition.*



emergent herbicides are very effective, but must be applied directly to targeted species as they are likely to be harmful to actively growing crop trees (Fig. 6). Common post-emergent herbicides used in the establishment of hardwood plantations that are regulated for general use include glyphosate (Accord® and Roundup®) and picloram (Tordon RTU®). Picloram is a residual herbicide, that is to say, it is applied as a post-emergent foliar product, but the active ingredients stay in the soil and have residual control as well. Glyphosate is a broad-spectrum, non-selective, systemic herbicide. It is useful on essentially all annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants. Since glyphosate is a non-selective herbicide at all rates of application, it is necessary to either carefully shield crop species from over-spray or apply the herbicide after emergence of target species, but prior to emergence of crop species. Picloram controls a wide range of broad-leaved weeds except mustards, but is ineffective against most grasses.

Throughout the Central Hardwood Region, old field vegetation will commonly be green before the planting season is over. This is often the ideal time to apply post-emergent herbicides. Because many post-emergent herbicides are not soil-active, they may be applied immediately prior to planting without causing detrimental effects to crop trees. This same methodology of application may also be effective for subsequent years, so long as application is done prior to bud-break of crop trees, but while competitors are actively growing. Directed application of post-emergent herbicides may also be accomplished after crop tree emergence, but great care must be taken to limit contact with target species.

**Pre- and Post-emergent combinations.** The most effective and cost efficient weed control may be accomplished through an application of a pre- and post-emergent herbicide combination. A properly timed, one-time application of such a combination will provide control of existing perennial vegetation and prevent the establishment of residual annual vegetation throughout the year. Use of a properly calculated one-time application will prove beneficial by reducing material costs, time expenditures, and trafficking of the planting site.

Several other pre- and post-emergent herbicides may be used for effective weed control in the establishment of hardwood plantations, but are generally restricted for use by the general public. If a landowner is unable to effectively control vegetative competition with the above described general-use herbicides it may be necessary to contact a certified applicator, professional forester, or local government agency to obtain more chemical control options.

**Application methods and equipment.** Herbicides may be applied to hardwood plantations using various methods and equipment. Selection of the proper application method will be dependent upon the terrain and size of area to be treated, height of weeds and seedlings, and type of herbicide being applied. Herbicides are commonly applied to hardwood plantations by broadcast, band, or spot applications. The chosen method of application will dictate the equipment to be used. Chemical weed control of hardwood plantations throughout the Central Hardwood Region is commonly accomplished through the use of tractors or all-terrain vehicles (ATV) with mounted boom sprayers, or with backpack sprayers. Regardless of the type of equipment used, it is vital to properly calibrate the herbicide output through nozzle selection and speed of application (Holt 1993).

A broadcast application refers to the treatment of the entire planting area. This method is only performed prior to planting or before crop tree foliage has emerged, as contact with crop trees is almost guaranteed. Broadcast application is commonly the most expensive method of chemical application, as it requires the greatest amount of chemical, although this will also depend on the cost of the herbicide and the equipment available. Flat, open fields commonly allow broadcast application with a tractor-mounted boom sprayer (Fig. 7). Broadcast application may also be achieved aerially with a helicopter, but this is less common as plantations must be of adequate size to make this economically practical (generally greater than 50

***Figure 7.*** *Broadcast application of herbicide with a tractor treats the entire planting area non-selectively and must be conducted prior to crop species bud-break. (Photo courtesy of Zach Lowe)*

***Figure 8.*** *ATV with mounted boom sprayer can be very useful for small planting areas or uneven terrain. (Photo courtesy of Ron Rathfon)*

acres) (Miller 1993). ATV-mounted boom sprayers may also be used for broadcast applications. While an ATV's boom size may be limited, ATV's are often better suited than tractors for handling rough terrain, tight rows, and small fields.

Band- or strip-application involves the treatment of individual planting rows, but is only advisable when rows are well defined. Band-application uses about half as much chemical as a broadcast application, but still requires at least an equal amount of time for implementation. While band-application may be directed away from crop tree foliage allowing treatment after bud-break of crop trees, over-spray from band-application may still occur on windy days. Band-application is commonly performed with tractor- or ATV-mounted boom sprayers (Fig. 8). Tractor booms can commonly apply chemical to 2 to 4 rows per pass, while ATV's are often limited to 1 to 2 rows per pass.

Alternatively, bands may be applied one row at a time using a backpack sprayer. This method may reduce fuel costs and soil trafficking, but will greatly increase time expenditure. Bands should be about as wide as the trees are tall, but not less than 4 feet (Byrnes et al. 1973). Band-width may be adjusted through proper tip selection (fan width) and boom height.

Spot application is most often applied as a circular, tree-centered treatment. Spot application is always applied with a backpack sprayer or other hand-held wand device (Fig. 9). This method may be used for any type of planting, but is ideal when rows are not well defined. While spot application uses the least amount of chemical, it requires more intensive labor and time expenditure. The diameter of treated circles should be about equal to the height of the tree, but never less than 4 feet (Byrnes et al. 1973).

Each method of application has its advantages and disadvantages. Growth response of crop trees often increases in proportion to the area treated (Dougherty and Lowery 1991). The more vegetative competition eliminated per site, the greater the gains for crop trees. Additionally, the greater the area treated, the greater the time until reinvasion (Dougherty and Lowery 1991). Therefore, while the original capital and time costs of an intensive initial treatment may be greater, supplemental treatments may not be required as soon, as with less intensive treatments.

## Physical

Physical barriers or mulching systems involve the installation of either manufactured or organic barriers to control vegetative competition and enhance microclimatic conditions for planted

***Figure 9.*** *Backpack sprayers can allow for a more controlled application of herbicides. (Photo courtesy of Amy L. Ross-Davis)*

seedlings. These systems are not a common means of weed control because of the high up-front costs and labor intensive installation, and are therefore most practical for small plantings (Byrnes et al. 1973). However, physical barriers may be an effective means of weed control, particularly in areas where herbicides are restricted or where mechanical operations are not practical. Physical systems are beneficial, as they will often provide effective weed control for the entire growing season and even through subsequent years. These barriers may offer further benefits to crop trees by increasing water retention in the soil (Walker and McLaughlin 1989) and providing warmer winter soil temperatures, possibly increasing root growth of crop trees. Additionally, physical barriers will reduce erosion of planting sites and decrease sedimentation into watersheds (Dao 1987). Physical barriers have also been shown to cause some detrimental effects to crop trees, as elevated temperatures from barriers may cause heat-girdling damage and provide cover for rodents that girdle trees (Byrnes et al. 1973).

**Manufactured barriers.** Manufactured barriers commonly consist of 4 ft. x 4 ft. black, white, or clear plastic films placed around the base of a seedling (Fig. 10). These films may be impermeable or porous. Van Sambeek et al. (1995) found no significant differences between porous black, solid black, or solid white plastics. Plastic films have been found to be an effective method of weed control (Lambert et al. 1994) and even provide superior weed control when compared to both herbicide and cultivation (Van Sambeek et al. 1995). While plastic films require intensive anchoring during installation, proper installation allows for extensive persistence, as Van Sambeek et al. (1995) did not notice deterioration of plastic films until 2 to 3 years after application.



*Figure 10. Manufactured barriers can be labor intensive to install, but will provide effective weed control for several years.*

**Mulching.** Organic mulches may consist of straw, sawdust, wood chips, etc. This mulch is commonly spread around the base of a seedling after planting. For maximum efficacy, all vegetation should be removed prior to spreading mulch (Byrnes et al. 1973). When properly applied, organic mulches have proven to be an effective means of weed control for hardwood plantations (Lambert et al. 1994). However, their disadvantages are comparable (costs are often less, but installation is still as intensive) to that of manufactured barriers, yet their efficacy is not as persistent.

**Cover crop.** Use of a planted cover crop may often provide an effective means of weed control for hardwood plantation establishment (Fig. 11). The planting of a low-stature, cool-season, herbaceous crop prior to plantation establishment may serve to shade-out undesired vegetative competition. Further, the use of a legume cover crop may increase soil nitrogen availability for crop trees, while reducing competition from weeds (Ponder 1994). Ponder (1994) identified several criteria for a land manager to consider when selecting a cover crop:

1) necessary site preparation → minimal
2) if the crop's establishment and growth is sufficient to shade out competitors → high density
3) stem form → low mat of decumbent or climbing stems
4) growing season → cool season, as to not compete with tree growth

After seedling establishment, these cover crops may be allowed to persist or may be removed with herbicide. In the latter scenario, it may be beneficial to select a crop that can be easily removed with a selective herbicide.

## Integrated Vegetation Management

Integrated Vegetation Management (IVM) programs are a more modern approach to vegetation competition control. IVM is a continuous process used to understand, justify, selectively apply, and monitor different types of treatments, with an overall goal of determining site-specific, ecologically-sensitive, cost-effective, and socially responsible treatment effects that achieve the management objectives. It combines low-volume herbicide applications with mechanical control methods to most effectively and efficiently reduce vegetation competition.

***Figure 11.*** *Planted sorghum cover crop at Vallonia Nursery. Cover crops can help effectively control weed competition and improve the nutrient status of the planting site. (Photo courtesy of Jim Wichman)*

***Figure 12.*** *A well-maintained plantation will help the landowner protect their investment by increasing growth and survival of planted seedlings, and help them realize their final objectives more quickly. (Photo courtesy of Douglass F. Jacobs)*

IVM programs fit the appropriate vegetation management strategy to the individual situation. Low-volume herbicide treatments are specifically designed to remove only targeted, undesirable vegetation, with the intent of preserving the ecologically important components of the vegetation, such as valuable grass, herb, or shrub species for wildlife habitat. An example of practical IVM implementation may involve tilling coupled with chemical treatments. Tilling works well to eliminate mainly perennial woody or semi-woody species yet enhances the growth of herbaceous weeds, which would then be controlled by herbicides that easily eliminate herbaceous vegetation.

This management strategy is often favorable, as a landowner may achieve complete weed control while using relatively low rates of herbicides. However, consulting with a professional forester is recommended to find the most effective combination of mechanical and chemical control methods for specific sites and species.

## Summary

All seedlings in a hardwood plantation, established almost anywhere in the Central Hardwood Region will receive vegetative competition. Without some sort of weed control, growth and survival of crop trees will suffer. Regardless of the rationale for plantation establishment, appropriate weed control will help to protect a landowner's original investment and achieve the final objectives more quickly (Fig. 12). The use of any of the aforementioned methods, or combinations thereof, for weed control is an essential component of plantation establishment for at least the first two to three years. A landowner should choose a weed control strategy based upon the final management objectives, economic ability, time constraints, and site and species specific requirements. Because each plantation is unique, the most effective weed control strategies should be

planned and applied prior to planting the first seedling. While all methods of weed control may not be an effective option all of the time, one of the aforementioned methods should prove applicable to any situation. While effective weed control does not guarantee a successful plantation, failure to control vegetative competition will assuredly contribute to reduced productivity and survival.

## Literature Cited


Bey, C.F., J.E. Krajicek, R.D. Williams, and R.E. Phares. 1976. Weed control in hardwood plantations. pp. 69-84 In: Holt, H.A. and B.C. Fischer (eds.), *Herbicides in Forestry, John S. Wright Forestry Conference Proceedings*, Purdue University, West Lafayette, IN.

Byrnes, W.R., J.E. Krajicek, and J.R. Wichman. 1973. Weed control. pp. 42-48 In: Black walnut as a crop, *Black Walnut Symposium*, USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN, Gen. Tech. Rep. NC-4.

Dao, T.H. 1987. Crop residues and management of annual grass weeds in retention of atrazine by wheat stubble. *Weed Science* 32(1): 24-27.

Dougherty, P.M. and R.F. Lowery. 1991. Spot-size of herbaceous control impacts loblolly pine seedling survival and growth. *Southern Journal of Applied Forestry* 15: 193-199.

Erdmann, G.G. 1967. Chemical weed control increases survival and growth in hardwood plantings. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN, Res. Note NC-34, 4 p.

Hansen, E., D. Netzer, and W.J. Rietveld. 1984. Weed control for establishing intensively cultured hybrid poplar plantations. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN, Res. Note NC-317, 6 p.

Holt, H.A. 1993. Spray equipment calibration. Purdue University, Cooperative Extension Service, West Lafayette, IN. FNR-114.

Kennedy, H.E. 1984. Hardwood growth and foliar nutrient concentrations best in clean cultivation treatments. *Forest Ecology and Management* 8(2): 117-126.

Lambert, F., B. Traux, D. Gagnon, and N. Chevrier. 1994. Growth and N nutrition, monitored by enzyme assays, in a hardwood plantation: effects of mulching materials and glyphosate application. *Forest Ecology and Management* 70: 231-244.

Miller, J.H. 1993. Oak plantation establishment using mechanical, burning, and herbicide treatments. pp. 264-289 In: Loftis, D. and E.C. McGee (eds.), *Oak regeneration: Serious problems, practical recommendations, Symposium Proceedings.* USDA Forest Service, Southeastern Forest Experiment Station, Asheville, NC, SE-84.

Ponder, F. 1994. Leguminous ground covers could reduce herbicide use in forestry. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN, Res. Pap. NC-316, 4 p.

Seifert, J.R. 1993. Weed control for tree and shrub seedlings. Purdue University, Cooperative Extension Service, West Lafayette, IN. FNR-135.

Van Sambeek, J.W., J.E. Preece, C.A. Huetteman, and P.L. Roth. 1995. Use of plastic films for weed control during field establishment of micropropagated hardwoods. pp. 496-506 In: Gottschalk, K.W. and S.L.C. Fosbroke (eds.), *Proceedings 10th Central Hardwood Forest Conference*, USDA Forest Service, Northeastern Forest Experiment Station, Radnor, PA, Gen. Tech. Rep. NE-197.

Walker, R.F. and S.B. McLaughlin. 1989. Black polyethylene mulch improves growth of plantation-grown loblolly pine and yellow-poplar. *New Forests* 3(3): 265-274.

Zutter, B.R., L.R. Nelson, P.J. Minogue, and D.H. Gjerstad. 1987. Hardwood plantation growth following weed control using herbicides and cultivation. *Southern Journal of Applied Forestry* 11: 134-138.




*This publication is printed on recycled paper using soy-based inks.*

EXPERT REVIEWED

Purdue Extension Knowledge to Go 1-888-EXT-INFO

NEW 3/07

FNR-224