How to get the most out of your weed management program in Christmas tree production?

Non-chemical Weed Control in Christmas Tree Production

DEBALINA SAHA
ASSISTANT PROFESSOR, DEPARTMENT OF HORTICULTURE, MICHIGAN STATE UNIVERSITY

To produce high-quality, marketable Christmas trees, a good weed management plan is essential. Effective weed control is extremely important for initial conifer seedling survival and in the first three years after transplanting (during the establishment period) in the field (Figure 1). The establishment phase of Christmas trees is critical as weed competition, particularly for water, can lead to suppression of tree growth and can even cause death of the trees. In the second and third year of the establishment phase, the rate of tree growth is directly related to the amount of weed competition. In later stages of rotation, when trees are larger, weeds interfere with production practices such as pruning and spraying pesticides and can even shade lower branches of trees. Hence, this new article series "How to get the most out of your weed management program in Christmas tree production?" will be focusing on understanding both non-chemical and chemical weed control strategies including aspects of herbicide modes of action, herbicide resistance, new(er) herbicide products, adjuvants and surfactants, etc.

Christmas tree growers mostly rely on mechanical mowing and applications of chemical herbicides to control the weeds in their production fields. However, repeated applications of the same herbicides have resulted in the development of herbicide-resistant weed species. In Michigan there are recent reports on common ragweed resistance to clopyralid (Stinger), a synthetic auxin herbicide, by some Michigan Christmas tree growers, especially in Montcalm County (Hill, 2012). Many postemergence herbicides can even cause severe phytotoxic injuries to different species of Christmas trees including stunted growth, burning and dropping of needles, chlorosis, and even complete death of the tree. During the establishment phase in particular, young Christmas trees are sensitive to these chemical herbicides. In addition, there can be negative environmental issues such as herbicide leaching, drift, and run-off. Due to the issues surrounding herbicide use and increasing concern among some consumers related to pesticide applications, many growers are interested in strategies to reduce or even eliminate chemical weed control. The purpose of this very first article in this new series is to provide an overview of nonchemical weed control strategies in Christmas tree production.

Prevention: Prevention of weed seed introduction to the Christmas tree field is the first step to effective non-chemical weed control. Although natural dispersing agents including wind, water, birds, mice, etc. can move weed seeds into fields, weed seeds, rhizomes, parts of roots and stems can be also moved from site to site on equipment or clothing. Preventing the introduction of weed seeds requires controlling weeds along

farm roads, maintaining clean equipment and equipment yards, and eliminating new weed species before they start seeding or becoming established. If topsoil is introduced to a site, it should be clean and free of roots, rhizomes, seeds, and other weed propagules. Regular scouting for weed species needs to be undertaken by growers in their fields and immediate hand removal is encouraged as later mowing in between the Christmas tree rows can spread the seeds and rhizomes.

Mechanical Control: Mechanical control, which includes cultivation and mowing, can help in preventing development of herbicide-tolerant resistant weed species.

a. **Cultivation:** Weeds around the bases of the Christmas trees can be controlled by hand or mechanical cultivation. Cultivation can be helpful in controlling the small seedlings of many weeds for the first 2 or 3 years after transplanting the Christmas trees. Cultivation requires more frequent application than other methods for effective control and is not feasible on sloped land due to possible erosion and can damage tree roots. Moreover, overuse of cultivation can spread perennial weed species such as field bindweed or Canada thistle [*Cirsium arvense* (L.) Scop.] throughout the field, can increase cultivation-resistant species such as common purslane (*Portulaca oleracea* L.), or can damage soil structure in later years (Peachey et al., 2017). As Christmas trees grow and fill in spaces between rows, it can become more difficult to get cultivation equipment through the plantation and cultivation becomes less effective for controlling weeds.

b. **Mowing:** Mowing at the right time prior to weed seed development helps to reduce the number of seeds produced by the weeds and can significantly reduce the weed competition with the trees. With large mowing equipment, the potential for damaging the trees increases. Hence the use of deflection shields often becomes necessary to minimize damage to larger trees. Growers need to prevent trunk damage to reduce entry ports for disease and insect organisms. Where weeds immediately around trees and within rows are not controlled by mowing, weed or mechanical trimmers are often used. These weed trimmers can serve dual functions and can be used in the shearing operation by adding of a cutting blade. These trimmers are available in a variety of styles with different power sources, some trimming with a monofilament line, some with metal or plastic blades (Appleton and Hill, 1997).

Figure 1 – *An example of poorly managed weeds in a Christmas tree production during the establishment phase. Photo credits: Debalina Saha, MSU Horticulture.*

Figure 2. *Organic mulching can suppress weed growth and improve Christmas tree transplant survival rate. Photo credits: Debalina Saha, MSU Horticulture.*

Mulching:

a. **Organic mulching:** Vegetation can be controlled around Christmas trees by one or more varieties of organic mulch which may include grass clippings, nut hulls, wood chips, compost, bark, sawdust, and other organic materials. Organic mulch (Figure 2) can improve soil moisture, reduce soil erosion and compaction, maintain optimal soil temperatures, increase soil nutrition, enhance root establishment, transplant survival, and improve plant establishment and overall tree growth. Weeds can increase daily evapotranspiration of soil moisture by 25% in summer (Harris

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et al., 2004). In contrast, organic mulches can increase soil moisture content by increasing percolation and retention, reducing evaporation, and reducing weeds. An appropriate mulch layer will significantly reduce the amount of irrigation needed, and in certain cases can eliminate it altogether. Coarse and large particle size organic mulch such as pine bark and pine straw have shown better weed control than fine particle-sized hardwood mulch (Saha et al., 2020). Coarse organic mulches can hold water much like a sponge, thereby capturing rainfall and irrigation water for later release and preventing runoff. In addition to drought stress, mulch can also protect trees from other environmental stresses such as cold injury. Organic mulches help to maintain optimal soil temperatures in that soil can be kept cooler in hot conditions and warmer in cold conditions. Temperature modification is extremely important near the soil surface as hot or cold surface soils can kill new transplants that have not had time to generate a large root mass and establish into deeper, more moderate, surrounding soils. Numerous studies have demonstrated that improved water retention and reduced weed growth are correlated with increased root growth and exploration by desirable plants. Hence, mulches allow roots of trees to extend and establish far beyond the trunk compared to bare soil and thus become increasingly stabilized. Choosing the right type of organic mulch is important in determining how well the roots of Christmas trees will expand in the underlying soil. It was observed that root development and density was greatest under organic mulches compared to plastic mulch, bare soil or living mulches. Organic mulches have an additional advantage of releasing nutrients as they decay. It is recommended to use old (>6 months) sawdust, bark, or chip mulch so that the initial decay has started, and the time required for early nitrogen demand has already passed (Appleton and Hill, 1997).

b. **Inorganic mulching:** Inorganic mulch materials act as physical barriers that limit or exclude weeds and regulate soil temperature and moisture, which aids seedling establishment and survival. True physical barriers, which do not allow water percolation into the soil but restrict the amount of evaporation away from the soil, include asphalt shingles or plastic sheets of various kinds (Appleton and Hill, 1997). Porous inorganic mulch material such as ground rubber does allow rainwater percolation (Appleton and Hill, 1997). Solid inorganic surfaces such as concrete and synthetic mulches including asphalt, fabrics and plastics are poor at controlling soil temperatures. However, chunky inorganic mulches such as gravel and lava rock are more effective temperature moderators. Soil temperatures may be raised or lowered by black plastic mulch, depending on how much light is absorbed by the plastic and whether heat is retained or reflected.

Cover Crops and Vegetated Strips: Cover crops can directly compete with weed species and can suppress weed emergence. In addition to weed suppression, cover crops can reduce soil erosion, improve soil physical properties and nutrient content. Incorporating cover crops into Christmas tree plantations may improve tree growth and quality, soil fertility and can be an alternative to commercial nitrogen fertilizers. Cover cropping is widely recognized and promoted as a practical method to enhance soil productivity and environmental quality. Groundcover management involves the use of mowed, tilled, or killed cover crops to add organic matter to soil, conserve soil humus, reduce soil erosion, increase soil organic matter levels, and steadily release available nutrients for associated or succeeding Christmas tree uptake as the organic matter breaks down. Planting either legume cover crops [e.g., alfalfa (*Medicago sativa* L.) and white clover (*Trifolium repens* L.)] or grasses [e.g., perennial ryegrass (*Lolium perenne* L.)] in the interspaces of Christmas tree can increase plant residue inputs to soils and, therefore, may stimulate soil microbial activity (Dinesh et al., 2004; Mendes et al., 1999). Because cover crops can produce significant amounts of biomass, thrive when repeatedly mowed, fix atmospheric nitrogen through symbiotic association with nitrogen-fixing bacteria, and/or scavenge excess nitrogen left in the soil that would otherwise be lost by leaching, they are considered as ideal candidates for "living mulch". Agricultural management practices that leave plant residues on the soil surface, such as cover cropping and no tillage, often result in higher concentrations of soluble organic carbon compounds, which may greatly influence soil microbial populations and activities.

However, there are potential drawbacks of cover crops which include heavy consumption of moisture from the soil, increased pest populations and diseases, competition with Christmas trees and reduced tree growth. White clover as ground cover decreased the height of *Abies nordmanniana* and *Abies lasiocarpa* by 30% compared to thorough weed control (Sæbø et al., 2009). Both grasses and clover sown as living mulch damaged the Christmas trees more than the natural weed vegetation (Sæbø et al., 2009). Christmas tree growers may incur additional costs for planting and killing cover crops.

Vegetated strips may include permanent grass strips which may take 3 to 4 years to establish and can be planted between tree rows before or after Christmas trees are planted. This permanent grass strip can significantly reduce the number of perennial and annual weeds and can also provide a stable soil surface in the winter for harvest.

Thermal weed Control: Thermal weed control methods include flame, hot water, steam and infrared heater.

Flaming can cause the suppression of many different annual weed species, but it is less effective on larger weeds, perennials, and grasses. Flame weeding is occasionally used in Christmas tree production but needs to be applied with caution. The major challenge to flame weeding in Christmas trees is that there are many weeds at different growth stages and this method is most effective when weeds are very small (usually at the two- to three- leaf stage). This method of open flame weeding in summer can be extremely dangerous when senescing weeds and tree trimmings may provide enough fuel to ignite the entire Christmas tree field. Flame weeding in spring is more energy intensive because humidity and soil moisture are relatively high, and air temperatures are low. However, an advantage of flame weeding is that the soil remains undisturbed, and the chances of weed germination and emergence are reduced. Alternatives to open flame weeders are steam weeders and infrared heaters that use propane to generate heat which is applied indirectly to the weeds (Peachey et al., 2017). Solarization is another form of thermal weed control which involves heating the soil surface using plastic sheets on moist soil to trap solar radiation. This method of solarization has been shown to provide effective control of many different weed species such as pigweeds (*Amaranthus* spp. L.), common purslane, and henbit (*Lamium amplexicaule* L.) (Horowitz et al., 1983). However, solarization requires several weeks and warm, sunny weather to be effective. Thermal weed control strategies may be useful in seedling or transplant production but are not common in Christmas tree production systems.

Biological Weed Control: True biological control agents are host-specific and only attack a single species. These biological control agents contrast with generalist herbivores (or pathogens) that consume (or infect) a number of species and are not host-specific. Several insects have been used as biological agents to selectively control certain weed species. Cinnabar moth (*Tyria jacobaeae* Linnaeus, 1758) can be used to control tansy ragwort (*Senecio jacobaea* L.) (Bucher and Harris, 1961). The chrysomelid beetle (*Chrysolina quadrigemina* Suffrian, 1851) is used for controlling Klamath weed (*Hypericum perforatum* L.) (Andres, 1985). *Tyta lactuosa* Denis and Schiffermuller, 1775, the field bindweed moth, two species of puncturevine weevils and another two species of mite can attack bindweed (Peachey et al., 2017). Selection of these biological control agents is extremely important as there are instances of damage to non-target plants. These different species of biological agents need to be released carefully, and their populations should be monitored in order to achieve successful weed suppression in the Christmas tree production. Research is still continuing on many potential bioherbicides/ biological control agents, but problems with mass-production, formulation, and commercialization continue to prevent their use.

Conclusion: Although there are several non-chemical methods to control weeds in Christmas tree production, proper planning and integration of different methods are required for a successful weed control program. Solely depending on non-chemical methods for controlling weeds can be labor intensive, expensive, and time consuming as constant scouting is required to reduce the weed germination and growth in the field. In most instances, integrated management is required for effective weed control. While various studies have been conducted on non-chemical methods of weed control, more research is required as it relates to Christmas tree production. The next articles of this series will be discussing various aspects of the chemical control strategies helping the growers to plan for their effective weed management and herbicide program.

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