MICHIGAN STATE UNIVERSITY | Extension

E3237 • 2023

Weed Control in Christmas Trees

Why Weed Control in Christmas Trees Matters

Weeds compete with Christmas trees for nutrients, water, space, and light, and can harbor pests and pathogens. Weeds interfere with tree growth at every stage of production and every time of year. When left unchecked, weeds can reduce the growth of Christmas trees by 50% (Warren et al., 1987).

Effective weed control is particularly important in seedling beds and in the first three years after transplanting in the field (Figure 1). Weed competition during the establishment stage (the first two years in the field after transplantation) may suppress tree growth and can lead to tree mortality (Figure 2). Young trees that grow with minimal weed competition develop extensive root systems that allow them to better withstand drought and adverse conditions.

The rate of growth in the second and third years is related directly to the amount of weed competition in the previous years. On light-textured soils, weeds may use up all of the available moisture, leaving young trees to succumb to drought stress. In stands of larger trees, weeds interfere with field practices such as shearing, spraying for pests, and harvesting trees.

It is hard for workers to access fields infested with Canada thistle, horsenettle, poison ivy, horseweed, ragweed, pokeweed, sumac, and other large or toxic weeds. Volunteer tree saplings and the stems of tall woody weeds like ragweed can interfere with shearing operations. Tall vegetation may also block other pesticide sprays from reaching the trees, increasing insect and disease pressure on them. Weeds that have grown into the tree canopies, such as some grasses with troublesome seedheads, bindweed or bittersweet with troublesome vining stems, and tall weeds with woody stems can be difficult to remove from the trees at harvest.

Effective weed control programs help growers balance the need to reduce competition from weeds with the need to protect soil and water resources (Peachey et al., 2017, p. 1). Such programs may combine nonchemical methods such as mowing and hand weeding with chemical methods such as applying residual preemergence or postemergence herbicides (or both) that have different modes of action.

In this bulletin we will discuss nonchemical and chemical weed control methods, herbicides that are labeled for use in Christmas trees, herbicide-resistant weeds, and the potential negative effects of herbicides on the environment.

Figure 1 (left). Successful management of weeds in Christmas tree production typically requires a combination of mechanical control methods (such as mowing) and proper herbicide application. (Photo: Debalina Saha, MSU Department of Horticulture)

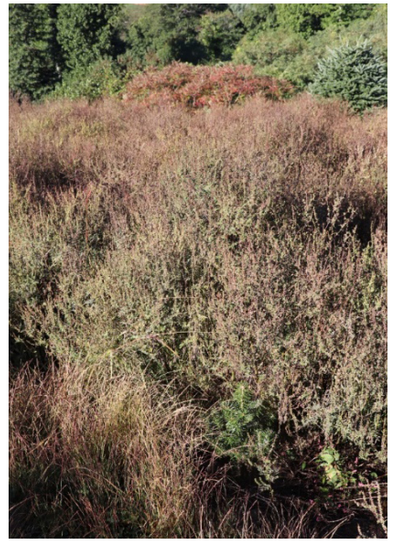

Figure 2. Weeds competing with Christmas trees during the establishment stage (left) and later, during the mature stage (right). (Photos: Joe Neal, North Carolina State University [right], and Debalina Saha, MSU Department of Horticulture [left])

Weed Management Strategies

Weeds are persistent organisms. In 1879, MSU Professor William Beal began an experiment to study how long seeds from 23 weed species would remain viable in the soil. When one of Beal's original bottles was dug up and the seeds inside were planted in 2021, several *Verbascum blattaria* (moth mullein) plants sprouted. Michigan Christmas tree growers aren't likely to face off against 142-year-old weed seeds, but most will need to combine non-chemical and chemical methods to manage the persistent weeds in their fields. This section will discuss both weed control strategies, starting with non-chemical methods.

Non-Chemical Weed Control

Preventing weeds from getting established on your tree farm is one of the most important steps in a non-chemical weed management plan. Weeds can grow from seeds, rhizomes, or parts of roots and stems. They also can easily be distributed by human movement, on vehicles, equipment, and even clothing. Once weeds have become established, they can be difficult and costly—in terms of time, money, and effort—to control.

Be aware of what weed species are present in specific fields and try to limit the movement of people, equipment, and trees from infested to uninfested sites. Keeping equipment and equipment yards clean, and controlling weeds along roadways near your tree stand, will help reduce the chance of new weeds entering the field.

If adding topsoil, mulch, or manure to a field, make sure the material is free of weed seeds and other plant debris. By regularly scouting fields, you will see when new weed species are encroaching or have been introduced. Removing new weed species before they can get established and reproduce will reduce weed pressure in future years.

MOWING

Mechanical control methods involve using a tool, implement, or practice that can damage, remove, kill, or otherwise prevent weeds from completing their life cycles. The most common mechanical control method Christmas tree growers use is mowing.

In addition to reducing weed pressure on the trees, mowing:

- Shortens weeds, thereby improving air flow and drainage around the trees and making the microenvironment less conducive to insect and disease development.
- Improves access to the field and to the trees for maintenance practices like shearing and tagging.
- Makes the environment around the trees less habitable for wildlife that may feed on the trees (such as rabbits and voles).

Many types of mowers are used in Christmas tree fields, such as walk-behind rotary or sickle-bar mowers. Growers also can use string weed trimmers to target weeds growing close to trees that mowers cannot cut without damaging the trees.

The timing of mowing is important—it should be completed before weeds produce seeds.

CULTIVATION

Cultivation is another mechanical weed control method. Cultivators such as rototillers, disks, and harrows physically eliminate weeds by cutting them off directly under the soil surface. Cultivators can be especially useful to prepare fields before planting by removing perennial weeds. Cultivation may also be an effective weed management practice in recently planted trees.

The disadvantages of cultivation include that it:

- Must be repeated often to continually eliminate new weed seedlings as they emerge.
- Leads to greater soil erosion on steep slopes.
- Becomes harder to maneuver equipment between tree rows and to avoid damaging tree branches and expanding root systems as the trees mature.

HEAT

Thermal weed control involves using a heat source (such as flame, steam, hot water, or infrared) to damage and kill weeds. This form of weed control works best on young weed seedlings (at the two- to three-leaf stage). It is much less effective on larger weeds, perennials, and grasses.

Other challenges include the potential for the heat source to ignite other material in the field, sparking dangerous wildfires. This can be especially problematic in the spring months.

Two advantages to thermal weed control are that it doesn't disturb the soil and it inhibits weed germination and emergence.

MULCHES

Growers can use inorganic mulch (such as black landscaping fabric) or organic mulch (such as wood chips, bark, compost, or sawdust) to help manage weeds. Mulch creates a physical barrier between germinating weed seeds in the soil and the soil surface, thereby preventing weed establishment.

Coarse textured mulches with large particle sizes, such as pine bark, tend to control weeds better than fine textured mulches with small particle sizes, such as hardwood chips. Organic mulch can also improve the physical properties of soil. Mulches can reduce soil compaction and erosion, improve water and nutrient holding capacity, and moderate soil temperatures.

Many studies have found increased growth of Christmas tree with the use of mulches (Saha et al., 2020); however, using mulch can be costly. Currently, most Christmas tree growers apply mulch by hand, which is highly labor intensive. However, mulch application equipment that has been developed for use with other agricultural commodities could be modified for Christmas tree plantations.

Growers need to be aware of two cautions related to using mulch:

- Covering Christmas tree stems with mulch can lead to rotting stems and dead trees.
- Organic mulches draw nitrogen from the soil profile as they break down over time. Using organic mulches that have been aged for at least 6 months typically won't draw as much nitrogen from the soil profile as using fresher mulches would.

COVER CROPS

Cover crops (such as hard fescue, sudangrass, and spring type oats) can be planted in Christmas tree stands to compete directly with weeds and suppress or prevent weed emergence. And like organic mulches, cover crops can improve the physical properties of the soil. Depending on the species, other benefits of using cover crops include:

- Preventing soil erosion and compaction.
- Fixing nitrogen in the soil (if the cover crop is a legume).
- Increasing soil organic matter.

Seeded areas should be free of weeds before planting a cover crop. Plant with either a narrow row seed drill or a broadcast seeder at high rates.

If managed incorrectly, cover crops may become weeds themselves, competing directly with Christmas tree plantings, reducing soil moisture and nutrient availability, and increasing pest and disease pressure. Consequently, growers should carefully consider the management requirements of the cover crops they are evaluating. For example, a small grain cover crop should be mowed or otherwise controlled before it gets tall enough to interfere with tree growth or field management. Shorter cover crops, such as winter annual clover, may not require such intervention.

For more information on cover crop establishment and management, visit MSU Extension's "Cover Crops: Getting Started and Management" page at https://bit.ly/3zThSEe.

OTHER NON-CHEMICAL CONTROL METHODS

Two seldom-used non-chemical weed control options that could become more common are biological agents (such as insects and fungi) that target specific weed species, and domestic animals, which are less discriminating about their feeding targets.

Significant research has shown that specific biological control species have potential, but they have not yet been used in the field. Currently no biocontrols are available for weed control in Christmas tree production.

Domestic animals won't normally browse on Christmas trees if other food sources are available, so they do have potential as

weed control agents. However, they can damage small trees by stepping on them and large trees by walking between them.

Sheep are less likely to damage trees than cows or horses. Research has shown that Shropshire sheep may be especially useful in controlling weeds in Christmas tree plantations (Saha et al., 2020). Trials conducted in North Carolina have shown that sheep will feed on Fraser fir and white pine Christmas trees, but not on spruce.

Research conducted by Mueller et al. (1999) showed that geese harm Christmas trees less than sheep do, but geese are vulnerable to owls, hawks, coyotes, and foxes. Goats are often used for invasive weed control but are indiscriminate browsers and will eat Christmas trees along with the weeds.

Chemical Weed Control

Chemical weed control is an essential component of an effective weed management plan in Christmas tree plantations. Growers can use a variety of pre- and postemergence herbicides to control the weeds in their Christmas tree fields.

PREEMERGENT HERBICIDES

Preemergence herbicides require rainfall or irrigation to activate them in the soil, where they target the radicle or shoot growth of germinating seedlings and prevent further development. For new tree plantings, it is important to let the soil settle around tree roots before applying herbicides so the roots aren't damaged by direct contact with the herbicides.

Apply preemergence herbicides soon after transplanting to reduce weed competition. Some herbicides work better against grass or against broadleaf weeds, but not both. For best results, apply a combination of preemergence herbicides that target both weed types (Kuhns & Harpster, 2018).

POSTEMERGENCE HERBICIDES

Postemergence herbicides are foliar active and are applied to the shoots and leaves of weeds already growing in the field. The weeds absorb most of the chemicals through the leaf surface, then their cell membranes rupture, arresting production of essential compounds or distorting growth by hormone mimicry. Postemergence herbicides can be classified as either *contact herbicides*, which damage the tissues they are directly applied to, or *translocated herbicides*, which cause damage as they move throughout the plant.

Trees can be sensitive to postemergence herbicides, and it is important to follow label instructions about tree age, size, and herbicide timing (Gallina et al., 2022). Postemergence herbicides can cause severe injuries to some species of Christmas trees, including stunted growth, burning, dropping of needles, chlorosis, and even death (Saha et al., 2020). Directing the spray to avoid tree contact helps to minimize tree injury.

PRE- & POSTEMERGENCE HERBICIDES

Some herbicides have both pre- and postemergence activity, such as SureGuard (flumioxazin), Velpar (hexazinone), and Mission (flazasulfuron) (Peachey et al., 2017).

Herbicides & Recommended Uses

This section lists common herbicides by active ingredients and gives recommended uses for each. (**Note:** The information presented is for educational purposes only. Reference to commercial products or trade names does not imply endorsement by MSU Extension or bias against those not mentioned.)

COMMON PREEMERGENCE HERBICIDES & RECOMMENDED USES

1. *Dichlobenil* (Casoron 4G): Group 20 (inhibition of cellulose synthesis) herbicide used to control difficult perennials such as curly dock, Canada thistle, and horsetail (genus *Equisetum*). Dichlobenil is highly volatile; apply it only in midwinter as a soil surface treatment, preferably before a cold rain or snow to reduce volatility and enhance weed suppression. Use only around well-established plants (at least 1 year after transplanting). Re-entry interval (REI): 12 hours.
2. *Indaziflam* (Marengo or Esplanade): Group 29 (inhibition of cellulose synthesis) selective, broad-spectrum herbicide that is applied to the soil surface before weeds emerge in fall or spring. It has high soil persistence and is used to control grasses, sedges, and broadleaves. This herbicide needs rain or irrigation water for activation. Growers are advised not to apply this herbicide to newly transplanted trees until soil around transplants settles. REI: 12 hours.
3. *Isoxaben* (Gallery): Group 21 (inhibition of cellulose synthesis) herbicide that is used to control annual broadleaves. Apply in late winter or early spring, before summer annual weed seeds germinate, or in late summer or early fall for winter annual broadleaf weed control. Does not control grass weeds. REI: 12 hours.
4. *Napropamide* (Devrinol): Group 15 (very long chain fatty acid synthesis inhibitor) herbicide that controls annual grasses and a few small-seeded broadleaves. Some suppression of nutsedge has been reported. REI: 12 hours.
5. *Pendimethalin* (Pendulum 3.3 EC, Pendulum Aquacap): Group 3 (microtubule assembly inhibitor) herbicide applied at planting or before weed seeds germinate. It requires precipitation for activation before weed seeds emerge. REI: 24 hours.
6. *Pronamide* (Kerb 50W): Group 3 (microtubule assembly inhibitor) herbicide that is surface-applied in fall (before freezing temperatures). To control cool-season grasses, this restricted use pesticide (RUP) can be applied in late winter or early spring. It is used only around well-established plants (more than 1 year after transplanting). It requires soil moisture for activation before weed seeds emerge, is prone to runoff and leaching, and is known to move on gentle slopes. It is used for annual and perennial grass weeds, common chickweed, and mustard weed control in Christmas tree plantations. To control quackgrass, use the higher labeled dose. REI: 24 hours.
7. *Metolachlor* (Pennant Mangum): Group 15 (very long chain fatty acid synthesis inhibitor) herbicide that is applied in spring before weeds germinate. It is used to control annual grasses, pigweeds, yellow nutsedge, and nightshades in Christmas tree plantations. REI: 24 hours.
8. *Simazine* (Princep): Group 5 (triazine that inhibits photosynthesis at Photosystem II [PSII]) herbicide that is applied in late winter or late summer before weeds emerge. Controls broadleaf weeds and offers short-residual control of annual grasses. Tank mix with another herbicide to improve residual grass control. Do not apply simazine over actively growing trees unless it is done immediately before rain. REI: 48 hours.

COMMON POSTEMERGENCE HERBICIDES & THEIR RECOMMENDED USES

1. *Asulam* (Asulox): Group 18 (dihydropteroate synthase inhibitor) herbicide used for bracken fern control and only labeled for Douglas-firs, Grand firs, Noble firs, and Scotch pine. REI: 12 hours.
2. *Clethodim* (Envoy Plus and others): Group 1 (acetyl CoA carboxylase, or ACC, inhibitor) herbicide that is applied to actively growing grasses. It is used for controlling annual and perennial grasses in Douglas-fir and true firs (*Abies* spp.). Multiple applications are typically required to control larger annual grasses or perennial grasses like quackgrass. For best results start applications when grasses are young, less than 8 inches tall. REI: 24 hours.
3. *Clopyralid* (Stinger, Lontrel): Group 4 (auxin-mimic) herbicide, applied as a broadcast or directed spray during active growth of weeds. It is one of the most commonly used postemergence herbicides to control annual and perennial broadleaf weeds including dandelion, Canada thistle, clover, horseweed, ragweed, and knapweeds. Michigan growers have reported several cases of clopyralid-resistant common ragweed in Christmas tree production systems. Growers are advised to use this herbicide only around well-established plants (more than 1 year after transplanting) to avoid growth distortion or needle curling. REI: 12 hours.
4. *Fluazifop-butyl* (Fusilade): Group 1 (ACC inhibitor) herbicide that is used to control actively growing grasses in early spring. Multiple applications are typically required to control larger annual grasses or perennial grasses like quackgrass. For best results start applications when grasses are young, less than 8 inches tall. REI: 12 hours.
5. *Glufosinate-ammonium* (Finale XL, Cheetah Pro): Group 10 (glutamine synthetase inhibitor) herbicide that is applied to actively growing weeds. To avoid crop injury, avoid contact with conifer foliage; do not apply over top of Christmas trees. REI: 12 hours.
6. *Glyphosate* (Roundup, many others): Group 9 (5-enolpyruvylshikimate 3-phosphate synthase [EPSPS] inhibitor) herbicide that is used to control most annual and perennial weeds, including woody weeds with repeated applications. Glyphosate-resistant weeds are common, particularly horseweed, pigweeds, lambsquarters, ragweed, and annual ryegrass. To avoid crop injury, apply glyphosate before budbreak or after new growth has hardened in fall (Ahrens & Bennett, 2011). Directed or spot applications, avoiding contact with the crop, are possible during the growing season. REI: Varies among formulations from 4 hours.
7. *Sethoxydim* (Segment): Group 1 (ACC inhibitor) herbicide that is applied to actively growing annual and perennial grasses. Multiple applications are typically required to control larger annual grasses or perennial grasses. For best results start applications when grasses are young, less than 8 inches tall. REI: 12 hours.
8. *Triclopyr* (Garlon 3A, Vastlan): Group 4 (auxin mimic) herbicide that is used for controlling woody plants and perennial and broadleaf weeds. It is applied in late summer

or early fall after terminal growth of trees has hardened off, but before target weeds drop leaves. REI: 48 hours.

9. *2,4-D* (Turret, Weedar 64, others): Group 4 (auxin-mimic) herbicide that can be applied only over dormant Douglas-fir trees (do not apply over true firs [*Abies* spp.], spruce, or pines) or as directed spot sprays to actively growing weeds. REI: 48 hours.

COMMON PREEMERGENCE + POSTEMERGENCE HERBICIDES & THEIR USES

1. *Atrazine* (many products): Group 5 (PSII site A inhibitor) herbicide used to control many broadleaves and some grass weeds. Atrazine (RUP) is primarily used as a preemergence herbicide but has postemergence activity on certain broadleaf weeds. For best results, combine atrazine with another herbicide with better residual control of grasses. It is applied to soil before or after new transplants, or to dormant established trees in late fall or early spring. REI: 12 hours.
2. *Flazasulfuron* (Mission): Group 2 (Acetolactate synthase [ALS] inhibitor) herbicide that controls many broadleaves and grasses less than 4 inches. It may be applied as directed spray during growth, or over the top of trees before budbreak or after new growth has hardened in fall. REI: 12 hours.
3. *Flumioxazin* (SureGuard): Group 14 (Protoporphyrinogen oxidase [PPO] inhibitor) preemergence and postemergence herbicide used for controlling annual broadleaf weeds and some grasses. It must be applied before spring budbreak or after new growth has hardened off. It is only safe for established Christmas trees in the field. REI: 12 hours.
4. *Hexazinone* (Velpar): Group 5 (PSII site A inhibitor) herbicide that is applied to Christmas tree plantations in April. At the high labeled rates, Velpar is effective for controlling trailing blackberries. It is registered for new plantings, but variable tree injury has been observed. REI: 48 hours.
5. *Oxyfluorfen* (Goaltender, Goal 2E): Group 14 (PPO inhibitor) herbicide used to control many annual grasses and broadleaves. It can be applied when trees are not actively growing and over top of dormant trees. Oxyfluorfen is also labeled for use in conifer seedbeds and transplant beds. REI: 24 hours.
6. *Topramezone* (Frequency): Group 27 (4-hydroxyphenyl-pyruvatedioxygenase [4-HPPD] inhibitor) herbicide used to control broadleaf weeds (such as horseweed, common chickweed, clover, smartweed, and nightshades) and grasses (such as barnyardgrass, large crabgrass, and johnsongrass). It should not be applied over top of Christmas trees or injury may occur. Directed applications are recommended. REI: 12 hours.

Every herbicide has specific application guidelines and weed control spectra. Christmas trees vary in herbicide tolerance levels by species and age, so growers need to be careful when applying herbicides to avoid injuring Christmas trees. Using appropriate equipment to apply herbicides is important to obtain maximum weed control and avoid tree injury. Check labels before making aerial applications. Use pesticides safely by wearing protective clothing and safety devices as recommended on the label.

The herbicides listed in the Appendix: Herbicide Tables are labeled for use in Christmas trees. Many other brand names and formulations with the same active ingredients are also available. Check the labels for use instructions for Christmas trees. Keep the labels of all pesticides you apply on file.

Managing Herbicide Resistance

Repeated applications of a single herbicide, or of herbicides with the same mode of action, can result in the development of herbicide-resistant weed populations. Herbicide-resistant weeds are no longer affected by herbicides that previously provided control. For example, glyphosate used to control most horseweed and pigweed, but over time these (and other weeds) have become glyphosate-resistant and that herbicide no longer provides adequate control.

Herbicide resistance originates in genetic differences among individual weeds in a population. Individual weeds not controlled by a herbicide survive its effects and produce seeds. The seedlings of this population, and of later generations, carry the genetic trait that imparts resistance. Development of resistance isn't reversible because the resistant trait stays in the weed population. It can be managed by switching to herbicides with different modes of action or by using non-chemical control strategies such as mulching, cultivating, flame weeding, or mowing.

To help prevent herbicide resistance from developing:

- Use a combination of chemical and non-chemical weed control practices.
- Use herbicides with different modes or sites of action in rotation, in combination, or in sequence.
- Use crop rotation to diversify herbicides, farming practices, and weed populations. (Of course, crop rotation may not be practical on most Christmas tree plantations.)
- Scout fields and record weed escapes to keep track of resistant populations and devise management tools.
- Follow preventive measures to avoid introducing resistant weed seeds into fields, such as cleaning tools and equipment between fields, not introducing weed-infested stock plants into fields, and maintaining weed-free soil, compost, and mulch piles.

Herbicides in the Environment

The fate of herbicides in the environment is complex. Once herbicides are applied, many processes can occur to reduce their effectiveness or even make them inactive. For example, herbicides can:

- Be degraded by sunlight.
- Become bound to soil particles.
- Be broken down by microbial and other chemical reactions in the soil (College of Agriculture, Forestry and Life Sciences, 2023).

Herbicide persistence is a measure of how long it takes for the chemical to break down to half its original concentration (known as the half-life). The persistence of herbicides in the environment varies from only a few days to months or even years.

Unfortunately, wind, water, and other forces can move herbicides from where they were applied to other locations, where the chemicals become environmental hazards. Common agricultural herbicides, such as atrazine, have been detected in aquifers, streams, and other bodies of water. This movement poses a danger to humans and the environment because both can be negatively affected by even low concentrations of herbicides (Peachey et al., 2017). Understanding the properties of herbicides, how they can become pollutants, and strategies for minimizing their movement in the environment are important in protecting natural resources, human health, and drinking water supplies.

Pollution can occur from point and non-point sources. According to the U.S. Environmental Protection Agency (EPA), point source pollution is, “Any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack” (National Ocean Service, n.d., paragraph 1).

Non-point source pollution is pollution that originates from a source that cannot be easily identified or from multiple sources (Gibb, 2013). For example, a soil-applied herbicide could leach through the soil and enter the groundwater. Some herbicides are more prone to becoming non-point sources of pollution than others because of their solubility, binding to soil particles, and persistence in the soil.

Soil type can have a strong effect on herbicide leaching, which is greater in soils with high sand content and low organic matter. Clay soils or soils with high organic matter typically bind herbicides more tightly and reduce leaching potential. Herbicides that are highly water soluble, have low adsorption (binding rates) to soil particles, and are very persistent are more likely to move off-site and become pollutants (Curell, 2013). When choosing herbicides, be mindful of their characteristics and potential as pollutants.

Growers can take many proactive steps to reduce the chance of herbicides becoming non-point source pollutants:

- Maintain application equipment and keep sprayers properly calibrated.
- Follow the label instructions on application rates and do not apply more product than the label dictates. If banding applications, make sure to account for the reduced application area.
- Follow the label instructions on setback requirements from environmentally sensitive areas such as streams and other bodies of water, on herbicide loading and mixing, and about application sites.
- Use vegetated buffer strips, which have been demonstrated to greatly reduce herbicide leaching (Peachey et al., 2017). Vegetated buffer strips are required for some herbicide application sites, but only recommended for others.
- Follow the label instructions about using the herbicide in specific soil types. Some herbicides are not labeled for use in soils that are predominately sand or light textured because they are more likely to leach through such soils.
- Do not apply herbicides to ground that is frozen or covered by snow or standing water. Herbicides applied in such conditions are prone to becoming non-point sources of pollution.

In addition to leaching through water, herbicides can also be moved off site by soil erosion (Peachey et al., 2017). The use of cover crops, organic mulches, filter strips, sod row middles, and other conservation practices are widely used to prevent soil erosion and thereby reduce pollution. Farms on highly erodible land (sometimes abbreviated to *HEL*) may have specific label use instructions, including the use of vegetated buffer strips to minimize leaching.

Literature Cited

Ahrens, J. (Ed.), & Bennett, K. P. (2011). *2011 New England guide to chemical weed and brush control in Christmas trees*. University of New Hampshire Cooperative Extension. https://bit.ly/41r9NlW

College of Agriculture, Forestry, and Life Sciences. (2023). *Herbicide fate*. Clemson University. https://bit.ly/41oJFb7

Curell, C., (2013). *Select and use herbicides without harming the environment*. Michigan State University, MSU Extension. https://bit.ly/3zZQ5C5

Gallina, G. C., Cregg, B. M., Patterson, E. L., & Saha, D. (2022). A review of chemical weed control practices in Christmas tree production in the United States. *Forests*, *13*(2), 250. https://doi.org/10.3390/f13020250

Gibb, T., (2013). *What's the point and non-point in water quality?* Michigan State University, MSU Extension. https://bit.ly/41bYuhF

Kuhns, L. J., & Harpster, T. (2018). *Weed control recommendations for Christmas tree growers* (Hort. Mimeo Series II). Pennsylvania State University, College of Agricultural Sciences.

Mueller, J. P., Poore, M. H., & Skroch, W. A. (1999). Damage assessment in Christmas tree plantations following vegetation control with sheep and geese. *Southern Journal of Applied Forestry*, *23*(1), 11-15. https://doi.org/10.1093/sjaf/23.1.11

National Ocean Service. (n.d.) Pollution tutorial: Point source (webpage). https://bit.ly/3L5YqsT

Peachey, E., Landgren, C., & Miller, T. (2017). *Weed and vegetation management strategies in Christmas trees* (PNW 625). Pacific Northwest Extension. https://bit.ly/43xNGfu

Saha, D., Cregg, B. M., & Sidhu, M. K. (2020). A review of non-chemical weed control practices in Christmas tree production. *Forests*, *11*(5), 554. https://doi.org/10.3390/f11050554

Warren, S. L., Skroch, W. A., Perry, K. B., & Monaco, T. J. (1987). Vegetation management: Its influence on survival and early growth of Fraser fir and Norway spruce. *Journal of the American Society for Horticultural Science*, *112*(6), 955-962.

Acknowledgments

Authors

Debalina Saha (corresponding author), Assistant Professor, Department of Horticulture, Michigan State University

Bill Lindberg, Christmas Tree Extension Educator, Michigan State University Extension

Manjot Kaur Sidhu, Graduate Research Assistant, Department of Horticulture, Michigan State University

This is a major revision of the 2018 edition by Bernard Zandstra, retired Extension Specialist in Weed Control and Professor Emeritus, MSU Department of Horticulture, and Jill O'Donnell, retired Senior Extension Educator for Christmas Tree Production, MSU Extension.

This bulletin was produced for MSU Extension (www.extension.msu.edu) by the MSU Extension Educational Materials Team.

Thank You

We would like to thank Dr. Joe Neal of North Carolina State University's Department of Horticulture for reviewing the content of and providing a photo for this bulletin.

Appendix: Herbicide Tables

(**Note:** The information presented in this appendix is for educational purposes only. Reference to commercial products or trade names does not imply endorsement by MSU Extension or bias against those not mentioned.)

Table 1. How well annual broadleaves respond to Christmas tree preemergence herbicides.

Trade name & registration number	Common name	[Wild] buckwheat	[Common] chickweed	[Common] lambsquarters	[Common] ragweed	[Marestail] horseweed	Mustards & wild radish	[Eastern black] nightshade	Pigweeds & amaranths	Smartweeds & ladysthumb	Velvetleaf
AATREX 4L (100-497 2022; RUP)	atrazine	G	G	G	G	G	G	G	G	G	F
BARRICADE 4 FL (100-1139 2022)	prodiamine	N	F	G	P	N	P	P	G	P	N
COBRA 2EC (59639-34 2022)	lactofen	G	G	G	G	P	G	G	G	F	P
GALLERY 75 DF (62719-145 2022)	isoxaben	G	F	G	G	E	F	G	F	G	G
GOALTENDER 4 SC (62719-447 2022)	oxyfluorfen	G	G	E	G	F	F	G	E	G	G
KERB 3.3 SC (62719-578 2022; RUP)	pronamide	N	G	P	P	P	F	F	F	F	N
MARENGO 0.622 SC (432-1518 2022, ESPLANADE 432-1516 2022)	indaziflam	G	G	F	F	F	G	G	G	F	G
MISSION 25 WG (71512-18-88783 2022)	flazasulfuron	G	G	G	G	F	G	G	G	G	F
PENDULUM AQUA CAP 3.8 CS (241-416 2022)	pendimethalin	F	G	G	F	P	G	P	G	G	G
PENNANT MAGNUM 7.62 EC (100-950 2022)	S-metolachlor	F	N	F	P	N	P	G	G	F	P
PRINCEP 4L (100-526 2022), PRINCEP CALIBER 90 (100-603 2022)	simazine	G	E	E	E	P	E	G	E	E	P
SUREGUARD 51 WDG (59639-120 2022), SUREGUARD 4 SC (71368-114 2022)	flumioxazin	G	G	G	G	G	G	G	G	G	G
SURFLAN 4 AS (70506-44 2022), SURFLAN FLEX (70506-308 2022)	oryzalin	P	E	G	P	P	F	N	G	P	P
TOWER 6 EC (7969-239 2022)	dimethenamid-P	N	N	P	P	N	F	G	G	F	N
TRIFLURALIN (4HF 34704-792 2022)	trifluralin	N	G	G	P	N	N	F	G	F	P
VELPAR (432-1576 2022), VELPAR L VU (432-1573 2022)	hexazinone	G	G	G	G	G	G	G	G	G	G

Note. E = Excellent control, G = Good control, F = Fair control, P = Poor control, N = No control. Repeated applications of a single herbicide, or herbicides with the same mode of action, can result in the development of herbicide-resistant weed populations. There are confirmed reports of weeds that have become resistant to glyphosate, triazines (atrazine and simazine), and clopyralid herbicides. Pigweeds and horseweed have become resistant to both glyphosate and triazine. Common ragweed has become resistant to clopyralid. It is recommended to follow integrated weed management strategies and to rotate herbicides with different modes of action to prevent and manage herbicide resistance among weed species.

Table 2. How well annual grasses respond to Christmas tree preemergence herbicides.

Trade name & registration number	Common name	Annual bluegrass	Barnyardgrass	[Downy] bromegrass	[Large] crabgrass	Fall panicum	[Giant, green, yellow] foxtails	[Field & longspine] sandbur	Witchgrass
AATREX 4L (100-497 2022; RUP)	atrazine	G	F	G	F	G	F	N	F
BARRICADE 4 FL (100-1139 2022)	prodiamine	G	E	P	F	G	G	P	G
COBRA 2EC (59639-34 2022)	lactofen	N	N	N	N	N	N	N	N
GALLERY 75 DF (62719-145 2022)	isoxaben	G	P	P	P	P	P	F	P
GOALTENDER 4 SC (62719-447 2022)	oxyfluorfen	G	F	P	F	F	F	P	F
KERB 3.3 SC (62719-578 2022; RUP)	pronamide	G	G	E	G	G	G	N	F
MARENGO 0.622 SC (432-1518 2022), ESPLANADE (432-1516 2022)	indaziflam	G	G	G	G	G	G	P	G
MISSION 25 WG (71512-18-88783 2022	flazasulfuron	G	F	G	F	G	G	G	G
PENDULUM AQUA CAP 3.8 CS (241-416 2022)	pendimethalin	G	G	F	G	G	G	G	G
PENNANT MAGNUM 7.62 EC (100-950 2022)	S-metolachlor	G	E	F	E	E	E	F	G
PRINCEP 4L (100-526 2022), PRINCEP CALIBER 90 (100-603 2022)	simazine	G	E	F	F	F	E	P	F
SUREGUARD 51 WDG (59639-120 2022), SUREGUARD 4 SC (71368-114 2022)	flumioxazin	G	G	P	G	G	G	G	G
SURFLAN 4 AS (70506-44 2022), SURFLAN FLEX (70506-308 2022)	oryzalin	G	G	F	G	G	E	P	E
TOWER 6 EC (7969-239 2022)	dimethenamid-P	G	E	G	E	E	E	G	G
TRIFLURALIN 4HF (34704-792 2022)	trifluralin	G	G	G	G	G	G	G	N
VELPAR (432-1576 2022), VELPAR L VU (432-1573 2022)	hexazinone	G	G	G	F	G	G	G	G

Note. E = Excellent control, G = Good control, F = Fair control, P = Poor control, N = No control. Repeated applications of a single herbicide, or herbicides with the same mode of action, can result in the development of herbicide-resistant weed populations. There are confirmed reports of weeds that have become resistant to glyphosate, triazines (atrazine and simazine), and clopyralid herbicides. Pigweeds and horseweed have become resistant to both glyphosate and triazine. Common ragweed has become resistant to clopyralid. It is recommended to follow integrated weed management strategies and to rotate herbicides with different modes of action to prevent and manage herbicide resistance among weed species.

Table 3. How well annual broadleaves respond to Christmas tree postemergence herbicides.

Trade name & registration number	Common name	[Wild] buckwheat	[Common] chickweed	[Common] lambsquarters	[Common] ragweed	[Marestail] horseweed	Mustards & wild radish	[Eastern black] nightshade	Pigweeds & amaranths	Smartweeds & ladysthumb	Velvetleaf
COBRA 2 EC (59639-34)	lactofen	G	G	F	G	P	G	G	G	F	P
DEFY AMINE 4 (66222-221); WEEDAR 64 (71368-1)	2,4-D	G	P	F	G	P	G	F	G	G	G
ENVOY PLUS 0.97 EC (59639-132)	clethodim	N	N	N	N	N	N	N	N	N	N
FUSILADE DX 2L (100-1070), FUSILADE II 2E T&O (100-1084)	fluazifop-butyl	N	N	N	N	N	N	N	N	N	N
FREQUENCY (7969-281)	topramezone	P	G	G	P	F	G	G	G	NL	G
GARLON 3A (62719-37), SPYDER (228-408)	triclopyr	E	G	G	G	E	G	G	G	G	G
GOALTENDER 4 SC (62719-447)	oxyfluorfen	G	G	G	G	F	F	G	E	G	G
ROUNDUP PRO (524-475), many others	glyphosate	E	E	E	E	F	E	E	E	E	G
SEGMENT (7969-398)	sethoxydim	N	N	N	N	N	N	N	N	N	N
STINGER 3L (62719-73), LONTREL (62719-305)	clopyralid	F	N	N	G	G	N	G	N	F	N

Note. E = Excellent control, G = Good control, F = Fair control, P = Poor control, N = No control, NL = Not labeled. Repeated applications of a single herbicide, or herbicides with the same mode of action, can result in the development of herbicide-resistant weed populations. There are confirmed reports of weeds that have become resistant to glyphosate, triazines (atrazine and simazine), and clopyralid herbicides. Pigweeds and horseweed have become resistant to both glyphosate and triazine. Common ragweed has become resistant to clopyralid. It is recommended to follow integrated weed management strategies and to rotate herbicides with different modes of action to prevent and manage herbicide resistance among weed species.

Table 4. How well annual grasses respond to Christmas tree postemergence herbicides.

Trade name	Common name	Annual bluegrass	Barnyardgrass	[Downy] bromegrass	[Large] crabgrass	Fall panicum	[Giant, green, yellow] foxtails	[Field, longspine] sandbur	Witchgrass
COBRA 2 EC	lactofen	N	N	N	N	N	N	N	N
DEFY AMINE 4; WEEDAR 64	2,4-D	N	N	N	N	N	N	N	N
ENVOY PLUS 0.97 EC	clethodim	F	G	G	G	G	G	G	G
FUSILADE DX 2L, FUSILADE II 2E T&O	fluazifop-butyl	P	E	F	G	G	E	G	E
FREQUENCY	topramezone	P	G	NL	G	G	G	NL	NL
GARLON 3A, SPYDER	triclopyr	P	P	P	P	P	P	P	P
GOALTENDER 4 SC	oxyfluorfen	G	F	P	F	F	F	P	F
ROUNDUP ULTRA 4L, many others	glyphosate	G	E	E	E	E	E	G	E
SEGMENT	sethoxydim	P	G	F	G	G	G	G	G
STINGER 3L, LONTREL	clopyralid	N	N	N	N	N	N	N	N

Note. E = Excellent control, G = Good control, F = Fair control, P = Poor control, N = No control, NL = Not labeled. Repeated applications of a single herbicide, or herbicides with the same mode of action, can result in the development of herbicide-resistant weed populations. There are confirmed reports of weeds that have become resistant to glyphosate, triazines (atrazine and simazine), and clopyralid herbicides. Pigweeds and horseweed have become resistant to both glyphosate and triazine. Common ragweed has become resistant to clopyralid. It is recommended to follow integrated weed management strategies and to rotate herbicides with different modes of action to prevent and manage herbicide resistance among weed species.

Table 5. How well perennial weeds respond to Christmas tree preemergence herbicides.

Trade name	Common name	[Field, hedge] bindweed	Canada thistle	[Wild] carrot	Dandelion	Goldenrod	[Wild] grape	Ground ivy	Hoary alyssum	Horsenettle	[Common] mallow	[Common] milkweed	[Yellow] nutsedge	[Buckhorn, broadleaf] plantain	Poison ivy	Quackgrass	[Perennial] sowthistle	[Crown] vetch	Virginia creeper
AATREX 4L (RUP)	atrazine	N	N	N	N	N	N	N	P	N	N	N	N	N	N	F	G	N	N
MARENGO 0.622 SC	indaziflam	N	N	P	F	P	N	F	F	P	P	N	P	G	F	P	G	G	P
BARRICADE 4 FL	prodiamine	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
GALLERY 75 DF	isoxaben	F	P	G	P	N	N	N	N	P	P	N	P	G	N	N	G	P	N
GOALTENDER 4 SC	oxyfluorfen	P	P	N	P	N	N	N	P	P	N	P	P	G	N	P	P	P	N
KERB 3.3 SC (RUP)	pronamide	N	N	N	N	N	N	N	P	N	N	N	P	N	N	G	P	N	N
MISSION 25 WG	flazasulfuron	N	F	G	F	P	N	NL	NL	P	G	N	G	F	P	G	G	G	N
PENDULUM AQUA CAP 3.8 CS	pendimethalin	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
PENNANT MAGNUM 7.62 EC	S-metolachlor	N	N	N	N	N	N	N	N	N	N	N	F	N	N	N	N	N	N
PRINCEP 4L, PRINCEP CALIBER 90	simazine	F	P	F	P	N	N	N	G	P	N	P	P	P	N	F	F	P	N
SUREGUARD 51 WDG, SUREGUARD 4 SC	flumioxazin	F	G	P	G	P	N	G	G	G	G	N	P	G	N	P	G	N	N
SURFLAN 4 AS	oryzalin	N	N	N	P	N	N	N	N	N	N	N	N	N	N	P	P	N	N
TOWER 6 EC	dimethenamid-P	N	N	N	N	N	N	N	N	N	N	N	G	N	N	N	N	N	N
TRIFLURALIN 4H	trifluralin	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
VELPAR 2L VU	hexazinone	F	F	G	F	F	N	N	G	N	G	F	P	G	F	F	G	G	N

Note. E = Excellent control, G = Good control, F = Fair control, P = Poor control, N = No control, NL = Not labeled.

Table 6. How well perennial weeds respond to Christmas tree postemergence herbicides.

Trade name	Common name	[Field, hedge] bindweed	Canada thistle	[Wild] carrot	Dandelion	Goldenrod	[Wild] grape	Ground ivy	Hoary alyssum	Horsenettle	[Common] mallow	[Common] milkweed	[Yellow] nutsedge	[Buckhorn, broadleaf] plantain	Poison ivy	Quackgrass	[Perennial] sowthistle	[Crown] vetch	Virginia creeper
DEFY AMINE 4	2,4-D	G	G	G	E	P	F	P	G	P	P	P	P	E	F	N	F	F	P
ENVOY PLUS 0.97 EC	clethodim	N	N	N	N	N	N	N	N	N	N	N	N	N	N	G	N	N	N
FREQUENCY	tompramezone	P	P	NL	G	NL	NL	G	NL	F	G	NL	NL	NL	NL	NL	NL	NL	NL
FUSILADE DX 2L, FUSILADE 2II 2E T&O	fluazifop-butyl	N	N	N	N	N	N	N	N	N	N	N	N	N	N	G	N	N	N
GARLON 3A	triclopyr	G	G	G	G	G	G	F	G	F	G	G	N	E	G	N	G	G	G
GOALTENDER 4 SC, GOAL 2E	oxyfluorfen	P	P	N	P	N	N	N	P	P	N	P	P	G	N	N	P	P	N
ROUNDUP PRO, many others	glyphosate	P	F	E	G	G	F	G	G	F	F	F	F	F	G	F	G	F	G
SEGMENT	sethoxydim	N	N	N	N	N	N	N	N	N	N	N	N	N	N	F	N	N	N
STINGER 3L, LONTREL	clopyralid	F	G	N	G	P	P	P	N	P	N	N	N	F	N	N	G	G	N

Note. E = Excellent control, G = Good control, F = Fair control, P = Poor control, N = No control, NL = Not labeled.

Table 7. Preemergence weed control in seedbeds, recent transplants, and first-year Christmas trees.

Trade name	Common name	Mechanism of action WSSA & (HRAC) group [a]	Amount of product (& active ingredient) per acre	Tree species on label	Timing	Comments & limitations
AATREX 4L (restricted use pesticide [RUP])	atrazine	Photosystem II (PS II) inhibitor 5(C1)	1–2 qt/acre (1–2 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch); Spruce (Blue); True fir (Grand, Noble, White)	New transplants: apply to soil before or after transplanting.	AAtrex controls many annual broadleaves and grasses and suppresses quackgrass at higher rates. Apply over the top of trees or as a directed spray between trees. Biotypes of some weed species are resistant to atrazine, so it should be used in rotation with other herbicides.
BARRICADE 4F	prodiamine	Mitosis inhibitor 3(K1)	12–21 fl oz/acre (0.375–0.656 lb AI/acre)	Pine (Scotch, White); True fir (*Abies* sp.)	Apply after transplanting and before budbreak in spring.	Annual broadleaf and grass control. Apply after soil has settled on new plantings. May be applied at any time on established plantings. Water into soil with 0.5 in. of rain or irrigation.
COBRA 2 EC	lactofen	PPO inhibitor 14(E)	**Seedbeds:** 0.5–1 pt/acre (0.125–0.25 lb AI/acre)	Douglas-fir; Pine (Eastern white, Scotch); Spruce (Blue, Norway); True fir (Fraser, Grand, Noble)	Apply after seeding or transplanting and before budbreak.	Controls broadleaves up to 4 in. tall. Do not apply when conifers are under stress. Maximum 26 fl oz/acre/year. The ground should be tilled and weed free.
GOALTENDER 4 SC	oxyfluorfen	PPO inhibitor 14(E)	**Conifer Seedbeds:** 0.5–2 pt/acre (0.25–1 lb AI/acre) **Trees in containers and in field:** 2–4 pt/acre (1–2 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Blue, Norway); True fir (Fraser, Grand, Noble)	**Seedbeds:** Apply Goaltender preemergence after seeding, or 5 weeks after seedling emergence. **Containers and field:** Apply in spring before budbreak, and after new growth has hardened in fall.	**Preemergence:** Goaltender provides good preemergence control of broadleaves and grasses. Do not apply Goaltender on stressed trees or during periods of active growth. **Postemergence:** Goaltender has postemergence activity against most annual broadleaves. Include a nonionic surfactant (NIS) in postemergence applications.
PENDULUM AQUA CAP 3.8 CS	pendimethalin	Mitosis inhibitor 3(K1)	2.1–4.2 qt/acre (2–4 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Blue, Norway, White); True fir (Balsam, Fraser, White)	Apply after transplanting or in spring to established trees.	Controls annual grasses and broadleaves. Apply Pendulum over the top of trees or to soil between trees before weeds germinate. Apply after soil has settled around new transplants.
PENNANT MAGNUM 7.62 EC	S-metolachlor	VLCFA Synthesis Inhibitor 15(K3)	1.3–2.6 pt/acre (1.2–2.5 lb AI/acre)	Douglas-fir; Pine (*Pinus* spp.); Spruce (*Picea* spp.); True fir (*Abies* spp.)	Apply before weeds emerge.	Annual grasses, nightshades, pigweeds, and yellow nutsedge control. To avoid tree injury, do not apply to seedbeds, cutting beds, or unrooted cuttings before transplanting or to plants in field until soil has settled firmly around roots. When broadcast over the top of plant foliage, follow with sufficient overhead irrigation to wash it from the foliage to reduce potential injury.
SURFLAN 4 AS AG (70506-43 2022) Surflan 4 AS Specialty	oryzalin	Mitosis inhibitor 3(K1)	2–4 qt/acre (2–4 lb AI/acre)	Pine (*Pinus* spp.); Spruce (*Picea* spp.); True fir (*Abies* spp.)	Apply before weeds germinate.	Annual grass control. Apply to transplanted trees after soil has settled around trees and roots. Do not apply to seedbeds or seedling transplant beds. Do not apply to Douglas-fir.
TOWER 6 EC	dimethenamidP	VLCFA Synthesis Inhibitor 15(K3)	21–32 fl oz/acre (0.98–1.5 lb AI/acre)	Douglas-fir; Pine (all species); Spruce (Colorado Blue, Norway); True fir (*Abies* sp.)	Apply after soil has settled around transplants.	Controls grasses, yellow nutsedge. May be used in seedling nurseries and new field plantings. Apply after soil has settled around new transplants. Do not apply during bud break. Maximum of two applications and 64 fl oz/acre/year.
VELPAR 2 LVU	hexazinone	PS II inhibitor 5(C1)	2–3 qt/acre (1–1.5 lb AI/acre)	Pine (Austrian, Scotch); True fir (Fraser, Grand, Noble)	**New transplants:** apply on trees 2 years or older. Apply after soil has settled around seedlings and roots.	Do not use in nurseries or seedbeds. Maximum of one application per year. Rates vary, depending on soil type. Use low rate on sandy soil.

[a] WSSA = Weed Science Society of America. HRAC = Herbicide Resistance Action Committee.

Table 8. Postemergence weed control in seedbeds, recent transplants, and first-year Christmas trees.

Trade name	Common name	Mechanism of action WSSA & (HRAC) group [a]	Amount of product (& active ingredient) per acre	Tree species on label	Timing	Comments & limitations
COBRA 2 EC	lactofen	PPO inhibitor 14(E)	0.4–1 pt/acre (0.1–0.25 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (Fraser, Grand, Noble)	Apply before budbreak or after hardening.	Controls broadleaves up to 4 in. tall. Do not apply when conifers are under stress. Max 20 fl oz/acre/year.
ENVOY PLUS 0.97E	clethodim	ACCase inhibitor 1(A)	932 fl oz/acre (0.09–0.24 lb AI/acre)	Douglas-fir; Pine (*Pinus* spp.); Spruce (*Picea* spp.); True fir (*Abies* sp.)	Apply to actively growing grasses.	Controls grasses. Include 0.25% NIS (non-ionic surfactant) or 1% COC (crop oil concentrate). For control of mature grasses, include ammonium sulfate (AMS) at 17 lb/100 gal of spray solution. Wait 30 days before planting after an application of Envoy Plus.
FUSILADE DX 2E, FUSILADE II 2E T&O	fluazifop-butyl	ACCase inhibitor 1(A)	16–24 fl oz/acre (0.25–0.375 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (*Abies* sp.)	Apply to actively growing grasses.	Controls grasses. Include 0.25% NIS or 1% COC. Include AMS at 17 lb/100 gal of spray solution for large grasses. Perennial grasses may require multiple applications for control.
GOALTENDER 4 SC	oxyfluorfen	PPO inhibitor 14(E)	**Seedbeds:** 0.5–1.0 pt/acre (0.25–0.5 lb AI/acre) **Trees in containers and field:** 2–4 pt/acre (1–2 lb AI/acre)	Douglas-fir; Pine (Scotch, White); Spruce (Blue, Norway); True fir (Fraser, Grand, Noble)	**Seedbeds:** Apply 5 weeks after emergence. **Containers and field:** Apply before budbreak in spring and after hardening in fall.	Goaltender controls annual broadleaves both pre- and postemergence. Maximum of 4 pt/acre/year pre- and postemergence. Do not apply inside greenhouses; do not apply to conifers under stress. May be sprayed over the top of Christmas trees except during active bud and shoot growth.
SEGMENT	sethoxydim	ACCase inhibitor 1(A)	2.25–3.75 pt/acre (0.28–0.47 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Colorado blue, Norway, Black Hills, white); True fir (*Abies* spp.)	Apply to actively growing grasses.	Sethoxydim controls grasses. Segment requires no additional surfactants.
STINGER 3L	clopyralid	Synthetic auxin 4(O)	¼–⅔ pt/acre (0.09–0.23 lb AI/acre)	Douglas-fir; Pine (White); Spruce (Blue); True fir (Balsam, Fraser, Grand, Noble)	Apply when susceptible weeds are at 3- to 5-leaf stage; for Canada thistle and spotted knapweed control, apply the high rate before weed bud stage.	Controls composites, legumes, nightshade, smartweeds, and plantains. Do not exceed 8 fl oz/acre (0.188 lb AI) on blue spruce. Do not use an adjuvant or surfactant to avoid tree injury. Do not apply with air blast sprayers; may be applied over the top of trees at any stage. Do not exceed ⅔ pt/acre in annual growing season. With blue spruce do not exceed ½ pt/acre.

[a] WSSA = Weed Science Society of America. HRAC = Herbicide Resistance Action Committee.

Table 9. Preemergence weed control in established Christmas trees.

Trade name	Common name	Mechanism of action WSSA & (HRAC) group[a]	Amount of product (& active ingredient) per acre	Tree species on label	Timing	Comments & limitations
AATREX 4L (RUP)	atrazine	PS II inhibitor 5(C1)	1–4 qt/acre (1–4 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch); Spruce (Blue); True fir (Grand, Noble, White)	Apply to dormant established trees in late fall or early spring. Apply before weeds are 1.5 in. tall.	AAtrex controls annual broadleaves and grasses. For quackgrass control, apply the high rate in fall or early spring when trees are dormant. Apply over the tops of trees or directed to soil between rows. Several weed species have biotypes that are resistant to atrazine.
BARRICADE 4 FL	prodiamine	Mitosis inhibitor 3(K1)	21–48 fl oz/acre (0.6–1.5 lb AI/acre)	Pine (Scotch, White); True fir (*Abies* sp.)	Preemergence to weeds.	Controls grasses and some broadleaves. Apply anytime over the top or as a directed spray.
GALLERY 75 DF	isoxaben	Cellulose synthesis inhibitor 21(L)	0.67–1.33 lb/acre (0.5–1 lb AI/acre)	Pine (Austrian, Scotch, White); Spruce (Blue, Norway, White); True fir (Balsam, White)	Apply in the spring before annual weeds germinate.	Controls annual broadleaves. No control of grasses or perennial weeds. Apply to trees established in the field after soil has settled around the plants. May be applied over the top of trees or as a directed spray.
GOALTENDER 4 SC	oxyfluorfen	PPO inhibitor 14(E)	1–2 qt/acre (1–2 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Blue, Norway); True fir (Fraser, Grand, Noble)	Apply to established trees in the field or in containers. Apply before budbreak or after new growth has hardened.	Trees in field and in containers. Goaltender provides good preemergence and postemergence control of many broadleaves. Do not apply Goaltender on stressed trees or during periods of active tree growth.
KERB 3.3 SC (RUP) KERB 3.3 SC T&O (RUP)	pronamide	Mitosis inhibitor 3(K1)	2.5–5 pt/acre (1–2 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (*Abies* spp.)	Apply in late fall when soil temperature is below 55 °F.	Controls annual and perennial grasses, common chickweed, and mustard weeds. Apply to trees established in the field at least 1 year. May be applied over the top of trees or as a directed spray between rows. Control lasts 6 to 8 weeks in spring.
MARENGO 0.622 SC	indaziflam	Cellulose synthesis inhibitor 29(L)	7.5–15.5 fl oz/acre (0.036–0.075 lb AI/acre)	Christmas trees and conifer plantations	Apply before weeds germinate in spring.	Use on trees established in the field at least 1 year. Controls most annual weeds. Keep off foliage, apply as a directed spray to soil at base of trees. Good control of most annual broadleaves. Fair control of common ragweed and horseweed.
MISSION 25 WG	flazasulfuron	ALS inhibitor 2(B)	2.14–2.85 oz/acre (0.033–0.045 lb AI/acre)	Douglas-fir; Pine (Eastern White, Red, Scotch, White); Spruce (Blue, Norway); True fir (Balsam, Fraser, Noble, Nordman, White)	Apply in spring before budbreak, or in fall after foliage has hardened off.	Mission has both pre- and postemergence activity. Controls most annual grasses and broadleaf weeds, including Carolina geranium, redstem filaree, and field pansy. Do not apply within 1 year of seeding trees. May be applied over the top in spring or after new growth has hardened in fall. Directed spray is preferred to reduce phytotoxicity.
PENDULUM AQUA CAP 3.8 CS	pendimethalin	Mitosis inhibitor 3(K1)	2.1–4.2 qt/acre (2–4 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Blue, Norway, White); True fir (Balsam, Fraser, White)	Apply after transplanting or in spring to established trees.	Controls annual grasses and broadleaves. Apply Pendulum over the top of trees or to soil between trees before weeds germinate.
PENNANT MAGNUM 7.62 EC	Smetolachlor	VLCFA Synthesis Inhibitor 15(K3)	1.3–2.6 pt/acre (1.2–2.5 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (*Abies* sp.)	Apply in spring before weeds emerge.	Controls annual grasses, nightshades, pigweeds, yellow nutsedge.
PRINCEP 4L	simazine	Photosystem II inhibitor 5(C1)	2–4 qt/acre (2–4 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Blue, Norway, White); True fir (Balsam, Fraser, White)	Apply to dormant trees more than 2 years old.	Make sure the planting slit is closed and soil is firmly settled around the roots. Controls many annual broadleaf weeds and grasses and suppresses quackgrass. Apply 2 qt in fall and 2 qt in spring for quackgrass control. Some weed species have biotypes resistant to simazine.
PRINCEP CALIBER 90 WDG	simazine	Photosystem II inhibitor 5(C1)	2.2–4.4 lb/acre (2–4 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Blue, Norway, White); True fir (Balsam, Fraser, White)	Apply to dormant trees more than 2 years old.	Make sure the planting slit is closed and soil is firmly settled around the roots. Controls many annual broadleaf weeds and grasses and suppresses quackgrass. Apply 2 qt in fall and 2 qt in spring for quackgrass control. Some weed species have biotypes resistant to simazine.
SUREGUARD 51 WDG SUREGUARD 4 SC	flumioxazin	PPO inhibitor 14(E)	8–12 oz (0.255–0.383 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Blue, Norway); True fir (Fraser, Grand, Noble, Turkish, White)	Apply in spring before budbreak, or later in season after new growth has hardened.	Controls most annual broadleaves and grasses. Apply over the top of trees before budbreak. Sureguard may cause light needle burn. Do not use Sureguard on Christmas tree seedlings less than 1 year after emergence. Do not tank mix with an EC (emulsifiable concentrate) formulation of any other pesticide to avoid needle burn. Poor long-term horseweed control.
TOWER 6 EC	dimethenamid-P	VLCFA Synthesis Inhibitor 15(K3)	21–32 fl oz/acre (0.98–1.5 lb AI/acre)	Douglas-fir; Pine (all species); Spruce (Colorado Blue, Norway); True fir (*Abies* sp.)	Apply preemergence to weeds and after soil has settled around transplants.	Controls grasses, some broadleaves, and yellow nutsedge. Apply anytime except at budbreak. Maximum of two applications and 64 fl oz/acre/year.
TRIFLURALIN 4 HF	trifluralin	Mitosis inhibitor 3(K1)	1–2 pt/acre (0.5–1 lb AI/acre)	Pine (Austrian, Scotch, white); Spruce (Colorado blue, Norway, White); True fir (Balsam, White)	Apply only to established plantings that are into their final growing location for a sufficient period to allow the soil to be firmly settled around roots from packing and rainfall or irrigation.	Controls annual grasses and broadleaf weeds. Do not apply to Christmas tree seedling beds. Also, do not apply over 12 lb AI/acre total of trifluralin within a 12-month period.
VELPAR 2L	hexazinone	Photosystem II inhibitor 5(C1)	2–4 qt/acre (1–2 lb AI/acre)	Pine (Austrian, Scotch); Spruce (Sitka); True fir (Fraser, Grand, Noble)	Apply broadcast before budbreak in spring or as a directed spray after budbreak.	Controls most herbaceous broadleaves and some woody perennials. Apply on soil with more than 1% organic matter and less than 85% sand. Apply only once per year.

[a] WSSA = Weed Science Society of America. HRAC = Herbicide Resistance Action Committee.

Table 10. Postemergence weed control in established Christmas trees.

Trade name	Common name	Mechanism of action WSSA & (HRAC) Group [a]	Amount of product (& active ingredient) per acre	Tree species on label	Timing	Comments & limitations
ASULOX 3.34 SL (70506-139 2022)	asulam	DHP (cell division) inhibitor 18(I)	4 qt/acre (3.34 lb AI/acre)	Douglas-fir; Pine (Scotch); True fir (Grand, Noble)	Apply after hardening of new tree growth.	Bracken fern control. Use a minimum of 20 gal water per acre. Do not use an adjuvant. Maximum of one application per season. Do not apply by air.
COBRA 2 EC	lactofen	PPO inhibitor 14(E)	0.4–1 pt/acre (0.1–0.25 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (Fraser, Grand, Noble)	Apply before budbreak or after hardening.	Cobra controls many annual broadleaves up to 4 in. tall. Avoid application to conifers under stress. Maximum 26 fl oz/acre/year.
DEFY AMINE 4	2,4-D – dimethylamine salt	Synthetic auxin 4(O)	1–4 qt/acre (0.95–3.8 lb AI/acre)	All conifer species	Apply before budbreak in spring or in late summer after new growth has hardened.	Controls herbaceous and woody broadleaved species. Apply before budbreak in spring as a directed spray to control annual weeds in all conifer species. Avoid spraying tree foliage. Do not apply to diseased or stressed seedlings. May be applied in late summer after new conifer growth has hardened to control woody plants. May cause injury to *Pinus* species if applied as a broadcast spray.
ENVOY PLUS 0.97E	clethodim	ACCase inhibitor 1(A)	12–32 fl oz/acre (0.09–0.24 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (*Abies* sp.)	Apply to actively growing grasses.	Controls grasses. Include 0.25% NIS (non-ionic surfactant)or 1% COC (crop oil concentrate). Include ammonium sulfate (AMS) at 17 lb/100 gal of spray solution for large grass control.
FUSILADE DX 2E FUSILADE II 2E T&O	fluazifop-butyl	ACCase inhibitor 1(A)	16–24 fl oz/acre (0.25–0.375 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (*Abies* sp.)	Apply to actively growing grasses.	Controls grasses. Include 0.25% NIS or 1% COC. Include AMS at 17 lb/100 gal of spray mix for large grasses. Perennial grasses may require multiple applications for complete control.
GARLON 3A	triclopyr triethylamine salt	Synthetic auxin 4(O)	2–5 pt/acre (0.75–1.75 lb AI/acre)	All conifer species; Spruce (Blue); True fir (Balsam, Fraser) (**Note**: Douglas-fir and white pine may be sensitive to triclopyr.)	Apply Garlon in late summer or early fall after conifer terminal growth has hardened and weeds and woody plants are still growing.	Controls woody and herbaceous broadleaves. Apply to Christmas trees established in the field for at least 1 year. Spray toward the base of the trees. Do not apply to newly seeded grass alleys or to legume cover crops.
GOALTENDER 4 SC	oxyfluorfen	PPO inhibitor 14(E)	**Trees in containers and field:** 2–4 pt/acre (1–2 lb AI/acre)	Douglas-fir; Pine (Scotch, White); Spruce (Blue, Norway); True fir (Fraser, Grand, Noble)	Apply before budbreak in spring and after foliage has hardened in fall.	Goaltender controls annual broadleaves. Maximum of 4 pt (2 lb AI)/acre/year; do not apply inside greenhouses; do not apply to conifers under stress. May be sprayed over the top of Christmas trees except during periods of active growth.
MISSION 25 WG	flazasulfuron	ALS inhibitor 2(B)	2.14–2.85 oz/acre (0.033–0.045 lb AI/acre)	Douglas-fir; Pine (Eastern White, Red, Scotch, White); Spruce (Blue, Norway); True fir (Balsam, Fraser, Grand, Noble, Nordman, White)	Apply to broadleaf weeds and grasses less than 4 in. tall.	Controls many broadleaves and grasses. Apply after new tree growth has hardened. May be applied over top of trees. Apply as directed spray during periods of active growth. Maximum of 9.6 oz (0.15 lb AI) per acre per year. Do not apply within 1 year of seeding trees. Minimum of 3 months between treatments.
ROUNDUP PRO	isopropylamine salt of glyphosate	Shikimic acid pathway inhibitor 9(G1)	1–8 pt/acre (0.5–4 lb AI/acre)	Douglas-fir; Pine; Spruce; True fir (*Abies* sp.); Other conifers	Apply after new growth has hardened in fall. Avoid contact with new tree growth.	Use glyphosate formulations without surfactants. Glyphosate applied at 1–2 qt/acre kills most annual weeds. 2–4 qt/acre kills most perennial weeds. Woody species may be killed with multiple applications. Does not control field horsetail (*Equisetum arvense*). Do not apply over the top of Christmas trees. Apply as a directed spray to weeds using a hand boom or wiper applicator.
SEGMENT	sethoxydim	ACCase inhibitor 1(A)	2.25–3.75 pt/acre (0.28–0.47 lb AI/acre)	Douglas-fir; Pine (Austrian, Scotch, White); Spruce (Colorado blue, Black Hills, White); True fir (*Abies* spp.)	Apply to actively growing grasses.	Controls grasses. Requires no additional surfactants.
STINGER 3L	clopyralid	Synthetic auxin 4(O)	¼–⅔ pt/acre (0.09–0.23 lb AI/acre)	Douglas-fir; Pine (White); Spruce (Blue); True fir (Balsam, Fraser, Grand, Noble)	Apply when susceptible weeds are at 3- to 5-leaf stage. For Canada thistle and spotted knapweed control, apply the high rate before weed bud stage.	Controls composites, legumes, nightshade, plantains, smartweeds, and thistles. Do not exceed 8 fl. oz/acre on blue spruce. Do not add an adjuvant or surfactant. Do not apply with air blast sprayers. May be applied over the top of trees at any stage. Do not exceed ⅔ pint/acre in annual growing season.

[a] WSSA = Weed Science Society of America. HRAC = Herbicide Resistance Action Committee.

Table 11. Registered herbicides containing glyphosate or a glyphosate compound as the active ingredient that can be applied in Christmas tree plantations for weed control.

Trade name	Active ingredient	EPA [a] registration number	Manufacturer	Comments
ACCORD XRT	glyphosate, dimethylamine salt	62719-556	Dow/Corteva	Generally, surfactant is not required. But may be added to highly dilute spray solutions or when the application rate being used is at the low end of the effective rate range.
ACCORD XRT II	glyphosate, dimethylamine salt	62719-556	Dow	No additional surfactant required.
BUCCANEER GLYPHOSATE	glyphosate, isopropylamine salt	55467-10	Tenkoz	Do not use this product as over the top broadcast spray. Non-ionic surfactants (NIS) may be added.
BUCCANEER 5 EXTRA	glyphosate, isopropylamine salt	55467-15	Tenkoz	Surfactant may be included in the tank mix if desired and should only be done so based on field experience or further recommendation of your local Extension staff, crop consultant, or field representative. This product needs to be applied as post-directed spray and as spot treatment.
BUCCANEER PLUS	glyphosate, isopropylamine salt	55467-9	Tenkoz	NIS may be added.
CORNERSTONE 5 PLUS	glyphosate, isopropylamine salt	1381-241	WinField United	Surfactant may be added.
CORNERSTONE PLUS	glyphosate, isopropylamine salt	1381-192	WinField United	NIS may be added.
CORNERSTONE PLUS	glyphosate, isopropylamine salt	524-454-1381	WinField United	NIS may be added.
CREDIT 41 EXTRA	glyphosate, isopropylamine salt	71368-20	Nufarm	No additional surfactant required.
CREDIT 5.4 EXTRA	glyphosate, isopropylamine salt	71368-126	Nufarm	No additional surfactant required.
CREDIT XTREME	glyphosate, isopropylamine salt + glyphosate, potassium salt	71368-81	Nufarm	No additional surfactant required.
ENVY	glyphosate, isopropylamine salt	89168-17-89391	Innvictis Crop Care	NIS may be added
ENVY INTENSE	glyphosate, isopropylamine salt	89168-17-89391	Innvictis Crop Care	NIS may be added.
ENVY SIX MAX	glyphosate, isopropylamine salt	89167-47-89391	Innvictis Crop Care	No additional surfactant required.
FORESTERS' NON-SELECTIVE	glyphosate, isopropylamine salt	228-381	Nufarm	NIS may be added.
FOUR POWER PLUS	glyphosate, isopropylamine salt	34704-890	Loveland	No additional surfactant required.
GLY STAR5 EXTRA	glyphosate, isopropylamine salt	42750-59	Albaugh/Agristar	Surfactant may be included in the tank mix if desired and should only be done so based on field experience or further recommendation of your local Extension staff, crop consultant, or field representative.
GLY STAR K-PLUSF	glyphosate, isopropylamine salt	42750-122	Albaugh/Agristar	Generally, surfactant is not required.
GLY STAR ORIGINAL	glyphosate, isopropylamine salt	42750-60	Albaugh/Agristar	NIS may be added.
GLY STAR PLUS	glyphosate, isopropylamine salt	42750-61	Albaugh/Agristar	Additional surfactants labeled for use with herbicides may be used.
GLYPHOGAN	glyphosate, isopropylamine salt	66222-105	ADAMA	NIS may be added.
GLYPHOGAN PLUS	glyphosate, isopropylamine salt	6622-176	ADAMA	No additional surfactant required.
GLYPHOSATE 4 PLUS	glyphosate, isopropylamine salt	81927-9	Alligare	No additional surfactant required.
HONCHO K6	glyphosate, potassium salt	524-539	Bayer	Although not always required, surfactant may be added to spray solutions.
KLEENUP PRO	glyphosate, isopropylamine salt	34704-890	Loveland	Additional surfactants labeled for use with herbicides may be used.
MAD DOG	glyphosate, isopropylamine salt	34704-889	Loveland	NIS labeled for use with herbicides may be used.
MAD DOG PLUS	glyphosate, isopropylamine salt	34704-890	Loveland	No additional surfactant required. Can be applied as an over-the-top broadcast spray in Christmas tree plantations.
MAKAZE	glyphosate, isopropylamine salt	34704-890	Loveland	No additional surfactant required.
RANGER PRO	glyphosate, isopropylamine salt	524-517	Monsanto (now Bayer)	No additional surfactant required.
RAZOR PRO	glyphosate, isopropylamine salt	228-366	Nufarm	NIS may be added.
RAZOR EXTREME	glyphosate, isopropylamine salt + glyphosate, potassium salt	71368-81	Nufarm	No additional surfactant required.
RODEO	glyphosate, isopropylamine salt	62719-324	Dow/Corteva	NIS needs to be added.
ROUNDUP POWER MAX	glyphosate, potassium salt	524-549	Bayer	No additional surfactant required.
ROUNDUP PRO	glyphosate, isopropylamine salt	524-475	Bayer	No additional surfactant required.
ROUNDUP PRO CONCENTRATE	glyphosate, isopropylamine salt	524-529	Bayer	No additional surfactant required.
ROUNDUP PROMAX	glyphosate, potassium salt	524-579	Bayer	No additional surfactant required.
ROUNDUP WEATHERMAX	glyphosate, potassium salt	524-537	Bayer	No additional surfactant required.
SHOWDOWN	glyphosate, isopropylamine salt + glyphosate, monoammonium salt	71368-25-5905	Helena	NIS labeled for use with herbicides may be used.
SUNPHOSATE 41%	glyphosate, isopropylamine salt	87659-3	Wynca	NIS may be added.

Note. The re-entry interval (REI) for all products listed in Table 11 is 4 hours.
[a] EPA = U.S. Environmental Protection Agency.

Table 12. Modes of action of common herbicides that are used in Christmas tree production for weed control.

WSSA group	Active ingredient	Trade name
1 (A)—ACCase(Acetyl CoA Carboxylase) inhibitor	clethodim	ENVOY PLUS 0.97 EC
1 (A)—ACCase inhibitor	fluazifop-butyl	FUSILADE DX 2L, FUSILADE II T&O 2E
1 (A)—ACCase inhibitor	sethoxydim	SEGMENT 1, SEGMENT II 1EC
2 (B)—ALS (Acetolactate Synthase) inhibitor	flazasulfuron	MISSION 25 WG
3 (K1)—Mitosis inhibitor	prodiamine	BARRICADE 4F
3 (K1)—Mitosis inhibitor	pronamide	KERB 3.3 SC, KERB 3.3 SC T&O (RUP)
3 (K1)—Mitosis inhibitor	pendimethalin	PENDULUM AQUA CAP 3.8 CS
3 (K1)—Mitosis inhibitor	trifluralin	TRIFLURALIN 4 HF
4 (O)—Synthetic auxin	2,4-D	DEFY AMINE 4
4 (O)—Synthetic auxin	triclopyr triethylamine salt	GARLON 3A
4 (O)—Synthetic auxin	clopyralid	STINGER 3L
5 (C1)—PSII (Photosystem II) inhibitor	atrazine	AATREX 4L (RUP)
5 (C1)—PSII inhibitor	simazine	PRINCEP 4L, PRINCEP Caliber 90
5 (C1)—PSII inhibitor	hexazinone	VELPAR 2 L VU
9 (G1)—Shikimic acid pathway inhibitor	isopropylamine salt of glyphosate	ROUND-UP (ADDITIONAL TRADE NAMES)
14 (E)—PPO (Protoporphyrinogen oxidase) inhibitor	lactofen	COBRA 2EC
14 (E)—PPO inhibitor	oxyfluorfen	GOALTENDER 4 SC
14 (E)—PPO inhibitor	flumioxazin	SUREGUARD 51 WDG, SUREGUARD 4 SC
15 (K3)—VLCFA (Very long-chain fatty acids) synthesis inhibitor	S-metolachlor	PENNANT MAGNUM 7.62 EC
15 (K3)—VLCFA synthesis inhibitor	dimethenamid-P	TOWER 6 EC
18(1)—DHP (7,8-dihydro-pteroate synthetase) inhibitor	asulam	ASULOX 3.34 SL
21 (L)—Cellulose synthesis inhibitor	isoxaben	GALLERY 75DF
29 (L)—Cellulose synthesis inhibitor	indaziflam	MARENGO 0.622 SC

Note. WSSA = Weed Science Society of America.