

PERENNIAL AND BIENNIAL THISTLE CONTROL

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BIENNIAL NOXIOUS THISTLES

Most thistles in the western United States are native species that generally go unnoticed and likely will never cause significant losses as weeds. However, thistle species introduced from Europe, Africa, and Asia can be very aggressive opportunists. They often invade overused or otherwise disturbed land. The plants spread rapidly, out-compete established and introduced plant species for nutrients, and can render pastures, rangeland, and forests nearly unusable.

Thistles are especially troublesome following cool wet summers and falls, when seed production and seedling establishment are high. An integrated weed control program that combines chemical, cultural (such as crop rotation or grass competition), mechanical and biological methods is most likely to be successful. Keys to controlling all thistles include:

- Establish a three- to five-year management program using several integrated methods.
- Control small patches before they spread.
- Use proper stocking rates and rotate pastures.
- Reseed disturbed areas immediately with desired species.

Biennial thistles such as musk (*Carduus nutans* L.), plumeless (*Carduus acanthoides* L.), and bull thistle [*Cirsium vulgare* (Savi) Tenore] are not as difficult to control as the perennial thistle species but spread rapidly by seed and can become severe problems in some areas. All biennial thistles considered noxious are native to Europe or Eurasia and were introduced into North America as seed contaminants. Biennial thistles spread by seed (achenes) that are produced in great number by all the noxious species, ranging from 8400 seeds per plant with plumeless thistle to 120,000 seeds per plant from musk thistle.

Biennial thistle seed generally germinates in the summer and fall, and the plant over-winters as a rosette. The following spring the plant resumes vegetative growth, bolts, and flowers. Numerous, generally large flower heads are produced from May to October depending on the species. After setting seed, the plants die thereby completing the life cycle. Occasionally biennial thistles have winter annual, annual, or short-lived perennial characteristics.

Biennial thistles tend to invade over-grazed or otherwise disturbed pastures, rangeland, roadsides, and waste areas. Movement into cropland is generally from nearby non-cropland or roadsides. Biennial thistles reproduce only from seed, so the key to a successful management program is to control the plants before flowering.

PLUMELESS THISTLE

Plumeless thistle tends to be shorter than other noxious biennial thistles and generally reaches 1 to 4 feet tall. The stems are winged, very branched, and very spiny giving the plant a candelabra appearance (Figure 1A). Rosettes have wavy leaves with yellow spines along the leaf margins. Rosette leaves are often pubescent on the under side along the mid-vein. The flowers are usually pink to purple in color, with thin bracts and very sharp spines (Figure 1B). The plants flower from May to July in warmer climates and as late as October in Canada. Seeds are dispersed 1 to 3 weeks after flowering.

Plumeless thistle is seldom found in

Figure 1A. Candelabra appearance of plumeless thistles showing spiny winged stems.





Figure 1B. Plumeless flower with short very sharp spines on the bracts.

cultivated fields, even when infestations are nearby in roadsides or pastures. Plumeless thistle can germinate in and tolerate a soil pH range from 3 to 9. Vesicular arbuscular mycorrhiza has been found on plumeless thistle in Europe. These organisms live symbiotically with the thistle roots and can help the plant with water and nutrient absorption. Well established stands of plumeless thistle are self-renewing because other species provide little competition and old stalks catch snow to insulate the rosettes and increase moisture for the next season's growth.

Figure 2B. Musk thistle rosette which often grows two feet or more in diameter has no pubescence on the underside of the leaf which helps distinguish it from plumeless thistle rosettes.



MUSK THISTLE

Musk thistle is one of the more common biennial noxious thistles and is relatively easy to identify because it often grows in excess of 6 feet tall, has very large flowers that tend to droop, and the flower has very characteristic brown bracts that resemble pine cones (Figure 2A). The flowers usually are deep rose in color, solitary, and very large ranging from 1.5 to 3 inches in diameter. The average musk thistle plant produces in excess of 10,000 seeds per plant and under favorable conditions may produce 120,000 seeds per plant. Seed germination generally averages 30 percent. Rosettes are dark green with a light green midrib and often grow 2 feet in diameter or more (Figure 2B). Rosette leaves are usually smooth and lacking pubescence.



Figure 2A. Musk thistle flower with large brown bracts and the tendency to nod or lean because of the large size of the flower.

Musk thistle generally invades areas that are especially dry and over-grazed. Musk thistle seed is readily dispersed after introduction, so plants cover many acres in only one or two seasons. Infestations are generally more dense than with other biennial thistles, but less dense than perennial noxious thistles. Flowering is indeterminant, starting in early June and continuing for at least 8 to 10 weeks. A late-blooming cycle often occurs just prior to frost. Seed from the late-bloom is primarily responsible for the limited success of seed-feeding weevils (*Rhinocyllus conicus*) introduced for biological control of musk thistle. These insects attack the earlier blooms but have completed their life cycle before the last flowers set seed.

BULL THISTLE

Bull thistle is generally the least serious of the noxious thistles. It occurs in all 48 contiguous states and most of Canada, but is designated noxious in only four states. The plant is fairly short growing, 2 to 5 feet. A distinguishing characteristic of bull thistle is the leaves (Figure 3A). Leaf margins are deeply toothed, and toothed again (double dentate) with prominent stiff spines. The leaves have prickly hairs above and are cottony below. The plant appears bushy rather than the candelabra appearance of plumeless or Canada thistle (Figure 3B).

The seeds readily germinate; however, survival is low and bull thistle is generally found as single or only scattered plants. The rosettes of bull thistle are very pubescent with dark purple ribs.



Figure 3A. Double dentate leaf with long stiff spines at each tooth, prickly pubescence along the leaf mid vein and winged stem which is very pubescent during the rosette and early bolt growth stages of bull thistle.

The heads are gumdrop-shaped with long stiff yellow tipped spines. Bull thistle

flowers from July to September, which is somewhat later than other thistles in the region. The flowers are usually purple, but a rare white flowering variety has been collected in the region.

Figure 3B. Bushy appearance of bull thistle with spiny conical shaped flower heads.



PERENNIAL NATIVE AND NOXIOUS THISTLES

Perennial thistles such as Canada [*Cirsium arvense* (L.) Scop.], Flodman thistle [*C. flodmanii* (Rydb.) Arthur], and wavyleaf thistle [*C. undulatum* (Nutt.) Spreng.], are generally more difficult to control than the biennial thistles because they spread by both root and seed. Topgrowth control is not enough; one must design a program to deplete the root system for effective control of a perennial thistle.

Both wavyleaf and Flodman thistle are native species that generally are only a problem when the land has been overused. Canada thistle was introduced from Europe and like many introduced weeds has spread rapidly because of the lack of natural enemies. All perennial noxious thistles are aggressive invaders and can become the dominant species in an area within a few seasons of introduction if not properly controlled.

Figure 4B. Canada thistle rosette form with spiny tips and wavy leaves.



CANADA THISTLE

Canada thistle was introduced in North America as a seed contaminant in both French and British colonies. The first legislation to control the weed was passed by Vermont in 1795. The native distribution of Canada thistle includes Europe, North Africa, and central Asia. It is also found in China and Japan and has spread so extensively that it is difficult to distinguish the plant's original native range. Canada thistle grows best in the northern regions of North America where temperature and rainfall are moderate. Canada thistle is adapted to a wide range of soils, but it produces deeper roots in clay or muck soils than in sand, gravel, or limestone soils. Canada thistle requires a 14- to 16-hour photoperiod to bolt and flower, and growth ceases when temperatures exceed 85 degrees for extended periods. Canada thistle is considered to be naturalized in the northern Great Plains.

Canada thistle usually grows 2 to 3 feet tall and bears alternate, dark green leaves that vary in size (Figure 4A). The leaves are oblong, usually deeply cut, and have spiny, toothed edges (Figure 4B). Canada thistle has small (three-fourths inch diameter), compact flower heads that appear on the upper stems and



Figure 4A. Bolted Canada thistle with cluster flowers and waxy wavy leaves.

range in color from lavender to pink or white.

Canada thistle has been classified into several varieties. Within these varieties are many ecotypes which differ in growth characteristics, response to daylength, and susceptibility to herbicides and cultivation. For example, leaf shape, head structure, and the number and size of spines can differ with ecotype. Flower color can range from purple to light lavender or even white. Stem color also can

differ from green to lavender. Some ecotypes show variable response to herbicides and/or cultivation.

Flowering occurs from June to September. Male and female flowers are produced on different plants, so cross pollination is necessary for seed production. Flowers produce from 40 to 80 seeds per head. The smooth, light brown seeds have a conical point and are loosely attached to a tannish pappus at the tip, which aids in seed dispersal by wind. Seeds mature rapidly and are able to germinate within eight to 10 days after pollination.

Canada thistle generally spreads from field to field in contaminated crop seed or forage. Within a Canada thistle population some seed remains in the flower head or falls at the base of the plant. The remaining seed can be dispersed by wind, either attached to the cottony pappus in late summer or later in the winter when it is moved by wind driven snow across fields.

Once the plant becomes established, roots are the most important means of propagation. Canada thistle has an extensive underground root system that may penetrate the soil to a depth of 10 feet or more and grow laterally 12 to 15 feet per year. Root buds occur randomly along the roots and initiate new shoots whenever environmental conditions are favorable. Root segments as small as 0.6 inch can initiate shoot growth and become established.

FLODMAN THISTLE

Flodman thistle is a deep-rooted perennial that is native to North America and usually grows 3 to 4 feet tall (Figure 5A). It occurs from Saskatchewan and Manitoba to Iowa and Colorado. Flodman thistle is more competitive than most other native species and has the potential to infest large areas. It is tolerant to high salt concentration in soil but not as tolerant as Canada thistle. Although it grows best under moist conditions as most thistles do, it can survive under drought conditions, which gives it a competitive advantage on semi-arid rangeland.

The leaves of Flodman thistle are shiny green on top,

Figure 5B. Flodman thistle flower has a sticky secretion on the oval shaped heads which often attracts and catches insects.



Figure 5A. Flodman thistle flowering plant showing deeply toothed leaves.

white and pubescent below, rigid, and deeply lobed. The lobes stick out at near right angles (flipping). A sticky secretion is often found on the small oval-shaped heads which attracts and catches insects (Figure 5B). Flodman thistle usually flowers from mid July through September in North Dakota. The flower color ranges from red to violet and very rarely white.

WAVYLEAF THISTLE

Wavyleaf thistle is a perennial native plant that is often confused with Flodman thistle. Wavyleaf thistle tends to flower from July to September, which is a week or two earlier than Flodman thistle. Wavyleaf thistle tends to be more spiny and the leaves less deeply lobed than Flodman thistle (Figure 6A). Also, wavyleaf thistle is found in well-drained soils, generally in drier locations than those occupied by Flodman thistle. Wavyleaf thistle grows 3 to 4 feet tall and is often associated with sagebrush

Figure 6A. Wavyleaf thistle is very pubescent and often gray in color with leaves less divided than Flodman thistle.



Figure 6B. Wavyleaf thistle flowers vary in color from lavender to pink and stems are often white and very pubescent.

communities and rangeland but is less common in moist meadows.

Wavyleaf thistle is sometimes called gray thistle because it has a white cast (Figure 6B). The leaves are very pubescent with long wavy hairs on both upper and lower surfaces. The large globe shaped heads contain glands that are tipped with strong yellow spines. The flowers are most often pink or purple but there is a white flowered form, f. *album* Farwell, which is most often found in Saskatchewan.

THISTLE CONTROL

Prevention is the best control method for both perennial and biennial thistles. Thistles often invade overused or disturbed land such as cultivated fields. Plant weed free seed to help prevent introduction into cropland and keep field borders thistle free. The best preventive measure in non-cropland is to maintain a thick plant cover and to reseed disturbed areas with a desirable species as soon as possible. Proper grazing management and rotational grazing practices should be established and maintained to prevent thistle establishment in grazing land.

Controlled and rotational grazing can prevent thistle establishment because overgrazing weakens desirable species, making the pasture more susceptible to invasion. Pastures protected from overgrazing have little thistle establishment. An adequate fertility program insures a healthy and vigorous pasture with species competitive to thistle. Avoid spreading thistle seed to uninfested areas with manure, mowers, or other farm equipment. Establishing competitive grasses can reduce the size of rosettes and decrease thistle height, root weight, and crown size.

Once thistle invades an area, several control options are available depending on the location and land use. Control options include cultural, mechanical, chemical, and biological methods. It is generally better to combine two or more control options in an integrated management program rather than relying on a single control method.

MECHANICAL CONTROL

Repeated mowing will reduce thistle infestations, especially if the plants are biennial. Mow whenever the plants are in the early bud growth stage to prevent seed-set. Several mowings a year are needed because plant populations vary in maturity. Mow as close to the surface as possible. If plants are cut above the terminal bud before the stems elongate, they likely will regrow. It is important to mow before the flowers start showing color because plants mowed after that will likely produce some viable seed. Mowing for several years will reduce the root vitality of the perennial species and will prevent seed production, reducing the seed reserve. Mowing should be combined with a chemical control program for best results.

Tillage is an effective method for perennial thistle control and will completely control biennial species. Rotations out of forage crops to annual crops will eliminate biennial thistle. Cultivate fields before the perennial species are 3 inches tall and repeat before regrowth reaches 3 inches tall until freeze-up. Cultivation depletes the energy reserves of the root system and eventually will control an established stand. Persistence and proper timing are important for control.

Fallowing and repeated cultivation for one or more seasons prevents crop production and may expose fields to serious soil erosion. Integrating cultural, mechanical and chemical control practices into a single system is the preferred approach for perennial thistle control.

CHEMICAL CONTROL

Long-term control of thistles with herbicides depends on timely application for maximum effectiveness and on retreatments to reduce the seed bank of all thistles and root reserves of perennial thistles. The most current edition of Circular W-253, Agricultural Weed Control Guide, provides specific herbicide rates and crop rotation for thistle control in North Dakota. Always consult the herbicide label for specific application rates, timing, and cropping sequence.

CROPLAND

Biennials. Biennial thistles do not survive under crop rotation since they cannot tolerate tillage or crop competition. Planting infested areas to any crop will eliminate biennial thistles. However, this practice may not be suitable for rolling, sloping, and erodible fields.

Perennials. Canada thistle is the only thistle in North Dakota that has become a cropland pest. The best approach to Canada thistle control in cropland should include an in-crop herbicide treatment to suppress Canada thistle growth, minimize crop yield losses, and prepare the thistle for a fall post-harvest treatment. Preharvest and fall-applied treatments provide the most effective long-term control. The best herbicide to use will vary depending on crop rotation. However, the control program must be uninterrupted for two to three years if the infestation is to be reduced.

Herbicides that can be used for Canada thistle growing in small grains are 2,4-D, MCPA, dicamba, Curtail (clopyralid plus 2,4-D), Curtail M (clopyralid plus MCPA), Ally (metsulfuron), Amber (triasulfuron), Canvas (metsulfuron plus thifensulfuron plus tribenuron), Express (tribenuron), Finesse (chlorsulfuron plus metsulfuron), and Harmony Extra (thifensulfuron plus tribenuron) (Table 1). Of these, Curtail provides the best and most consistent control, but a single application will not provide long-term control.

Products containing clopyralid provide good Canada thistle control and are labeled in flax (Curtail M is labeled yearly through Section 18 registration. Contact N.D. Department of Agriculture

for current status. Section 3 registration pending.), sugarbeet (Stinger), and corn (Accent Gold, Hornet, and Stinger) (Table 1). Clopyralid may have a soil residual, and peas, lentils, potatoes and broadleaf crops grown for seed should not be seeded until 18 months after treatment. Most other crops can be seeded the following growing season.

Canada thistle may be suppressed in corn with products containing dicamba (Celebrity Plus, Distinct, Northstar and others) (Table 1). Dicamba gives better control than 2,4-D with less risk of corn injury.

Canada thistle growing in soybean or dry bean can be suppressed with Basagran (bentazon) (Table 1). A second application is required 10 to 14 days after the first for satisfactory suppression. If Canada thistle has grown taller than the soybean crop, glyphosate can be applied through a selective ropewick or roller-type applicator as a salvage treatment.

Glyphosate can be used to control Canada thistle in glyphosate resistant corn, soybean, and canola (Table 1). In-crop applications will not kill established thistle stands. However, when used as part of an overall management program, glyphosate can reduce field infestations. Apply glyphosate at the correct crop stage and at labeled rates for each crop. Application beyond designated timing or using higher than labeled rates may result in crop injury. Some formulated premixes are available for use in each crop. Use caution at application to prevent drift to sensitive crops.

Good Canada thistle control is often achieved when herbicides are applied as a preharvest treatments, especially during wet summers. Glyphosate, 2,4-D, dicamba, or combinations of these herbicides can be used for preharvest Canada thistle control in wheat. Glyphosate is labeled for preharvest application in wheat, corn, soybean, field pea, chick pea, and lentil. Allow a seven day preharvest interval for broadcast applications and a 14 day preharvest interval for spot treatment. Use a 2% solution for spot treatment and apply to Canada thistle at or beyond the bud stage.

Glyphosate, clopyralid, 2,4-D, and dicamba or combinations of these herbicides provides effective Canada thistle control and good stand reduction when applied as postharvest treatments to any crop or in the fall, prior to a killing frost and when soil moisture is good. Canada thistle should have 8 to 12 inches of new regrowth. Dicamba or glyphosate provides greater stand reduction than 2,4-D. However, dicamba at lower rates can be mixed with 2,4-D, which may provide greater control than 2,4-D alone with less risk of carryover. High rates of dicamba should not be used in cropland to avoid herbicide carryover into the next cropping season. More cost-effective control may be possible by combining glyphosate with 2,4-D rather than applying glyphosate alone at high rates. Glyphosate is sold commercially in premix form with 2,4-D (Landmaster BW) or dicamba (Fallow Master) and can be used for Canada thistle suppression. Tillage should be delayed at least three days after herbicide application.

ROSETTE TECHNIQUE

An option for Canada thistle in row crops and fallow that includes both tillage and herbicides is known as the rosette technique. The objective is to prevent the plants from bolting by using tillage and/or herbicide treatments until the daylength is less than 15 hours, the photoperiod required for most Canada thistle plants to bolt. The thistles will then regrow as rosettes only. Research at NDSU has found herbicide absorption and translocation to the roots of Canada thistle is greater when applied to the rosette growth stage than when applied to bolted plants, making fall treatment of rosettes the most cost-effective method for long-term Canada thistle control.

The rosette technique for Canada thistle control in fallow includes the use of tillage and fall-applied herbicides, while control in row crops includes in-crop herbicide treatments, tillage, and fall-applied herbicides. Periodic tillage in fallow is used to control Canada thistle shoots and other weeds until late July when the daylength is less than 15

hours. Herbicides used for Canada thistle control, such as glyphosate, Curtail, or Stinger, are then applied to rosettes in late September or early October (Table 1).

In row crops, herbicides and/or tillage can be used to control Canada thistle in the crop to prevent bolting. Cultivation should be continued until canopy closure in soybean and until early July in corn. Research at NDSU has found that cultivation until late-June prevented more than 90% of Canada thistle from bolting in corn and soybean. A second option in soybean is to apply a split application of bentazon in lieu of tillage (Table 1). Herbicides are then applied in the fall following harvest for Canada thistle control. The rosette technique controls Canada thistle in both fallow and row-crops during the season and maximizes the number of rosettes for better herbicide absorption and translocation in the fall.

PASTURE, RANGELAND, AND NONCROPLAND

Biennials. Fall is the preferred time for applying herbicides for biennial thistle control. Fall applications allow for more time to apply herbicides than in the spring and correspond to the most effective time for thistle control. Seedlings that emerge in summer after tillage or previous herbicide applications will not bolt but remain in the rosette stage. Biennial thistles are most susceptible to herbicides in the rosette form.

Herbicides should be applied as late as possible in the fall but prior to a killing frost to allow for maximum seedling emergence and rosette size. Seedlings that emerge after spraying will remain vegetative until the following spring and can be treated then. Long-term eradication of biennial thistles is difficult because of the large number of seeds each plant can produce.

Biennial thistles can be effectively controlled with Stinger (clopyralid), Tordon (picloram), or dicamba (Table 2). Stinger and Tordon are the most effective of these herbicides and may be applied in the spring or fall. Tordon and clopyralid (Curtail) are often mixed with 2,4-D for broad spectrum weed control. Weedmaster (dicamba plus 2,4-D) is an effective treatment and is best applied when the thistles are in the rosette growth stage. Redeem (triclopyr plus clopyralid) is labeled for thistle control in non-cropland and CRP. Escort (metsulfuron) will control bien-

Table 1. Herbicides for Canada thistle control in cropland.

	Product/A (lb ai/A)	Thistle Location	When to Apply	Comments
MCPA or 2,4-D amine or ester	1.5 pints amine (0.75) 1.33 pints ester (0.66)	Wheat and barley	Crop: Tiller stage.	Patch spray at higher rates may injure crop but may provide greater thistle control. Small grains are more tolerant to MCPA than 2,4-D.
	2 to 4 pints of 4 lb/gal conc. (1 to 2)	Fallow or postharvest.	12 inches tall and actively growing.	Cultivate fallow until early July to achieve rosette stage at time of application. Spray in late August or September. Retreatment necessary.
Dicamba + MCPA	0.125 to 0.25 pint + 0.5 to 0.75 pint of a 4 lb/gal conc. (0.06 to 0.12 + 0.25 to 0.38)	Hard red spring and durum wheat.	Crop: Up to 5-leaf stage.	Proper timing of application is important to avoid crop injury. Dicamba must be applied before the 6-leaf stage. Use low dicamba rate and high MCPA rate on 4-leaf wheat.
Dicamba + 2,4-D	0.125 pint + 0.5 pint (0.06 + 0.25)		Crop: 4- to 5-leaf stage.	Must be applied only at the 4- to 5-leaf stage to avoid crop injury. Do not use on barley.
Curtail (clopyralid + 2,4-D)	2 pints (0.09 + 0.5)	Wheat and barley.	Wheat and barley: 4-leaf through jointing.	Rosette technique: Stinger or Curtail fall-applied to Canada thistle in the rosette stage provides greater control than when applied to bolting or flowering stems.
	4 pints (0.19 + 1)	Fallow		
Curtail M (clopyralid + MCPA ester)	1.75 to 2.33 pints (0.09 to 0.122 + 0.5 to 0.68)	Wheat and barley.	Wheat and barley: 3-leaf to jointing.	
Ally (metsulfuron)	1/10 oz DF + (0.075 oz)	Wheat, barley and pasture.	Thistle: Rosette to pre-bud stage.	Sulfonylurea herbicides should be applied with 2,4-D or MCPA + dicamba. Provides season-long Canada thistle control. Apply with a nonionic surfactant except when adding 2,4-D or MCPA at 0.75 pint/A.
Harmony Extra (thifensulfuron + tribenuron)	1/2 to 6/10 oz DF (0.375 to 0.45 oz)	Wheat and barley		
Express (tribenuron)	1/6 to 1/3 oz DF (0.125 to 0.25 oz)			
Canvas (metsulfuron + thifensulfuron + tribenuron)	5 A/pack (0.075 oz Ally + 0.225 oz Harmony Extra.)			
Finesse (chlorsulfuron + metsulfuron)	2/10 to 4/10 oz DF (0.15 to 0.225 oz)			
Amber (triasulfuron)	0.56 oz DF (0.42 oz)			

Table 1. Herbicides for Canada thistle control in cropland. (continued)

Product/A (lb ai/A)	Thistle Location	When to Apply	Comments
Curtail M (clopyralid + MCPA)	Flax	Flax: 2 to 6 inches tall.	Available through yearly Section 18 registration. Contact N.D. Department of Agriculture for current status. Allow a 72 day preharvest interval. Follow rotational crop intervals and other precautions on the product label.
Stinger (clopyralid)	Sugarbeet	Sugarbeet: 2 to 8 leaves.	Rosette technique: Fall application to Canada thistle in the rosette stage provides greater control than when applied to bolting or flowering stems. Refer to label for tank-mix options and crop rotation restrictions.
	Corn	Corn: Up to 24 inches tall. Use drop nozzles on 20 to 24 inch corn.	
Hornet (flumetsulam + clopyralid)			Add a nonionic surfactant at 0.25% v/v or oil additive at 1% v/v. Refer to label for tank-mix options and crop rotation restrictions.
Accent Gold (nicosulfuron + clopyralid + flumetsulam)			Apply with oil additive at 1 to 2% v/v. Do not use on corn varieties less than 88 day maturity. Refer to label for tank-mix options and crop rotation restrictions.
Dicamba	Corn	Corn: Up to 5 inches tall.	Use low rate on coarse textured or low organic matter soils.
		Corn: Up to 36 inches tall.	Use drop nozzles after corn is 8 inches tall to reduce drift. Can be applied 15 days prior to tasseling.
	Fall or postharvest.	Canada thistle: At least 6 inches tall. Most effective when thistle is in the rosette stage.	Rotate only to wheat, corn, soybean, or sorghum. May be tank-mixed at a lower rate with 2,4-D or glyphosate to reduce soil residual. Addition of nonionic surfactant at 0.25% v/v improves consistency of control.
	Patches in fallow.	Canada thistle: Most effective when in rosette stage.	
Celebrity Plus (nicosulfuron + dicamba + diflufenzopyr)	Corn	Corn: 4 to 16 inches tall with 6 or fewer collars. Use drop nozzles on 16 to 36 inch corn.	Add nonionic surfactant at 0.5% + liquid fertilizer at 1 to 2 qt/A or a basic blend adjuvant at 1% v/v.
Distinct (dicamba + diflufenzopyr)	Corn and non cropland	Corn: 4 to 16 inches tall with 6 or fewer collars.	Add nonionic surfactant at 0.25% v/v + 28% liquid ammonium at 1.25 quart/A or ammonium sulfate at 17 lb/100 gallons. Provides greater perennial weed control than dicamba. Refer to label when tank-mixing with other herbicides.

Table 1. Herbicides for Canada thistle control in cropland. (continued)

	Product/A (lb ai/A)	Thistle Location	When to Apply	Comments
Northstar (dicamba + primisulfuron)	5 oz DF (2.2 oz + 0.375 oz)	Corn	Corn: 4 to 20 inches tall. Use drop nozzles on 20 to 36 inch corn	Add nonionic surfactant at 0.25% v/v or oil adjuvant at 1.5 to 2 pints/A. Liquid fertilizer may also be added.
Basagran (bentazon)	2 pints applied twice (1/1)	Soybean, corn and dry bean.	Canada thistle: 8 inches to bud stage	Apply with oil additive. Apply second treatment at 1 quart/A 7 to 10 days after first application.
Glyphosate	4 to 6 pints of a 3 lb ae/ gal conc. or 3 to 4.5 pint of a 4 lb ae/gal conc. (1.5 to 2.25)	Patches in corn, wheat, oat or soybean.	Prior to heading or flowering.	Rosette technique: Glyphosate fall-applied to Canada thistle in the rosette stage provides greater control than when applied to bolting or flowering plants.
	1 to 4 pints of a 3 lb ae/gal conc. or 0.75 to 3 pints of a 4 lb ae/gal conc. (0.38 to 1.5)	Roundup Ready corn: Up to 30 inches tall. Roundup Ready soybeans: Emergence through full flowering. Roundup Ready canola: Prior to bolting.		Apply with ammonium sulfate fertilizer. Avoid drift to non-target plants. Conventional crop in treated area will be killed. Refer to product label for maximum rate allowed on each Roundup Ready crop. Applying a rate higher than labeled in Roundup Ready crops may result in crop injury. Preharvest applications in conventional crops: Allow a 7 day preharvest interval for broadcast applications and 14 day preharvest interval for spot treatment, do not apply to crop used for seed the following year. Use a 2% solution for spot treatment prior to harvest.
	2 pints of a 3 lb ae/gal conc. or 1.5 pints of a 4 lb ae/gal conc. (0.75 to 2.25)	Preharvest wheat, corn, soybean, field pea, chick pea, and lentil.	When crop seed is physiologically mature and Canada thistle is at or beyond bud stage.	
	2 to 6 pints of a 3 lb ae/gal conc. or 1.5 to 4.5 pints of a 4 lb ae/gal conc. (0.75 to 2.25)	Fallow or postharvest.	Canada thistle: Rosette or beyond bud stage.	Wait 3 or more days after application before tillage.

nial thistles in the spring and will eliminate seed production when applied in the bolting to bud growth stages.

Perennials. Curtail (clopyralid plus 2,4-D), Tordon (picloram), Tordon plus 2,4-D amine, dicamba, Redeem (triclopyr plus clopyralid), or 2,4-D will suppress or control perennial thistles (Table 2). Control is greatest when applied to thistle at the early-bud growth stage (early summer) or in the fall to

plants in the rosette form. These herbicides applied at low rates may be the most cost-effective method for controlling dense infestations that require broadcast application. Annual retreatment will be necessary for several years to obtain long-term control.

2,4-D is used for suppression only and is most effective when applied in the spring to thistles in the vegetative growth

stage (Table 2). Tordon at 1 to 2 quarts per acre (0.5 to 1 pound per acre), dicamba at 3 to 4 quarts per acre (3 to 4 pounds per acre), Stinger (clopyralid) at 1.3 pints per acre (0.5 pound per acre), or Curtail at 3 quarts per acre (0.28 plus 1.5 pounds per acre) will provide near complete control for several years, but are expensive treatments. Redeem should be applied at 2.5 to 4 pints per acre (0.7 plus 0.25 to 1.1 plus 0.4 pounds per acre) Redeem herbicide

Table 2. Herbicides for thistle control in pasture, rangeland, and non-crop.

	Perennial Product/A (lb ai/A)	Biennial Product/A (lb ai/A)	Comments ^a
Tordon (picloram)	1 to 4 pints (0.25 to 1)	0.5 to 2 pints (0.125 to 0.5)	Restricted use. Use high rate for patch treatments.
Dicamba	1 to 8 pints (0.5 to 4)	1 to 2 pints (0.5 to 1)	Use surfactant. Use high rate for patch treatment.
Stinger (clopyralid)	0.67 to 1.3 pints (0.25 to 0.5)	0.33 to 1.3 pints (0.125 to 0.5)	Expensive but very effective.
Curtail (clopyralid + 2,4-D)	6 pints (0.3 + 1.5)	4 to 6 pints (1 to 1.5)	Cost-effective for large infestations. Labeled for CRP.
Redeem (triclopyr + clopyralid)	2.5 to 4 pints (0.7 to 1.1 + 0.25 to 0.4)	1.5 to 2 pints (0.4 to 0.6 + 0.15 to 0.2)	Very cost-effective, non-restricted use. Labeled for CRP.
Dicamba + 2, 4-D	1.5 to 4 pints + 1 quart of a 4 lb/gal conc. (0.75 to 2 + 1)	1 to 4 pints + 1 quart of a 4 lb/gal conc. (0.5 to 2 + 1)	Use surfactant. A commercial premix is available as Weedmaster.
Tordon (picloram) + 2,4-D	0.5 to 2 pints + 1 quart of a 4 lb/gal conc. (0.125 to 0.5 + 1)	0.5 to 1 pint (0.125 + 1)	Restricted use.
Distinct (dicamba + diflufenzopyr)	6 oz WDG (3 + 1.2 oz)	6 oz WDG (3 + 1.2 oz)	Canada thistle suppression only. Non-crop use only.
2,4-D	1.5 to 2 quart of a 4 lb/gal conc. (1.5 to 2 lb/A)	1.5 to 2 quart of a 4 lb/gal conc. (1.5 to 2 lb/A)	Suppression of perennials only.
Escort (metsulfuron)	1.5 to 2 oz DF (0.9 to 1.2)	0.5 to 2 oz DF (0.3 to 1.2)	Use surfactant. Suppression of musk and Canada thistle only. Tank-mix with an auxin herbicide to improve control.
Glyphosate	2 to 6 pints of a 3 lb/gal conc. or 1.5 to 4.5 pints of a 4 lb/gal conc. (0.75 to 2.25)	1 qt (0.75)	Non-cropland use. Many trade names so check label for use rate and surfactant needed.

^aConsult the specific label for use and grazing restriction, surfactant requirements, and application rate specific to thistle species.

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contains 0.75 pounds per gallon of clopyralid and may be a more cost effective treatment than Curtail which contains 0.4 pounds per gallon clopyralid.

GRAZING RESTRICTIONS VARY WITH HERBICIDE AND APPLICATION RATE SO READ THE LABEL CAREFULLY BEFORE USING.

For perennial thistle control in non-cropland, in addition to herbicides listed above, glyphosate may be applied in the summer or fall when thistle is at or beyond the bud stage of growth (Table 2). Perennial thistle control is usually greater when glyphosate is applied in fall rather than spring.

Insect biocontrol agents have been released on both musk thistle and Canada thistle with limited success. The seed weevil *Rhinocyllus conicus* was introduced from Eurasia to control musk thistle by reducing seed production. Larvae develop in the flower head and consume the seed as it develops. The weevils can reduce seed production by nearly 80%, but they are attracted more to earlier blooming rather than to later blooming flowers. The late season flowers produce seeds with little damage from the weevil, which sustains the musk thistle population. It takes five to 10 years to build a high enough population of insects to greatly reduce seed production.

R. conicus will also attack seed heads of Canada thistle and many other thistle species, both native and introduced. However, the resulting damage to various thistle populations has been minimal to date.

Another weevil introduced for musk thistle control is *Trichosirocalus horridus* which feeds on the apical meristem of the thistle rosette and developing stems. The feeding causes multiple stems to be formed when the plant bolts instead of a single stem. The multiple stems produce small flowers with few seeds, which is beneficial to the *Rhinocyllus* population. However, even with the two biological agents working together musk thistle is only partially controlled. A second control method such as chemical is needed to stop the spread of the weed.

Two biological control agents have been introduced for Canada thistle con-

trol, and a third was accidentally introduced. To date, none have been effective at reducing the weed on a large scale. Larvae of the *Ceutorhynchus litura* weevil feed on the underground parts of Canada thistle which in turn are winter-killed. The effects of the weevil must be supplemented by another biocontrol agent or chemical control for effective control. A gall-producing fly, *Urophora cardui*, causes meristematic galls but does little long-term damage to the perennial thistle. The Canada thistle bud weevil *Larinus planus* was an accidental introduction into North America. The insect feeds on developing flowers to prevent seed production. Although *L. planus* can survive under a wide range of climates, it has not reduced established Canada thistle stands.

The painted lady butterfly (*Vanessa cardui*) can be a very effective biological control agent but only on an intermittent basis. Larvae of the butterfly feed on Canada thistle plants and can eliminate an infestation. However, the insect generally is only found in southern states such as Arizona and New Mexico and will build up populations large enough to migrate north only once every eight to 11 years. The insect will migrate north as far as Canada and those fortunate enough to reside within the migratory pathway will see a dramatic decrease in the Canada thistle population.

Photos by Rodney G. Lym.



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