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# **Integrated chemical and biological control of leafy spurge**

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## **Introduction**

Leafy spurge grows on a wide variety of terrain from flood plains to river banks, grasslands, ridges, and mountain slopes (Hanson and Rudd, 1933). It is primarily found in untilled non-cropland habitats such as abandoned cropland, pastures, rangeland, woodland, roadsides, and waste areas (Selleck *et al.*, 1962; Dunn, 1979 and 1985). The plant grows in diverse environments from dry to subhumid and from subtropic to subartic. It occurs on many topographic positions from the flat bottom of glacial lakes to the slopes of sand dunes and glacial moraines. After leafy spurge is introduced into an area, there does not seem to be any topographic limits to its invasion of new areas.

## **Chemical control**

Leafy spurge is difficult to eradicate, but topgrowth control and a gradual decrease in the underground root system is possible with a persistent management program. Nearly all experimental herbicides have been tested on leafy spurge since the introduction of 2,4-D [(2,4-dichlorophenoxy) acetic acid] in the 1940s (Alley *et al.*, 1984; Lym and Messersmith, 1985). Most of these herbicides have little or no activity on leafy spurge.

Herbicides commonly used to control leafy spurge include 2,4-D, dicamba (3,6-dichloro-2-methoxybenzoic acid), glyphosate [*N*-(phosphonomethyl)glycine], and picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) (Lym and Messersmith, 1985). Picloram, dicamba, and 2,4-D are selective herbicides that control broadleaf weeds, while glyphosate is nonselective and controls both grass and broadleaf weeds. However, when glyphosate is applied with 2,4-D in early summer, they provide better leafy spurge con-

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trol than glyphosate alone and grass injury is minimal. Dichlobenil (2,6-dichlorobenzonitrile) suppresses leafy spurge growth only and can be used under trees (Lym and Messersmith, 1982) and fosamine [ethyl hydrogen (aminocarbonyl) phosphonate] can be used adjacent to water (Lym and Messersmith, 1988).

Long-term control of leafy spurge is extremely difficult to achieve. The most cost-effective control method depends on the size and location of the infested area. Small patches of leafy spurge can be eliminated with a persistent herbicide program, but large areas will require continuing control measures. A combination of chemical and cultural treatments such as cultivation, cropping and grazing may be necessary to stop the spread of leafy spurge (Alley *et. al.*, 1984; Dersheid *et. al.*, 1985; Sedivec and Maine, 1993).

The key to controlling leafy spurge is early detection and treatment of the initial invading plant. A persistent management program is needed to control topgrowth and to gradually deplete the nutrient reserve in the root system.

Picloram and 2,4-D are the most frequently used herbicides for leafy spurge control. Picloram reduces leafy spurge density the most effectively but 2,4-D controls the leafy spurge foliage at the lowest cost. Both herbicides are poorly absorbed (generally less than 30%) and 5% or less of the absorbed chemical is translocated to the roots (Lym and Moxness, 1989). Most herbicides that effectively control leafy spurge must be applied at relatively high rates, have a long soil residual, and/or cannot be applied in environmentally sensitive areas. Glyphosate plus 2,4-D is an exception, but it cannot be applied to the same area 2 consecutive yr to avoid severe grass injury.

The most widely used treatment for both leafy spurge control and improved forage production is picloram plus 2,4-D at 0.28 plus 1.1 kg ae/ha (Lym and Messersmith, 1990). About 93,000 ha in North Dakota are treated with picloram plus 2,4-D annually to control leafy spurge. Over \$2 million are spent annually in the Northern Great Plains for leafy spurge control alone, and the weed infestation continues to increase.

Picloram plus 2,4-D at 0.28 plus 1.1 kg/ha costs \$35/ha and needs to be applied annually for 3 to 5 years to obtain approximately 90% control (Lym and Messersmith, 1987). This treatment plus application would cost landowners and government agencies over \$20 million annually if the total infested acreage were treated. Leafy spurge control with herbicides is not always practical due to the high cost of treating large areas of infestation especially because the economic return is low on range and untilled land where it most frequently occurs. Also, the weed frequently occurs in environmentally sensitive areas where herbicide use is prohibited. Thus, control with biological agents offers the best solution for control on a large scale and in the diverse environments where leafy spurge grows.

## **Integrated control**

A major program for leafy spurge biocontrol was initiated across the United States in the 1980s. Since then, seven insects for biological control of leafy spurge have been released in North Dakota (Carlson and Mundal, 1990). The spurge hawkmoth (*Hyles euphorbiae* L.), a foliar feeder, generally has not survived and when it does, provides

control too late in the growing season to be very useful (Messersmith and Lym, 1990). Four root-feeding flea beetles, *Aphthona cyparissiae* Koch, *A. flava* Guill, *A. czwalinae* Weise, and *A. nigriscutis* Foudras, and a gall midge, *Spurgia esulae* Gagné, have established and reproduced well at several research sites in the state and region. A stem-boring beetle, *Oberea erythrocephala* Shrank, has been released at two locations in North Dakota and has established but not in sufficient numbers to allow integrated research.

The *Aphthona* spp. have had the most effect on leafy spurge because the larvae feed on the root system, the population has increased rapidly since introduction, and the insect is easily captured for transport to additional locations. *A. nigriscutis* has been the most successful biological control agent and has been redistributed to all 52 North Dakota counties 5 years after its introduction into the state.

*Aphthona* spp. are well established at many sites, but leafy spurge control has been slow. The insect populations must be high enough so several larvae feed on each root and the insects do not move rapidly from the center of establishment. Some flea beetle release sites have been sprayed with herbicides because the farmer, rancher, or county weed control officer were impatient after a couple of years waiting for leafy spurge to disappear.

Dramatic increases in biological control agent population and subsequent leafy spurge control have been observed in the field when herbicides were combined with biocontrol insects. (Unpublished data. R.G. Lym and R.B. Carlson, NDSU, Fargo 59105.) For example, a release of 250 adult *A. nigriscutis* near Minot, North Dakota in 1989 increased to over 1 million by 1993. The Minot insectory site had been sprayed accidentally with picloram plus 2,4-D in both 1991 and 1992. The leafy spurge density was reduced by 80% in a 2 ha area and 500,000 insects were redistributed to other infested areas. This was the largest increase in insect population (>4000-fold) and decrease in leafy spurge density in any of the 27 release sites in the state. A similar incident at the North Dakota Army National Guard Camp Grafton training location resulted in near complete leafy spurge control when an *A. nigriscutis* insectory was accidentally sprayed in the fall. The observations from these incidents support the hypothesis that insect and herbicide treatments can be integrated to enhance leafy spurge control and have lead to the preliminary research of combining herbicides with biological agents.

The herbicide rates and dates of application must be timed to be least disruptive to the insect's life cycle. Preliminary research at North Dakota State University has shown that picloram plus 2,4-D at 0.5 plus 1 lb/A fall-applied to leafy spurge infested with *A. nigriscutis* has reduced a leafy spurge infestation faster than either the biocontrol agent or herbicides alone. When herbicides were applied in spring during the true-flower growth stage, leafy spurge density was reduced similarly, whether the herbicides were applied alone or combined with biocontrol agents. However, *A. nigriscutis* populations tended to decline following a spring-applied but not fall-applied herbicide treatment.

The *Spurgia esulae* gall midge was introduced in North Dakota in 1986 as a biocontrol agent for leafy spurge. *S. esulae* causes stem tip galls thereby decreasing seed production and has been most successful near wooded areas. However, a second control method is needed to reduce the leafy spurge infestation and prevent spread from roots. Picloram or 2,4-D applied to leafy spurge will reduce the number of *S. esulae* galls but not the number of larvae per gall (Lym and Carlson, 1994). Long-term *S. esulae* popula-

tions are not affected by herbicide application. The integration of herbicides with *S. esulae* would prevent leafy spurge spread from a wooded area and would reduce seed production within an area where herbicides generally cannot be used.

Herbicides have also been combined with goat grazing of leafy spurge. Initial results indicate that season-long grazing reduced leafy spurge stand density but rotational grazing increased stand density. Spring grazing followed by picloram plus 2,4-D in the fall was the best integrated treatment and resulted in 99% leafy spurge control averaged over both grazing systems. When herbicides were applied in the spring followed by fall grazing, control varied from 73% stand reduction using continuous grazing to a 64% increase using the rotational grazing system.

Some perennial grass species can effectively compete to provide leafy spurge control. Based on both herbage yield and leafy spurge reduction, 'Rebound' smooth brome (*Bromus inermis* Leyss.), 'Arthur' Dahurian wildrye (*Elymus cinereus* L.), and 'Reliant' intermediate wheatgrass (*Agropyron intermedium* Secar) were the best species to plant into a leafy spurge infestation in a clay soil at Fargo, North Dakota. Evaluation are under way with these and other species in a sandy loam soil near Jamestown, North Dakota.

Leafy spurge control must be considered a long-term management program. A land owner should attempt to contain present infestations to keep the weed from spreading and design a long-term program to gradually eliminate dense infestations of leafy spurge. The long-term program should include biological and/or cultural control methods to be most cost-effective and to reduce pesticide use especially in environmentally sensitive areas. NO SINGLE TREATMENT WILL ERADICATE THIS WEED. An annual treatment program provides the best long-term control. After a high level of control is achieved, often only isolated patches remain that can be spot treated, or a less expensive herbicide such as 2,4-D can be applied for one or more years to maintain satisfactory control.

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