Leafy Spurge Control: 10 Years of Research Enhancement

Calvin G. Messersmith and Rodney G. Lym

Leafy spurge (Euphorbia esula L.) has been recognized as a weed problem in North Dakota for over 50 years, and the North Dakota Agricultural Experiment Station (NDAES) has conducted research on leafy spurge and its control almost every year since the late 1920s. A significant commitment to enhance research for leafy spurge control was made by the NDAES in 1979 and a larger field research program was begun in the summer of 1980. The purpose of this report is to reflect on leafy spurge control past, present, and future, with emphasis on documenting changes during the 10 years of program enhancement.

HISTORY

Leafy spurge was first reported in North Dakota in 1909. Plant scientists as early as the late 1920s recognized that leafy spurge probably would become a serious weed problem. Reports in the 1930s on leafy spurge biology and control included Hanson (1931) and Hanson and Rudd (1933) in North Dakota and Bakke (1936) in Iowa and on grazing by sheep by Helgeson and Thompson (1939) and Helgeson and Longwell (1942) in North Dakota.

Following World War II, the most extensive research was conducted by Canadian scientists in the 1950s and 1960s; the names R.T. Coupland, J.F. Alex, G.W. Selleck, and M.V.S. Raju were especially common. In the United States, L.A. Derscheid in South Dakota and M.K. McCarty in Nebraska had modest programs for leafy spurge control. Many examples of the contributions of these scientists are cited in the Weed Science Society of America monograph, Leafy Spurge (Watson, 1985).

Many people recognized the importance of leafy spurge control and “bootlegged” research, i.e., conducted a limited number of leafy spurge control experiments as an adjunct to their assigned research responsibilities. The results of most of these experiments were reported only in annual research reports in their states or in a regional publication. This scenario was true of the NDAES until 1972 when C.G. Messersmith established a perennial weed control project in the agronomy department, with leafy spurge as the top priority. However, only 35 percent of his time initially was assigned to this project and this decreased to 25 percent as student enrollments and teaching responsibilities increased.

It should be noted that several neighboring states were ahead of North Dakota in mustering political support for leafy spurge control. For example, the Wyoming Leafy Spurge Control Act that provided state funding for leafy spurge control was passed in 1978. The Montana State Weed Control Conference was actively developing legislation and garnering support for leafy spurge control in the 1970s.

COOPERATIVE REGIONAL PROGRAM

Ad hoc program

The current regional research effort began with the Leafy Spurge Symposium, June 26 and 27, 1979, in Bismarck, N.D. The innovator was Dan McIntyre, supervisor, Custer National Forest, U.S. Forest Service, Billings, Montana. He visited H.R. Lund, director of the NDAES, and the outcome of the discussion was establishment of a steering committee to conduct a symposium in Bismarck; E.H. Amend, associate director of the North Dakota Cooperative Extension Service, was chairman.

About 125 educators, scientists, land managers, farmers, ranchers, legislators, and concerned citizens primarily from Montana, Nebraska, North Dakota, South Dakota, and Wyoming attended the Bismarck symposium. A follow-up meeting, the Northern Regional Leafy Spurge Conference, was held in Billings, Montana, on December 17 and 18, 1979, with total attendance similar to the Bismarck symposium.

The administrators of several key agencies, including directors of the agricultural experiment stations, area directors for the U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS), supervisors for the U.S. Forest Service, formed an ad hoc committee to sustain the momentum for enhanced leafy spurge control. These people made some personnel and funding changes within their own administrative units to support the effort. They appointed a Regional Leafy Spurge Working Committee of research and extension scientists to develop a plan of action, with R.J. Lorenz, USDA-ARS, Mandan, N.D., chairman.

Program coordination

The major outcome of the Regional Leafy Spurge Working Committee was approval by the Great Plains Agricultural Council of a research committee, GPC-14 Leafy Spurge Control in the Great Plains, as a recognized organization to facilitate program coordination. The first GPC-14 meeting was held in June 1981 at Fargo, and annual meetings have been held since then.

1982 — Bozeman, MT
1983 — Sundance, WY
1984 — Dickinson, ND
1985 — Bozeman, MT
1986 — Riverton, WY
1987 — Fargo, ND
1988 — Rapid City, SD
1989 — Bozeman, MT

Messersmith is professor and Lym is associate professor, Department of Crop and Weed Sciences.
Enhanced funding

An immediate objective adopted at the Bismarck symposium was to submit a request to the Old West Regional Commission for research funding. A cooperative project of the agricultural experiment stations of all five states, Montana, Nebraska, North Dakota, South Dakota, and Wyoming, with North Dakota was the lead state, was funded from March 1981 through February 1982. To provide continuity, the USDA-ARS, through the Metabolism and Radiation Research Laboratory in Fargo, established separate cooperative agreements with Montana, North Dakota, and Wyoming that provided funding for various durations during 1981 to 1985.

Grant funds supported most of the initial research. However, the biggest boost to the program has been through redirection and enhancement of research efforts by the agricultural experiment stations, especially in Montana and North Dakota, and by the USDA, initially by the ARS and since 1988 by the Animal and Plant Health Inspection Service (APHIS).

To use North Dakota as an example, enhancement began when Director H.R. Lund immediately committed $100,000 at the Bismarck symposium to fund a temporary research associate position, which was filled by R.G. Lym in October 1979. Subsequently, the 1983 Legislature upgraded this to a permanent position and provided technical support positions. Concurrently, Director Lund provided internal redirection by reassigning R.B. Carlson of the entomology department to biocontrol with insects, L.J. Littlefield of the plant pathology department to biocontrol with diseases, and D.G. Galitz of the botany department to plant physiology. Within the USDA-ARS at the Metabolism and Radiation Research Laboratory in Fargo, D.G. Davis was reassigned to cell and tissue culture of leafy spurge and D.S. Frear studied the metabolism of picloram. Also, S.E. Lingle was a postdoctoral scientist for two years, studying 2,4-D metabolism in leafy spurge.

An early cooperative effort was the Leafy Spurge News, a newsletter initially edited and published by the Montana Agricultural Experiment Station. Publication began in April 1980, and there have been three or four issues per year with up to 1,200 recipients per issue since then. Editors have been Clare Barreto, Bruce Maxwell, and Celestine Lacey of Montana State University and currently R.J. Lorenz, North Dakota State University.

CHEMICAL CONTROL

Herbicides have been the backbone of control efforts to date, because they are the most available and effective developed technology. However, many refinements have been made in the past 10 years. For example, the paper on chemical control presented at the 1979 symposium refers to “light rates” of 2,4-D as 2 to 6 pounds per acre and “heavy rates” as 20 to 40 pounds per acre, and picloram was used frequently at 2 pounds per acre. Now, picloram usually is applied at 0.25 to 0.5 pounds per acre in combination with 2,4-D at 1 to 2 pounds per acre (Lym and Messersmith, 1985). Also, we now understand that the most effective time of treatment is during true flower development with a secondary time for control during the fall when leafy spurge has established regrowth (Figure 1).

Among other herbicides, dicamba has provided better results in the Intermountain states (Montana and Wyoming) than farther east but is less effective than picloram. Glyphosate can be used under trees, on cropland, and near water, but may cause too much injury to be acceptable on grazing land. However, experiments are in progress to determine whether glyphosate can be applied in the fall to grass entering dormancy without causing unacceptable grass injury. Many other herbicides have been evaluated, especially clopyralid, fluroxypyr, fosamine, sulfometuron, and tri­clopyr, but none have provided control and crop safety comparable to the older herbicides.

Several other generalizations about herbicide use have been developed in the past 10 years. Wipe-on applicators, e.g., roller and pipe-wick, can be used to apply picloram to leafy spurge, but control generally is not improved over picloram plus 2,4-D broadcast applied (Messersmith and Lym, 1985). Withdrawal of the granular formation of picloram from the market in 1986 meant loss of one tool for leafy spurge control, especially for spot treatment of small (usually new) patches of leafy spurge. Herbicides generally provide longer term control in drier areas, but more grass injury occurs also. Awareness of adverse effects of herbicides, especially of picloram, on the environment has increased, so the herbicides are being applied at lower rates and with more care than when the enhanced research program began. Despite the advances, most herbicide treatments for leafy spurge control are not economical.

CULTURAL CONTROL

Options for cultural control of leafy spurge are limited. Leafy spurge is occurring more frequently on tilled land now due to reduced tillage. Mowing and burning have been ineffective for reducing leafy spurge, except they may result in uniform regrowth that allows more timely treatment with herbicides. Nitrogen fertilizer in combination with herbicide treatment has not improved control of leafy spurge. There may be differences in competitive ability of forage species with leafy spurge, but they will not eliminate the weed.

Sheep and goats can be considered as cultural control, if they are used as an alternative to raising cattle. The percentage of situations where sheep or goats are an economical alternative to raising cattle. The percentage of situations where sheep or goats are an economical alternative to raising cattle. The percentage of situations where sheep or goats are an economical alternative to raising cattle.
alternative to raising cattle or to using other control methods is low, but they can be used to fill special niches.

BIOCONTROL WITH INSECTS

Insects for biocontrol have been considered a viable research goal for many years. The leafy spurge hawkmoth (Hyles euphorbiae) was released as early as 1966 and 1973 in Gallatin County, Montana. Leafy spurge hawkmoth introductions frequently have not survived, and when they do, they provide too little control too late in the growing season. A stem and root borer, Oberea erythrocephala, was released in 1979 in Canada and in 1980 in Wyoming and Oregon but so far either has not survived or had minimal impact on leafy spurge.

Through increased research, primarily by Agriculture Canada and the USDA-ARS, several insects have been screened and approved for release on leafy spurge. For example, two flea beetles, Aphthona flava and A. cyparissiae, were released in Saskatchewan in 1982 and in Montana in 1985. A gall midge, Bayeria capitigena (a.k.a. Spurgia esula), was released in Montana in 1985. Biocontrol with insects currently is the most rapidly growing area of research activity.

Seven insect species have been released on leafy spurge in North Dakota. The leafy spurge hawkmoth was introduced in 1984 and multiple introductions were made in 1985, but apparently this insect has not survived. The stem-boring weevil, Oberea erythrocephala, was introduced in 1985 and has become established, although it has not had a large impact on leafy spurge. The gall-forming midge, Bayeria capitigena, was introduced in 1986. It reproduces readily but has had minimal impact on the density of leafy spurge in the area of release.

Four flea beetles have been introduced to date; Aphthona flava and A. cyparissiae in 1986, A. caerulea in 1988, and A. nigriscutis in 1989. Adult flea beetles lay eggs at the stem base and the larvae feed on roots. A. nigriscutis has reduced the population of leafy spurge stems over 90 percent at an experimental site in Spruce Woods Park, west of Winnipeg, Manitoba. The flea beetles have fed extensively on leafy spurge roots in the field and greenhouse in North Dakota, so flea beetles presently show the most promise for effectively reducing the density of leafy spurge.

BIOCONTROL WITH DISEASES

One native disease, Alternaria tenuissima f. sp. euphorbiæ, first collected near Mandan, N.D., has shown the most virulence on leafy spurge (Krupinsky and Lorenz, 1983). It controls leafy spurge when infection occurs, but environmental conditions are not favorable for infection over a broad area. Other species, especially Melampsora spp. and Uromyces striatus, have been evaluated as potential biocontrol candidates, but virulent strains that can be reproduced effectively have not been identified. At this point, better organisms are needed before diseases can contribute to leafy spurge biocontrol.

PLANT PHYSIOLOGY AND BASIC RESEARCH

The general morphology, anatomy, and ecology of leafy spurge has been studied fairly extensively. Scientists doing the early research on leafy spurge, such as Hanson and Rudd (1933), reported the basic studies on these subject matter areas that still are valid today. Although many questions concerning anatomy, ecology, and morphology remain unanswered, the knowledge base in these areas probably is not the limiting factor to developing better weed control programs. Conversely, the basic understanding of leafy spurge physiology and genetics is limited.

Taxonomic studies indicate that leafy spurge is a genetically diverse species. Although some taxonomists divide this plant complex into several species, most scientists believe it is one species, Euphorbia esula, that is diverse. Studies of chemotaxonomy, allelopathy, and natural product chemistry indicate this diversity exists, but the role of these compounds in leafy spurge physiology or how to use specific chemical characteristics to improve leafy spurge control remains largely unknown.

Physiological characteristics of the roots and of latex are not well understood. Picteram and 2,4-D are released rapidly from roots (Hickman et al., 1990; Lingle and Suttle, 1985). The carbohydrate content of roots fluctuates rapidly from day to day; for example, soluble carbohydrate content of root changes within hours and varies inversely with temperature (Lym and Messersmith, 1987). Starch storage in the latex is irreversible (Nissen and Foley, 1986).

Physiological characteristics regulating bud growth and survival are not well understood. Crown buds that begin growth in the fall stop development, apparently when exposed to light. Crown buds and root buds differ in susceptibility to freezing temperatures (Schimming and Messersmith, 1988). Whether bud growth can be altered to increase winterkill is not known.

MISCELLANEOUS OBSERVATIONS

Benefits of leafy spurge

Latex with its high hydrocarbon content has been evaluated as an alternate source either for fuel or rubber, but neither alternative is economically viable at this time. Honey from leafy spurge is of low quality for human preferences. However, it is desirable for bees, because it is an early season food and it does not granulate easily, which is desirable for overwinter feeding. As a somewhat 'tongue in cheek' benefit, sometimes leafy spurge competition is less detrimental to survival of native plant species than overgrazing by cattle.

Miscellaneous projects

Unique attempts at control have included using high voltage to electrocute plants or paired rollers to pull plants. Neither alternative was effective.

PUBLIC AWARENESS

Many meetings, newspaper articles, extension bulletins, and radio and television reports have been presented to the public. Leafy spurge control was the impetus that lead to formation of the North Dakota Weed Control Association and has been a goal of similar associations in Montana, Wyoming, and probably other states. All of these efforts have lead to state and federal legislative action including financial support for some new research scientist positions and buildings at the agricultural experiment stations and the USDA. Also, there is cost-sharing for chemical control in several states and long-range projects like USDA-APHIS programs to establish insectaries to expedite redistribution of biocontrol agents.

Overall, there probably is as much public awareness of leafy spurge as any other weed, although we all recognize that more must be done. Because so many people in North
Dakota are aware of the adverse impact of leafy spurge, they responded immediately when they were informed of the possible adverse impact of spotted knapweed in the state.

**FUTURE FOR LEAFY SPURGE CONTROL**

In the next five to 10 years, herbicides will remain the backbone of the leafy spurge control program. Any improvements in efficacy of herbicides will be small, although there may be advances either in minimizing adverse environmental impacts or reducing the cost of control.

Biocontrol with insects includes many promising leads, so a widespread distribution program and localized visible success should be accomplished in the next 10 years. A breakthrough in using diseases for biocontrol apparently is not imminent; perhaps diseases as biocontrol agents can advance in 10 years to the point where insects are today.

Additional information on the basic physiology of leafy spurge will be developed. It is unclear where major breakthroughs in plant physiology that result in new leafy spurge control methods or improvement of biological or chemical control are most likely to occur.

Long-term management methods that include both herbicides and insecticides probably will be the standard management program by the year 2000. Leafy spurge will not be eradicated but persistent control programs initiated in the 1980s will reduce the density of leafy spurge in many areas so land currently considered nonproductive will be providing positive income.

**LITERATURE CITED**


