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Leafy spurge 1986 annual meeting

Program / 1985 Minutes / 1986 Minutes

GPC-14 Leafy Spurge Control in the Great Plains – Program

July 9, Morning Session

6:30 a.m.	Group Breakfast
8:00 a.m.	Welcome and Introductory Remarks. R. G. Lym
8:10 a.m.	**Leafy Spurge, a Rangeland Invader - (slide tape).** T. D. Whitson, University of Wyoming, Laramie.
8:30 a.m.	**Impact of Leafy Spurge on the Plant Community.** R. M. Nowierski and-S. J. Harvey, Montana State University, Bozeman.
8:50 a.m.	**Leafy Spurge Control in North Dakota - 1986.** C. G. Messersmith and R. G. Lym, North Dakota State University, Fargo.
9:10 a.m.	**Herbicide and Fire to Control Seed Germination of Leafy Spurge.** A. J. Bjugstad, U.S.D.A. Forest Service Res. Lab., Rapid City, SD.
9:30 a.m.	**The Effect of 2,4-D Application Timing on Leafy Spurge Seed Viability.** G. Heneidi, M. A. Ferrell, and S. D. Miller, University of Wyoming, Laramie.
9:50 a.m.	Break
10:10 a.m.	**Picloram Exudation by Leafy Spurge Roots.** M. V. Hickman and C. G. Messersmith, North Dakota State University, Fargo.
10:30 a.m.	**The Effect of Glyphosate on Bound Auxins in Leafy Spurge.** D. D. Biesbor and J. H. Westwood, University of Minnesota, St. Paul.
10:50 a.m.	**Cotyledon Chlorophyll Assay for Measuring Injury to Leafy Spurge.** W. L. Koukkari and D. D. Biesbor, University of Minnesota, St. Paul.
11:10 a.m.	No Latex Starch Utilization in Leafy Spurge (*Euphorbia* esula L.). S. J. Nissen and M. E. Foley, Montana State University, Bozeman.
11:30 a.m.	**Physiological and Microscopic Characteristics of a Regenerating Leafy Spurge Culture.** D. G. Davis, D. L. Stalzenberg, and P. A. Olson, U.S.D.A. Metabolism and Radiation Res. Lab., Fargo, ND.

11:40 a.m. **Relations of Nitrogen Source and Molybdenum Content of Media to Regeneration of *Euphorbia esula* L. Cell Cultures.** D. G. Davis and K. J. Evenson, U.S.D.A. Metabolism and Radiation Res. Lab., Fargo, ND.

11:50-1 p.m. Group Lunch

July 9, Afternoon Session

1:15 p.m. **The Leafy Spurge Taxonomy Problem Reviewed.** S. J. Harvey, R. M. Nowierski, and P. Mahlberg, Montana State University, Bozeman, and Indiana University, Bloomington.

1:35 p.m. **Some Fungi Parasitizing Leafy Spurge.** R. M. Hosford, Jr., North Dakota State University, Fargo.

1:55 p.m. **Preliminary Evaluations of Biocontrol Insect Releases in North Dakota.** R. B. Carlson and D. A. Mundal, North Dakota State University, Fargo.

2:15 p.m. ***Aphthona cyparissae*, a New Flea Beetle for Leafy Spurge Control in the United States.** R. W. Pemberton, U.S.D.A. Western Regional Research Center, Berkeley, CA.

2:35 p.m. **Two Year Survey for Picloram in North Dakota Groundwater.** K. M. Christianson and R. G. Lym, North Dakota State University, Fargo.

2:55 p.m. **Alternative Granular Formulations of Picloram to Replace Tordon 2 K.** P.K. Fay and E. S. Davis, Montana State University, Bozeman.

3:15 p.m. Break

3:30 p.m. Leafy Spurge Control-Open Discussion

Subject 1: How to replace Tordon 2K and 10K now and Tordon 22K next year.

Subject 2: Distribution methods for large scale dispersal of biological control agents.

Subject 3: Reduced funding for research and control efforts, what next?

Subject 4: Open forum for other areas of concern. Those wishing to present data but not a formal paper are welcome to do so.

6:00 p.m. Group Dinner

7:30 p.m. GPC-14 Executive Meeting

July 10, Morning Session

6:30 a.m. Group Breakfast

7:30-1 p.m. Tour of University of Wyoming Leafy Spurge Research Control Plots.

T. D. Whitson and M. A. Ferrell,

University of Wyoming, Laramie.

12 p.m. Group Lunch

The 1986 GPC-14 meeting is sponsored jointly by North Dakota State University and the University of Wyoming.

GPC-14 Executive Committee:

Dr. Rodney G. Lym - President
Or. David G. Davis - Vice-President
Dr. Robert M. Nowierski - Secretary
Dr. Don E. Anderson - Administrative Advisor

Local Arrangements Committee:

Dr. Tom D. Whitson
Dr. Mark A. Ferrell

1985 Minutes

Minutes from the Great Plains Council (GPC-14) committee meeting

The meeting was called to order at 1 p.m. by Dr. Peter Fay. Minutes from the last meeting were read. It was moved by Dr. Don Anderson and seconded by Dr. Rod Lym that they be accepted as read, motion passed.

Dr. Fay reported that the Leafy Spurge Multi-States pamphlet on distribution biology and control has been published. Copies of the publication (MSU Extension Service Circular 309) are available at the desk.

Old Business:

1) Newsletter: Because Montana State University will no longer be publishing a newsletter, North Dakota will be taking over the publication for a few years. Dr. Lorenz reported on the status of the takeover. The newsletter will become a North Dakota State University/Agricultural Research Service endeavor with Dow Chemical Company contributing monies for its distribution. Dr. Lorenz has retired from the Agricultural Research Service and will be editor of the newsletter for at least one year or until NDSU obtains an Extension Specialist on noxious weeds. If the latter happens, this duty might be incorporated as part of the Extension Specialist's duties and the newsletter might include several noxious weeds. For now the newsletter will stay as the Leafy Spurge Newsletter. The number of issues will be reduced from the present 4/year to 3/year. The next one will be published soon after this meeting, in December 1985, and in April 1986. Articles are to be sent directly to Dr. Lorenz, Box 459, Mandan, North Dakota 58554. A computer listing of recipients of the newsletter has not yet been transferred to NDSU, but it should be completed soon.

Dow Chemical Company has approached the North Dakota Stockman's Association and Dow is willing to pay the cost of one issue of the newsletter as an insert to the Stockman's Association magazine. It will probably also appear in the Montana Stockman Association magazine. Dr. Ally suggested that the same thing be done in Wyoming. Dr. Fay suggested possibly Idaho might be interested in doing the same thing. A large percentage of the names and addresses on the mailing list of the Leafy Spurge Symposium are from Montana and therefore, on the surface there appears to be more interest in the newsletter in Montana. However, this insertion into the Stockman's Association magazine will undoubtedly generate considerably more interest in the newsletter. The issue that will be inserted may be a regular issue, or it may be a special issue for that purpose. This will be decided later. Dr. Lorenz indicated that he needs a good cartoonist for some caricatures to continue the tradition set by Montana. It was felt that this would create a little more interest.

2) Dr. Lym reported that there was $500.00 left over from the Dickinson meeting. Dr. Lym proposed that this be set aside to cover unexpected expenses that might occur in meetings. Dr. Ally moved and Dr. Davis seconded the motion. Motion passed.

3) A new secretary (who will become president elect and president) is needed for this committee. As a part of this consideration, discussion was made as to whether a meeting should be held every year, or on alternate years. Dr. Bjustad pointed out that the meetings

with the Range Science Society of America will be held in Billings in 1989, in February, and might be considered as an ideal time for a symposium for that year.

The meeting was recessed at 1:30 p.m. and reconvened at 3:15 p.m.

It was decided that there would be a meeting in 1986 in Wyoming. Although Dr. Lym is the next president and is from North Dakota, because the 1984 meetings were held in North Dakota, Wyoming was indicated as a better site for 1986. Lars Baker, Freemont County, Wyoming, indicated that it would be OK to hold the meetings in Wyoming at Riverton. Possible location sites would include the Community College in Riverton, with a field trip to the plots in Lander, Wyoming. Local arrangements will be conducted by Dr. Whitson and Lars Baker. The local arrangements committee will decide upon the date after discussion with the members of the Committee. Discussion was made as to whether to completely separate technical aspects of the meeting from those talks designed more for the layman. Dr. Fay indicated that an attempt was made at the present meeting to do that, but it was difficult to get the message to many of the people, without discouraging them from attending the meetings at all. The format of the meeting will have to be determined by the Local Arrangements Committee and the officers of the GPC-14 Committee.

Dr. Robert Nowierski, Montana State University, was nominated for the next secretary, with the nomination seconded by Cal Messersmith. A unanimous vote was cast for Dr. Nowierski.

Dr. Lym indicated that the annual research reports of each state on leafy spurge have not been published in the proceedings. The annual report apparently only goes to the universities and to those who request it. It was suggested that copies of these annual reports be included with the proceedings along with the December issue of the newsletter. Dr. Lorenz moved and it was seconded that a request be sent along with the September newsletter to the effect that individuals also send their annual reports to Dr. Lorenz so that they may be mailed along with the newsletter. Motion passed. Dr. Bjustad indicated that there is a greater need to publicize the publications by the committee. Dr. Anderson indicated that the GPC-14 protocol has been rewritten and approved for the next five years. The Executive Secretary of the Great Plains Council has resigned and a replacement is being sought.

No further new business was proposed and the meeting was adjourned at 3:35 p.m.

Respectively submitted,

David G. Davis, Secretary,

GPC-14 Committee

1986 Minutes of the GPC-14 Meeting

9 July 1986
Riverton, WY

Discussions focused on locations for future meetings - Fargo, ND 1987

The possibility of holding the meeting in Bozeman, MT in 1988 was discussed. However, Dennis Clark read a letter from the South Dakota State Department of Agriculture to consider holding the 1988 meeting in either Rapid City or Spearfish, SD. This would allow farmers, ranchers, land managers, educators, and scientists in South Dakota to benefit from the new research and educational ideas generated by the symposium.

A motion was made and seconded to hold the 1988 meeting in South Dakota.

The motion was amended to include the nomination of Dennis Clark for VP of the committee in 1987 so that he will rotate into the President position when the meeting is held in South Dakota in 1988. The motion and amendment passed.

It was agreed that Bob Nowierski should remain as Secretary for the 1987 symposium so that he will rotate into the President slot in 1989 when the symposium will be held in Bozeman, MT. A formal motion to maintain Nowierski as Secretary in 1987 was made, seconded, and passed.

The problem of not enough money or left over money from the symposium was discussed. It was mentioned that the last time the symposium was held in North Dakota, several hundred dollars were left over which was used to help publish the leafy spurge newsletter.

A motion was made, seconded, and approved to rotate the GPC-14 checking account cash each year to the location of the local arrangements committee for the symposium.

It was suggested that the leafy spurge newsletter will only go out to those who have sent in their cards, expressing an interest in maintaining their subscription.

Administrative advisor Don Anderson mentioned that progress in leafy spurge research continues to be made and that the symposium continues to establish a communications link between the scientists and action agencies involved in working on the problems of leafy spurge control.

Anderson mentioned that there has been some changes in the organizational structure of the Great Plains Council.

Comments from Norm Landgren, Executive Director of the Great Plains Agriculture Council:

> Well, I will cover very briefly what is evolving in terms of the structure. In 1985, in Fargo at the annual meeting, the council directed the objective committee to write a set of bylaws to set the future direction of the organization. This was done and the bylaws were unanimously approved in Bozeman last month at the 1986 council meeting. In terms of committees and task forces, this is what has evolved. There used to be a research committee and an extension committee and six standing committees in the

mittee and an extension committee and six standing committees in the council: water research, economics, forestry, wildlife, and so forth. The GPC-14 committee was formed by the research committee with annual reviews by the research committee and could be terminated or extended by the research committee. There is no longer going to be a research committee, there will no longer be an extension committee. There will be six standing committees of the council which will be the former standing committees reconstituted in membership plus a new committee called crops and soil. Now the membership of these committees will be able to form review-and terminate task forces. A committee such as GPC-14 will be designated a task force. The concept of a task force is something that has limited life on a specific assignment, but the bylaws provide for the activities of this sort of a committee. A research coordinating committee, it would be reviewed every three years by the standing committee to which you are affiliated.

The Executive committee has not made a decision as to which standing committee GPC-14 would be affiliated, but it probably would be with crops and soil or range and livestock. I think there will be arguments made both ways. The sort of restructuring the executive committee had in mind was to break down the dichotomy between research and extension and to integrate the functions of research, extension and programs within a committee. Also to bring the scientists and administrators within that single committee together. So, during the present year, this transition will take place and the standing committees will be constituted and GPC will be a task force. As Don said, it should not affect what you are doing because it seems you have research and extension and state program agencies involved. This is precisely what the council is perceiving. I would not be too concerned about it.

Dow chemical has set up an account to help produce leafy spurge newsletters. Russ Lorenz, editor of the newsletter, mentioned that getting articles in on time was the biggest problem. He suggested that short articles were best.

The content of the newsletter was discussed. It was suggested that the newsletter still focus on spurge with a miscellaneous section to allow short research tidbits on Canada thistle, spotted knapweed, etc. The next newsletter will contain information from the symposium in Riverton, Wyoming. It was suggested that sending the newsletter out three times per year would be sufficient.

The proposal to APHIS for the development of rearing and redistribution program for biological control agents of leafy spurge was discussed by Gary Cunningham. He discussed the potential role of APHIS in the redistribution of biological agents on rangeland weeds. He mentioned that the implementation of biocontrol agents against rangeland weeds is a relatively new thrust by APHIS. He mentioned that the proposal will be refined this fall and by next year APHIS should have an implementation plan.

It was suggested that the Regional Membership Directory for GPC-14 should be updated with names, addresses and phone numbers and included in the proceedings.

It was suggested that the meeting should be moved to an earlier date, possibly to the Tuesday and Wednesday following July 4, 1987.

Respectfully submitted,

Robert M. Nowierski

GPC-14 Secretary

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Impact of leafy spurge on the plant community

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The annual rate of spread and impact of leafy spurge on the grass and broadleaf plant community was studies at five locations in Montana from 1984 to 1986. Four study sites were initiated in 1984 (Bozeman, Ekalaka, Big Timber, and Choteau) and a fifth was added near Missoula, MT in 1985.

Three clones of leafy spurge were chosen at each location. All spurge plants on the edge of the clones were marked with painted nails to delineate the annual rate of spread in subsequent years. Annual increments of spread (as measured by the average clonal radii) observed for the Ekalaka, Big Timber, and Choteau sites were 10.4, 40.6, and 12.7 cm, respectively. Unfortunately the Bozeman study plot was destroyed from a real estate development project and hence no information on the annual rate of spread is available from that site.

To obtain information on the impact of leafy spurge on the plant community, 2 transects (at right angles) were established for each of the fifteen clones (5 locations). Transects extended through the clones and into the plant community outside the clones. Daubenmire frame samples (each 0.1 m) were taken along each of the transects at 1 m intervals and species composition, percent coverage of all plant species, and percent litter/bare ground were estimated.

Plant information (collected inside the leafy spurge clones at four sites [Choteau, Big Timber, Ekalaka, and Bozeman] in 1984 and a single site [Missoula] in 1985) was averaged over all quadrats taken within clones at each of the respective sites. In contrast, data collected in 1985 from Big Timber, Ekalaka, and Bozeman, MT was categorized as to plant material from low spurge densities (1-90 leafy spurge stems per sq. m), medium spurge densities (91-250 leafy spurge stems per sq. m), and high spurge densities (> 250 leafy spurge stems per sq. m). Plant material taken inside the leafy spurge clones was also categorized by leafy spurge height at the Bozeman site in 1986, in addition to categorization by leafy spurge density.

Choteau site

The mean percent coverage of grasses increased 7% inside the leafy spurge clones as compared to the outside in 1984. The sparse population of spurge and relatively large amount of bare ground inside the clones could have influenced this result. In contrast, the

mean percent cover of broadleaves was significantly reduced 67% inside the clones as compared to the outside ($p < 0.05$). Similar results were obtained at the Choteau site in 1985 with the grasses showing on average a 16% increase inside the leafy spurge clones as compared to outside, while the broadleaves showed a reduction inside the clones of 68%.

Big Timber site

Mean percent cover of grasses was reduced 18% inside the leafy spurge clones as compared to outside in 1984, while the broadleaves were significantly reduced by 62% inside the clones reduced by 48% inside the leafy spurge clones at spurge densities averaging 133 stems per square meter ($p < 0.01$; 1985).Similarly, the broadleaves were reduced by 75% at similar spurge densities, however these differences were not significantly different.

Ekalaka site

The mean percent cover of grasses was significantly reduced 44% inside the clones as compared to the outside in 1984 ($p < 0.01$). In contrast, the mean percent cover of broadleaves showed an increase of 17% inside the clones as compared to the outside. This result was likely due to the contribution of one of three clones at the site that had an abnormally high level of broadleaves inside the clone. The mean percent cover of grasses was reduced in 1985 by 19% at low spurge densities (on avg. 41 leafy spurge stems per sq. m) and significantly reduced by 76% at high spurge densities (on avg. 385 leafy spurge stems per sq. m; $p < 0.05$). In contrast, broadleaf cover showed a significant increase of 72% inside the clones at low spurge densities of 41 leafy spurge stems per sq. meter, again primarily from the contribution of one of three clones which had an abnormally high level of forbs. However, at high spurge densities (on avg. 385 leafy spurge stems per sq. m) broadleaf cover was reduced by 67% inside the clones as compared to outside.

Missoula site

The mean percent cover of grasses was reduced by 20% inside the leafy spurge clones as compared to the outside (1985). Similarly, the broadleaf cover was reduced on average 30% inside the leafy spurge clones.

Bozeman site

Mean percent cover of grasses was reduced 27% inside the leafy spurge clones as compared to outside the clones in 1984. A significant reduction of 89% was observed for broadleaf cover inside the clones as compared to outside. Significant reductions of grasses and broadleaves of 96 and 100%, respectively, were observed inside the leafy spurge clones as compared to outside in 1985 ($p < 0.01$) for high spurge densities (on avg. 428 leafy spurge stems per sq. m). Similar reductions in grasses and broadleaves

were observed in 1986 at the Bozeman site. Grass and broadleaf cover was significantly reduced by 93 and 100%, respectively, for high spurge densities which averaged 446 leafy spurge stems per sq. meter ($p < 0.05$ and $p < 0.01$, respectively).

In summary, a general reduction of grasses and broadleaves was observed inside the leafy spurge clones as compared to outside the clones for the five study sites considered (from 1984-1986). Broadleaves and bunch grasses appeared to be the first plant groups to be reduced or eliminated as the densities of leafy spurge increased, often leaving behind the rhizomenous grass species. Our conclusion is that leafy spurge is having a substantial impact on many native and naturalized grass and forb species. At higher spurge densities we see not only a decrease in plant species, but a tendency towards wetter site and/or introduced species.

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Leafy spurge control in North Dakota - 1986

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Annual picloram plus 2,4-D treatments, aerial application of picloram plus 2,4-D and evaluation of sulfometuron have been the emphasis of the leafy spurge control research program in 1986.

An experiment to determine the number of annual applications of picloram needed to provide 90 to 100% control of leafy spurge and to investigate possible synergism between picloram and 2,4-D was established at two locations in North Dakota. The experiment began on 25 August 1981 at Dickinson and on 11 June 1982 at Valley City. Dickinson, located in western North Dakota, generally receives much less precipitation than Valley City in eastern North Dakota. All treatments were applied annually except 2,4-D alone which was applied biannually (both spring and fall). Picloram treatments were applied in late August 1981 and in June of 1982 through 1984. Thus, the Dickinson site has received five picloram and picloram plus 2,4-D treatments and nine 2,4-D treatments, while the Valley City site has received four and eight treatments, respectively. The plots were 10 by 30 feet and each treatment was replicated four times in a randomized complete block design.

Picloram at 0.25, 0.375 and 0.5 lb/A provided 48, 75 and 90% leafy spurge control, respectively, in August 1985 when averaged across the Dickinson and Valley City locations (Table 1). Control gradually increased for the picloram at 0.375 and 0.5 lb/A treatment, but not the 0.25 lb/A treatment when compared to the August 1982 and 1983 evaluations. 2,4-D alone provided approximately 50% control of leafy spurge after biannual applications for five years.

Leafy spurge control tended to increase when 2,4-D was applied with picloram at 0.25 or 0.375 lb/A (Table 1). Leafy spurge control in June 1986 increased an average of 21, 12 and 19% with picloram at 0.25, 0.375 or 0.5 lb/A plus 2,4-D at 1.0 to 2.0 lb/A, respectively, when compared to the same picloram rate applied alone. The greatest enhancement with 2,4-D plus picloram seems to be with 2,4-D at 1.5 lb/A or less. After five treatments, picloram at 0.375 or 0.5 lb/A with 2,4-D is within 10% of the target of 90 to 100% leafy spurge control.

Table 1. Leafy spurge control from annual picloram or picloram plus 2,4-D treatments and biannual 2,4-D treatments at two locations in North Dakota since 1981.

		Site and 1986 evaluation		Mean			
				August			June
Herbicide	Rate	Dickinson	Valley City	1982	1983	1985	1986
	(lb/A)	(% control)					
Picloram	0.25	56	43	39	48	48	50
Picloram	0.375	62	82	65	62	75	72
Picloram	0.5	70	68	65	71	90	69
2,4-D bian	1.0	40	28	22	30	52	34
2,4-D bian	1.5	36	50	22	24	48	43
2,4-D bian	2.0	33	65	19	30	54	49
Pic+2,4-D	0.25+1.0	77	69	52	66	85	73
Pic+2,4-D	0.25+1.5	67	62	58	66	86	65
Pic+2,4-D	0.25+2.0	67	84	57	62	83	76
Pic+2,4-D	0.375+1.0	82	81	69	72	91	82
Pic+2,4-D	0.375+1.5	87	84	68	74	95	86
Pic+2,4-D	0.375+2.0	79	91	68	59	93	85
Pic+2,4-D	0.5+1.0	84	91	71	75	94	88
Pic+2,4-D	0.5+1.5	80	97	64	73	97	89
Pic+2,4-D	0.5+2.0	83	91	76	75	96	87
LSD (0.05)		19	23	18	14	16	17

An experiment to evaluate forage utilization by cattle in various densities of leafy spurge was begun in 1984 and continued in 1985 near Leonard, ND. The 300 A pasture carried 80 cow-calf pairs from May until mid-October. Caged plots were established on 23 April in four leafy spurge densities, 80% or above (high), 40-80% (moderate) 20-40% (low) and no infestation (zero). Four caged and uncaged 0.25 m^2 paired plots were established per density with four replications. Production was harvested on 12 July or 4 October and separated into cool or warm-season grasses, leafy spurge and forbs.

Forage availability was similar in all densities of leafy spurge in July, but was lower in all densities except the zero density by October (Table 2). Leafy spurge decreased warm-season grass production much more than cool and the decrease was greater with increasing leafy spurge density. Total disappearance was 22% in July in areas with zero leafy spurge infestation but was only 6% when averaged over all other densities. Visual observation indicated that most of the disappearance in the higher densities of leafy spurge was due to trampling. Thus, most of the grazing from April until mid-July was in uninfested portions of the pasture.

Total disappearance and utilization increased in all densities of leafy spurge in October compared to July. Cattle utilized an average of 54% of the total forage produced in the zero and low density leafy spurge infestations, but only 27 and 19% in the moderate and high density infestations, respectively.

Table 2. Forage utilization by cattle in four leafy spurge densities.

Leafy spurge density	Leafy spurge	Yield: Leafy spurge	Caged: Cool	Caged: Warm	Caged: Total	Uncaged: Cool	Uncaged: Warm	Uncaged: Total	Disappearance: Total	Utilization[a]	Mean[b]
(% cover)	(stems/ft^2)	(lb/A)							(%)		
July harvest											
0 (zero)	0	0	749	186	949	670	73	750	22		
20-40 (low)	10	172	385	181	565	364	160	529	6		
40-80 (moderate)	34	341	530	161	713	520	154	678	5		
80-100 (high)	55	951	697	193	895	604	216	824	7		
LSD (0.05)	7	239	228	129	283	228	129	283			
October harvest											
0 (zero)	--	0	1128	327	1456	360	65	425	69	57	44
20-40 (low)	--	127	593	265	858	293	76	319	63	51	43
40-80 (moderate)	--	18A	745	154	931	418	88	509	39	27	24
80-100 (high)	--	550	918	142	1063	584	65	650	31	19	10
LSD (0.05)		112	290	122	324	290	122	324	24		

[a]Estimate of utilization by cattle based on: Total disappearance - natural disappearance (12%).
[b]Average of 1985 and 1984 studies.

Helicopter application of herbicides for leafy spurge control has steadily increased in North Dakota. An experiment was begun near Minot, ND on 18 June 1985 to evaluate the most cost effective application rate, volume and 2,4-D formulation for aerial application. The plots were 15 by 50 feet and replicated four times in a randomized complete block design. Plots were individually covered with plastic tarps which were removed immediately prior to and replaced immediately after treatment. This allowed the plot area to remain relatively small, the experiment to be replicated and the helicopter to apply the treatments at a normal height and flight speed. Treatments were applied using single and double microfoil nozzles (manufactured by Union Carbide).

Leafy spurge control tended to be better when 2,4-D SULV was applied with picloram compared to 2,4-D amine and oil amine formulations (Table 3). Picloram plus 2,4-D SULV at 0.5 + 1.0 applied at 5.0 gpa using the 2 nozzle boom provided 79% leafy spurge control 12 months after application. Similar treatments using 2,4-D oil or water amine provided only 38 and 31% leafy spurge control, respectively. Leafy spurge control was similar with similar treatments applied at 5 and 10 gpa but declined 25% or more when applied at 2.5 gpa. Control averaged 42 and 41% for all treatments applied at 5 and 10 gpa, respectively, but only 14% when applied at 2.5 gpa.

The herbicide sulfometuron (tradename Oust) has provided leafy spurge control in initial unreplicated experiments. An experiment to evaluate sulfometuron for leafy spurge control spring or fall applied was begun near Hunter, ND on 27 June and 4 September 1986. Sulfometuron alone at 0.5 to 2.0 oz/A has given inconsistent leafy spurge control (Table 4). Plants generally stopped growth but remained green. However, when applied with an auxin herbicide, leafy spurge control with sulfometuron averaged 87 and 98% as a spring or fall applied treatment, respectively. Initially control is similar regardless which phenoxy herbicide is applied with sulfometuron. An extensive program to evaluate

these treatments for leafy spurge control and effect on forage production at various times and rates was begun in 1986.

Table 3. Leafy spurge control with picloram and various formulations of 2,4-D tank-mixed and applied using a helicopter with various water volumes.

Herbicide	Rate	Volume	Boom type [a]	Control Sept. 85	Control June 86
	(lb/A)	(gpa)		%	
Picloram + 2,4-D amine	0.25 + 1.0	5.0	2 nozzle	97	4
Picloram + 2,4-D SULV[b]	0.25 + 1.0	5.0	2 nozzle	99	26
Picloram + 2,4-D SULV[b]	0.25 + 1.0	2.5	1 nozzle	91	1
Picloram + 2,4-D SULV[b]	0.5 + 1.0	5.0	2 nozzle	100	79
Picloram + 2,4-D oil amine	0.5 + 1.0	5.0	2 nozzle	99	38
Picloram + 2,4-D amine	0.5 + 1.0	5.0	2 nozzle	100	31
Picloram + 2,4-D amine	0.5 + 1.0	5.0	1 nozzle	100	59
Picloram + 2,4-D amine	0.5 + 1.0	2.5	1 nozzle	97	26
Picloram + 2,4-D amine	0.5 + 1.0	10.0	2 nozzle	99	42
Picloram + 2,4-D amine	0.25 + 1.0	5.0	Ground	96	11
LSD (0.05)				8	39

[a] Micro-foil boom with one or two rows of parallel nozzles - Manufactured by Union Carbide.
[b] Ultra low volume formulation of 2,4-D mixed amines - Manufactured by P.B.I. Gordon.

Table 4. Leafy spurge control with sulfometuron.

Treatment	Rate	Control/applied Spring Aug. 85	Control/applied Spring June 86	Control/applied Fall June 86
	(oz/A)	(%)		
Sulfometuron	0.5			16
Sulfometuron	1	0	6	95
Sulfometuron	1.5	0	63	
Sulfometuron	2.0	0	36	
Sulfometuron + 2,4-D	1 + 16	95	76	99
Sulfometuron + dicamba	1 + 32	96	85	97
Sulfometuron + picloram	1 + 8	70	96	99
LSD (0.05)		25	22	26
Sulfometuron + 2,4-D	0.5 + 16	--	--	95
Sulfometuron + dicamba	0.5 + 32	--	--	97
Sulfometuron + picloram	0.5 + 8	--	--	99
LSD (0.05)				26

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Herbicide and heat to reduce seed germination of leafy spurge

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The seeds of leafy spurge are about the size and shape of pearl millet–2 to 2.5 mm long. Each seed plant can produce up to 150 seeds. Seeds are thrown up to 15 feet when the ripe fruit dehisces explosively. Most seeds germinate in the spring of the year when air temperatures reach the low 80ºs, others germinate later at different temperatures. Most of the viable seeds germinate within 2 years but the others remain viable up to 8 years. These latent seeds are enough to reestablish the infestation. Therefore, a chemical control treatment to kill the plant followed by a fire treatment to kill the embryos in the seeds to curtail seedling development would be very effective and economically acceptable in the control of leafy spurge on the northern High Plains.

Therefore, the objectives of our study were to determine if leafy spurge seedling development which re-establishes the infestation can be curtailed with fire and also to determine which combinations of herbicide and fire best control leafy spurge seedling development–early summer or fall applied herbicide treatment followed with back fire in the fall or back fire in the spring.

Research plots, 50 x 50 feet with 10 borders between plots were located in the Little Missouri National Grassland near Medora, and in the Sheyenne National Grassland near Lisbon, North Dakota. These study areas had a relatively high density and long age of the leafy spurge infestation. Study plots on the Medora Ranger District were defined as an upland site–east Twin Butte–and a floodplain site–Wannagan Creek. The plots in eastern North Dakota were low semi-wet meadow and a rolling upland sites.

The herbicide application was a tank mix of 1 pound acid equivalent of 2,4-D and 1/2 pound picloram per acre applied in June and September of 1985. This mixture was applied in water at 50 gallons of water per acre, low pressure spray (20 to 40 lbs. pressure). This was done by a certified applicator. Plots with herbicide application in June received heat (fire) treatments in October and those with the herbicide application in September received heat treatments the spring of 1986.

The heat treatment (fire) was accomplished through the use of a back fire (backed against the wind). Fires were initiated after 11 a.m. when temperatures were above 50º F, relative humidity 20 to 30% and winds 9 mph or less. The 10 foot borders around each plot were mowed by a lawn mower and treated with a commercial fire retardent (phoschek, monsanto). The fire lines were initiated with drip torches.

Viability (ability to germinate) of leafy spurge seed naturally dispersed in the soil and surface mulch were tested after the heat treatments. Ten samples were collected with the use of a square foot blade to a depth of four inches. These samples were placed in individual zip-lock top plastic bags for transport to the laboratory in Rapid City. Sample materials were kept moist and cool until separation of the leafy spurge seed from the soil and surface mulch. The seeds, 20 seeds in each sample, were placed in seed germinators of which the temperature alternated between 68 to 86º F with each temperature period lasting 8 hours. The germination test was conducted for a 3-week period. Seeds were examined daily for indications of germination, appearance of the hypocotyl was counted as germinated. Number of germinated compared to those not germinated were used as an indication of seed viability and effects of the treatments.

Here's what we learned. The spring fire following a fall application of herbicide was very effective in reducing viability of leafy spurge seed in the low land leafy spurge (Fig. 1). However, the fall burn following spring application of the herbicide was also quite effective (Fig. 2). One noteworthy point was the spring applied herbicide was about twice as effective as the fall applied herbicide in the reduction of germination. The effect of the fire was not quite as strong on the uplands but fall and spring applications of fire were equally effective. Fire in combination with herbicide reduces seed viability which now is a big stumbling block in the management of leafy spurge.

Percentage of seeds expected to germinate per acre (X10) fall spray-spring burn Wannagan creek site

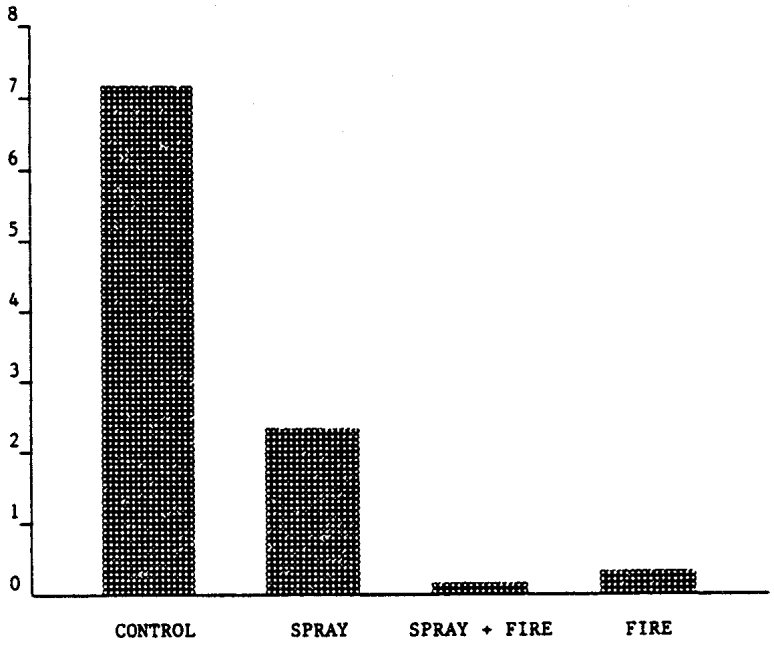

Fig. 1. Seed germination following fall spray and spring burn.

Percentage seeds expected to germinate per acre (X10) spring spray-fall burn Wannagan Creek site

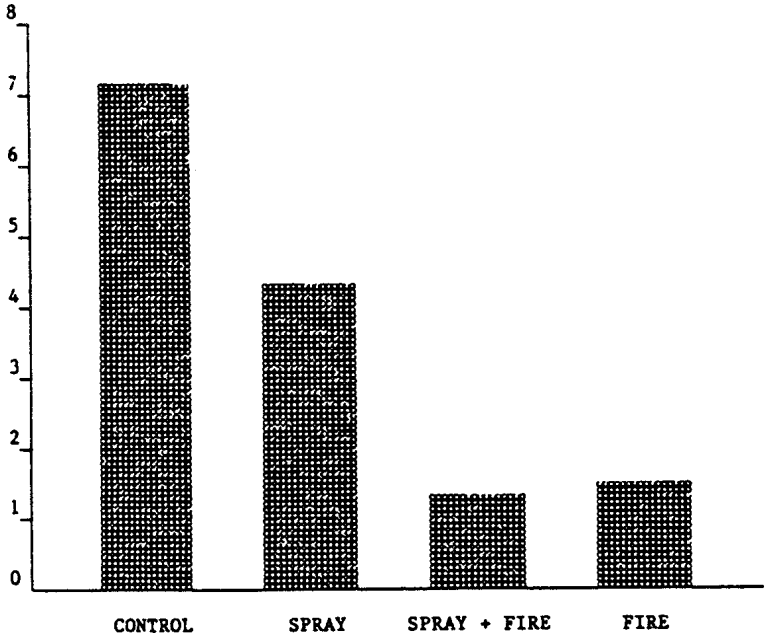

Fig. 2. Seed germination following spring spray and fall burn.

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The effect of 2,4-D amine timing on leafy spurge seed viability

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Leafy spurge is a troublesome weed that infests considerable areas of range and pastureland in the western United States. The successful spread of leafy spurge is due in part to its capability to reproduce by both seeds and underground roots. Spread of leafy spurge by seed occurs naturally. Expulsion of leafy spurge seed from the capsules can propel the seed up to 4.5 meters from the mother plant.

The purpose of this experiment was to evaluate the effect of 2,4-D amine spray timing on leafy spurge seed viability. The dimethyl amine formulation of 2,4-D (2 lb ai/A) was applied initially at the pre-bud to bud stage and at day intervals thereafter, until the seeds started dehissing from the seed capsules.

The experiment was conducted at Lander, Wyoming in 1985 and consisted of timing treatments plus a non-treated check. Seeds were collected in nylon netting which was wrapped around the top of the leafy spurge plants. Treatments were replicated ten times in a randomized complete block design.

Data collected included seed counts per plant, percent viable seed, viable seeds per plant, percent seed germination in water and GA_3 (Gibberellic acid) percent seed abnormality in water and GA_3 and number of seed with broken seedcoat.

Seed production, seed viability, seed germination, and seed abnormalities were influenced by timing of 2,4-D amine applications (Table 1). 2,4-D amine applications 0 and 7 days after bud initiation were most effective in eliminating viable seed production. However, 2,4-D applications 35 days after initiation were most effective in eliminating viable seed production. However, 2,4-D applications 35 days after bud initiation caused the greatest number of abnormal leafy spurge radicals when germinated in both water and GA_3. Leafy spurge seed germination tended to be higher in GA_3 than in H_20 regardless of 2,4-D timing.

Reference

Weeds of Wyoming, 1979. Univ. of Wyoming Agric. Exp. Sta. Bull. 498.

Table 1. Effect of 2,4-D amine timing on leafy spurge seed production, seed viability, seed abnormalities and germination.

Timing of 2,4-D applications (days after bud initiation)[1]	Total seeds/ plant (no.)	% viable (TZ)	Viable seed/ plant (no.)	% abnormality		% germination	
				H_20	GA_3	H_20	GA_3
0	0.7	48.7	0.3	50.0	10.0	9.0	18.0
7	7.0	52.0	3.6	4.0	8.0	1.0	8.0
14	113.9	68.0	77.5	8.0	9.0	8.0	16.0
21	35.1	72.0	25.3	30.0	52.0	12.0	20.0
28	52.0	80.0	41.6	12.0	14.0	8.0	11.0
35	57.0	80.0	45.6	34.0	42.0	14.0	14.0
Check	188.5	84.0	158.3	1.0	0	43.7	60.0
LSD (.05)	9.7	13.8	-----	22.1	4.9	1.9	7.6
Cv (%)	7.6	11.4	-----	44.2	14.4	24.3	20.8

[1]Each value an average of 10 replications.

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Two year survey for picloram in North Dakota groundwater

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Picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) is the main herbicide used for leafy spurge control. Leafy spurge currently infests over 900,000 acres in North Dakota in a variety of environments such as grasslands, wooded areas, wetlands and arid regions. Over 345,000 acres were treated with picloram in North Dakota in 1978 of which 82,000 acres were pasture and rangeland. The State of North Dakota began a concerted effort to control leafy spurge in 1981 when a cost share program to defray herbicide expense was begun. Picloram use has increased steadily since 1981 and it is estimated that over 230,000 acres of leafy spurge were treated in North Dakota during the summer of 1984 alone. Generally picloram plus 2,4-D at 0.25 plus 1.0 lb/A has been applied, but commonly small patches have been treated with picloram at 2.0 lb/A, the maximum labeled use rate. Most herbicide application has been by ground equipment, but helicopters and airplanes have been used in the more rugged areas of western North Dakota. The general public is becoming concerned about picloram contamination in North Dakota water as evidenced by an increased number of inquiries sent to various state agencies.

Herbicide application has been by certified personnel; however, direct accidental contamination of water or run-off from nearby application may be adversely affecting drinking water supplies, fish and wildlife. The purpose of this study was to determine if picloram was present in North Dakota groundwater especially in areas with high picloram use for leafy spurge control.

Ten North Dakota counties and at least 12 wells per county were chosen for the survey. Burleigh, Pierce, Morton, Stark, Stutsman, Ward, Wells and Williams counties had applied picloram in an active leafy spurge control program, and Cass and Dunn counties with minimal picloram application were the control sites. Stark and Ward counties were emphasized, because they included the Heart and Souris Rivers, respectively, and have conducted an active leafy spurge control program using picloram. The well locations were chosen based on the amount of picloram applied nearby, the well depth, and whether the well was in an aquifer as mapped by the United States Geological Survey (U.S.G.S.). Shallow wells located near areas that had received repeated picloram applications were emphasized as representing a site most likely to be contaminated. A total of 144 wells were sampled three times; in early June prior to the spray season, in mid-July immediately after the general spray season, and in September to detect possible changes

in herbicide content with time. Also, stream samples from the Des Lacs, Heart and Souris Rivers were collected in June and September from U.S.G.S. monitoring stations. Analyses was conducted using HPLC techniques with a detection limit of < 0.1 ppb.

An additional 44 wells were sampled in April 1986 which were located near wells where picloram was detected in 1985. These wells were chosen based on distance from contaminated wells regardless of well depth or use. Also, stream samples from the Des Lacs and Souris Rivers again were collected in June 1986.

Picloram was present in 5 wells in 5 counties in 1985 and all were within 1 mile of an area treated for leafy spurge control. Picloram was present at trace to 12.4 ppb levels. The presence of picloram was confirmed by GC-mass spectroscopy at an independent lab. The picloram concentrations detected are not a health hazard since the suggested no-adverse-response level (SNARL) is 1050 ppb. The picloram concentration of 12.4 ppb is higher than would be expected if the well had been contaminated by leaching during a weed control spraying program, and picloram was not found in nearby wells. Picloram concentrations ranging from a trace to 6 ppb were found in the Des Lacs and Souris Rivers in Ward County. No picloram was found in the Heart River or in well samples from the control counties.

Picloram concentrations had declined in the 5 contaminated wells sampled in 1986 compared to 1985. Concentrations in 1986 ranged from none detected to 6.7 ppb. Only one of the additional 44 wells sampled in 1986 contained picloram. The picloram concentration was 0.97 ppb and was within 1 mile of the contaminated well found in 1985. Picloram continued to be detected in the Des Lacs and Souris Rivers; the concentration had declined but it was detected further downstream than in 1985.

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Leafy spurge: A rangeland invader (Summary of a slide-tape script)

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Hanging may have been a solution to earlier day range thieves but today leafy spurge, a tougher range thief, is immune to hanging. It occupies 2.5 million acres of rangeland across the U.S. and Canada. Acreages of 860,000 are now reported in North Dakota with increases of 45,000 acres a year being reported. Other states reporting leafy spurge include: Minnesota - 800,000 acres; Montana - 600,000 acres; Nebraska - 105,000 acres; South Dakota -60,000 acres; and Wyoming - 49,000 acres.

Even though Wyoming has only 49,000 acres, every county in the state has some infested acres. Counties in northeastern Wyoming have the largest number of acres infested. Wyoming had only a few isolated patches 25 years ago, even though controls were limited then we can look back today and see an early control program could have saved the people of the state millions of dollars.

In 1978, Wyoming passed the Leafy Spurge Control Act in the state legislature appropriating 1.4 million dollars for control that year and approximately the same amount each year since then.

At the present time, 3700 cooperators have initially treated 48,551 acres and retreated 80,409 acres in Wyoming. Total costs in Wyoming since 1978 have been greater than $9,000,000 since this program started. In 1984, total costs of the program were 1.48 million dollars or $72.34 per acre treated. Factors limiting control of leafy spurge in Wyoming are high costs and lack of accessibility of the spurge to be treated.

Have we always had leafy spurge? No, the plant was originally native to Europe but was accidentally introduced in South Dakota about 1827 by Mennonite farmers.

The plant should be identified and watched to prevent and control infestations while they are small. The plant has heart or kidney shaped upper leaves with showy yellow bracts below the seed capsules. Leaves are lance shaped and individually connected to a long, slender stem. The plant has white latex milky sap throughout the growing season. It has tremendous spreading capabilities with seed and extensive root systems. It will grow on lowland wet sites or high altitude dry sites. Seed is produced in a three-valved capsule that explodes sending seed up to 15 feet when ripe. Thirty-four hundred pounds of seed can be produced in a single year with viability lasting up to seven years. Seed is spread through waterways and animals and birds. Numerous pink buds reproduce a plant from depths up to five feet.

Rangeland infested with leafy spurge will only produce one-third what it would before the infestation. Cattle will not graze in infested areas because of the bitter flavor of

spurge. One example of cattle carrying capacity reductions might be Montana. An area of 600,000 acres would run about 20,000 cows before the spurge infestation but would be limited to 6,600 cows where fields are covered with leafy spurge. This represents a loss to the people of Montana of between three and four million dollars annually. In 1982, North Dakota reported a 12.9 million dollar loss to the state economy caused by leafy spurge.

Many people are working to overcome the problem. Pathologists are studying disease introductions that might control the plant. Animal scientists have used sheep to partially control the problem, weed scientists are studying chemical controls while entomologists are working on biological control methods.

Insect species introduced have included the cerambycid beetle and the leafy spurge hawkmoth. Even though they serve as valuable controls in their native European habitats, it has been found that the subspecies of spurge in Wyoming contains a substance toxic to the introduced insects. Wyoming winters have also taken their toll on insect introductions as well. All insect introductions are being done with great caution to prevent unwanted species. Even though this process is slow and expensive, it could prove to be very valuable.

Plant pathologists are selecting strains of fungi such as rusts that could help control leafy spurge. These are isolated in order to find one that will aid in the control of this plant. None have been found at this time.

Animal scientists in Montana have found that sheep can consume up to 50% of their diets as leafy spurge with little detrimental effects. Even though sheep will graze the floral parts of the plant preventing seed formation, they will not permanently control leafy spurge. It acts as an irritant to the digestive tract when force-fed to cattle.

Chemicals are presently the most effective means to control this undesirable plant. Chemical recommendations have been made as a result of research conducted by weed scientists at the University of Wyoming.

Evaluations of chemicals started as early as 1952 when 2,4-D, ureas, triazines and benzoic acids were evaluated as they become available.

In 1963, picloram sold under the trade name Tordon, was introduced and has proven to be a very effective treatment in a large number of trials conducted by the University of Wyoming. Even though picloram has proven to be effective for two or three years, when soil residues are depleted, both seedlings and roots regenerate and the problem starts again. Retreatments are a must to keep leafy spurge from taking over the range.

New herbicides currently being tested at the University of Wyoming such as fluroxypyr, sold in Europe under the trade name Starane, is showing considerable activity on leafy spurge but needs further testing to determine long term effects on leafy spurge.

Where do we go from here to control this problem weed species? It will take a united effort to control and maintain control of this range bandit. Educational programs such as those conducted by the Extension Service must be united with control practices offered by the County Weed and Pest Districts. Benefits derived from cost sharing programs now will pay big returns in the future. Individual groups are needed now in every county in the state to seek out new infestations and be sure they are treated and retreated until control is attained.

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Exudation of picloram by leafy spurge

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Observations of picloram injury symptoms on untreated plants following picloram application to nearby leafy spurge suggested that the herbicide may be released into the soil from the roots of treated plants. In an initial laboratory experiment, up to 70% of the picloram translocated from the treated leaf was exuded into the media.

Laboratory experiments: Experiments were established to more thoroughly examine the process of herbicide exudation. ^{14}C-picloram was used to establish a time course of exudation. Leafy spurge plants were rooted and established from stem cutting of accession 79-MN-008. The cuttings were grown in a peat moss and perlite mixture for 6 weeks. The plants were transferred into a dilute nutrient solution and equilibrated 3 days before treatment. Treatment consisted of an application of approximately 90,000 dpm ^{14}C-picloram to each plant. A 0.1% surfactant solution was applied to the treated leaves before and after the labeled herbicide was applied. Plants were grown for 120 hours before harvest. The nutrient solution was completely changed At 12, 24, 48, 72, and 96 hours. The ^{14}C-picloram in the nutrient solutions was extracted and quantified by liquid scintillation spectroscopy.

An average of 41% of applied ^{14}C-picloram was absorbed by the treated plants. Twenty-four percent of the absorbed ^{14}C-picloram was exuded to the nutrient solution by 120 hours after application. The exudation process began very soon after herbicide application with 3.5% of absorbed picloram detected in the nutrient solution 12 hours after application. Picloram exudation continued throughout the 120-hour experiment, but the maximum rate of exudation occurred between 24 and 48 hours after application.

Field experiments. Experiments were established to determine the effects of plant growth stage, herbicide application rate, and time after treatment on picloram exudation. The field experiments were established at Sheldon and Hunter, ND in the spring of 1984 and were repeated in 1985.

Field experiments were arranged in a randomized, complete block design. The picloram was applied with a pipe-wick applicator to minimize herbicide contact on the soil. Picloram concentrations of 1:1, 1:3, and 1:7 (Tordon 22K:H20, v/v) were used. Applications were made to leafy spurge in the vegetative, flowering, and seed maturation stages of growth. Soil samples were collected at 1, 2, and 3 weeks after application from three depths within the profile (0 to 5, 5 to 10, and 10 to 15 inches). Concentrations of picloram in the soil were determined by sunflower bioassay.

Picloram residues were similar among soil samples taken at 1, 2, and 3 weeks following application. This indicates that picloram exudation in the field was essentially completed within 1 week after application.

The residue levels of picloram detected by bioassay tended to be less for the 10 to 15 inch depth than for the 5 to 10 inch depth (Table 1). The reduced picloram concentration at the lowest depth probably was due to fewer and smaller leafy spurge roots in the lower profile. The amount of exudation was not affected consistently by the plant growth stage at application. However, the rate of herbicide application did affect the total amount of exudation. Usually, the residue levels increased directly with the application rate. The 1:1 rate had the highest residue levels in all depths among all experimental conditions.

Table 1. Picloram concentrations in soil at 5 to 10 and 10 to 15 inch depths after foliar treatment with a pipe-wick applicator, averaged over samples taken 1, 2, and 3 weeks after treatment.

		1984				1985			
		Hunter		Sheldon		Hunter		Sheldon	
Growth stage	Herbicide rate[a]	5-10 inch	10-15 inch	5-10 inch	10-15 inch	5-10 inch	10-15 inch	5-10 inch	10-15 inch
		ppmw picloram							
Veg	1:1	294	344	469	180	332	154	256	284
Veg	1:3	74	116	238	52	280	115	202	129
Veg	1:7	166	202	200	55	230	93	160	151
Flower	1:1	299	231	262	144	365	105	181	232
Flower	1:3	137	139	172	172	443	56	165	189
Flower	1:7	71	84	44	62	318	45	86	111
Seed	1:1	64	282	197	356	438	434	386	148
Seed	1:3	48	236	75	274	395	196	426	156
Seed	1:7	36	235	41	111	257	83	323	154
LSD		95	80	101	107	96	102	120	131

[a] Ratio Tordon 22K:H20, v/v

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The effect of glyphosate on bound auxins in leafy spurge

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Introduction

Last year, we reported on the effects of the herbicide glyphosate on the amount of free indole-3-acetic acid (IAA) in various organs of leafy spurge. This year, we are reporting on the effect of glyphosate on auxin conjugates in leafy spurge. The primary intent of this research was to either support or refute speculation that the phytotoxicity of glyphosate is due to glyphosate-induced reductions in levels of IAA in the plant.

Conjugation of IAA

The majority of conjugated IAA in plants has been found to be either ester or amide conjugates (Cohen 1982). Ester conjugates appear to be the major form of bound IAA in seeds of cereal grains while amide conjugates predominate in legumes (Bandurski and Schulze, 1977). Ester conjugates include indole-3-acetyl myoinositol, IAA-myoinositol-arabinose, and IAA-glucose (Cohen and Bandurski, 1982). Approximately one-half of the ester conjugates are in the form of high molecules weight cellulosic glucans that contain one IAA residue for every 7 to 50 glucose units (Cohen and Bandurski, 1982). Endogenous ester conjugates have rarely been isolated from plant tissues except for seeds but the presence of IAA-myoinsitol has been confirmed in corn shoots and reported to represent about 19% of the ester conjugates in them (Chisnell, 1984).

Amide conjugates have been identified less frequently in plants. IAA-acetylaspartate is the only known endogenous amide conjugate and has been reported to comprise one-half of the total IAA in soybean (Cohen, 1982). Other amides conjugates have been detected in plants after the application of exogenous IAA to them. These include IAA-alanine, IAA-glutamic acid, IAA-glycine, IAA-lysine, and IAA-valine (Sembdner *et al*., 1980).

The conjugates are thought to serve several functions in plants such as the storage of IAA, protection of IAA against oxidation, transport of IAA, and hormonal homeostasis (Cohen and Bandurski, 1982).

Methods and materials

Plant material was greenhouse-grown leafy spurge, started from seed, and 4 months old. Plants were divided into 3 groups: glyphosate treated, decapitated plants, and controls. Details of the experimental treatment are the same as that given in last years report (Westwood and Biesboer, 1985). For conjugate analysis, the aqueous fractions from ether partitioning (Westwood and Biesboer, 1986) were combined and frozen until used. Ester conjugates were those compounds that could be partitioned in acidic ether after hydrolysis with IN NaOH at 23º C for 1 hour. Amide conjugates were compounds that could be partitioned in acidic ether after hydrolysis with 7N NaOH at 100º C for 3 hours. The aqueous phases were divided into two equal parts and one-half was subjected to mild hydrolysis while the other half underwent strong hydrolysis. Solid NaOH was used to adjust normalities, and ddH_2O was added as necessary to maintain a constant volume in the 7N hydrolysis. At the end of the hydrolysis period, both samples were acidified to pH3 using H_3PO_4 and partitioned 4 times against 10 ml aliquots of Et_2O. The ether phases were saved after each extraction and pooled before being brought to a pH greater than 8 using NH_4OH. The ether was evaporated under a stream of nitrogen gas leaving a small aqueous sample containing the freed IAA. Losses of conjugated IAA during the initial extraction and partitioning the efficiency of the strong hydrolysis were measured using known amounts of ^{14}C-aspartate in appropriate controls. Isolation and detection of IAA was done by reversed phase HPLC, ion-pair chomatography, and sequential fluorescent (excitation = 254nm; emission=340nm) and electrochemical (potential=+0.8 V) detection as previously reported (Westwood and Biesboer, 1985).

Results and discussion

Glyphosate treatment did not appear to affect the concentrations of conjugates in the roots, shoots, or leaves of leafy spurge. Two way analysis of variance did not reveal significant differences between control, decapitated, or glyphosate treated plants at the 90% confidence level. Amounts of conjugates did not increase or decrease during the time course of the experiment (Westwood and Biesboer, 1986). It is our opinion that the decrease in free IAA in leafy spurge caused by glyphosate treatment noted in last years report, could not be accounted for by increased conjugation of IAA.

In summary, it is worthwhile to compare the relative concentrations of different forms of IAA in the various organs of leafy spurge (control plants; Table 1). The crown region of the plant had the highest concentration of free IAA followed by shoots and roots containing 41.0, 32.5, and 25.6% of the free IAA respectively. The crowns may be expected to have the highest level of free IAA because of the large number of adventitious buds that will develop into adventitious shoots. Secondly, the differences in levels of conjugated IAA were less pronounced except that the concentrations of IAA-ester conjugates were higher in the shoot and roots than the crown region of the plant. It has been demonstrated that IAA conjugates can act as a storage form of 1AA (Hangarter and Good, 1981) and raises the possibility that the aerial portions of the plant may store 1AA and hydrolyze it when buds in the stem begin to grow. Concentrations of endogenous free and conjugated IAA in vegetative tissues exist in the ratio of about one-third free IAA and two-

thirds conjugated IAA. Finally, of the conjugates, esters and amides occur in approximately equal amounts.

Table 1. Relative distribution of the different forms of IAA in untreated 4-month-old leafy spurge plants.

Form of IAA	Percent of total IAA in individual plant parts			
	Shoot	Crown	Root	Average
Free	32.5	41.0	25.6	33.7
Ester conjugates	43.4	26.6	47.2	38.1
Amide conjugates	24.1	32.4	27.2	28.2

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Cotyldedon chlorophyll assay for measuring injury to leafy spurge

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Introduction

Recently, we initiated a project to examine the biology and physiology of leafy spurge, with a major focus on competitive species and allelochemicals. The chemicals when isolated from from the organism, will need to be assayed for allelopathic properties. Several assays are currently being examined. Some of the assays involve species other than leafy spurge, e.g., water cress. However, there are definite advantages for developing an assay that directly incorporates the species being studied. A biological assay which appears to be versatile in measuring the effects of various agents, including those of a chemical nature, is the cotyledon chlorophyll stress bioassay (Koukkari *et al*. 1984). This bioassay, which can be traced to earlier herbicide studies (Koukkari and Johnson 1979) has been used with several species to study the effects of chemical, mechanical, biological and thermal agents, as well as temporal changes in plant sensitivity during the course of a single day (Koukkari *et al*. 1984). Adapting this bioassay, perhaps with some modifications, to examine the effects of chemical stress to leafy spurge may provide a more direct method for the testing of allelochemicals.

Materials and methods

Seeds of leafy spurge, *Euphorbia esula* L., were either planted directly in soil (Experiment A) or first treated with 0.2% $KN0_3$ and then sown in soil contained in 200 cc plastic cups. Plants were maintained in controlled environment chambers under conditions similar to those described elsewhere (Koukkari 1980, Koukkari *et al*. 1984).

When the plants were ca. 27 days old (Experiment A), or 28, 33 and 38 days old (Experiment B), they were subjected to mechanical injury. This was accomplished by removing all but the top two leaves and the cotyledons from each plant.

Eleven day old plants (Experiment C) were inoculated with bacteria[1] by puncturing the center of each leaf with a dissecting needle containing *Psuedomonas syringae* pv. *tagetis*.

[1] Courtesy B. W. Kennedy, Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108.

Chlorophyll from the cotyledons was extracted with 95% ethanol, absorbance read at 654 nm, total chlorophyll calculated (Wintermans and DeMots 1965), and the values expressed as micrograms per milligram dry weight.

Results and discussion

Before testing the effects of chemical agents, it was necessary to confirm the basic premise that in leafy spurge, as in other species, the levels of chlorophyll in cotyledons of injured plants should be higher than those of uninjured plants. Leafy spurge was not an exception to what had been observed in other species. The levels of chlorophyll in the cotyledons of injured plants were more than twice the levels found in the uninjured plants (Table 1A).

The level of cotyledon chlorophyll may remain relatively high for at least 20 days after mechanical injury (Table 1B). In contrast, the uninjured plants have practically no detectable chlorophyll in the cotyledons.

Strain caused by bacterial stress may be quantified also by the cotyledon chlorophyll assay. The levels of cotyledon chlorophyll were approximately twice as high in the diseased plants (Table 1C).

Table 1. Total chlorophyll levels of leafy spurge, *Euphorbia esula*, L., on the 16th (A) 10th, 15th, 20th (B), and 10th day (C) following mechanical injury (A,B) or bacterial inoculation (C). All plants maintained on a 24 hour regimen of 16 hours of light followed by 8 hours of darkness at ca. 23 to 24° C. Each value represents the mean ug total chlorophyll per mg dry weight ± the standard error.

A. Mechanical (n = 4* and 8)**

Injury	Cotyledon Chlorophyll
None*	5.9 ± 1.7
Leaves Excised**	14.1 ± 2.1

B. Mechanical (n = 7)

Days After	Injury	
Injury	None	Mechanical
10	8.2 ± 2.9	14.8 ± 2.3
15	2.1 ± 1.1	10.2 ± 1.3
20	0.0 ± 0.0	10.2 ± 2.5

C. Bacterial (n = 2)

Inoculation	Cotyledon Chlorophyll
None	15.8 ± 7.7
Water Only	20.6 ± 0.6
Pseudomonas syringae pv. *tagetis*	35.3 ± 0.5

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No latex starch utilization in *Euphorbia esula* L.

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Utilization of leaf, stem, root, and latex starch was monitored in *Euphorbia esula* L. plants. Leaf, stem, and root starch decreased rapidly during a 52-day light starvation period while latex starch did not. Scanning electron and light microscope studies provided additional evidence that no changes in latex starch granules had occurred. Amylase activity (6.6 unit/mg protein) could be isolated from latex. However, latex starch granules were extremely resistant to enzymatic hydrolysis by latex amylases, *Bacillus subtilis* α-amylase and by amyloglucosiclase from *Aspergillus niger*. Results indicate that latex starch grains do not function as utilizable carbohydrate in this species under these conditions.

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Physiological and microscopic characteristics of a regenerating leafy spurge culture

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Aseptic tissue culture systems were used to determine environmental and physiological conditions for root and shoot formation of leafy spurge cells. Comparisons were made among three accessions: 1978A1 from Austria (presumably *Euphorbia esula*), 1979ND1 from North Dakota (possibly *E.* × *Psuedovirgata*) and 1978OR1 from Oregon (taxonomic classification unknown). The three accessions differ phenotypically: most conspicuous is the fact that 19780R1 has larger leaves than the other two accessions. Also, the Oregon accession has a slightly different latex composition than the other two. Shoots of accession 1978A1 grew from crown buds and produced flowers within two weeks in a greenhouse in North Dakota in May 1986; accession 1979ND1 required more than three weeks, and accession 1978OR1 four weeks to produce flowers.

All three accessions produced callus from stem sections on either B5 or MS media with either 2,4-D alone or with 2,4-D, NAA and kinetin at 0.4, 0.4 and 0.2 mg/L, respectively. Accession 19780R1 produced a more compact callus than the other two accessions. Organogenesis occurred in all accessions maintained (after the-initial callus formation) for three subcultures on B5 + 1 mg/L 2,4-D (B5 + 1) agar medium, followed by two subcultures in liquid MS with no growth regulators. Accession 1978A1 produced roots and a few shoots. Accession 1978OR1 produced extremely variable growth in suspension, but regenerated one 25 mm root and three shoots in one flask. Accession 1979ND1 produced numerous abnormal roots and root initials from callus induced with 2,4-D as the only growth regulator, and several more normal-looking roots and shoots from callus induced with all three growth regulators. This latter accession has been regenerated from suspension cultures maintained on B5 + 1 medium in our laboratory for the past three years, and is the accession used almost exclusively for the studies presented below. Therefore, all three accessions retained the capacity for organogenesis in culture, although to very different degrees, and the medium used to initiate the callus appears to be important.

Cell suspensions of accession 1979ND1 produced from freshly isolated callus cultures formed more roots than did suspensions that have been maintained for several months or years. Both large clumps and suspensions of small clumps produced roots: from several hundred to several thousand roots per flask. In most flasks, greater than 90% of the clumps in each flask formed roots. Cells grown in B5 + 1 medium up to 14 (and in

one experiment 20) days before transfer to 2,4-D-free media produced roots; therefore, the time from inoculation into fresh B5 + 1 medium before transfer into root inducing media did not appear to be critical.

Microscopic observations of the culture are being made to detect unusual cell types that may serve as targets for ultimate control of growth of the plant. Tracheary elements have been observed in most cultures. Non-regenerating cultures stained with toluidine blue in borax contained cells with a granular appearance. These cells may be identical to those located conspicuously near the base of roots in regenerating cultures. We are attempting to determine the relationship of these cells to other cells containing electron dense material (observed with an electron microscope) and cells stained with $FeS0_4$ (observed with a light microscope) that may be tannin-containing cells. Other cells were observed to form spherical droplets that eventually coalesced into non-spherical structures after staining with toluidine blue. Some granular cells, stained with toluidine blue, were located in similar regions of cell clumps and organs as were cells of unstained material that contained anthocyanins. However, these two cell types were not the same cells as indicated in our preliminary studies. Laticifers were observed within organized tissues near the base of the root.

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Relationship of nitrogen source and molybdenum content of media to regeneration of leafy spurge cell cultures

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Cell suspension cultures of leafy spurge (*Euphorbia esula* L.) (1979ND1) were used to determine if specific biochemical processes could be correlated with root regeneration when cultures were subjected to various nitrogen regimes. Nitrate reductase (NR) levels in whole plants fluctuate in response to environmental conditions such as pH, plant age, light and temperature, and with the presence of various nutrient elements including nitrate, ammonium, molybdenum, potassium, sulfur and sucrose. If developmental changes in activities of nitrogen assimilating enzymes, such as NR can be monitored and correlated with leafy spurge regeneration, a better understanding of the mechanism of root formation in leafy spurge might lead to specific biological or chemical control measures.

In preliminary experiments, root formation in leafy spurge cultures was low or absent in high NO_3^- B5 media (27 mM $N0_3^-$, 2 mM NH_4^+) containing 3% sucrose. At the same time, greater root numbers and longer roots were found in high NH_4^+ B5 media (23 mM NH_4^+, 4 mM NO_3^-) containing 3% sucrose. Consequently, NR activity may also differ between rootforming and non-rootforming cultures. Because molybdenum (Mo) induces the formation of the protein moiety of NR, removal of Mo from the media should decrease root formation if NR is critical to root regeneration.

Low Mo status cells were obtained by subculturing cells in B5 medium containing 1 mg/L 2,4-D without Mo for three passages. Low Mo cells and control cells (grown with 1 µM Mo) were then transferred to either high NH_4^+ or high NO_3^- B5 medium but without 2,4-D. Root regeneration occurred almost exclusively in the control cells grown with high NH_4^+. *In vivo* NR activity and soluble protein concentration differed significantly between cells grown in high NH_4^+ or high NO_3^- media during the first two weeks of growth. In all cultures of low Mo status, NR activity was reduced. Fresh weights were greater for cultures grown in high NO_3^- media compared to high NH_4^+ media during the first two weeks of growth. NO_3^- was utilized completely in control cells grown in high NO_3^-, but NO_3^- remained in both media when cultures were Mo-deficient.

Root numbers induced in the above experiments were low (less than 30 roots per flask) possibly because the cultures had been maintained longer than one year (cells had been subcultured 10 times as callus and 40 times as suspensions in B5+1 mg/L 2,4-D before the first experiment). When recently isolated cultures (subcultured once as callus and nine times as cell suspensions in B5 + 1) were grown in the same high NO_3^- or high NH_4^+ media, the results were opposite those seen in the older cultures, i.e. higher root numbers (~3000/flask) were found in the high NO_3^- media compared to the high NH_4^+ media (~1000/flask). Maximum NR activity was higher in the older cultures (rootforming and non-rootforming) however, the same patterns of NR activity were seen in highly regenerative younger cultures.

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Testing alternative formulations of Tordon for use as substitutes for Tordon 22K

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Introduction

Recently, the Dow Chemical Company announced they intend to stop production of Tordon 2K pellets. The loss of this useful product will impact ranchers and weed district personnel in Montana who use the dry material effectively. The ease and convenience of Tordon pellets for hand broadcasting onto pioneer patches of leafy spurge will be lost with the loss of 2K. The purpose of this research was to determine if granular or dry formulations of Tordon could be produced which would provide effective control of leafy spurge.

Methods and materials

Ammonium sulfate fertilizer, complete fertilizer (17-17-17), Tidy Kat® cat litter, an organic kitty litter product produced from wood chips in Montana, and autoclaved oat kernels were used as carriers for Tordon. Known amounts of the above materials except oat kernels were placed on plastic sheets and sprayed with Tordon 22K to a point somewhat less than saturated. These impregnated materials were then weighed to calculate the amount of active ingredient absorbed onto their surfaces. Oat kernels were autoclaved to kill them and placed in a beaker with Tordon 22K for 48 hours. The kernels were then allowed to air dry and weighed to determine the amount of active ingredient absorbed.

Research plots were established at Bozeman and Whitehall, Montana in mid-May 1986. The plots were 7 x 25 feet long and arranged in a randomized complete block design with three replications. The dry materials were weighed out and applied to the plots (Table 1). Plots were treated with Tordon 22K and Tordon 2K as standards. The percent leafy spurge control was determined on July 12, 1986, at both locations.

Results and discussion

The most effective treatment for leafy spurge control was Tordon 22K with 84 and 98% control at rates of 0.5 and 1 lb/A respectively (Table 1). All of the impregnated products performed as well as Tordon 2K. Tidy Kat® applied at a rate of 1 lb/A provided 94% leafy spurge control.

It appears that effective substitutes could be produced to replace Tordon 2K. However, it appears at this time that the major reason for discontinuing production of 2K is pollution potential. In a second experiment, the off-target movement was measured for each of the above products. Several products, especially ammonium sulfate impregnated with Tordon appear to be as safe as Tordon 22K, the liquid product. Extremely small amounts of precipitation completely dissolved the ammonium sulfate product which permitted downward movement of Tordon. There was no trace of surface, lateral movement using a greenhouse bioassay. While efficacious impregnated products can be produced, it appears that the issue is not product production but off target pollution.

Table 1. The effect of Tordon formulation on leafy spurge control at 2 locations in MT. The experiments were established in May 1986 and rated July 12, 1986.

Tordon Formulation	Active Ingredient	Leafy Spurge Control Rate of Application 0.5 lb/A	1.0 lb/A
		%	
22K	2 E.C.	84	98
2K	2%	48	65
Ammonium Sulphate fertilizer	0.43%	37	66
17-17-17 fertilizer	0.43%	35	58
Tidy Kat®	2%	37	94
Organic Kitty litter®	1%	45	75
Dead oat kernels	1%	43	37
Control	----	0	0

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Leafy spurge taxonomy: A re-evaluation

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Introduction

Leafy spurge is a very aggressive noxious perennial weed of great and increasing economic importance in rangelands of central and western North America (Morton, 1937). Chemical, cultural and biological strategies are being developed to control this difficult weed. It is important to both chemical and biological control that we properly identify the target weed. In biological control management it is important to correlate the target weed to the equivalent type in the plants' native range for identification of appropriate biological control agents (Harris, 1979).

Using current classification schemes, we have been unable to satisfactorily assign the plants we see at field sites to any one specific taxon, but rather we find that several taxa are present. These classification schemes rely heavily on morphological characteristics of vegetative structures, particularly leaves. Great variability of these characteristics has been noted, including within site and within-plant variation (Bakke, 1936, Dunn and Radcliffe-Smith, 1980; Groh, 1935; Moore, 1958; Radcliffe-Smith, 1985).

We are also interested in the potential of chemical constituents in the plants as taxonomic indicators. For biological control, the differences between host plants and non-host plants are likely to be chemically related rather than morphological and the efficiency of searches for biological control agents of North American spurge are likely to be low until these differences are identified (Harris, 1979).

The purpose of our study was 1) to quantify the within-plant, within clone, between-clone and between-site variability of leaf characteristics, 2) to quantify the within-plant, within-clone, between-clone and between-site variability of latex triterpenoid composition, 3) to determine if there were any logical groupings of accessions based on leaf and/or triterpenoid characteristics, and 4) to evaluate the taxonomic value of those characteristics. European reference specimens were included in the study to relate Montana specimens to European specimens. Four of the European specimens were root cuttings from the Austrian specimens used in the Ebke and McCarty (1983) study and verified as *E. esula* by Radcliffe-Smith for that work.

Materials and methods

Multiple root cuttings from 27 Montana and 12 European accessions were established in the greenhouse in the summer of 1984. Leaves from flowering stems were collected in January and February, 1985. Every 15th leaf was removed from the plant and preserved

between a self-adhesive acetate sheet and standard graph paper (a total of 1,776). This technique allowed the leaves to dry while preserving their shape and dimensions. From these leaves, the three longest from each plant were selected for measurement of length, width, length/width ratio, and area. Leaf shape, shape of the leaf apex and shape of the leaf base were also recorded.

Latex triterpenoid content. Latex exuded from severed leaves from each accession was collected in acetone-washed vials containing spectroscopic grade acetone. The acetone was then evaporated and the vials sealed until analysis. Gas chromatic analysis (GC) of the latex triterpenoids was done at Indiana University, using a Hewlett-Packard 5710A gas-liquid chromatograph.

Individual compounds (peaks) were identified by their retention time (adjusted to theinternal standard for each sample) and quantified on a Hewlett-Packard 3380A integrator with data expressed as area percent.

Results and discussion

Leaf morphological characteristics. Overall leaf shape, shape of the leaf apex, shape of the leaf base, and position of the maximum leaf width are qualitative leaf charateristics that have been used as taxonomic characters in published classifications of leafy spurge (for example, see Radcliffe-Smith, 1981, 1985). Leaf shape and the position of maximum leaf width were well correlated. Shape of the leaf apex and shape of the leaf base were independent from leaf shape, position of greatest width and from each other.

Within a plant leaf morphological characteristics vary markedly. Sampling only the longest leaves reduces the variation, but does not eliminate it. Within-clone variation is also high; 80% of the clones sampled in Gallatin County showed marked variation for either position of maximum width or shape of the leaf apex. Leaf base shape was less variable, but 40% of the clones still contained marked variation.

Between-site variation in Montana is similar to the between-clone variation, with more than 60% of the sites having marked variation for position of maximum width and leaf apex shape.

Leaf phenetic characteristics. Leaf dimensions were as variable as leaf morphology. Statistical analysis for within-plant, within-clone, between-clone and between-site coefficients of variation for length, width, length/width ratio and area detected no significant differences.

Taxonomists increasingly use multivariate methods to guide the choices of characteristics for taxonomic evidence and for grouping specimens into taxa (Gaugh, 1982). Detrended correspondence analysis (Hill, 1979) of the data was employed to objectively determine groupings of replications amongst all accessions. Three clusters and one outlier were identified, but replications from individual clones occurred in two or even all three of the different clusters. This suggested that the groups were very 'artificial' rather than 'natural' groups and that the leaf characteristic that was the driving force for the selection of the groups (maximum width position) was not a valid characteristic for distinguishing taxa. Analysis of variance of data set based on these groupings showed no significant dif-

ference between groups ($P > 0.10$, df = 21), reflecting the large variation of the leaf characteristics.

A second detrended correspondence analysis using only leaf phenetic characteristics (i.e. leaf dimension data) was employed to determine which dimension characteristics were most important and to see if any groups were evident from only dimension data. The analysis could not distinguish any meaningful groupings of replicates and strongly indicates a continuum of leaf dimensions (The first factor endpoints were determined by leaf width and leaf area, but only 6% of the variance in the data was accounted for in the analysis).

Triterpenoid content. Analysis of variance of within-plant composition, within-clone composition, between-clone composition at a single site and between-sites in Montana were all non-significant ($P > 0.85$) and suggested strong similarity.

The triterpenoid composition was also analyzed with detrended correspondence analysis using three different forms of the data: i) original percent area data, ii) downweighting of the rare peaks (see Gaugh, 1982; Hill, 1979), and iii) data transformed to presence/absence form. The total variance accounted for by the first factors were only 11.5%, 10.4% and 21.5% for the original data form, rare downweighting and presence/abscence form, respectively. All three analyses produced similar results; no clear groupings of triterpenoid profiles and one outlier. Although some clustering of samples occurs, samples from the same clone and even from the same plant appear in more than one cluster. The reliability of any clusters is also doubtful with the low eigenvalues associated with the analyses, therefore the clusters do not represent any definable taxonomic entities. The results support the conclusion that the inherent variability of the plants is high even for these chemical components.

Classification. Sample data has four components: redundancy, relationships, outliers and noise (Gaugh, 1982). In our study, replication within a plant (several leaves or multiple latex samples from the same plant) and replication within a clone (an assumed genetic individual) represent redundancy. When a data set includes diverse samples, clear sample relationships will emerge despite any imperfections in the individual samples if the difference in the between-sample variation exceeds the within sample variation (Gaugh, 1982). Among relationships we see are the similarity of different clones and different sites for leaf morphology, leaf dimensions and triterpenoid profiles. Our study identified one well defined outlier that is clearly not in the '*esula* complex'.

The fourth component of sample data is noise. Noise is composed of both sampling error and inherent variability. By growing the plants in a uniform environment (i.e., the greenhouse) we have eliminated any environmental variation present in field collected specimens (i.e., herbarium collections and field studies). This type of variability falls into the sampling error category since it does not represent genotypic variability that is the basis for a natural classification. The inclusion of large replicate samples also reduces the potential for sampling error (Snedecor and Cochran, 1980). Multivariate analysis is a good test for homogeneity and discontinuous versus continuous variation (Goodall, 1954), and the orthoganality of the method maximizes the variance that is accounted for in the original data set (Gaugh, 1982). Detrended correspondence analysis demonstrated the presence of continuous variation in leaf dimension and in latex composition. The

European samples included in the study to represent the European leafy spurge complex were indistinguishable from the Montana plants.

Our study indicates that the common leaf characteristics used as taxanomic indicators, both singly and in combination, are highly variable and produce very artificial groupings of questionable value for classifying Montana and European accessions. Others have also noted the variation in leafy spurge (Ebke and McCarty, 1983; Bakke, 1936; Groh, 1935; Moore, 1958). Latex triterpenoid composition did not enhance the ability to detect meaningful clusters of samples.

There is little agreement in the literature on the proper taxon that this diverse group of plants belongs to. *E. esula* L. was preferred by Wheeler (1939) and Moore (1958), but Hanson and Rudd (1933), Groh (1935), Bakke (1936), and Morton (1937) preferred *E. virgata* Wald. & Kit. while Radcliffe-Smith (1980, 1985) has asserted that several taxa are present in this polymorphic complex. However, Croizat (1945, 1947) proposed *E. podperae* Croiz. for the complex, as it includes *E. esula*, *E. virgata*, and *E. intercedens*. The chronological history for the name is complicated and has, been reviewed by Richardson (1968) and Galitz (1980).

All the accessions in our study must be considered as one taxonomic unit based on the characteristics that we used, which included those leaf characteristics used in previously published classification schemes as well as triterpenoid profiles. In addition, the samples included in this study that represent the *E. esula-virgata* complex from Europe, and identified as being *E. esua* L., are indistinguishable from the Montana samples.

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Biological control of leafy spurge Progress report to GPC-14 Nov. 14, 1986

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Wilt and root rot

A Fusarium species was isolated from the few dead and dying leafy spurge (*Euphorbia esula*) plants found by Dr. Hosford in Washington and Wyoming in June-July 1986. Inoculation of soil around spurge plants in the greenhouse with the Fusarium alone has not, to date, resulted in wilt or root rot. In November 1986 a nonsporulating fungus was repeatedly isolated by Mr. Jordahl from brown streaks in roots of wilting leafy spurge plants growing in Sunshine Mix (a soilless mixture of peat moss, peralite and vermiculite from Canada). Spurge plants will be inoculated with this fungus.

Alternaria species

In September 1985 Dr. Hosford observed a disease killing some inflorescences and then the flowering stem of *Euphorbia esula* (leafy spurge) in western North Dakota, central Montana and southern Oregon. The disease was scattered in patches of spurge at one site in North Dakota and one site in Montana and abundant in a solid 100-acre stand of leaf spurge covering a valley in southern Oregon. In May 1986, he and Don Mundal observed a similar disease in eastern North Dakota. Alternaria was repeatedly isolated from the advancing edge of stem lesions from all these sites. In 36-65 hour wet periods isolates B1-1 and B1-6 of Alternaria from central Montana caused small dark spots to extensive dark lesioning, killing flowers, leaves and stems of leaf spurge biotypes 113, 110 and 108 in greenhouses at Fargo, ND. All 27 conidial inoculated plants developed spotting and/or top dieback. The 25 water inoculated check plants were not spotted. Alternaria resembling B1-1 and B1-6 were reisolated from the lesions and not from healthy check plants. On 4-30-86 Dr. Joe Krupinsky sent us two of his stem killing isolates of Alternaria from Mandan, North Dakota (4).

In the prairie provinces of Canada Alternaria spp. have caused leaf spotting to top dieback in up to 10% of the leafy spurge at some sites (5). *A. tenussima* f. sp. *euphorbiae* caused leaf spotting and top dieback in North Dakota, but artificial field inoculation at 3 sites in 1984 resulted in only a little infection, probably due to inadequate moisture (4, L. J. Littlefield personal communication).

Uromyces striatus

The rust, *Uromyces striatus* was detected killing leafy spurge near Lidgerwood in southeastern North Dakota in 1982. It spread slowly from plant to plant through 1982-84. In 1985 it spread quickly by aerial spores to scattered plants over 3 acres of spurge. In 1985 its uredispores were found on alfalfa in the fields, then produced in the greenhouse and stored in liquid nitrogen. On May 7, 1986 Dr. Hosford and Dr. Mundal found a rust disease resembling *U. striatus* killing a few plants near Lisbon, ND but not in an adjacent alfalfa field. We have a report of this rust on a few leafy spurge plants south of Carrington, ND. The rust kills the spurge plant. We are looking for another alternate host other than alfalfa or clover (3) from which spurge may be infected.

Malampsora euphorbiae, *Uromyces* spp. and *Endophyllum* spp.

In September 1985 we found a *Malampsora euphorbiae*-like rust on an Oregon State University herbarium specimen of *E. esula* collected in Medford, Oregon in 1964. We did not find the rust in Medford, but M. R. Hubbel, who collected it in 1964, is looking for it for us. *Melampsora* rust spp. occur on *Euphorbia* spp. and are highly specific for their hosts. This combined with their urediospore on *Euphorbia* spp. makes them good candidates for biocontrol of leafy spurge. *Melampsora euphorbiae* was collected at Victoria, B.C. by Dr. Littlefield in August, 1984 and sent to the Plant Disease Research Laboratory (PDRL) at Frederic, Maryland. *Uromyces euphorbiae* was collected by Dr. Littlefield on a collecting trip to Eastern Europe in the spring of 1984, and that rust was also sent to PDRL. Evaluation of these rusts for host range, prior to release to us, is in progress. At Frederic Dr. W. L. Bruckart is studying these and other microorganisms that he, Dr. Littlefield and others have collected (1). Dr. Bruckart reports that in Swiss studies by Dr. G. Defago *et al*. *Uromyces scutellatus* is reducing stands of cypress spurge by 90% (1, 2). He found that *M. euphorbiae* from Eastern Europe caused very limited infection on spurge collections other than those from which it came (1). We plan to look for these fungi on leafy spurge in the United States. Harris *et al*. (3) recommended the "autoecious rusts, such as *Melampsora euphorbiae* (Schub.) Cast., *Uromyces scutellatus* (Pers.) Lev. and Endophyllum species, as possible biocontrol agents for control of North American leafy spurge." On Oct. 21, 1986 Dr. Larry Littlefield sent us the uredial/telial stage of an autoecious rust (*Uromyces proeminens* or *U. magorii*?) on *Euphorbia dentata* (?), toothed spurge, in Oklahoma. Dr. Statler is testing this rust for pathogenicity to leafy spurge. On August 19, 1986 Sharon Collman, County Agent for King County, Washington sent us an orange rust severely rusting petty spurge (*Euphorbia peplus*) in King County. On October 7, 1986 Joseph Kropf, County Agent for Cowlitz County, Washington sent us an orange rust severely rusting petty spurge in Cowlitz County. On Nov. 7, 1986 Jack Waud, County Agent for Clallam County, Washington sent us an orange rust and leaf spots on small to medium size spurge plants in Clallam County. Dr. Statler is testing these rusts for pathogenicity to leafy spurge.

Sclerotium rolfsii

Dr. Littlefield obtained *Sclerotium rolfsii* isolates from southern United States. On January 28, 1986 10 ml of 2 two-week-old petri plate cultures of sclerotia and mycelium of *S. rolfsii* in 50 ml of water plus 2 drops of Tween 20 were poured on the base of each of 5 plants of leafy biotype 113. The plants in each of 5 pots were watered daily. By 8-18 days after inoculation the stems of the inoculated plants were killed at the soil surface, but new stems grew from the roots. Five water inoculated check plants were undamaged. This fungus damages many important plants and crops in the southern United States. It is assumed that it will not survive northern winters. If it were to survive, it might become a serious problem. We are studying this fungus only in the greenhouse in the winter.

Conclusions

We should continue studying root rot and wilt diseases for a potential control of leafy spurge and look for more virulent or aggressive isolates of Alternaria and autoecious rusts, such as *Melampsora euphorbiae* (Schub.) Cast, *Uromyces scutellatus* (Pers.) Lev., and Endophyllum species, on North American leafy spurge. We should also look for any other organisms, fungi, bacteria, viruses, nematodes, etc., that may be damaging leafy spurge.

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Aphthona cyparissiae, a new flea beetle for leafy spurge control in the United States

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Aphthona cyparissiae (Koch) (Coleoptera: Chrysomelidae), a flea beetle, is one of the many *Aphthona* species which attack *Euphorbia* species in Europe and Asia. Like other *Aphthona* species, the adults of *A. cyparissiae* feed on host leaves, while the larvae feed upon the root hairs and within the roots. *A. cyparissiae* is native to Spain through central and eastern Europe to Russia. It has been recorded to feed on *Euphorbia cyprissias* L., *E. esula* L., *E. helioscopia* L., *E. pannonica* Host, *E. seguierana* Necker and *E. virgata* Waldst. and Kit. (Sommer and Maw 1982). The beetle has a single generation each year.

This insect was first evaluated as a biological control candidate for leafy spurge (*Euphorbia esula*) by G. Sommer and E. Maw at the Commonwealth Institute of Biological in Delemont, Switzerland[1] (Sommer and Maw 1982). Their research demonstrated that *A. cyparissiae* was specific to plant species belonging to the genus *Euphorbia*. This work provided the basis on which the insect was approved for release in Canada (McClay and Harris 1984) and imported into our USDA, Albany, California quarantine for additional testing.

More research was required because of the large number of nontarget native *Euphorbia* species in the United States that could become host plants for introduced leafy spurge biological control agents with broad host specificity ranges. Canada has only 8 native *Euphorbia* species, none of which are rare, whereas the United States has 113 species of *Euphorbia*[2] (USDA 1982), including 2 rare species that are legally protected, and 9 others that are under review for protected status (USDI 1985). The host plant specificity research at Albany enables us to detect and select among the *Euphorbia* feeding insects those species which will attack the various forms of leafy spurge but not most of the native species (Pemberton, in press). *Aphthona cyparissiae* was tested against 10 native *Euphorbia* species, selected to represent the various subgenera occurring in North America. The test plants used (Table I) included species which are weedy, ornamental, rare, sympatric with leafy spurge and those that could carry the insects around the country (bridges).

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[1] The Sommer and Maw research was funded by the Canada Department of Agriculture and to a lesser degree by the United States Department of Agriculture.

[2] Includes the postrate subgenus chamaesyce species which are considered to be genus *Chamaesyce* species in some taxonomic treatments.

The measures of host plant acceptability that were studied were adult feeding, oviposition and longevity. Table II summarizes the results. In these tests, *A. cyparissiae* was restricted to species belonging to the subgenus esula, the group to which leafy spurge belongs. Within this subgenus, *Euphorbia incisa* Engelm., *E. robusta*, (Engelm.) Small and the control (leafy spurge) were suitable for oviposition, while the rare species *E. purpurea* (Raf.) Fernald and *E. telephiodes* (Chapm.) were not. This research allows the prediction that 9 or fewer of the perennial subgenus *esula Euphorbia* species native to the United States could be potential host plants of *A. cyparissiae,* if it were able to colonize the entire country. This level of risk was acceptable to the Federal Working Group on Biological Control of Weeds, which approved the beetle's release in the United States.

Table I. Native euphorbias used in host specificity testing for *Aphthona cyparissiae.*

Species	Habit	Subgenus	Sympatric with leafy spurge	Potential bridge	Endangered species	Weed	Ornamental
Euphorbia heterophylla	Ann.	Poinsettia	X	X		X	X
E. maculata	Ann.	Chamaesyce	X	X		X	
E. serphyllifolia	Ann.	Chamaesyce	X	X			
E. robusta	Peren.	Esula section esula	X	X			
E. spatulata	Ann.	Esula section galarrhoei	X	X			
E. purpurea	Peren.	Esula section not placed	X		X		
E. telephioides	Peren.	Esula section ipeccacuahae			X		
E. incisa	Peren.	Esula section esula	possibly				
E. marginata	Ann.	Agaloma	X	X			X
E. corollata	Peren.	Agaloma	X	X			X

The first release of *A. cyparissiae* in the United States was made in Fremont County, Wyoming during July 1986 by J. Littlefield (University of Wyoming, Laramie), L. Baker (Fremont County Weed and Pest District) and myself (RWP). Subsequent releases were made during August in Crook County, Wyoming, by J. Littlefield and in Barnes County, North Dakota by R. Carlson and D. Mundal (University of North Dakota, Fargo). The beetles that were released were collected in Austria from *Euphorbia cyparissias* by P. Pecora and L. Fornasari (USDA, Biological Control of Weeds Laboratory, Rome, Italy). These beetles were then screened in our Albany quarantine prior to release. This entailed setting up pairs of adult beetles on bouquets of leafy spurge shoots. Each pair was observed for normal leaf feeding and egg laying before being shipped for field release. Con-

firmation of the identity of *A. cyparissae* was made by M. Biondi (Institute of Zoology, Rome, Italy) and R. White (USDA, Smithsonian National Museum, Washington, D. C.).

Table II. Summary of *Aphthona cyparissiae* host plant specificity testing on native North American *Euphorbia* species, Albany 1985.

Test Plant Species	Subgenus	% of plants with adult feeding	% of plants supporting oviposition	% of adults living 1 mo. or longer
Euphorbia esula (Control)	Esula	100	100	75
Euphorbia incisa	Esula.	100	100	60
Euphorbia robusta	Esula	80	80	70
Euphorbia purpurea	Esula	60	0	10
Euphorbia telephioides	Esula	40	0	0
Euphorbia spatulata	Esula	10	0	0
Euphorbia maculata	Chamaesyce	0	0	0
Euphorbia serphyllifolia	Chamaesyce	0	0	0
Euphorbia corollata	Agaloma	0	0	0
Euphorbia marginata	Agaloma	0	0	0
Euphorbia heterophylla	Poinsettia	0	0	0

Since *A. cyparissiae* has successfully overwintered in Saskatchewan, Canada (McClay and Harris 1984), it appears to have sufficient cold tolerance to establish in the United States. Through its root feeding, this beetle could limit the ability of the plants to absorb water, inducing water stress and reduced vigor. *A. cyparissiae* is the second *Aphthona* species to be released in the United States. The first, *A. flava* Guill., was first released in 1985 (Pemberton and Johnson 1986) and again this summer. In Europe, *A. cyparissiae* has a more northern distribution than *A. flava* (Sommer and Maw. 1982), which suggests that it may do better in colder areas. *A. cyparissiae* may also do better than *A. flava* on drier sites (suggested by data from Maw 1981). A third species, *Aphthona czwalinae* Koch, has been under study in Albany and may be cleared for release in 1987. It appears to prefer moister sites than either *A. flava* or *A. cyparissiae* (interpreted from data in Maw 1981). The introduction of a complex of *Aphthona* species should increase our chances of controlling leafy spurge in the diverse habitat it infests.

The *Aphthona* species have been selected for use because they damage the absorptive roots of leafy spurge. Additional insects, that attack other parts of the plant, have also been introduced. *Oberea erythrocephala* (Schrank) (Cerambycidae) which bores the stems and larger roots, and *Hyles euphorbia* (L.), which eats the leaves and flowers, have been established in Montana (Rees *et al*. 1986). A gall midge, *Dasineura* (*Bayeria*) *capitigena* (Bremi), that attacks the growing shoots, was first released in 1985 and again this year 1986 (Pemberton and Johnson 1986). Other gall midges and leaf feeding Lepidoptera are under study.

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Experiment no.: 86020005.
Title: The effectiveness of sheep grazing and herbicides for control of leafy spurge. Peterson ranch, Judith Gap, Montana.

CROP INFORMATION

Crop: PASTURE		Seeding Depth:
Planted:		Row Width:
Experimental Design:	RCB	Seeding Rate:
Replications: 2		Plot Size: 10 X 100

SOIL INFORMATION

Soil Type:		Previous Crop:
Organic Matter:	pH:	Fertilizer Used:

HERBICIDE APPLICATION JUNE 5 1986 TREATMENTS 1-11

Mixed By: FAY	Surfactant Used: NONE	In Trt.
Applied By: FAY & DAVIS	Surfactant Rate:	
Sprayer: BACKPACK	Pressure: 40 PSI	Volume: 12.2 GPA
Propellant: CO2	Nozzles: 8002	
Time: 3:00 PM	Rel. Humidity: 65%	
Wind Speed: 5-7 MPH	Air Temperature: 70º F	
Wind Direction: NORTH	Soil Temp.: 2"-72º F; 4"-70º F	
Note:		
Crop Stage:		

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	VEG. 4-8 IN. TALL	HEAVY

RATING INFORMATION number 01 OF 01 TOTAL RATINGS

Rated By: FAY	Date: 6-19-86	Crop Stage:

Rating Method: 0=NO CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	VEG. 6-14 IN TALL	HEAVY

REMARKS

THE PURPOSE OF THIS EXPERIMENT IS TO MEASURE THE IMPACT OF SHEEP GRAZING OF SPURGE USED IN COMBINATION WITH HERBICIDE APPLICATIONS. THE HERBICIDES WERE APPLIED ON JUNE 5, 1986 TO 4 TO 8 INCH SPURGE ABOUT 1 WEEK AFTER THE SHEEP WERE REMOVED.

HALF OF THE EXPERIMENTAL AREA WAS FENCED AFTER SPRAYING TO EXCLUDE SHEEP. THE EXPERIMENT WILL BE MONITORED EACH YEAR FOR SEVERAL YEARS.

LOW RATES OF TORDON ALONE AND IN COMBINATION WITH STARANE AND 2,4-D PROVIDED GOOD TO EXCELLENT CONTROL OF SPURGE. STARANE ALONE AND OUST WITH 2,4-D PROVIDED EXCELLENT SPURGE CONTROL. THE EXPERIMENTAL AREA WAS GRAZED IN LATE SUMMER SO FALL RATINGS WERE NOT TAKEN.

Experiment 86020005
The effectiveness of sheep grazing and herbicides for control of leafy spurge. Peterson ranch. Judith Gap.

TREATMENT					
TRT NO.	CHEMICAL	FORM	RATE LB/A	TIMING	PERCENT CONTROL 6-19 SPURGE CONTROL
1	TORDON	2 EC	.125	FLOWERING	.0
2	TORDON	2 EC	.25	FLOWERING	32.5
3	TORDON	2 EC	.5	FLOWERING	75.0
4	T0RDON + STARANE	2 EC + 1.67 EC	.125 + .125	FL0WERING	77.5
5	TORDON + STARANE	2 EC + 1.67 EC	.25 + .25	FLOWERING	95.0
6	TORDON + 2,4-D	2 EC + 4 EC	.25 + 1.0	FLOWERING	96.5
7	TORDON + 2,4-D	2 EC + 4 EC	.125 + 1.0	FLOWERING	91.3
8	TORDON	2 EC	1.0	FLOWERING	92.5
9	STARANE	1.67 EC	.50	FLOWERING	97.5
10	CHECK				.0
11	OUST + 2,4D	75DF + 4EC	1 OZ + 1.0	FLOWERING	98.0
				C.V. -	2.92
				LSD 5% -	4.46

Experiment no.: 86020004.
Title: Combinations with Oust for leafy spurge control. Ray Gillespie Farm, Whitehall, Montana.

CROP INFORMATION

Crop: PASTURE		Seeding Depth:
Planted:		Row Width:
Experimental Design:	RCB	Seeding Rate:
Replications: 3		Plot Size: 7 X 25

SOIL INFORMATION

Soil Type:		Previous Crop: PASTURE
Organic Matter:	pH:	Fertilizer Used: NONE

HERBICIDE APPLICATION JUNE 17,1986 TREATMENTS 1-4

Mixed.By: LINDQUIST	Surfactant Used: X-77	In Trt. l-?.
Applied By: FELLOWS	Surfactant Rate: .25%	
Sprayer: BACKPACK	Pressure: 40 PSI	Volume: 12 GPA
Propellant: CO2	Nozzles: 8002	
Time: 9:30 AM	Rel. Humidity: 40%	
Wind Speed: 0 MPH	Air Temperature: 83º F	
Wind Direction:	Soil Temp.: 2"-66º F; 4"-62º F	
Note:		
Crop Stage: GRASSES 12 IN.TALL		

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWER STAGE	HEAVY

RATING INFORMATION number 01 OF 02 TOTAL RATINGS
Rated By: FAY, FELLOWS Date: 7-11-86 Crop Stage:
Rating Method: O=NO CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	SEED FILL	HEAVY

RATING INFORMATION number 02 OF 02 TOTAL RATINGS
Rated By: FAY, MCKONE Date: 8-22-86 Crop Stage:
Rating Method: 0=NO CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	RIPE	HEAVY

REMARKS

OUST ALONE DID NOT VISIBLY INSURE LEAFY SPURGE. ON JULY 11, 1986 IT WAS APPARENT THAT OUST ALONE DID DELAY FLOWERING. IN COMBINATION WITH 2,4-D IT PROVIDED EXCELLENT CONTROL OF LEAFY SPURGE. IT SHOULD BE NOTED THAT 2,4-D PERFORMED EXTREMELY WELL ALONE AT THIS LOCATION IN 1986 SO RATINGS WILL HAVE TO BE CLOSELY OBSERVED IN 1987. IT DID EITHER BLOCK SEED PRODUCTION OR DELAY FLOWERING.

Experiment No. 86020004.
Combinations with Oust for leafy spurge control. Ray Gillespie Farm. Whitehall, Montana.

TREATMENT						
TRT NO.	CHEMICAL	FORM	RATE AMT/A	7-11-86 % SPURGE CONTROL	7-11-86 % CONTROL SEED PRO	8-22-86 % SPURGE CONTROL
1	OUST	75 DF	1 OZ	15.0	100.0	.0
2	OUST+2,4-D	75 DF + 4 EC	1 OZ + 1 LB	98.7	98.3	97.0
3	OUST+BANVEL	75 DF + 2 EC	1 OZ + 2 LB	23.3	56.7	28.3
4	OUST+TORDON	75 DF + 2 EC	1 OZ + .25 LB	30.0	40.0	20.7
5	CHECK			.0	.0	.0
			C.V.	18.10	9.91	20.27
			LSD 5%	11.72	11.01	11.14

Experiment No.: 86020003.
Title: Banvel and Tordon combinations for leafy spurge control. Ray Gillespie Farm. Whitehall, Montana.

CROP INFORMATION

Crop: PASTURE
Planted:
Experimental Design: RCB
Replications: 3
Seeding Depth:
Row Width:
Seeding Rate:
Plot Size: 7 X 25

SOIL INFORMATION

Soil Type:
Organic Matter: pH:
Previous Crop:
Fertilizer Used:

HERBICIDE APPLICATION JUNE 17, 1986 TREATMENTS 1-14

Mixed By: LINDQUIST
Applied By: FELLOWS
Sprayer: BACKPACK
Propellant: CO2
Time: 9:30 A.M.
Wind Speed: 0 MPH
Wind Direction:
Note:
Crop Stage: PASTURE
Surfactant Used: NONE In Trt.
Surfactant Rate:
Pressure: 40 PSI Volume: 12 GPA
Nozzles: 8002
Rel. Humidity: 40%
Air Temperature: 83º F
Soil Temp.: 2"-66º F; 4"-62º F

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWER STAGE	HEAVY

REMARKS

THE COMBINATION OF BANVEL AND TORDON IN TREATMENT 7 PROVIDED 88% CONTROL, BETTER CONTROL OF LEAFY SPURGE THAN EITHER CHEMICAL ALONE. BANVEL OR TORDON IN COMBINATION WITH 2,4-D ALSO PROVIDED EXCELLENT CONTROL. EH 680, A PHENOXY MIXTURE WITH DICAMBA FROM PBI GORDAN LOOKED VERY GOOD AT A RATE OF 3 PINTS PER ACRE.

THE EXPERIMENT WILL BE RATED AGAIN IN 1987.

Experiment No. 36020003.
Banvel and Tordon combinations for leafy spurge control. Ray Gillespie Farm. Bozeman, Montana.

TREATMENT				
TRT NO.	CHEMICAL	RATE LB/A	7-11-86 % SPURGE CONTROL	8-22-86 % SPURGE CONTROL
1	BANVEL	2.0	20.0	10.0
4	BANVEL	4.0	46.7	35.0
3	TORDON	.25	15.0	6.7
4	TORDON	.5	33.3	36.7
5	TORDON	1.0	62.3	61.7
6	BANVEL + TORDON	1.0 + .25	57.3	65.3
7	BANVEL + TORDON	1.0 + .5	80. 3	83 3
8	BANVEL + TORDON	.5 + .25	34.0	25.0
9	BANVEL + TORDON	.5 + .5	51.7	56.7
10	BANVEL + 2,4-D	.5 + 1.0	83.3	94.0
11	TORDON + 2,4-D	.25 + 1.0	71.7	98 3
12	EH 680	1.0 PT	85.0	80.7
13	EH 680	2.0 PT	84.7	87.0
14	EH 680	3.0 PT	98.3	96.7
15	CHECK		.0	.0
		C.V. -	11.66	23.83
		LSD 5% -	10.71	22.41

Experiment No.: 85015006.
Title: Effect of herbicides on leafy spurge roots. Brass Lantern Estates. Bozeman, Montana.

CROP INFORMATION

Crop: RANGE
Planted:
Experimental Design: RCB
Replications: 1

Seeding Depth:
Row Width:
Seeding Rate:
Plot Size: 12 X 50

SOIL INFORMATION

Soil Type: GRAVELY LOAM
Organic Matter: pH:

Previous Crop; RANGE
Fertilizer--Used: NONE

HERBICIDE APPLICATION JUNE 20, 1985 TREATMENTS 1-6.

Mixed By: FAY
App1ied By: CEL LACEY
Sprayer: BACKPACK
Propellant: CO2
Time: 12:00 PM
Wind Speed: 0-8 MPH
Wind Direction: NORTH WEST
Note:
Crop Stage:

Surfactant Used: NONE In Trt.
Surfactant Rate:
Pressure: 40 PSI Volume: 15.4 GP
Nozzles: 8002
Rel. Humidity: 25%
Air Temperature: 85º F
Soil Temp.: 2"-86º F; 4"-84º F

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FULL BLOOM	HEAVY

RATING INFORMATION number 01 OF 01 TOTAL RATINGS

Rated By: FAY, DAVIS Date: 6-12-86 Crop Stage: RANGE
Rating Method: 0=NO CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWERING	MODERATE

REMARKS

ONE YEAR AFTER APPLICATI0N, STARANE, 2,4-D AND BANVEL PROVIDED UNACCEPTABLE CONTROL OF LEAFY SPURGE. TORDON AT ONE AND TWO POUNDS PER ACRE WAS EFFECTIVE.

TREATMENT				
TRT NO.	CHEMICAL	FORM	RATE LB/A	6-12-86 % SPURGE CONTROL
1	TORDON	2EC	.5	40.3
2	TORDON	2EC	1.0	90.0
3	TORDON	2EC	2.0	95.0
4	BANVEL	4EC	4.0	30. 0
5	2,4-D AMINE	4EC	2.0	. 0
6	STARANE	1.67EC	1.0	10.0
7	CHECK			. 0
			C.V. -	**********
			LSD 5% -	**********

Experiment No.: 86020001.
Title: Testing DPD for control of leafy spurge. Ray Gillespie Ranch. Whitehall, Montana.

CROP INFORMATION

Crop: PASTURE		Seeding Depth:
Planted:		Row Width:
Experimental Design:	RCB	Seeding Rate:
Replications: 3		Plot Size: 7 X 25

SOIL INFORMATION

Soil Type:		Previous Crop:
Organic Matter:	pH:	Fertilizer Used:

HERBICIDE APPLICATION JUNE 20, 1986 TREATMENTS 1-6

Mixed By: DAVIS	Surfactant Used: LI-700 In Trt. 1-5.
Applied By: BIGLEN	Surfactant Rate: 2Q/100
Sprayer: BACKPACK	Pressure: 40 PSI Volume: 34 GPA
Propellant: CO2	Nozzles: 8006
Time: 12:00 PM	Rel. Humidity: 60%
Wind SDeed: 4-6 MPH	Air Temperature: 74º F
Wind Direction: SOUTH	Soil Temp.: 2"-92º F; 4"-73º F
Note:	
Crop Stage: PASTURE	

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWERING	HEAVY

RATING INFORMATION number 01 OF 01 TOTAL RATINGS

Rated By: FAY/FELLOWS Date: 7-11-86 Crop Stage:

Rating Method: 0 = NO CONTROL 100= COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	SEED FILL	HEAVY

REMARKS

DPD ESTER, A MIXED ESTER FORMULATION FROM WEST CHEM, PROVIDED EXCELLENT CONTROL OF LEAFY SPURGE THROUGH AUGUST FOLLOWING A MAY 20 APPLICATION. THIS DEGREE OF CONTROL IS MORE THAN EXPECTED FROM A PHENOXY HERBICIDE.

THE EXPERIMENT WILL BE MONITORED IN 1987.

Experiment No. 86020001
Testing DPD ester for leafy spurge control. Ray Gillespie Farm. Whitehall, Montana.

TREATMENT					
TRT NO.	CHEMICAL	RATE LVA	TIMING	7-11-86 % SPURGE CONTROL	8-22-86 % SPURGE CONTROL
1	DPD ESTER	2.0	FLOWERING	86.7	96.7
2	DPD ESTER	4.0	FLOWERING	99.3	99.0
3	DPD ESTER + TORDON	2.0 + 2.5	FLOWERING	96.7	99.3
4	DPD ESTER + BANVEL	2.0 + .5	FLOWERING	93.7	100.0
5	DPD ESTER + TORDON	4.0 + .25	FLOWERING	99.0	100.0
6	TORDON	1.0	FLOWERING	79.0	89.3
7	CHECK			.0	.0
			C.V. -	5.50	4.48
			LSD 5% -	7.76	6.65

Experiment no.: 86020002.
Title: Herbicides for leafy spurge control. Ray Gillespie Farm. Whitehall, Montana.

CROP INFORMATION

Crop: PASTURE
Planted:
Experimental Design: RCB
Replications: 3
Seeding Depth:
Row Width:
Seeding Rate:
Plot Size: 7 X 25

SOIL INFORMATION

Soil Type:
Organic Matter: pH:
Previous Crop: PASTURE
Fertilizer Used: NONE

HERBICIDE APPLICATION JUNE 17, 1986 TREATMENTS 1-14

Mixed By: DAVIS
Applied By: COBLE
Sprayer: BACKPACK
Propellant: CO2
Time: 9:30 AM
Wind Speed: 0 MPH
Wind Direction:
Surfactant Used: X-77 In Trt.
Surfactant Rate: .25%
Pressure: 40 PSI Volume: 14.5GPA
Nozzles: 8002
Rel. Humidity: 40%
Air Temperature: 83º F
Soil Temp.: 2"-66º F; 4"-62º F
(Note: * X-77 WAS ADDED TO TREATMENTS 1-9, 12 & 13 AT A RATE OF .25%)
Crop Stage: GRASSES 12 IN.TALL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWERING	HEAVY

RATING INFORMATION number 01 OF 02 TOTAL RATINGS
Rated By: FAY, FELLOWS Date: 7-11-66 Crop Stage: PASTURE
Rating Method: O=NO CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	SEED FILL	HEAVY

RATING INFORMATION number 02 OF 02 TOTAL RATINGS
Rated By: FAY, MCKONE Date: 8-22-86 Crop Stage: PASTURE
Rating Method: O=NON CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	RIPE	HEAVY

REMARKS

OUST AND ESCORT ALONE AND IN COMBINATION DID NOT PROVIDE EFFECTIVE CONTROL OF LEAFY SPURGE. KRENITE S CONTINUES TO BE UNEFFECTIVE IN OUR TRIALS. THE DUPONT COMPANY OBTAINED A LABEL FOR SPURGE CONTROL BASED ON COMPANY RESULTS WHICH ARE VERY PROMISING. THIS DISCREPANCY IS VERY PERPLEXING.

OUST WITH 4 OZ. OF 2,4-D PROVIDED GOOD SPURGE CONTROL. THE POSSIBLE-INTERACTION BETWEEN PHENOXYS AND SULFONYLUREAS MUST BE STUDIED MORE CLOSELY SINCE ENORMOUS POTENTIAL EXISTS IF SYNERGISM IS A REALITY.

Experiment No. 86020002.
Herbicides for leafy spurge control. Ray Gillespie Farm. Whitehall, Montana.

TREATMENT					
TRT N0.	CHEMICAL	RATE AMT/A	7-11-86 % SPURGE CONTROL	7-11-86 % CONTROL SEED PRODUCTION	8-22-86 % SPURGE CONTROL
1	OUST	.7 OZ	10.0	91.7	3.3
4	OUST	1.5 OZ	16.7	97.7	5.0
3	ESCORT	.3 OZ	3.3	74.3	2.3
4	ESCORT	6 OZ	6.7	83.3	5.0
5	OUST+ESCORT	.75 OZ + .3 OZ	6.7	91.7	.0
6	OUST+ESCORT	.75 OZ + .6 OZ	10.0	97.1	3.3
7	OUST+ESCORT	1.3 OZ + .3 OZ	15.0	100.1	10.0
8	OUST+ESCORT	1.0 OZ + .6 OZ	16.7	92.7	1.7
9	OUST+ROUNDUP	1.0 OZ + 1 QT	31.7	85.0	10.7
10	KRENITE S	1 GAL	18.3	73.3	8.3
11	KRENITES S	2 GAL	36.3	100.0	20.7
12	OUST+KRENITES	1.5 OZ + 1 GAL	40.0	100.0	18.3
13	OUST+2,4-D	1 OZ + 4 OZ	82.3	95.0	80.7
14	TORDON	1 LB	67.0	73.3	83.7
15	CHECK		.0	.0	.0
		C.V. -	30.45	13.96	35.75
		LSD 5%. -	12.24	19.61	10.08

Experiment No.: 86020006.
Title: Starane combinations for leafy spurge control. Ray Gillespie Ranch. Whitehall, Montana.

CROP INFORMATION

Crop: PASTURE		Seeding Depth:
Planted:		Row Width:
Experimental Design:	RCB	Seeding Rate:
Replications: 3		Plot Size: 7 X 25

SOIL INFORMATION

Soil Type:		Previous Crop: PASTURE
Organic Matter:	PH:	Fertilizer Used: NONE

HERBICIDE APPLICATION JUNE 17, 1986

TREATMENTS 1-10	
Mixed By: DAVIS	Surfactant Used: X-77 In Trt. 9&10
Applied By: COBLE	Surfactant Rate: .25%
Sprayer: BACKPACK	Pressure: 40 PSI Volume: 14.5GPA
Propellant: CO2	Nozzles: 8002
Time: 10:30 AM	Rel. Humidity: 40%
Wind Speed: 0 MPH	Air Temperature: 83º F
Wind Direction:	Soil Temp.: 2"-66º F; 4"-62º F
Note:	
Crop Stage:	

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWERING	HEAVY

HERBICIDE APPLICATION JULY 29, 1986

TREATMENTS 11-20	
Mixed By: WOOD	Surfactant Used: X-77 In Trt. 19,20
Applied By: DAVIS	Surfactant Rate: .25%
Sprayer: BACKPACK	Pressure: 40 PSI Volume: 14 GPA
Propellant: CO2	Nozzles: 8002
Time: 10:30 AM	Rel. Humidity: 50%
Wind Speed: 3-5 MPH	Air Temperature: 84º F
Wind Direction: SOUTH	Soil Temp.: 2"-70º F; 4"-65º F
Note:	
Crop-Stage:	

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	LATE FLOWER-SEED FILL	HEAVY

HERBICIDE APPLICATION SEPTEMBER 17, 1986

Mixed By: TOWNSEND	Surfactant Used: LI-700 In Trt. 29,30	
Applied By: DAVIS	Surfactant Rate: .25%	
Sprayer: BACKPACK	Pressure: 40 PSI	Volume:15 GPA
Propellant-: CO2	Nozzles: 8002	
Time: 12:00 PM	Rel. Humidity: 32%	
Wind Speed: 3-6 MPH	Air Temperature: 73º F	
Wind Direction: NORTH	Soil Temp.: 2"-60º F; 4"-55º F	

Note:
Crop Stage:

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	SENESCENCE	HEAVY

RATING INFORMATION number 01 OF 02 TOTAL RATINGS
Rated By: FAY, FELLOWS Date: 7-11-86 Crop Stage:
Rating Method: 0=NO CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	SEED FILL	HEAVY

RATING INFORMATION number 02 OF 02 TOTAL RATINGS
Rated By: FAY, MCKONE Date: 8-22-86 Crop Stage:
Rating Method: 0=NO CONTROL 100=COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	RIPE	HEAVY

REMARKS

STARANE WAS TESTED ALONE AND - IN COMBINATION WITH TORDON OR 2,4-D IN SPURGE. TEN TREATMENTS WERE APPLIED ON JUNE 17, JULY 29, AND SEPTEMBER 17.

RATINGS TAKEN THIS YEAR INDICATE EFFECTIVE CONTROL WAS ACHIEVED WITH ALL OF THE STARANE TREATMENTS. OUST ALONE AND IN COMBINAT'ION WITH TORDON WAS INEFFECTIVE.

Experiment No. 36020006.
Starane combinations for leafy spurge control. Ray Gillespie Farm. Whitehall, Montana.

TREATMENT					
TRT NO.	CHEMICAL	RATE LB/A	TIMING	7-11-86 % SPURGE CONTROL	8-22-86 % SPURGE CONTROL
1	STARANE + TORDON	.25 + .25	JUNE 17	70.3	88.3
2	STARANE + TORDON	.25 + .50	JUNE 17	79.7	96.7
3	STARANE + TORDON	.25 + 1.0	JUNE 17	82.3	94.0
4	STARANE + 2,4-D	.0	JUNE 17	91.0	91.7
5	STARANE + 2,4-D	.50 + 1.0	JUNE 17	97.7	88.3
6	STARANE + 2,4-D	.50 + 2.0	JUNE 17	89.3	94.7
7	STARANE	.50	JUNE 17	91.0	90.7
8	TORDON	.50	JUNE 17	23.3	10.0
9	OUST	1 oz	JUNE 17	10.0	.0
10	OUST + TORDON	1 oz + .125	JUNE 17	16.0	5.0
31	CHECK			.0	.0
			C.V. -	12.12	10.75
			LSD 5% -	12.21	10.97

TREATMENT				
TRT NO.	CHEMICAL	RATE LB /A	TIMING	8-22-86 % SPURGE CONTROL
11	STARANE + TORDON	.25 + .25	JULY 29	99.0
12	STARANE + TORDON	.25 + .50	JULY 29	100.0
13	STARANE + TORDON	.25 + 1.0	JULY 29	100.0
14	STARANE + 2,4-D	.25 + 1.0	JULY 29	66.7
15	STARANE + 2,4-D	.50 + 1.0	JULY 29	100.0
16	STARANE + 2,4-D	.50 + 2.0	JULY 29	100.0
17	STARANE	.50	JULY 29	98.3
18	TORDON	.50	JULY 29	85.7
19	OUST	1 oz	JULY 29	6.7
20	OUST+TORDON	1 oz + .125	JULY 29	18.3
31	CHECK			.0
			C.V. -	25.80
			LSD 5% -	30.95

Experiment No.: 86015001.
Title: Testing granular formulations of Tordon for leafy spurge control. Brass Lantern Estates. Bozeman, Montana.

CROP INFORMATION
Crop: RANGE
Planted:
Experimental Design: RCB
Replications: 3
Seeding Depth:
Row Width:
Seeding Rate:
Plot Size: 7 X 25

SOIL INFORMATION
Soil Type: GRAVELY LOAM
Organic Matter: pH:
Previous Crop: RANGE
Fertilizer Used: NONE

HERBICIDE APPLICATION MAY 14, 1986 TREATMENTS 2-8, 10-16
Mixed By: FAY
Applied By: DAVIS
Sprayer: SHAKER
Propellant:
Time: 10:00 AM
Wind Speed: 8-20 MPH
Wind Direction: SOUTH WEST
Note:
Crop Stage:
Surfactant Used: In Trt.
Surfactant Rate:
Pressure: Volume:
Nozzles:
Rel. Humidity: 40%
Air Temperature: 27º F
Soil Temp.: 2"-27º F; 4"-27º F

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	PREBLOOM	HEAVY

HERBICIDE APPLICATION MAY 20, 1986 TREATMENTS 1 & 9
Mixed By: DAVIS
Applied By: DAVIS
Sprayer: BACKPACK
Propellant: CO2
Time: 10:00 AM
Wind Speed: 1-3 MPH
Wind Direction: WEST
Note:
Crop Stage:
Surfactant Used: NONE In Trt.
Surfactant Rate:
Pressure: 40 PSI Volume: 14 GPA
Nozzles: 8002
Rel. Humidity: 45%
Air Temperature: 55º F
Soil Temp.: 2"-50º F; 4"-49º F

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	PREBLOOM	HEAVY

RATING INFORMATION number 01 OF 01 TOTAL RATINGS
Rated By: FAY, DAVIS Date: 6-12-86 Crop Stage:
Rating Method: 0=NO CONTROL 100= COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWERING	HEAVY

REMARKS

THE LOSS OF TORDON 2K PELLETS WILL BE FELT IN MONTANA THEREFORE "DRY" HERBICIDE FORMULATIONS WERE PREPARED IN ORDER TO TEST THE POTENTIAL OF LOCALLY FORMULATED SUBSTITUTES.

THE FOLLOWING MATERIALS WERE COATED WITH TORDON 22K, THE LIQUID FORMULATION: BLENDED FERTILIZER (14-14-14), AMMONIUM SULFATE FERTILIZER (34-0-0), “TIDY CAT” CAT LITTER, "HAGEN" CAT LITTER, AUTOCLAVED (DEAD) OAT KERNELS, AN ORGANIC KITTY LITTER PRODUCT MADE FROM WOOD CHIPS.

THE FERTILIZER CONTAINED 0.43% ACTIVE INGREDIENT (PICLORAM) THE CONVENTIONAL KITTY LITTERS CONTAINED 2% ACTIVE INGREDIENT AND THE ORGANIC KITTY LITTER AND THE DEAD OAT KERNELS CONTAINED 1% ACTIVE INGREDIENT. THESE FORMULATIONS WERE COMPARED TO TORDON 22K AND TORDON 2K.

THE RESULTS AT THE BOZEMAN LOCATION WERE UNFORTUNATELY NOT RATED IN AUGUST. THE EARLY JUNE RATINGS INDICATE THAT TIDY CAT AT 1 LB. PICLORAM PER ACRE WAS VERY EFFECTIVE. DEAD OAT KERNELS WHICH WORKED WELL AT WHITEHALL DID NOT PROVIDE ACCEPTABLE CONTROL AT BOZEMAN.

Experiment No. 8601500l.
Testing granular formulations for leafy spurge control. Brass Lantern Estates. Bozeman Montana.

TREATMENT				
TRT NO.	CHEMICAL	FORM	RATE LB/A	SPURGE CONTROL
1	TORDON	22 K	0.5	84.3
2	TORDON	2 K	0.5	48.3
3	TOROON-BLENDED FERTILIZER	.43 G	0.5	35.0
4	TORDON-AMS04	.43 G	0.5	36.7
5	TORDON-TIDY CAT	2 GM	0.5	26.7
6	TORDON-HAGEN KITTY LITTER	2 G	0.5	40.0
7	TORDON-DEAD OATS	1 G	0.5	42.7
8	TORDON-ORGANIC KITTY LITTER	1 G	0.5	45.0
9	TORDON	22 K	1.0	98.3
10	TORDON	2 K	1.0	65.0
11	TORDON-BLENDED FERTILIZER	.43 G	1.0	58.3
12	TORDON-AMS04	.43 G	1.0	66.7
13	TORDON-TIDY CAT	2 G	1.0	94.0
14	TORDON-HAGEN KITTY LITTER	2 G	1.0	70.7
15	TORDON-DEAD OATS	1 G	1.0	36.7
16	TORDON-ORGANIC KITTY LITTER	1 G	1.0	75.0
17	CHECK			.0
			C.V. -	33.86
			LSD 5% -	30.59

Experiment No. 86022001.
Title: Testing granular formulations of Tordon for leafy spurge control. Ray Gillespie Ranch. Whitehall, Montana.

CROP INFORMATION

Crop: PASTURE
Planted:
Experimental Design: RCB
Replications: 3
Seeding Depth:
Row Width:
Seeding Rate:
Plot Size: 7 X 25

SOIL INFORMATION

Soil Type:
Organic Matter: pH:
Previous Crop: PASTURE
Fertilizer Used: NONE

HERBICIDE APPLICATION MAY 14, 1986 TREATMENTS 2-8, 10-16

Mixed By: FAY
Applied By: DAVIS
Sprayer: SHAKER
Propellant:
Time: 3:00 PM
Wind Speed: 4-15 MPH
Wind Direction: SOUTH WEST
Note:
Crop Stage:
Surfactant Used: NONE In Trt.
Surfactant Rate:
Pressure: Volume:
Nozzles:
Rel. Humidity: 40%
Air Temperature: 60º F
Soil Temp.: 2"-60º F; 4"-58º F

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	PREBLOOM	HEAVY

HERBICIDE APPLICATION JUNE 17, 1986 TREATMENTS 1 & 9.

Mixed By: DAVIS
Applied By: COBLE
Sprayer: BACKPACK
Propellant: CO2
Time: 9:00 AM
Wind Speed: 0 MPH
Wind Direction:
Note:
Crop Stage:
Surfactant Used: NONE In Trt.
Surfactant Rate:
Pressure: 40 PSI Volume: 14.5GPA
Nozzles: 8002
Rol. Humidity: 40%
Air Temperature: 83º F
Soil Temp.: 2"-66º F; 4"-62º F

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	FLOWERING	HEAVY

RATING INFORMATION number 01 OF 02 TOTAL RATINGS
Rated By: FAY, FELLOWS Date: 7-11-86 Crop Stage:
Rating Method: 0=NO CONTROL 100-COMPLETE CONTROL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	SEED FILL	HEAVY

RATING INFORMATION number 02 OF 02 TOTAL RATINGS
Rated By: FAY, MCKONE Date: B-22-86 Crop Stage:
Rating Method: 0=NO CONTROL 100- COMPLETE KILL

Weeds Present	Stage of Growth	Population Density
LEAFY SPURGE	RIPE	HEAVY

REMARKS

THE LOSS OF TORDON 2K PELLETS WILL BE FELT IN MONTANA, THEREFORE "DRY" HERBICIDE FORMULATIONS WERE PREPARED IN ORDER TO TEST THE POTENTIAL OF LOCALLY FORMULATED SUBSTITUTES.

THE FOLLOWING MATERIALS WERE COATED WITH TORDON 22K, THE LIQUID FORMULATION: BLENDED FERTILIZER (14-14-14), AMMONIUM SULFATE FERTILIZER (34-0-0), "TIDY CAT" CAT LITTER, "HAGEN" CAT LITTER, AUTOCLAVED (DEAD) OAT KERNELS, AN ORGANIC KITTY LITTER PRODUCT MADE FROM WOOD CHIPS.

THE FERTILIZER CONTAINED 0.43% ACTIVE INGREDIENT (PICLORAM) THE CONVENTIONAL KITTY LITTERS CONTAINED 2% ACTIVE INGREDIENT AND THE ORGANIC KITTY LITTER AND THE DEAD OAT KERNELS CONTAINED 1% ACTIVE INGREDIENT. THESE FORMULATIONS WERE COMPARED TO TORDON 22K AND TORDON 2K.

ALL OF THE EXPERIMENTAL FORMULATIONS WORKED AS WELL AS THE COMMERCIAL FORMULATIONS WHEN RATED ON 8-22-86. TIDY CAT AND THE 2 FERTILIZER FORMULATIONS AT 1 LB/A WERE ESPECIALLY EFFECTIVE. DEAD OAT KERNELS SOAKED IN TORDON WERE VERY EFFECTIVE AT WHITEHALL. IT APPEARS THAT THE ABSORPTION PROPERTIES OF PICLORAM ARE AMENDABLE TO IMPREGNATION ON A WIDE RANGE OF SUBSTRATES.

Experiment No. 8602200l .
Testing granular formulations of Tordon for leafy spurge control . Ray Gillespie Farm. Whitehall, Montana.

TREATMENT					
TRT NO.	CHEMICAL	FORM	RATE LB/A	7-11-86 % SPURGE CONTROL	3-22-8 % SPURGE CONTROL
1	TORDON	22K	0.5	43.3	15.0
2	TORDON	2K	0.5	30.0	66.3
3	TORDON-BLENDED FERTILIZER	.43 G	0.5	11.7	27.3
4	TORDON-AMS04	.43 G	0.5	37.3	61.7
5	TORDON-TIDY CAT	2 GM	0.5	26.0	56.7
0	TORDON-HAGEN KITTY LITTER	2 G	0.5	26.7	36.3
7	TORDON-DEAD OATS	1 G	0.5	16.7	40.0
8	TORDON-ORGANIC KITTY LITTER	1 G	0.5	16.7	41.7
9	TORDON	22K	1.0	30.0	53.3
10	TORDON	2K	1.0	62.7	31.7
11	TORDON-BLENDED FERTILIZER	.43 G	1.0	46.0	92.7
12	TURDON-AMS04	.43 G	1.0	71.7	95.3
13	TORDON-TIDY CAT	2 G	1.0	54.0	98.3
14	TORDON-HAGEN KITTY LITTER	2 G	1.0	43:3	80.0
15	TORDON-DEAD OATS	1 G	1.0	70.0	100.0
16	TORDON-ORGANIC KITTY LITTER	1 G	1.0	28.3	81.0
17	CHECK			.0	.0
			C.V. -	46.30	43.06
			LSD 5% -	27.83	42.62

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Sulfometuron for leafy spurge control[1]

RODNEY G. LYM and CALVIN G. MESSERSMITH

Sulfometuron is an analog of chlorsulfuron but with less soil residual and a different wood control spectrum. Sulfometuron currently is used for grass suppression along roadsides and also has shown broadleaf weed control of some species including leafy spurge. The purpose of this experiment was to evaluate sulfometuron alone and in combination with auxin herbicides for leafy spurge control.

The experiment was established in cropland near Hunter, ND that was severely infested with leafy spurge. Spring and fall treatments were applied on June 17 and September 4, 1985, respectively. Leafy spurge was 26 to 36 inches tall and beginning seed set in June while fall regrowth following summer dormancy had begun when treatments were applied in September. The herbicides were applied with a tractor-mounted sprayer delivering 8.5 gpa at 35 psi. All plots were 10 by 30 feet in a randomized complete block design with four replications. Evaluations were based on percent stand reduction as compared to the control.

		Application and evaluation dates				
		June 27, 1985			September 4, 1985	
Treatment	Rate	August 21, 1985	May 29, 1986	August 18, 1986	May 29, 1986	August 18, 1986
	(oz/A)	(% control)				
Sulfometuron	0.5	---	---	---	16	0
Sulfometuron	1	0	6	0	95	7
Sulfometuron	1.5	0	63	25	---	---
Sulfometuron	2	0	36	6	---	---
Sulfometuron + 2,4-D	1+16	95	76	26	99	17
Sulfometuron + dicamba	1+32	96	85	40	97	23
Sulfometuron + picloram	1+8	70	96	59	99	74
Sulfometuron + 2,4-D	0.5 + 16	---	---	---	95	24
Sulfometuron + dicamba	0.5 + 32	---	---	---	97	51
Sulfometuron + picloram	0.5 + 8	---	---	---	99	40
Sulfometuron + metsulfuron	2 + 0.5	0	60	24	88	13
DPX-L5300	1	---	---	---	44	6
LSD (0.05)		25	22	26	26	30

[1] Published with approval of the Agric. Exp. Stn., North Dakota State Univ., Fargo.

Leafy spurge growth stopped following application of sulfometuron alone regardless of date. Plants treated with sulfometuron in June had chlorotic leaves when evaluated in August and root bud elongation was inhibited. Leafy spurge top growth was killed when treated with sulfometuron plus an auxin herbicide and root bud growth was inhibited. Leafy spurge root buds were white and short on plants treated with sulfometuron, compared to pink elongated buds found on control plants. Sulfometuron plus an auxin herbicide provided better leafy spurge control than sulfometuron alone, and long-term control was better when sulfometuron was mixed with picloram than with 2,4-D or dicamba. Leafy spurge control declined rapidly between the June and August 1986 evaulations. The optimum herbicide application rates and date and the effectiveness of various retreatments will be evaluated to determine if sulfometuron plus an auxin herbicide can provide cost-effective leafy spurge control.

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Leafy spurge control with picloram plus various 2,4-D formulations or pH-buffered spray solution[1]

RODNEY G. LYM and CALVIN G. MESSERSMITH

Picloram remains the most effective herbicide for leafy spurge control. Previous research at North Dakota State University has shown annual application of picloram + 2,4-D at 0.25 + 1.0 lb/A to be more cost effective than picloram at 1.0 to 2.0 lb/A applied once. The purpose of these experiments was to compare the effect of a mixed amine or alkanolamine formulation of 2,4-D and pH-buffered spray solution with picloram on leafy spurge control.

The 2,4-D formulation experiments were established on the Sheyenne National Grasslands near McLeod, ND on June 15, 1984 and near Hunter, ND on May 30, 1985. The herbicides were applied using a tractor-mounted sprayer delivering 8.5 gpa at 35 psi. All plots were 10 by 30 feet in a randomized complete block design with four replications. Evaluations were based on percent stand reduction as compared to the control. Picloram plus the mixed amine ormulation of 2,4-D provided better leafy spurge control compared to picloram plus 2,4-D alkanolamine (Table). Leafy spurge control with picloram + 2,4-D mixed amine at 0.25 + 1.0 lb/A was similar to picloram at 0.5 lb/A alone and was approximately 30% less expensive. Similarly, leafy spurge control from picloram plus dicamba was greater when applied with 2,4-D mixed amine than with the alkanolamine. Neither 2,4-D formulation alone controlled leafy spurge.

Previous greenhouse research at North Dakota State University has shown increased picloram uptake and translocation to leafy spurge roots when applied in a pH 4.75 buffered solution compared to higher or lower pH solutions. A field experiment to evaluate long-term leafy spurge control with buffered and unbuffered spray solutions was established on June 3, 1985. The experimental methods were similar to the 2,4-D formulated experiments except citric acid was added to the picloram:water solution as necessary to maintain a pH of 4.75. Leafy spurge control was less when the spray solution was buffered to pH 4.75 compared to unbuffered solutions regardless of picloram rate. The buffered spray solution tended to desiccate the leafy spurge leaves which probably resulted in poor herbicide uptake. The temperature was 74º F with 60% relative humidity when the treatments were applied, but buffered picloram solutions in the greenhouse experiments were applied following a topical surfactant application which may have prevented leaf injury. Thus application during a period of high humidity in the field may result in less leaf injury and increased translocation to the roots as shown in greenhouse experiments:

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Table. Leafy spurge control with picloram alone and in combination with various 2,4-D formulations and a buffer solution. (Lym and Messersmith).

Treatment	Rate	Evaluation date				
		Aug 1984	May 1985	Aug 1985	June 1986	Aug 1986
	(lb/A)	(% control)				
2,4-D formulations, Sheyenne, ND						
Picloram	0.25	76	23	4	1	---
Picloram	0.5	95	75	43	10	---
Picloram + 2,4-D alkanolamine	0.25+1.0	78	14	6	3	---
2,4-D mixed amine[a]	4.0	47	7	13	0	---
Picloram + 2,4-D mixed amine[a]	0.25+1.0	94	72	23	21	---
2,4-D alkanolamine	4.0	42	20	7	5	---
LSD (0.05)		15	25	15	12	
2,4-D formulations, Hunter, ND						
Picloram + dicamba + 2,4-D mixed amine[a]	0.25+1.0+2.0	---	---	99	98	89
2,4-D mixed.amine[a]	4.0	---	---	6	3	0
2,4-D alkanolamine	4.0	---	---	5	0	0
Picloram + dicamba +2,4-D alkanolamine	0.25+1.0+2.0	---	---	51	51	25
Picloram + dicamba	0.25+1.0	---	---	53	38	15
LSD (0.05)				15	15	15
pH-buffered, Hunter, ND						
Picloram	0.5	---	---	54	30	36
Picloram	1.0	---	---	83	79	46
Picloram + buffer[b]	0.25	---	---	54	11	6
Picloram + buffer[b]	0.5	---	---	29	7	13
Picloram + buffer[b]	1.0	---	---	38	27	24
LSD (0.05)				17	38	36

[a]Mixed amine salts of 2,4-D (2:1 dimethylamine:diethanolamine)-EH736
[b]Citric acid buffered to pH 4.75.

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Leafy spurge control with resulting forage production from several herbicide treatments[1]

RODNEY G. LYM and CALVIN G. MESSERSMITH

An experiment to evaluate long-term leafy spurge control and forage production was established at two sites in North Dakota in 1983. The predominate grasses were bluegrass (*Poa* spp.) with occasional crested wheatgrass, smooth brome, big bluestem, or other native grasses. The treatments were selected based on previous research conducted at North Dakota State University and included 2,4-D at 2 lb/A, picloram + 2,4-D at 0.25 + 1 lb/A, picloram 2 lb/A, and dicamba at 8 lb/A and were applied in August 1983 or June 1984 as fall or spring treatments. The 2,4-D at 2 lb/A and picloram plus 2,4-D treatments were applied annually while the picloram alone and dicamba treatments were reapplied when leafy spurge control declined to 70% or less. Thus, picloram at 2 lb/A was reapplied at Valley City in August 1985 and at Dickinson in June and August 1986. Dicamba at 8 lb/A was reapplied in June 1985 and 1986 at both locations as spring treatments and at Dickinson in September 1985 and at both locations in 1986 as a fall treatment. The plots were 15 by 50 feet with four replications in a randomized complete block design at each site. Forage yields were obtained by harvesting a 4 by 25 feet section with a rotary mower in July 1984, 1985, and 1986. Sub-samples were taken by hand along each harvested strip and separated into leafy spurge and forage so the weight of each component in the mowed sample could be calculated. The samples were oven dried and are reported with 12% moisture content. Economic return was estimated by converting forage production to animal unit days (AUD) and then to pounds of beef at $0.60/lb minus the cost of the herbicide and estimated application cost, i.e. 2,4-D = $2.00/lb ae, dicamba = $11.75/lb ai, picloram = $40.00/lb ai, and application = $2.05/A. The cost of treatments applied in fall 1986 is not subtracted from the net return.

Most treatments have resulted in an economic loss at Dickinson despite excellent leafy spurge control from several treatments. This site general receives 8 to 10 inches less precipitation annually than the Valley City location. Total forage production averaged after 3 years across all treatments was 2,315 lb/A at Dickinson and 4,018 lb/A at Valley City (Table). Leafy spurge control from 2,4-D at 2 lb/A was not satisfactory from spring or fall applications at either site. However, it did provide short term control resulting in an economic gain at Valley City of $31/A and $2/A and at Dickinson of $8/A and $15/A as spring and fall applied treatments, respectively. Leafy spurge control with picloram + 2,4-D at 0.25 + 1 lb/A averaged over both locations was 67% as a spring applied treat-

[1] Published with approval of the Agric. Exp. Stn., North Dakota State Univ., Fargo.

ment which was an increase from 44% control in 1985. Above average precipitation was received at both locations in 1986 allowing vigorous leafy spurge regrowth. The stems were only 3 to 5 inches tall but numerous in August 1986. Leafy spurge control was poor with picloram + 2,4-D at 0.25 + 1 lb/A fall applied, but average forage production of 2,989 lb/A was only slightly less than the spring average of 3,484 lb/A.

Picloram at 2 lb/A spring applied provided 94% leafy spurge control at Valley City and 53% control at Dickinson 36 months after application (Table). Dicamba generally gave good leafy spurge control as a fall but not as spring applied treatment. All treatments have reduced leafy spurge production compared to the control except the fall application of 2,4-D at 2 lb/A at Valley City.

Table. Leaf spurge control, forage production and estimated net return from several herbicide treatments at two sites in North Dakota.

Original treatment date		Re-treatment time				Control		Yield[a]			Total Net return[b]
Herbicide	Rate	Herbicide	Rate	Year	Cost	June	Aug	Forage	Leafy spurge	Utilization	
	(lb/A)		(lb/A)		($/A)	-------- (%) --------		------(lb/A)------		(AUD)	($/A)
								Valley City			
Spring 1984		**Spring**									
2,4-D	2	2,4-D	2[c]	84-86	18	0	24	3266	2475	82	31
Picloram + 2,4-D	0.25 + 1	Picloram + 2,4-D	0.25[c] + 1	84-86	42	31	74	4188	1480	105	21
Picloram	2	---	---	---	82	94	86	4401	1266	110	-16
Dicamba	8	Dicamba	.8[d]	85, 86	288	30	97	3868	1509	97	-230
Fall 1983		**Fall**									
2,4-D	2	2,4-D	2[C]	84-86	18	0	0	2580	3220	65	21
Picloram + 2,4-D	0.25 + 1	Picloram + 2,4-D	0.25 + 1[c]	84-86	42	37	8	3950	2120	99	17
Picloram	2	Picloram	2[d]	85	164	98	94	5227	256	131	-85
Dicamba	8	Dicamba	8[d]	86	192	84	58	4662	660	117	-122
		Control						3814	3738	0	
LSD (0.05)						17	18	770	587		
								Dickinson			
Spring 1984		**Spring**									
2,4-D	2	2,4-D	2[c]	84-86	18	0	18	1767	293	44	8
Picloram + 2,4-D	0.25 + 1	Picloram + 2,4-D	0.25 + 1[c]	84-86	42	35	59	2779	105	69	-1
Picloram	2	Picloram	2[d]	86	164	53	96	2759	84	69	-123
Dicamba	8	Dicamba	8[d]	85, 86	288	38	72	1960	136	49	-259
Fall 1983		**Fall**									
2,4-D	2	2,4-D	2[b]	84-86	18	0	4	2176	646	55	15
Picloram + 2,4-D	0.25 + 1	Picloram + 2,4-D	0.25 + 1[c]	84-86	42	14	3	2027	856	51	-12
Picloram	2	Picloram	2[d]	86	164	71	35	2714	35	68	-41
Dicamba	8	Dicamba	8[d]	85, 86	288	96	42	2334	54	58	-157
		Control				0	0	1907	1348	0	
LSD (0.05)						13	23	613	283		

[a] Total production of 1984, 1985 and 1986 harvest.
[b] Total net return for 1984, 1985 and 1986. Fall 1986 treatment cost is not subtracted from net return.
[c] Annual retreatment.
[d] Applied when control declines to less than 70%.

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Spring or fall applied granular picloram and dicamba for leafy spurge control in North Dakota[1]

RODNEY G. LYM and CALVIN G. MESSERSMITH

Granular and liquid formulations of picloram and dicamba were compared for leafy spurge control in two experiments established in 1980 on June 25 and September 3 near Valley City. Eight experiments to compare picloram 2% and 10%G formulations were established on September 14, 1982 and June 10, 1983 near Sheldon, September 9, 1982, June 21, 1983, and June 13 and September 11, 1984 near Dickinson, and June 14 and September 18, 1984 in the Sheyenne National Grasslands. Blank pellets were included in the experiments conducted at Sheldon so the number of pellets applied per plot was similar to improve uniformity of distribution of the picloram 10%G formulation. All experiments were in a randomized complete block design with four replications and 10 by 30 feet plots. The granules were applied uniformly by hand, while the liquid formulations were applied with a tractor-mounted sprayer delivering 8.5 gpa at 35 psi. Evaluations were based on percent stand reduction compared to the control. A significant interaction on between site and treatments occurred, so experimental sites will be discussed individually.

Leafy spurge control with picloram and dicamba was better from fall than spring applied treatments at Valley City, especially when evaluated 24 to 60 months, after treatment (Table 1). The control averaged across all treatments after 24, 48, and 60 months was 54, 22, and 13% for spring applications and 78, 62, and 26% for fall applications, respectively. Fall applied dicamba at 8 lb/A and picloram at 2 lb/A as liquids provided similar control after 5 years, but control with granular picloram was better than with granular dicamba. Dicamba and picloram applied in the spring of 1980, generally did not give satisfactory leafy spurge control by 1982 and 1983, respectively. The exception was picloram at 2 lb/A which provided satisfactory control until 1984. Only fall applied picloram 2%G at 1.5 and 2 lb/A provided satisfactory leafy spurge control after 48 months at 83 and 86%, respectively, but no treatment provided satisfactory control 60 months after application.

Picloram 2%G and 10%G at equal rates generally provided similar leafy spurge control at both Sheldon and Dickinson (Table 2). Fall applications of picloram 2%G and 10%G at all application rates, except 2.0 lb/A, provided better leafy spurge control after 9 months than spring applications after 3 months. This difference could be due to insufficient moisture to completely disperse the granules following the June application, be-

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cause the treatments generally were similar 12 and 24 months after application. Leafy spurge control in 1985 at Sheldon was similar to control in 1984. However, the treatments at Dickinson did not provide satisfactory leafy spurge control in 1985, so specific evaluations were not taken. The soil at Sheldon is very sandy compared to the mostly clay soil at Dickinson which may have allowed deeper picloram movement in the soil profile and thus better long-term leafy spurge root control at Sheldon than Dickinson.

Leafy spurge control with picloram at 1 and 2 lb/A was similar for the 2%G and 10%G when blanks were added, but was much worse with 10%G than 2%G pellets without blanks (Table 2). The picloram 2%G and 10%G pellets were similar in size and 80% fewer pellets per acre are applied with picloram 10%G than with 2%G. Thus, uniform distribution with hand-held application equipment was difficult which probably accounted for the decreased control. Visible grass injury was negligible with either picloram formulation. In general, leafy spurge control with picloram at 2 lb/A declined more rapidly when the liquid (2S) formulation was used compared to 2%G or 10%G.

Similar experiments were begun in 1984 using a new formulation of picloram 10% with smaller pellets which resulted in more pellets per square foot than the previous 10%G formulation at similar rates. Picloram 2%G and 10%G gave similar leafy spurge control at all application rates except 0.5 lb/A (Table 3). Blanks were not mixed with the new 10%G formulation but a uniform distribution still was obtained. Control was much lower at Dickinson than at Sheyenne which again probably was due to deeper picloram movement in the sandy soil at Sheyenne than in the clay soil at Dickinson. Unlike previous experiments, spring application of picloram granules provided better leafy spurge control than fall application when evaluated 12 months after treatment. Fall precipitation was below normal and the soil was very dry until late October in 1984. The dry soil conditions after application apparently caused poor long-term control despite adequate moisture in 1985.

Granular and liquid formulations of dicamba and picloram generally provided similar control at comparable rates. Picloram 2%G and 10%G provided similar leafy spurge control either when blanks were included with the 10%G pellets or when the number of 10%G pellets per square foot was increased by use of a smaller pellet. Generally spring and fall treatment provided similar long-term control except when application was made during very dry conditions. Picloram granules provided better long-term control in sandy compared to clay soils.

Table 1. Spring and fall applied granular picloram and dicamba for leafy spurge control at Valley City, ND.

			Application and evaluation date																		
			Spring treatment (25 June 1980)									Fall treatment (3 Sept 1980)									
Herbicide		Rate	6-81	9-81	6-82	9-82	6-83	9-83	6-84	9-84	6-85	6-81	9-81	6-82	9-82	6-83	9-84	5-84	9-84	6-85	8-85
		(lb/A)	(% control)																		
Picloram 2%G		1.0	97	80	53	25	44	22	10	8	3	95	86	84	55	76	52	51	52	18	10
Picloram 2%G		1.5	98	89	87	22	77	38	29	26	11	99	100	100	96	98	97	87	83	59	48
Picloram 2%G		2.0	99	98	90	53	85	72	56	62	28	100	100	99	100	100	98	93	86	68	63
Dicamba 5%G		4.0	74	55	9	3	4	0	4	0	0	94	74	43	31	31	29	18	20	17	9
Dicamba 5%G		6.0	82	54	25	3	16	5	4	3	1	96	99	89	58	55	55	41	40	22	6
Dicamba 5%G		8.0	91	75	45	19	29	6	5	6	0	99	100	98	83	84	78	66	67	39	20
Picloram	2S	2.0	100	99	98	90	94	79	64	71	54	100	100	100	100	98	94	79	78	50	28
Dicamba	4S	8.0	94	74	28	12	42	13	7	5	4	99	99	100	97	92	83	69	72	47	33
LSD (0.05)			9	14	21	17	20	11	11	12	20	3	10	22	29	24	24	29	23	26	23

Table 2. Leafy spurge control using picloram 2%G and 10%G of similar size.

Picloram formation	Rate	Evaluation date									
		1983		1984		1985		1983		1984	
		June	Aug	June	Aug	June	Aug	June	Aug	June	Aug
	(lb/A)	(% control)									
Applied Fall 1982		Sheldon						Dickinson			
2%G + blanks	0.5	66	26	8	21	11	16	38	5	18	5
2%G + blanks	1.0	86	41	29	33	31	18	69	15	42	13
2%G + blanks	1.5	87	67	48	48	47	24	90	37	71	51
2%G	2.0	99	76	80	66	71	44	96	53	79	64
10%G + blanks	0.5	39	11	3	31	0	0	34	9	19	0
10%G + blanks	1.0	83	60	52	56	39	30	84	21	45	36
10%G + blanks	1.5	81	60	43	58	54	38	88	35	55	47
10%G + blanks	2.0	87	63	77	56	65	45	89	40	75	64
10%G	1.0	53	26	11	13	18	13	---	---	---	---
10%G	2.0	89	61	45	45	52	57	---	---	---	---
Liquid (2S)	2.0	94	67	55	44	30	35	94	42	60	41
LSD (0.05)		16	30	19	23	24	25	18	28	30	33
Applied Spring 1983											
2%G + blanks	0.5	---	28	27	10	21	8	---	38	28	12
2%G + blanks	1.0	---	38	58	13	55	14	---	57	53	43
2%G + blanks	1.5	---	86	95	36	92	50	---	62	83	60
2%G	2.0	---	97	94	69	93	62	---	76	89	65
10%G + blanks	0.5	---	26	11	6	18	4	---	25	20	2
10%G + blanks	1.0	---	54	61	16	52	28	---	32	42	23
10%G + blanks	1.5	---	74	70	26	58	35	---	78	75	56
10%G + blanks	2.0	---	92	92	56	92	56	---	63	76	70
Liquid (2S)	2.0	---	93	79	39	76	57	---	96	94	51
LSD (0.05)			22	14	14	23	15		23	19	29

Table 3. Leafy spurge control using picloram 2%G, 10%G, and 2S as spring or fall applied treatment.

Picloram. formulation	Rate	Evaluation date							
		1984	1985		1986		1984	1985	
		Aug	June	Aug	June	Aug	Aug	June	Sept
	(lb/A)	(% control)							
Applied Spring 1984		Sheyenne					Dickinson		
2%G	0.5	83	89	53	56	34	0	0	0
2%G	1.0	96	99	83	79	54	38	48	8
2%G	1.5	96	100	97	95	91	43	62	13
2%G	2.0	98	100	98	98	94	83	88	53
10%G	0.5	64	75	19	4	4	3	0	4
10%G	1.0	95	99	84	86	82	31	43	23
10%G	1.5	97	99	94	93	86	56	45	16
10%G	2.0	97	99	94	94	86	72	56	31
Liquid (2S)	2.0	98	100	99	98	94	98	80	28
LSD (0.05)		8	10	16	17	24	23	24	21
Applied Fall 1984									
2%G	0.5	---	94	57	76	7	---	71	16
2%G	1.0	---	100	91	91	74	---	85	39
2%G	1.5	---	100	96	98	83	---	97	56
2%G	2.0	---	100	97	97	86	---	98	81
10%G	0.5	---	82	42	43	6	---	46	15
10%G	1.0	---	96	81	66	52	---	79	36
10%G	1.5	---	99	91	89	81	---	91	45
10%G	2.0	---	99	91	96	73	---	95	68
Liquid (2S)	2.0	---	100	99	97	88	---	99	47
LSD (0.05)		---	6	16	14	26	---	9	17

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Leafy spurge control with various picolinic acid herbicides[1]

RODNEY G. LYM and CALVIN G. MESSERSMITH

Picloram is the main herbicide used for leafy spurge control. Picloram is often applied at 1 to 2 lb/A for long-term control or at 0.25 to 0.5 lb/A as an annual treatment. The use of picloram, especially near open water or in areas with high water tables, has been criticized because of its high water solubility, potential to leach into groundwater and high phytotoxicity. The purpose of these experiments was to compare several picolinic acid herbicides both alone and in combination with 2,4-D or picloram for leafy spurge control.

The experiments were established near Hunter, ND on June 3, 1985. Leafy spurge was 18 to 24 inches tall and beginning seed set. Plots were 10 by 30 feet in a randomized complete block design with four replications. Herbicides were applied using tractor-mounted sprayer delivering 8.5 gpa at 35 psi. The weather was partly cloudy and 64º F with 60% relative humidity and the soil temperature at 2 inches was 64º F. Evaluations were based on a visual estimate of percent stand reduction as compared to the control.

The first experiment compared clopyralid, fluroxypyr and triclopyr alone and in various combinations to picloram for leafy spurge control. Clopyralid alone did not control leafy spurge and tended to reduce control when combined with picloram compared to picloram alone (Table 1). Picloram at 1 lb/A averaged 93 and 81% control compared to 77 and 43% control when combined with clopyralid at 1 lb/A 12 and 14 months after application, respectively. Fluroxypyr and triclopyr provided moderate leafy spurge control the season of application. Control decreased when fluroxypyr or triclopyr were combined with clopyralid and when triclopyr was combined with 2,4-D. Picloram at 1 and 2 lb/A gave 81 and 95% leafy spurge control, respectively, 15 months following application. No other treatment provided satisfactory leafy spurge control at the 15-month evaluation.

Previous research at North Dakota State University has shown that picloram at 0.25 to 0.5 lb/A plus 2,4-D at 1 lb/A provides increased control of leafy spurge compared to picloram alone at similar rates. The second experiment was designed to determine whether a similar enhancement of leafy spurge could be obtained by adding 1 lb/A of 2,4-D to low application rates of clopyralid, fluroxypyr, triclopyr, and dicamba. No treatment provided satisfactory leafy spurge control by August 1985 (Table 2).

[1] Published with approval of the Agric. Exp. Stn., North Dakota State Univ., Fargo.

Picloram alone or with 2,4-D provided better leafy spurge control than other picolinic acid herbicides or dicamba. Previous research has shown that picloram uptake and translocation are not increased when applied with 2,4-D. Metabolism studies are in progress to determine why this combination treatment provides synergistic leafy spurge control. Whatever the mechanism, it apparently does not function with other picolinic acid herbicides or dicamba.

Table 1. Leafy spurge control with various picolinic acid herbicides.

Treatment	Rate	Evaluation date		
		21 Aug 1985	29 May 1986	18Aug 1986
	(lb/A)	(% control)		
Triclopyr	4	28	28	5
Triclopyr	8	55	42	20
Triclopyr + clopyralid	2 + 2	6	5	4
Triclopyr + clopyralid	3 + 3	1	12	18
Triclopyr + 2,4-D	0.5 + 1	3	0	0
Triclopyr + 2,4-D	1 + 2	9	15	5
Picloram	0.5	75	23	9
Picloram	1	93	93	81
Picloram	2	100	97	95
Picloram + clopyralid	0.25 + 0.25	41	23	21
Picloram + clopyralid	0.5 + 0.5	61	33	11
Picloram + clopyralid	1 + 1	95	77	43
Clopyralid	2	6	3	5
Clopyralid	4	0	0	0
Clopyralid + fluroxypyr	0.5 + 0.5	14	4	1
Clopyralid + fluroxypyr	1 + 1	29	13	4
Clopyralid + fluroxypyr	2 + 2	14	3	0
Fluroxypyr	1	40	15	21
Fluroxypyr	2	22	0	0
Fluroxypyr	4	64	33	2
LSD (0.05)		25	27	27

Table 2. Leafy spurge control with 2,4-D combined with various auxin herbicides.

Treatment	Rate	Evaluation date	
		21 August 1985	29 May 1986
	(lb/A)	(% control)	
Triclopyr+2,4-D	0.5 + 1	13	2
Triclopyr+2,4-D	1 + 1	1	2
Clopyralid+2,4-D	0.5 + 1	0	1
Clopyralid+2,4-D	1 + 1	0	0
Fluroxypyr+2,4-D	0.5 + 1	0	1
Fluroxypyr+2,4-D	1 + 1	0	6
Triclopyr+clopyralid	0.5 + 0.5	0	0
Dicamba+2,4-D	0.5 + 1	0	4
Dicamba+2,4-D	1 + 1	11	2
LSD (0.05)		5	5

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Leafy spurge control with low rate annual picloram and 2,4-D combination treatments[1]

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Previous research at North Dakota State University as shown that annual treatments of picloram + 2,4-D for 3 to 5 years will give leafy spurge control similar to expensive high rate picloram treatments. Picloram + 2,4-D at 0.25 + 1 lb/A generally gives 20 to 30% better leafy spurge control than picloram at 0.25 lb/A alone, but the benefit of a herbicide combination declines as the picloram or 2,4-D rate increases. Picloram + 2,4-D at 0.5 + 1 lb/A tends to give only 5 to 10% better control than picloram at 0.5 lb/A alone. The purpose of this experiment was to evaluate long-term leafy spurge control from annual treatments of picloram + 2,4-D amino at relatively low application rates.

The experiment was established at four locations in North Dakota. Spring treatments were applied on June 13, 18 and 19, 1984 at Dickinson, Hunter, and Valley City, respectively, and the fall treatments were applied on September 5 and 18, 1984 at Valley and the Sheyenne National Grasslands near McLeod, respectively. The soil was a loamy fine sand at Dickinson, a silty clay loam at Hunter, Sheldon and the Sheyenne National Grasslands, and a loam at Valley City. Dickinson, located in western North Dakota, generally receives much less precipitation than the other two sites located in eastern North Dakota. The spring and fall treatments were applied annually in June or September 1984 and 1985. The herbicides were applied with a tractor-mounted sprayer delivering 8.5 gpa at 35 psi. All plots were 10 by 30 feet in a randomized complete block design with four replications except at Hunter which had 8 by 25 feet plots and 3 replications. Evaluations were based on a visual estimate of percent stand reduction as compared to the control.

The results from the Dickinson location were different than the other sites and will be discussed separately. Picloram at 0.12, 0.25, 0.38, and 0.5 lb/A provided 2, 28, 63 and 67% leafy spurge control, respectively, as a spring applied treatment at Hunter and Valley City but only 0, 1, 6, and 27% control, respectively, as a fall applied treatment at Sheyenne and Valley City when evaluated 24 months following initial application (Table). The addition of 2,4-D to picloram tended to increase leafy spurge control slightly from spring but not fall applied treatments. The slight increase in control was similar regardless of 2,4-D rate. The increased leafy spurge control obtained when 2,4-D was applied with picloram as a spring treatment was not found when similar treatments were fall applied. Leafy spurge generally begins regrowth in mid to late-July following a fall application and had become reestablished by the following fall. However, spring applied treatments generally maintained control all season and regrowth was typically 0 to 3

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inches tall when a killing frost occurred. This limited growth may predispose the plants to winter kill and allow gradually increased control.

The reason for poor control at Dickinson compared to the other locations is not known. A similar experiment begun in 1981 at the same location has resulted in annually increased leafy spurge control. This location has received above average precipitation for the last 24 months and the leafy spurge may be growing more vigorously than previously.

This experiment must be continued for several years to determine whether the presently used picloram at 0.25 to 0.5 lb/A + 2,4-D at 1 lb/A treatment is the most cost effective application rate for an annual leafy spurge control program or whether the picloram and/or 2,4-D rate can be reduced and still maintain acceptable control.

Table. Leafy spurge control from annual picloram or picloram plus 2,4-D amine treatments spring or fall applied at four locations in North Dakota.

		Application time/location/1986 evaluation date											
		Spring							Fall				
		Hunter		Dickinson		Valley City		Mean[a]	Sheyenne		Valley City		Mean[b]
Treatment	Rate	May 29	Aug 18	June 10	Sept 16	June 3	Aug 20		May 30	Aug 24	June 3	Aug 20	
	(lb/A)	(% control)											
Picloram	0.12	4	7	0	18	0	39	2	42	0	3	0	0
Picloram	0.25	14	37	0	28	39	88	28	67	0	25	1	1
Picloram	0.38	68	80	10	29	60	90	63	74	9	56	3	6
Picloram	0.5	67	88	19	16	67	90	67	89	16	92	38	27
Picloram + 2.4-D	0.12 + 0.12	3	12	3	31	51	41	30	72	0	32	8	4
Picloram + 2,4-D	0.12 + 0.25	2	13	1	18	6	56	4	62	8	12	0	4
Picloram + 2,4-D	0.12 + 0.5	0	7	5	35	17	65	10	67	2	7	0	1
Picloram + 2,4-D	0.25 + 0.12	23	87	3	21	28	89	26	70	5	19	1	3
Picloram + 2.4-D	0.25 + 0.25	11	68	11	45	26	54	21	64	0	18	1	1
Picloram + 2.4-D	0.25 + 0.5	22	75	8	35	35	68	29	58	2	35	6	4
Picloram + 2,4-D	0.38 + 0.12	46	85	6	23	54	80	50	81	15	56	11	13
Picloram + 2.4-D	0.38 + 0.25	82	96	10	34	61	84	70	75	6	48	3	4
Picloram + 2,4-D	0.38 + 0.5	42	87	18	34	78	88	63	89	18	64	3	10
Picloram + 2,4-D	0.5 + 0.12	85	95	6	61	89	90	87	78	15	75	8	11
Picloram + 2.4-D	0.5 + 0.25	84	96	15	36	67	96	74	93	22	89	18	20
Picloram + 2.4-D	0.5 + 0.5	70	92	11	30	89	95	80	94	18	81	15	17
Picloram + 2,4-D	0.25 + 1.0	15	53	16	23	69	90	46	92	12	63	6	9
LSD (0.05)		20	19	11	NS	37	29	23	28	NS	31	15	11

[a]Average control at Hunter and Valley City 24 months following the original 1984 treatment date.
[b]Average control 24 months following the original 1984 treatment date.

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Picloram and 2,4-D combination treatments for long-term leafy spurge management

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Picloram is an effective herbicide for leafy spurge control especially when applied at rates from 1 to 2 lb/A. However, the high cost of picloram at 2 lb/A makes it uneconomical to treat large acreages in pasture and rangeland weed control programs. Research by North Dakota State University has suggested that picloram at 0.25 to 0.5 lb/A applied annually will give satisfactory leafy spurge control after 3 to 5 years. The purpose of this experiment is to establish the number of annual applications of picloram needed to provide 90 to 100% control of leafy spurge and to investigate possible synergism between picloram and 2,4-D.

The experiment was established at three locations in North Dakota and began on 25 August 1981 at Dickinson, 1 September 1981 at Sheldon and on 11 June 1982 at Valley City. The soil at Dickinson was a loamy fine sand with pH 6.6 and 3.6% organic matter, at Sheldon was a fine sandy loam with pH 7.7 and 2.1% organic matter, and at Valley City was a loam with pH 6.7 and 9.4% organic matter. Dickinson, located in western North Dakota, generally receives much less precipitation than the other two sites located in eastern North Dakota. All treatments were applied annually except 2,4-D alone which was applied biannually (both spring and fall). Picloram treatments were applied in late August 1981 and in June of 1982 through 1986. The Sheldon location was discontinued following the fall evaluations in 1985. Thus, the Dickinson site has received six picloram and picloram plus 2,4-D treatments and 11 2,4-D treatments, while the Valley City site has received five and ten treatments, respectively. The plots were 10 by 30 feet and each treatment was replicated four times in a randomized complete block design at all sites. Evaluations were based on percent stand reduction as compared to the control.

Picloram at 0.25, 0.375 and 0.5 lb/A provided 58, 77 and 86% leafy spurge control, respectively, 48 months after treatment when averaged across all locations (Table). Control had gradually increased for all picloram treatments over the experiment. 2,4-D alone provided an average of 50% control of leafy spurge after biannual applications for 5 years.

Leafy spurge control increased when 2,4-D was applied with picloram at 0.25 or 0.375 lb/A (Table). Leafy spurge control increased an average of 26 and 14% with picloram at 0.25 or 0.375 lb/A plus 2,4-D at 1 to 2 lb/A, respectively, when compared to the same picloram rate applied alone 48 months after treatment. Picloram at 0.5 lb/A plus 2,4-D provided an average of 95% leafy spurge control and was similar to picloram at 0.5 lb/A alone at 8%. The greatest enhancement with 2,4-D plus picloram seems to be with 2,4-D at 1.5 lb/A or less and picloram at 0.375 lb/A or less. In general, leafy spurge control has been similar at all sites and does not seem to be influenced by soil types, pH, or

organic matter. However, leafy spurge control at Dickinson had declined in 1986 compared to 1985 which probably was due to above average precipitation and excellent growing conditions in 1986 following several years of below average precipitation. After six treatments with picloram at 0.5 lb/A alone and all picloram plus 2,4-D treatments provided control of leafy spurge near or at the 90 to 100% target level.. Some type of treatment will need to be continued to maintain control, but perhaps more economical treatments will sustain the target control level.

Table. Leafy spurge control from annual picloram or picloram plus 2,4-D treatments and biannual 2,4-D treatments at two locations in North Dakota.

		Site and 1986 evaluation date				Months after treatment			
		Dickinson		Valley City					
Herbicide	Rate	June	Sept.	June	Aug.	12[a]	24	36	48
	(lb/A)	(% control)							
Picloram	0.25	52	48	43	81	39	48	48	58
Picloram	0.375	62	76	82	82	65	62	52	77
Picloram	0.5	70	76	68	78	65	71	81	86
2,4-D bian	1	40	47	28	46	22	30	38	50
2,4-D bian	1.5	36	25	50	41	22	24	26	45
2,4-D bian	2	33	24	65	53	19	30	26	54
Pic+2,4-D	0.25+1	77	83	69	87	52	66	63	85
Pic+2,4-D	0.25+1.5	67	77	62	82	58	66	70	85
Pic+2,4-D	0.25+2	67	73	84	82	57	62	66	83
Pic+2,4-D	0.375+1	82	83	81	90	69	72	70	90
Pic+2,4-D	0.375+1.5	87	91	84	89	68	74	76	93
Pic+2,4-D	0.375+2	79	85	91	89	68	59	76	91
Pic+2,4-D	0.5+1	84	92	91	93	71	75	84	94
Pic+2,4-D	0.5+1.5	80	90	97	94	64	73	80	97
Pic+2,4-D	0.5+2	83	99	94	94	76	75	81	95
LSD (0.05)		19	20	23	16	18	14	19	14

[a]Mean values include data from the Sheldon location which was discontinued after 1985.

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Leafy spurge control following a seven-year management program

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An experiment to evaluate long term leafy spurge management was established at four sites (Sheyenne National Grassland near McLeod, Sheldon and two near Valley City) in North Dakota in 1980. All sites were established in early June except one site at Valley City which was established in September 1980. The herbicides applied in 1980 included 2,4-D and picloram as liquid (2S) and granule (2%G) formulations, and picloram applied using the roller and pipe-wick applicators. The conventional broadcast treatments were applied using a tractor-mounted sprayer delivering 8 gpa water at 35 psi. A granular applicator was used to apply the picloram 2%G treatments. Solution concentration in the roller was 0.25 lb/gal; this is the same solution concentration as picloram at 2 lb/A sprayed at 8.5 gpa. The solution concentration was increased for the pipe-wick applicator to picloram at 0.5 lb/gal since the pipe-wick applied about half the total volume per acre as the roller applicator. The roller and pipe-wick applicator height was adjusted to treat the top one-half of the tallest leafy spurge stems. The additive in the roller and pipe-wick treatments was a 5% (v:v) oil concentrate (83% paraffin based petroleum oil plus 15% emulsifier). The plots were 15 by 150 feet and treatments were replicated twice at each site in a randomized complete block design. Each plot was divided into six 7.5 by 50 feet subplots and retreatments of 2,4-D, picloram 2S, dicamba or no treatment were applied in June 1981 except the fall Valley City site which was retreated in August 1981.

Original 1980 whole plot treatments were reapplied in 1982 with several of the treatments changed. A carpet applicator was substituted for the roller applicator. The granular picloram treatments were replaced by picloram applied with the pipe-wick or carpet applicator with two passes, the second pass in the opposite direction to the first. Dicamba at 8 lb/A spray applied replaced the picloram plus oil concentrate pipe-wick applied treatment. The carpet applicator was designed by Magnolia Spray Equipment Corp., Jackson, MS, and consists of a 1 by 8 ft. carpet attached to a rectangular spray box. The herbicide solution was sprayed onto the backside of the carpet through nozzles inside the spray box. Excess solution was returned to the spray tank. The picloram solution on the carpet applicator was 0.25 lb/gal and 0.4 lb/gal for two and one pass applications, respectively. The whole plots were retreated in 1982 with the original treatment except picloram at 2 lb/A was reapplied to the control subplot only since subplots receiving annual retreatments maintained satifactory leafy spurge control. The experimental site at the Sheyenne National Grasslands was treated in the fall of 1982 to establish an equal number of spring and fall treatment sites. Subplot retreatments were again in 1983, 1984, and 1985. Evaluations are based on visual percent stand reduction as compared to the control.

In general, leafy spurge control was higher from spring applied treatments compared to similar fall applied treatments (Table). Previous research at North Dakota State University has shown spring or fall applied treatments to give similar leafy spurge control; however, in this study the fall treatments were applied to leafy spurge plants that had been harvested from yield in July of each year through 1984. Thus, the plants were shorter and in the vegetative growth stage compared to the normal fall growth stage. This reduced the plant leaf area treated and may have resulted in less herbicide uptake and translocation. The plants were not mowed in 1985 so this variable should not affect control from fall treatments in the future.

Picloram (2S) at 1 and 2 lb/A provided the best long-term leafy spurge control regardless of retreatment (Table). Picloram at 1 and 2 lb/A provided 45% control when averaged over rate and date but control increased to 78 and 57% for spring and fall, respectively, when averaged over dicamba and picloram retreatments. Thus, when higher rates of picloram are applied every few years, there is little advantage in using more than 1 lb/A initially when annual retreatments are applied.

Dicamba at 8 lb/A alone spring applied averaged 20% control, but control increased to 80 and 99% with retreatments of dicamba at 2.0 lb/A or picloram + 2,4-D at 0.25 + 1 lb/A (Table). Leafy spurge control from fall applied dicamba at 8 lb/A averaged 6% and increased to an average of 62% following retreatments of picloram at 0.25 lb/A, picloram + 2,4-D at 0.25 + 1 lb/A or dicamba, at 2 lb/A.

Annual application of 2,4-D, the most economical treatment in the study provided 0 and 15% leafy spurge control as a fall and spring applied treatment, respectively (Table). Leafy spurge control was increased to 84% when the 2,4-D original treatment was retreated with picloram + 2,4-D at 0.25 + 1 lb/A annually in the spring, but the same fall applied treatment provided only 19% control.

The annual retreatments that provided the highest leafy spurge control were picloram + 2,4-D at 0.25 + 1 lb/A and dicamba at 2 lb/A (Table). These retreatments averaged 85 and 56% leafy spurge control as spring and fall applied treatments, respectively, when averaged over all whole plot treatments. Annual retreatments of 2,4-D or dicamba at 1 lb/A averaged only 53 and 25% leafy spurge control as spring and fall applied treatments averaged over whole plot treatments, respectively. Leafy spurge control was increased 25% when 2,4-D was added to picloram at 0.25 lb/A compared to picloram at 0.25 lb/A alone as an annual treatment spring applied, but not when fall applied. Thus, the most practical retreatment when considering both cost and control were picloram at 0.25 lb/A alone in the fall or picloram + 2,4-D at 0.25 + 1 lb/A spring applied, but dicamba at 2 lb/A would be the retreatment of choice where picloram could not be applied such as in areas with a water table 10 feet or less below the surface.

No treatment using a reduced-volume applicator maintained satisfactory control alone. The reduced volume applicators would not have an economic advantage if several annual retreatments were required for satisfactory leafy spurge control. Several herbicide treatment alternatives provided 90% or more leafy spurge control 6 years after the initial treatment, but no treatment program had eradicated leafy spurge.

Table. Leafy spurge control in North Dakota following a seven-year management program.

Whole Plot						Retreatment subplot 1981, 1983-86/rate lb/A						
Treatment[a] 1980	Rate	Soln conc[b]	Treatment[a] 1982	Rate	Soln conc[b]	2,4-D 1.0	Dicamba 1.0	Dicamba 2.0	Picloram 0.25	Picloram + 2,4-D 0.25 + 1.0	Control 0	Mean
	(lb/A)	(lb/gal)		(lb/A)	(lb/gal)	(% control)						
Spring applied												
2,4-D	2.0	0.24	2,4-D	2.0	0.24	14	41	76	68	84	15	50
Plcloram 2%G	1.0		Picloram (carpet-2 pass)	---	0.25	51	39	67	64	88	0	51
Picloram 2%G	2.0	---	Picloram (wick-2 pass)	---	0.5	81	74	87	86	95	65	81
Picloram 2S	1.0	0.13	Picloram 2S	1.0	0.13	66	58	98	75	90	45	72
Picloram 2S	2.0	0.25	Picloram 2S[C]	2.0	0.25	55	83	75	62	86	27	64
Picloram (Roller)	---	0.25	Picloram (carpet)		0.25	54	49	76	46	91	25	57
Picloram + oil conc. (Roller)	---	0.25	Picloram (carpet)		0.25	52	67	83	85	91	30	68
Picloram (Wick)	---	0.5	Picloram (wick)		0.5	18	38	70	50	87	0	44
Picloram + oil conc. (Wick)	---	0.5	Dicamba	8.0	1.0	74	49	80	77	99	20	67
Control	---	---	Control	---	---	15	63	92	60	85	0	53
Mean						50	56	80	67	90	24	
LSD (0.05) whole plot = 11 subplot = 10 whole plot x subplot = 30												
Fall applied												
2,4-D	2.0	0.24	2.4-0	2.0	0.24	0	22	32	33	19	0	18
Picloram 2%G	1.0	---	Picloram (carpet-2 pass)	---	0.25	8	45	48	38	55	16	35
Picloram 2%G	2.0	---	Picloram (wick-2 pass)	---	0.5	37	28	61	55	52	24	43
Picloram 2S	1.0	0.13	Picloram 2S	1.0	0.13	17	33	58	50	63	42	44
Picloram 2S	2.0	0.25	Picloram 2S[C]	2.0	0.25	37	48	75	55	76	50	57
Picloram (Roller)	---	0.25	Picloram (carpet)	---	0.25	19	23	70	38	47	18	36
Picloram + oil conc. (Roller)	---	0.25	Picloram (carpet)	---	0.25	43	48	78	56	73	25	54
Picloram (Wick)	---	0.5	Picloram (wick)	---	0.5	8	31	54	32	35	9	28
Picloram + oil conc. (Wick)	---	0.5	Dicamba	8.0	1.0	14	21	62	65	60	6	38
Control			Control	---	---	0	15	47	44	42	0	25
Mean						18	31	59	46	52	19	25
LSD (0.05) whole plot = 15 subplots = 12 whole plot x subplot = 37												

[a]Spray applied except the treatments identified as roller, wick or carpet applicator applied.
[b]Herbicide:water (v/v)
[c]Applied to control subplot only.

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Leafy spurge control with chemical and mechanical treatments

LLEWELLYN MANSKE and PHILLIP SJURSEN

A study to test the effects of chemical (picloram) and mechanical (mowing) treatments on leafy spurge in rangeland was started in 1984 at the Dickinson Experiment Station. The test plots were located on private property in Golden Valley County, North Dakota. The plots were 22 x 30 foot arranged in a randomized block design with two replications. The soil was Havrelon silt loam. The vegetation on the site was predominantly leafy spurge with a thin understory of Kentucky bluegrass (*Poa pratenais*), prairie-sandreed (*Calamovilfa longifolia*) and needleandthread (*Stipa comata*).

The treatments were; in early June, mowing, mowing plus picloram, and picloram; in early July, mowing, mowing plus picloram and picloram; in mid August, picloram; and annually mowing in June, and in June and July. A control of no treatment was included in each replication. No retreatment has been made to these plots except the annual mow in June and in June and July plots. The early June, early July and mid August periods of treatment coincided with pre-flower, post flower (seed development) and early regrowth phenological stages of development for the leafy spurge plants, respectively. The mowing treatments were conducted with a sickle bar mower and the herbage was raked off the plots. The chemical treatment was applied at a rate of 2 lbs ai/acre of picloram in the form of 2K granules with a hand held whirlybird spreader. The data that were collected from these plots were; above ground herbage production, leafy spurge stem densities, and mean weight per leafy spurge stem collected monthly through the growing season. The only data included in this report will be the pretreatment stem densities collected in early June and the percent change in stem densities per foot squared compared to the control plots taken in early June of years following treatment (Table 1).

Single mowing treatments in June or July appear to increase stem densities one and two years after treatment. Annually repeated moving in June and in June and July appear to have some reduction in stem densities. Mowing plus chemical treatment has some effect on the stem density and has some added effect compared to chemical alone one year after treatment, June applied and two years after treatment, July applied. The effects of the treatments on these plots will be monitored one additional year.

Table 1. Percent change in stem density compared to control one and two years after treatment.

Treatment	1984	1985	1986
	#/ft^2	% of control	
Control	33.6	---	---
June	38.7	+20.0	+59.4
July	31.1	+27.9	+17.6
June annually	37.3	+17.2	-59.5
June + July mow annually	39.4	-39.1	-53.8
June mow + picloram	25.6	-74.7	-58.7
July mow + picloram	25.5	-98.2	-76.0
June picloram	28.7	-62.2	-94.7
July picloram	38.8	-98.1	-67.2
Aug. picloram	40.8	-98.2	-96.3

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Leafy spurge control with tebuthiuron

LLEWELLYN MANSKE

A study that tests the effects of tebuthiuron (Graslan) on leafy spurge in rangeland was started in 1983 at the Dickinson Experiment Station. Two similar sets of test plots were located on private property in Golden Valley County, North Dakota. One set of plots was established in 1983 and another set in 1984. The plots were arranged in a randomized block design with two replications. The vegetation on the sites were predominantly leafy spurge with an understory of Kentucky bluegrass (*Poa pratensis*).

Tebuthiuron is an herbicide that is primarily intended for use on shrubs in rangeland. The chemical is absorbed by the roots and translocated to the leaves. Photosynthesis is restricted. The leaves senesce prematurely and fall off and a new set of leaves develop. This process continues until the plant depletes its stored carbohydrates. The process may take one to four years before the plant dies completely depending on the species and the environmental conditions. In theory, this appears to be a desirable method to control leafy spurge.

The herbicide was broadcast applied with a hand held whirlybird spreader at three rates, 1, 2 and 3 lbs ai/acre, of 20% pellets on 12 July 1983 and 4 June 1984 for sites 1 and 2, respectively. A control of no chemical treatment was included in each replication. No retreatment has been made to these plots. The data that were collected from these plots were; above ground herbage production, leafy spurge stem densities, and mean weight per stem collected monthly through the growing season. The only data included in this report will be the pretreatment stem densities and the percent change in stem densities per foot squared compared to the control plots taken in early June of years following treatments (Tables 1 and 2).

Tebuthiuron does have a detrimental effect on leafy spurge one, two and three years after treatment for the three rates included in this trial. The desired level of control has not been reached after three years. A retreatment may be necessary to control leafy spurge with tebuthiuron. These plots will continue to be monitored.

Table 1. Percent change in stem density compared to control one to three years after treatment, site 1.

Treatment	1983 #/Ft^2	1984	1985	1986
		% of control		
Control	13.1	---	---	---
1 lb /acre	11.0	+ 1.6	-27.8	- 6.8
2 lb /acre	18.7	-18.6	-55.7	-70.0
3 lb /acre	22.4	-37.1	-66.3	-71.1

Table 2. Percent change in stem density compared to control one and two years after treatment, site 2.

Treatment	1984 #/Ft^2	1985	1986
		% of control	
Control	54.5	---	---
1 lb /acre	56.5	+ 0.9	-60.2
2 lbs /acre	49.2	- 9.0	-61.2
3 lbs /acre	62.3	-70.8	-82.7

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Evaluation of spring vs. fall original/ retreatment herbicide combinations affecting leafy spurge live shoot regrowth

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This field study located near Lander, Wyo. was established for accumulation of original/retreatment and fall vs. spring application data on leafy spurge. Six successive years of data have been collected since the study was established in the spring of 1980.

Origin spring and fall treatments were made May 23, and September 14, 1980. Liquid formulations were applied with a 21.5-foot boom, 13 nozzle truck mounted spray unit equipped with Teejet HSS8004 nozzles delivering 25 gpa water carrier. The granular formulations were applied with a hand operated centrifugal granular spreader. Plot size for the original treatments was 21.5 feet by 258 feet with one replication.

Retreatments were applied across the original treatments creating a split-block design and were made May 29 and September 12, 1981, May 24 and September 17, 1982, May 29 and September 15, 1983, May 31 and September 18, 1984, and May 22 and September 10, 1985. Retreatment plots were 21.5 feet by 21.5 feet with two replications. The retreatments were 2,4-D amine at 2.0 lb ai/A, dicamba at 2.0 lb ai/A, picloram at 0.5 and 1.0 lb ai/A, 2,4-D amine (spring and fall applied) at 2.0 lb ai/A, and an untreated check. The retreatments of picloram at 0.5 and 1.0 lb ai/A were terminated with the 1981 treatment. The leafy spurge was in the bud to flower stage-of-growth and 4 to 18 inches in height during the spring retreatments and was mature and had shed most of its seed when fall retreatments were made. Retreatments were applied with the truck-mounted sprayer used to apply the original treatments. The soil at the study site was a sandy loam (73% sand, 15% silt and 12% clay) with 1.3% organic matter and pH of 7.6.

The area has been flood irrigated since application of original treatments. However, irrigation was not uniform in the study area. There was poor grass cover on May 1980 when plots were established. By September 1981 grass was 20 to 24 inches in height and still green in treatment areas. Good grass cover has been maintained in treatment areas from 1982 through 1986.

Percent shoot control is based on reduction of live leafy spurge shoots per square foot recorded from treatment plots as compared to the untreated (check) plots. The percent leafy spurge shoot control has decreased in most of the original treatment plots over the six year period. There appears to be little difference in the effectiveness of the original treatments whether spring or fall applied. However, better shoot control has been maintained in the original treatments where picloram was applied regardless of rate or formulation. The reduction in shoot control is also apparent since the retreatments of picloram were terminated with the 1981 application. The 2,4-D amine retreatment applied both in

the spring and fall (S & F) was more effective than only the one yearly treatment applied either in the spring or fall. Retreatment areas have maintained better shoot control than single treatment applications. When picloram 1.0 lb ai/A was used as a retreatment on previously treated picloram areas in the spring study no advantage was found. This is probably due to leaching of the picloram out of the shallow soil in this area. There is also considerable variation in percent leafy spurge shoot control between other treatments and rates of application which may also indicate variation in soil and leaching of the herbicide out of the shallow soil profile. (Wyoming Agric. Exp. Sta., Laramie, WY 82071, SR_____.)

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Evaluation of 2,4-D LVE as a treatment prior to light rates of picloram for leafy spurge shoot control

M. A. FERRELL and T. D. WHITSON

As costs of controlling leafy spurge (*Euphorbia esula* L.) increase new methods of treatment are being evaluated to decrease costs and improve control. This experiment was established to evaluate the use of 2,4-D LVE as a setup treatment prior to the application of light rates of picloram.

Plots were established June 4, 1985 in a dense stand of leafy spurge 12 to 18 inches tall in the bud to full bloom stage-of-growth. Liquid formulas were applied with a 6-nozzle knapsack spray unit delivering 40 gpa water. There was an understory of perennial grasses 4 to 6 inches tall. Soil moisture was very low and the plots were located on an irrigated slope. Weather conditions were as follows: air temperature 76º F, relative humidity 34%, wind N at 5 mph, sky partly cloudy, and a soil temperature of 108º F at 1 inch. Soil was a sandy loam (72% sand, 15% silt and 13% clay) with 1.3% organic matter and 7.6 pH. Setup treatments with 2,4-D LVE were applied 17 days prior to application of 0.25 and 0.5 lb ai/A picloram. Plots were 9 by 30 feet arranged in a randomized complete design with three replications.

Leafy spurge shoot control

Treatment[1]	Rate lb ai/A	Percent[2] control
*2,4-D LVE + picloram	0.125 + 0.25	0
*2,4-D LVE + picloram	0.25 + 0.25	0
*2,4-D LVE + picloram	0.125 + 0.5	0
*2,4-D LVE + picloram	0.25 + 0.5	0
2,4-D LVE + picloram	0.125 + 0.25	0
2,4-D LVE + picloram	0.25 + 0.25	0
2,4-D LVE + picloram	0.125 + 0.5	0
2,4-D LVE + picloram	0.25 + 0.5	0
picloram + clopyralid	0.125 + 0.125	0
picloram + clopyralid	0.25 + 0.25	0
picloram + clopyralid	0.375 + 0.375	0
picloram	0.25	0
picloram	0.5	0
picloram	0.75	50
picloram	2.0	77

[1]Treatments applied June 4, 1985
[2]Visual evaluations June 4, 1986
*Plots treated with 2,4-D LVE 17 days prior to treatment with picloram

Visual ratings of leafy spurge shoot control made June 4, 1986, showed 2,4-D setup treatments and 2,4-D/picloram combinations to be ineffective in increasing the activity of picloram for the control of leafy spurge. Combinations of picloram + clopyralid were also ineffective. Picloram applied alone at 2.0 lb ai/A resulted in the most effective control at 77%, which is about 20% less than the control normally observed for this rate, one year after application The reduced control may have resulted from picloram leaching due to irrigation. (Wyoming Agric. Exp. Sta., Laramie, WY 82071, SR_____.)

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Biological control of leafy spurge Progress report to GPC-14 Nov. 14, 1986

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Wilt and root rot

A Fusarium species was isolated from the few dead and dying leafy spurge (*Euphorbia esula*) plants found by Dr. Hosford in Washington and Wyoming in June-July 1986. Inoculation of soil around spurge plants in the greenhouse with the Fusarium alone has not, to date, resulted in wilt or root rot. In November 1986 a nonsporulating fungus was repeatedly isolated by Mr. Jordahl from brown streaks in roots of wilting leafy spurge plants growing in Sunshine Mix (a soilless mixture of peat moss, peralite and vermiculite from Canada). Spurge plants will be inoculated with this fungus.

Alternaria species

In September 1985 Dr. Hosford observed a disease killing some inflorescences and then the flowering stem of *Euphorbia esula* (leafy spurge) in western North Dakota, central Montana and southern Oregon. The disease was scattered in patches of spurge at one site in North Dakota and one site in Montana and abundant in a solid 100-acre stand of leaf spurge covering a valley in southern Oregon. In May 1986, he and Don Mundal observed a similar disease in eastern North Dakota. Alternaria was repeatedly isolated from the advancing edge of stem lesions from all these sites. In 36-65 hour wet periods isolates B1-1 and B1-6 of Alternaria from central Montana caused small dark spots to extensive dark lesioning, killing flowers, leaves and stems of leaf spurge biotypes 113, 110 and 108 in greenhouses at Fargo, ND. All 27 conidial inoculated plants developed spotting and/or top dieback. The 25 water inoculated check plants were not spotted. Alternaria resembling B1-1 and B1-6 were reisolated from the lesions and not from healthy check plants. On 4-30-86 Dr. Joe Krupinsky sent us two of his stem killing isolates of Alternaria from Mandan, North Dakota (4).

In the prairie provinces of Canada Alternaria spp. have caused leaf spotting to top dieback in up to 10% of the leafy spurge at some sites (5). *A. tenussima* f. sp. *euphorbiae* caused leaf spotting and top dieback in North Dakota, but artificial field inoculation at 3 sites in 1984 resulted in only a little infection, probably due to inadequate moisture (4, L. J. Littlefield personal communication).

Uromyces striatus

The rust, *Uromyces striatus* was detected killing leafy spurge near Lidgerwood in southeastern North Dakota in 1982. It spread slowly from plant to plant through 1982-84. In 1985 it spread quickly by aerial spores to scattered plants over 3 acres of spurge. In 1985 its uredispores were found on alfalfa in the fields, then produced in the greenhouse and stored in liquid nitrogen. On May 7, 1986 Dr. Hosford and Dr. Mundal found a rust disease resembling *U. striatus* killing a few plants near Lisbon, ND but not in an adjacent alfalfa field. We have a report of this rust on a few leafy spurge plants south of Carrington, ND. The rust kills the spurge plant. We are looking for another alternate host other than alfalfa or clover (3) from which spurge may be infected.

Malampsora euphorbiae, *Uromyces* spp. and *Endophyllum* spp.

In September 1985 we found a *Malampsora euphorbiae*-like rust on an Oregon State University herbarium specimen of *E. esula* collected in Medford, Oregon in 1964. We did not find the rust in Medford, but M. R. Hubbel, who collected it in 1964, is looking for it for us. *Melampsora* rust spp. occur on *Euphorbia* spp. and are highly specific for their hosts. This combined with their urediospore on *Euphorbia* spp. makes them good candidates for biocontrol of leafy spurge. *Melampsora euphorbiae* was collected at Victoria, B.C. by Dr. Littlefield in August, 1984 and sent to the Plant Disease Research Laboratory (PDRL) at Frederic, Maryland. *Uromyces euphorbiae* was collected by Dr. Littlefield on a collecting trip to Eastern Europe in the spring of 1984, and that rust was also sent to PDRL. Evaluation of these rusts for host range, prior to release to us, is in progress. At Frederic Dr. W. L. Bruckart is studying these and other microorganisms that he, Dr. Littlefield and others have collected (1). Dr. Bruckart reports that in Swiss studies by Dr. G. Defago *et al*. *Uromyces scutellatus* is reducing stands of cypress spurge by 90% (1, 2). He found that *M. euphorbiae* from Eastern Europe caused very limited infection on spurge collections other than those from which it came (1). We plan to look for these fungi on leafy spurge in the United States. Harris *et al*. (3) recommended the "autoecious rusts, such as *Melampsora euphorbiae* (Schub.) Cast., *Uromyces scutellatus* (Pers.) Lev. and Endophyllum species, as possible biocontrol agents for control of North American leafy spurge." On Oct. 21, 1986 Dr. Larry Littlefield sent us the uredial/telial stage of an autoecious rust (*Uromyces proeminens* or *U. magorii*?) on *Euphorbia dentata* (?), toothed spurge, in Oklahoma. Dr. Statler is testing this rust for pathogenicity to leafy spurge. On August 19, 1986 Sharon Collman, County Agent for King County, Washington sent us an orange rust severely rusting petty spurge (*Euphorbia peplus*) in King County. On October 7, 1986 Joseph Kropf, County Agent for Cowlitz County, Washington sent us an orange rust severely rusting petty spurge in Cowlitz County. On Nov. 7, 1986 Jack Waud, County Agent for Clallam County, Washington sent us an orange rust and leaf spots on small to medium size spurge plants in Clallam County. Dr. Statler is testing these rusts for pathogenicity to leafy spurge.

Sclerotium rolfsii

Dr. Littlefield obtained *Sclerotium rolfsii* isolates from southern United States. On January 28, 1986 10 ml of 2 two-week-old petri plate cultures of sclerotia and mycelium of *S. rolfsii* in 50 ml of water plus 2 drops of Tween 20 were poured on the base of each of 5 plants of leafy biotype 113. The plants in each of 5 pots were watered daily. By 8-18 days after inoculation the stems of the inoculated plants were killed at the soil surface, but new stems grew from the roots. Five water inoculated check plants were undamaged. This fungus damages many important plants and crops in the southern United States. It is assumed that it will not survive northern winters. If it were to survive, it might become a serious problem. We are studying this fungus only in the greenhouse in the winter.

Conclusions

We should continue studying root rot and wilt diseases for a potential control of leafy spurge and look for more virulent or aggressive isolates of Alternaria and autoecious rusts, such as *Melampsora euphorbiae* (Schub.) Cast, *Uromyces scutellatus* (Pers.) Lev., and Endophyllum species, on North American leafy spurge. We should also look for any other organisms, fungi, bacteria, viruses, nematodes, etc., that may be damaging leafy spurge.

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