Reprinted with permission from: Proceedings of the South Dakota Academy of Science. 1984. 63:85-91.

Published by: South Dakota Agriculture Experiment Station, Journal Article No. 1998.

Comparison of leafy spurge (*Euphorbia esula*) infested and noninfested soils[1]

W. E. ARNOLD

Plant Science Department, South Dakota State University, Brookings, SD 57007

Abstract:

Ten leafy spurge (*Euphorbia esula* L.) infested sites were selected in two counties of northeastern South Dakota. Soil samples were taken at 15-cm intervals down to 60 cm from infested areas and adjacent noninfested areas to determine the effects of soil characteristics on ecesis of leafy spurge. Samples were analyzed for nitrates, organic matter, phosphorus, potassium, zinc, iron, manganese, copper, calcium, magnesium, pH, and soluble salts. Significant differences were infrequent and attributed to chance. Soil mineral composition, pH, organic matter, and soluble salts did not appear to influence ecesis of leafy spurge. Discriminant analysis was conducted but none of the variables were valuable in classifying the soils as infested or noninfested.

Introduction

Leafy spurge is a serious perennial weed in much of the northern United States and southern Canada. In South Dakota, leafy spurge is present in at least 73% of the counties, and total infestations of over 250 ha occur in at least 39% of the counties (Dunn, 1979). The weed commonly infests pastures and other noncultivated land, even though eight times more leafy spurge seeds germinate on cultivated land than on undisturbed land (Best *et al*., 1980). Leafy spurge was not found in any small grain field in a survey of 24 northern counties conducted in 1979 (Arnold and Auch, 1983). Ten of the counties have an abundance of leafy spurge and are major small grain producing counties.

Soil nutrient status has been shown to influence the ability of many plants to compete with other plants, because plants differ in tolerance to low nutrient levels (Pandy *et al*.,

[1] Contribution of the South Dakota Agric. Exp. Stn. as Journal Article No. 1998.

1971). Riceman *et al*. (1940) reported that copper-deficient calcareous sand of coastal South Australia is dominated by *Bromus madritensis* and *Lagurus ovatus*. However, *Lolium* sp. and other grasses as well as *Medicago sativa* and other legumes are able to grow with the application of copper fertilizer. Van den Bergh (1962) reported that *Lolium perenne* would dominate when grown with *Anthoxanthum odoratium* under high soil potassium and phosphorus. The reverse was true under low soil phosphorus and potassium. The results indicated a genotypic difference to utilize phosphorus and potassium.

Coaldrake and Haydock (1958) found no relationship between soil phosphorus and the distribution of native vegetation in southeastern Queensland, Australia. Carman and Brotherson (1982) compared the soil and plant characteristics of saltcedar (*Tamarix pentandra*) and Russian olive (*Elaeagnus angustifolia*) infested grassland with adjacent noninfested areas. They found saltcedar established on areas with high soluble salt concentrations whereas Russian olive was established on soil with low and medium levels of soluble salts. There was no difference in soil infested with saltcedar and the adjacent noninfested soil. However, sites Infested with Russian olive had lower levels of phosphorus and higher magnesium concentrations, clay content, and pH than adjacent uninfested sites.

Few investigations have been conducted to determine the influence of soil characteristics on the ecesis of leafy spurge. Selleck *et al*. (1962) found that 3.8% of the coarse textured soils in Saskatchewan were infested with leafy spurge while only 0.2% of the sandy and clay soils were infested, even though seed germination rates were higher in fine than coarse textured soils.

A better understanding of the ecesis of leafy spurge would aid in its control. Perhaps adjustment of soil nutrient levels could enable other plants to better compete with leafy spurge. Understanding the ecesis of leafy spurge may make it possible to predict potential sites of infestation and consequently adjust soil nutrients to reduce likelihood of infestation. Finally, leafy spurge control could possibly be improved by combining chemical control methods and fertilization with certain nutrients. The objective of this study was to study the relationship of soil nutrients to ecesis of leafy spurge in native grassland.

Materials and methods

Ten leafy spurge-infested sites were selected in Roberts and Marshall counties in northeastern South Dakota. Soils in the two counties developed under prairies, and parent material was of glacial origin. A description of each site is given in Table 1. Sites were located on pasture and wasteland. Sites having leafy spurge infestations with fairly distinct boundaries were selected.

Each site was arbitrarily divided into four quadrants. Ten soil cores from infested areas and ten from noninfested areas of each quadrant were collected. The samples were obtained from a 60-cm depth using a hand soil probe 2.5 cm in diameter. Each core was divided into 15-cm depth zones, with all samples from the same depth zone in a quadrant combined for analysis.

Soil samples were analyzed for mineral composition, organic matter content, pH and soluble salts at the South Dakota State University Soil Testing Laboratory, Brookings, South Dakota. Nitrates were determined with a nitrate electrode on a water extract. The modified Walkley Black procedure was used to determine organic matter content. Soil phosphorus was extracted with Bray 1. Potassium, calcium, and magnesium were extracted from soils with 1.0 N ammonium acetate. Soils were extracted with diethylenetriaminepenta-acetic acid for determination of zinc, manganese, iron, and copper. An atomic absorption spectrophotometer[2] was used to determine ion concentrations. Soil reaction of a 1:1 soil to water paste was obtained with a glass electrode pH meter. A 1:1 soil paste was also used for determination of soluble salts with an electrical conductivity bridge.

Table 1. Descriptions of sites studied.

Site number	Soil series	Soil texture[a]	Slope	Capability unit	Composition: Association	Composition: Proportion
			(%)			(%)
1,2	Peever-Tonka complex	cl-si	0-3	IIs-2	Peever	60
					Tonka	30
					included soils	10
3,9,10	Forman-Aastad	1	6-9	IIIe-2	Forman	60
					Aastad	25
					others	15
4	Lamoure	sicl	0-2	IVw-l		
5	Peever-Hamerly complex	si	0-2	IIc-3	Peever	30
					Hamerly	25
					Tonka	20
					others	5
6,7	Aastad	1	0-2	IIc-3		
8	Forman-Buse	1	15-25	VIe-1	Forman	55
					Buse	25
					others	20

[a]c = clay, l = loam, si = silt

Data obtained from infested and noninfested areas of each site were compared using Student's t-test. Student's t-test was also used to compare averages across all the sites. Discriminant analysis was used to determine which soil characteristics were useful for differentiating between infested and noninfested areas (Klecka, 1980). Data from each depth of all the sites were analyzed individually. Soil characteristics which made a significant contribution ($P \leq 0.05$) to the analysis were selected as indicator variables.

[2] Perkin-Elmer model 372.

Results and discussion

Macronutrients and organic matter

Leafy spurge infested soil had the same macronutrient and organic matter levels as noninfested soil when data were averaged across all sites. Differences in macronutrient and organic matter levels between infested and noninfested areas occurred randomly at seven of the ten sites. The inconsistency and infrequency of differences, suggested most of the differences occurred by chance. An exception to this statement may have been at site 4 where nitrate levels possibly influenced the ecesis of leafy spurge.

Nitrate levels at site 4 were 56 kg/ha at the 0- to 15-cm depth on infested soil and only 18 kg/ha on noninfested soils. The leafy spurge did not appear to be spreading outside a very distinct area. The site was located on an abandoned farmstead, and the leafy spurge may have been growing on an area which at one time had a hay stack or manure pile. Overall fertility of the site was high, and it was located on Lamour silty clay loam which tends to be undrained with high levels of available water. Leafy spurge dominated the portion of the site which had high soil nitrate levels, possibly because it took greater advantage of the favorable conditions than the associated grasses.

At two sites, analyses indicated phosphorus content was higher in infested areas than noninfested areas. Phosphorus levels were adequate inside and outside the infested areas, indicating pho*s*phorus probably was not a factor in leafy spurge ecesis. Similarly, potassium was not a factor in ecesis because high levels of potassium were found in both infested and noninfested areas of all the sites.

The inconsistency of results among the sites may indicate macronutrient levels do not have a major influence of the ecesis of leafy spurge. However, an interaction of several factors such as soil fertility, land type, management practices, and duration of leafy spurge infestation is possible. For example, at sites 3 and 9, nitrates at the 30- to 45-cm depth were higher in the infested area than in the adjacent noninfested area (Table 2). Magnesium levels were also higher in infested soil than noninfested soil at the 30- to 45-cm depth of site 9 and at the 45- to 60-cm depth of site 3 (Table 2). The sites were located in the same pasture, so management practices were similar. Invasion by leafy spurge may have occurred at approximately the same time. These two sites had similar fertility levels and belonged in the Forman-Aastad soil association.

Inconsistency among the sites cannot be explained by differences in soil association. Site 10 is also in the Forman-Aastad soil association, but macronutrients were the same on infested and noninfested areas. Two sites were located in the Peever-Tonka complex, and two sites in the Aastad soil association. There was no similarity in results between the sites within each association.

Duration of infestation probably has an influence on nutrient levels in infested areas compared to noninfested areas. However, the period of leafy spurge infestation could not be determined in the study. Long term studies would be needed to obtain such information.

Table 2. Soil nitrate and magnesium levels of leafy spurge infested grassland and adjacent noninfested grassland at sites 3 and 9.

Site number	Sample Depth[a]	NO_3 levels		Mg levels	
		Infested	Noninfested	Infested	Noninfested
	(cm)	------------- (kg/ha) -------------		------------- (ppm) -------------	
3	0-15	20.8	17.3	751	738
	15-30	4.0	12.6	929	796
	30-45	7.5	11.8*	964	857
	45-60	7.0	9.1	1096	895**
9	0-15	11.4	16.6	659	611
	15-30	7.5	10.4	794	672
	30-45	4.9	8.2**	1014	607*

[a]Samples were not taken from 45 to 60 cm depth at site 9 because of stone.
*Significant differences ($P < 0.05$) between pairs of means at each sample depth according to Student's t-test.
**Significant differences ($P < 0.05$) between pairs of means at each sample depth according to Student's t-test.

Micronutrients, pH, and salts

Copper levels at the 30- to 45-cm depth were 1.69 ppm in infested areas and 1.85 ppm in noninfested areas when data were averaged across sites. Similarly, iron levels at the 45- to 60-cm depth were 21.4 ppm in areas with leafy spurge and 23.2 in areas without. The differences, though small, were significant according to the t-test. Neither iron nor copper had an influence on the ecesis of leafy spurge, because within individual sites there were no differences in copper levels at any depth or in iron levels at the 45- to 60-cm depth. Statistical analyses indicated several differences in levels of other micronutrients, salts, and pH between infested and noninfested areas of individual sites. However, the differences demonstrated no consistent trend, were infrequent, and probably occurred by chance similar to the macronutrients.

Discriminant analysis

Discriminant analysis did not select any of the soil characteristics as indicator variables for classification of soils as infested or uninfested with leafy spurge. These results are further evidence that soil nutrient content, pH, salts, and organic matter are not important factors in ecesis of leafy spurge.

Literature cited

Arnold, W. E. and Duane Auch. 1983. Distribution and densities of weed species in Northern South Dakota small grain. So. Dak. Acad. of Sci. 62:34-48.

Best, K. F., G. G. Bowes, A. G. Thomas, and M. G. Maw. 1980. The biology of Canadian weeds. 39 *Euphorbia esula* L. Can. J. Plant Sci. 60:651-663.

Carman, John G. and Jack D. Brotherson. 1982. Comparisons of sites infested and not infested with saltcedar (*Tamarix pentandra*) and Russian olive (*Elaeagnus angustifolia*). Weed Sci. 30:360-364.

Coaldrake, J. E. and K. P. Haydock. 1958. Soil phosphate and vegetal pattern in some natural communities of southeastern Queensland, Australia. Ecology 39:1-5.

Dunn, P. H. 1979. The distribution of leafy spurge (*Euphorbia esula*) and other weedy *Euphorbia* spp. in the United States. Weed Sci. 27:509-516.

Klecka, William R. 1980. Discriminant analysis. Sage Publications. Beverly Hills, Calif., 71 pp.

Pandy, H.N., K. C. Misra, and K. L. Mukherjee. 1971. Phosphate uptake and its incorporation in some crop plants and their associated weeds. Ann. Bot. 35:367-72.

Riceman, D. S., C. M. Donald, and S. T. Evans. 1940. Australia. Council. Sci. Ind. Res. Pamphlet 96.

Selleck, G. W., R. T. Coupland, and C. Frankton. 1962. Leafy spurge in Saskatchewan. Ecol. Mong. 39:1-29.

Van den Bergh, J. P. and W. T. Elberse. 1962. Competition between *Lolium perenne* L. and *Anthoxanthum odoratum* L. at two levels of phosphate and potash. J. Ecol. 50:87-95.