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Studies on the reproductive biology of leafy spurge (*Euphorbia esula*)[1]

L. A. MORROW

A. Morrow is the Research Agronomist, U.S. Department of Agriculture, Science Education Administration, Agricultural Research Mandan, ND; presently located at U.S. Department of Agriculture, Science Education Administration, Agricultural Research, Washington State University, Pullman, WA 99164.

Abstract:

Studies on the development of leafy spurge (*Euphorbia esula* L.) were conducted in the field and growth room. Sixteen months after planting in field plots, leafy spurge plants arising from underground bud-producing root segments, transplanted seedlings, or seeds averaged 96, 83, and 136 shoots per plant, respectively, when grown free of interference from other vegetation. A number of plants arising from each source flowered the first year, and all plants flowered and produced seed the second year after planting. When grown in a perennial grass sod consisting of crested wheatgrass [*Agropyron desertorum* (Fisch. ex Link) Schult.] and smooth brome (*Bromus inermis* Leyss.), no plant flowered or produced additional shoots. Soil moisture was less where a dense sod was present. In the growth room, total dry matter of tops and roots was greatest at a soil temperature of 18.3º C or higher, and plant height was greatest at 33.3º C. An early emerging crop might suppress leafy spurge by utilizing the available soil moisture early in the growing season.

Additional index words:

Interference, *Agropyron desertorum* sod, *Bromus inermis* sod, soil temperature.

Introduction

Leafy spurge is a deep-rooting perennial plant that grows in a variety of environmental conditions: on coarse- or fine-textured soil, along waterways, or on dry upland

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sites. It occurs most often in grasslands and waste areas, sites which are not subject to frequent cultivation.

Leafy spurge is a native of Europe and was introduced into North America prior to 1827 (5, 7). Since that time it has spread throughout the northern United States and nearly all of Canada (2, 7). The significance of leafy spurge as a weed is probably related to its capacity to thrive under adverse conditions and to its mode of reproduction (6). It reproduces both by seed, which is the major source of new infestations, and vegetatively (5, 7). The increase in radius of a patch of leafy spurge was found by Selleck *et al*. (7) to be about .3 to .9 m per year.

Leafy spurge shoots generally originate from underground plant parts that are near the soil surface, but they are capable of emerging from buds that were formed at least 1 m deep (3, 4). Density of shoots, the mass of root material, and the depth to which the root penetrates may be responsible for the difficulty of controlling leafy spurge (2, 3, 6, 7).

Seeds are disseminated by a sudden splitting of the seed capsule and have been found as far as 4 m from the seed-producing plant (5, 7). Although leafy spurge seeds are capable of germination 16 days after capsule inversion (8), Selleck *et al*. (7) reported that germination was best after storing at room temperature for 1 year. Seedling survival in natural conditions in North Dakota was reported to be low (5). Selleck *et al*. (7) also found that a seedling plant is capable of producing root buds capable of reproduction within about 7 to 10 days after emergence.

The objectives of this study were to determine the rate of development of leafy spurge plants originating from underground bud-producing root segments, transplanted seedlings, and seeds, with and without interference from a dense stand of a perennial forage grass, and to determine the response of leafy spurge seedlings to different soil temperatures.

Methods and materials

Root segments with buds, seedling plants, and seeds of leafy spurge were planted in late spring in a field nursery on a Temvik silt loam (typic Haploborolls) at Mandan, North Dakota. Seedling plants had been grown to a height of 8 cm in the greenhouse prior to planting in the nursery. Plantings were made, by removing a soil core 6.4 cm in diameter, placing the plant into the opening, and packing the sod around the plant roots. Plants were spaced at 6.1 m intervals in each direction, with 10 replications randomized within each of two levels of interference. One was a plowed area that was maintained in a weed-free condition by removing other vegetation manually while the other was a dense sod of crested wheatgrass and smooth brome. Precipitation was 21.2 cm and 21.9 cm during the first and second growing seasons (May through August), respectively. Measurements of plant height, number of new shoots, and distance of these new shoots from the parent plant were made periodically during the year of planting and the year after planting. Shoots were considered new as soon as they appeared above the soil surface. Flowering dates and seed production were also recorded for the first shoot to flower on each plant. Seed-producing shoots were removed from the plants before shattering to prevent an additional source of plants. Soil moisture was monitored during the growing season to a

depth of 2.4 m in increments of 30 cm using a neutron moisture meter. Soil moisture tubes were placed in a patch of actively growing leafy spurge, in an area free of vegetation, and in the crested wheatgrass/smooth brome sod. Measurements were recorded early and late spring, summer, and fall.

Five seedlings were transplanted from sand flats into water-tight pots 15 cm in diameter by 18 cm tall containing 3 kg of silt loam from the Temvik series. The pots were placed in a constant temperature water bath to attain soil temperatures of 3.3, 8.3, 13.3, 18.3, 23.3, 28.3, and 33.3º C. The soil surface of the pots was covered with small gravel to reduce evaporation. Field capacity of the soil was determined to be 31%. Water was added three times weekly by weight to bring the water content to 28% by weight. Measurements of plant height and water use were recorded weekly and oven-dry weights of tops and roots were recorded at the end of the study. Water use was considered to be the amount of water necessary to adjust moisture to 28%. Air temperature remained constant at 23º C and a 16-hour photoperiod was used. There were four replications.

Results and discussion

Plants grown without interference were taller than those that were grown with interference, regardless of the plant source (Table 1). When interference from a perennial grass sod was present, leafy spurge plants did not change in height between 4 and 16 months after planting. Plants from seed were only about 6 cm tall, even after the second growing season. Plants originating from root segments or transplanted seedlings attained a greater height than those originating from seeds. Plants that were grown without interference increased in height during the second year after planting, regardless of plant source, but there was no difference between plant sources in either year.

Table 1. Height of leafy spurge plants 4 and 16 months after planting as root segments, transplanted seedlings, or seeds and grown with or without competition.[a]

	Grown with competition		Grown without competition	
Plant source	4 months	16 months	4 months	16 months
	(cm)			
Root	15b	15a	44a	67a
Seedling	29a	18a	38a	55a
Seed	3c	6b	34a	62a

[a]Means in the same column followed by the same letter are not statistically different at the 5% level using Duncan's multiple range test.

During the first growing season, few plants produced shoots other than the initial one. Those plants arising from root segments averaged 3 shoots per plant, at an average of 11 cm from the parent plant, when grown free of interference. Plants originating from trans-

planted seedlings or seeds produced no shoots other than the original one. The year after planting, however, an average of 96 shoots per plant (ranging from 38 to 172) were produced by plants arising from root segments. These shoots averaged 171 cm (with a range of 123 to 190 cm) away from the parent plant in the absence of interference. Shoots from plants arising from transplanted seedlings averaged 83 (range 10 to 191) shoots per plant with an average distance of 121 cm from the parent plant. Plants from seeds produced from 44 to 321 shoots and averaged 170 shoots per plant at a distance of 174 cm from the point of the original planting. Each type of plant produced an abundance of new shoots when grown without interference. However, no plant, when grown with interference, produced shoots other than the original one by the end of the second growing season. The perennial forage grasses reduced plant height and reduced the number of shoots that a leafy spurge plant produced. This reduction in growth may be related to a number of factors, one of which may be the amount of soil moisture present (Table 2). The grasses would be competing for moisture and may have a large effect on leafy spurge development. Soil moisture was lower where leafy spurge plants were growing than where no vegetation was present, but the least soil moisture was present where a dense sod was growing. Soil moisture was depleted to a deeper depth, also, where the sod was growing. Soil moisture was in short supply where the leafy spurge was planted into the perennial forage grass sod.

Plants grown from root fragments planted in early June and free of interference began to bloom in mid-July, and by mid-August, all 10 plants had flowered. By mid-September, 4 of the 10 plants set seeds, and by mid-October, all 10 of the plants had produced seeds. The following year, all plants originating from root segments flowered in late May and had produced seeds by mid-June. No plants grown with the forage grasses produced seeds in either year.

Three of the 10 plants arising from transplanted seedlings where sod was not present flowered and produced seeds the first year. By the end of the second season, all plants that had been transplanted as seedlings had flowered and set seeds. The most interesting plants were those that came from planted seeds. There were only eight plants because two did not germinate. By the end of the first growing season, six of the plants had produced seeds, and by mid-June of the second season, all plants had produced seeds. Selleck *et al*. (7) found in his studies that seedlings did not flower the first year. This observation might be explained by the difference in day length or the difference in soil moisture between Mandan, North Dakota, and Saskatoon, Saskatchewan, Canada.

Plants of leafy spurge arising from root segments, transplanted seedlings, or seeds appear to have seed-producing capabilities during the first year of growth when grown free of competition. Those plants originating from rhizome segments also appear to have the capability of vegetative reproduction during the first year of growth. Leafy spurge plants grown without interference appear to be capable of expanding the infestation from a single plant to an infestation more than 3 m in diameter. Those plants growing in the perennial grass sod were capable of maintaining themselves but were not able to reproduce under those conditions, at least during the first two growing seasons.

Table 2. Soil moisture in an actively growing leafy spurge patch, an area free of vegetation, and a crested wheatgrass/smooth brome sod.

		Sample site		
Time of year	Depth	Leafy spurge	Vegetation Free	Crested wheatgrass/ smooth brome sod
	(cm)	(cm of soil moisture/30 cm soil depth)		
Early spring	0-30	3.36	6.41	2.67
	30-60	3.81	4.82	2.71
	60-90	4.26	5.00	2.96
	90-120	5.41	6.02	3.25
	120-150	6.84	6.70	3.81
	150-180	7.02	7.62	4.33
	180-210	6.41	7.52	4.76
	210-240	7.40	4.70	5.50
Late spring	0-30	3.46	4.23	2.75
	30-60	3.62	5.12	2.38
	60-90	3.88	5.56	2.78
	90-120	4.80	6.14	3.21
	120-150	6.62	7.06	3.85
	150-180	7.01	7.75	4.43
	180-210	6.42	7.57	4.90
	210-240	7.56	4.76	5.72
Early summer	0-30	2.56	3.85	2.57
	30-60	3.42	4.82	2.35
	60-90	3.68	5.22	2.74
	90-120	4.54	6.00	3.14
	120-150	6.32	6.94	3.76
	150-180	6.66	7.52	4.73
	180-210	6.28	7.46	4.80
	210-240	7.43	4.71	5.49
Late summer	0-30	2.55	3.02	1.96
	30-60	3.26	4.01	2.29
	60-90	3.52	4.75	2.80
	90-120	4.51	6.04	3.19
	120-150	6.21	6.73	3.89
	140-180	5.82	7.32	4.33
	180-210	5.90	7.46	4.76
	210-240	7.24	4.86	5.60
Early fall	0-30	7.95	8.20	4.30
	30-60	3.80	5.65	2.30
	60-90	3.60	4.79	2.83
	90-120	4.76	6.24	3.26
	120-150	6.30	6.78	3.98
	150-180	5.54	7.40	4.41
	180-210	5.80	7.28	4.80
	210-240	7.04	4.92	5.36
Late fall	0-30	7.33	7.30	5.61
	30-60	8.33	8.24	6.41
	60-90	8.23	7.74	6.08
	90-120	6.82	8.72	3.52
	120-150	6.58	8.64	3.90
	150-180	5.52	9.17	4.41
	180-210	5.80	8.47	4.80
	210-240	7.04	5.22	5.70

Leafy spurge begins growth early in the spring, even to the extent that it begins growth earlier than alfalfa (1, 5). Leafy spurge plant height increased progressively as soil temperature increased, varying from less than 1 cm when plants were grown for 12 weeks at a soil temperature of 3.3º C to over 35 cm at 33.3º C (Table 3). Dry matter of tops exhibited the same trend, with the lower temperature resulting in almost no top growth and the highest temperature providing the greatest amount of top growth.

Dry matter produced by the roots appeared to stabilize at soil temperatures of 18.3º C and above. The soil temperature of 3.3º C produced the smallest amount of root growth. The amount of water used increased as the soil temperature increased. This would be expected since increased soil temperature increases transpiration. Vigor of the plants grown at temperatures of 13.3º C or warmer was greater than at the cooler temperatures; plants were a brighter green and they branched more. No plants flowered during the 12-week period that the study was conducted.

Leafy spurge is an early emerging plant under field conditions and flowers early in the summer. Its early emergence, coupled with its accelerated growth at higher soil temperatures, would result in adaptation to a wide soil temperature range. This would make it very competitive not only early in the season but during the entire season. Although not studied, air temperature may also be a controlling factor. Air temperature in this study was held constant at 23º C, a temperature that may or may not be conducive to optimal growth for leafy spurge.

Table 3. Growth of leafy spurge plants in response to different soil temperatures for 12 weeks in the growth room.[a]

Temperature	Plant height	Dry matter		Water used
		Top	Root	
(C)	(cm)		(gm)	
3.3	0.6a	0.01a	0.09a	520a
8.3	4.5a	0.08a	0.24a	950ab
13.3	11.3b	0.47ab	0.91ab	1490b
18.3	18.6c	1.34ab	2.22bc	2930c
23.3	23.0cd	1.93bc	3.31c	3900d
28.3	25.3d	2.07bc	2.74c	4170d
33.3	35.8e	3.56c	3.52c	6570e

[a]Means in the same column followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Leafy spurge is in aggressive perennial plant. It can reproduce by seeds or vegetatively and will spread rapidly where interference from other vegetation is not present. Allelopathy was not studied, but it may also be important in the development and establishment of a leafy spurge infestation. Leafy spurge appears to be adapted to a wide range of soil temperatures. An early emerging crop, such as a crested wheatgrass/smooth brome sod, that would use the available soil moisture early in the season may be capable

of limiting the spread and establishment of new infestations of leafy spurge. An effective method of control may be to keep grazing lands in a vigorous, healthy condition. In some instances, seeding extensive bare areas with early emerging grasses may be an effective tool in limiting the spread of leafy spurge.

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