Bulletin 266 March, 1933

Leafy Spurge

Life History and Habits

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TABLE OF CONTENTS

INTRODUCTION

LEAFY SPURGE (*Euphorbia virgata* Waldst. & Kit. [2]) has been known in the United States for over 100 years. According to Britton (1) there is a specimen of this weed in the New York Botanical Garden which was collected by Wm. Oakes at Newbury, Massachusetts, in 1827. For many years, Britton states, it was known from no other locality in the United States. It was recognized by Asa Gray in the first edition of his Manual, published in 1848, as a weed likely to become troublesome. It has now fulfilled this expectation in several states. According to information received, by correspondence, from state experiment stations and herbaria, leafy spurge is known to occur in a number of states from Maine to Washington. (See Map, Figure 1.) In Maine, New Hampshire and Connecticut it has been reported from very few localities. In Massachusetts the weed is reported as covering considerable stretches of the roadside near Newburyport as well as being scattered along roadsides and in waste land in Essex and Middlesex Counties. W. C. Muenscher reports that leafy spurge has been found in at least 15 counties in New York and is proving to be a serious pest in cultivated land, meadows and pastures. In New Jersey, M. A. Chrysler reports it as only locally abundant, as along roadsides near New Brunswick. In Maryland, Indiana, Michigan and Pennsylvania, the weed is reported as extremely rare. It is becoming abundant in several places in Iowa, Wiscon-

[1] A large portion of the work upon which the bulletin is based was done by Miss Velva E. Rudd during 1931 and 1932 in partial fulfillment for the Master of Science degree in Botany at the North Dakota Agricultural College.

[2] The name *Euphorbia virgata* Waldst. & Kit. has been adopted in place of *Euphorbia esula* L., for the leafy spurge found in North Dakota on the authority of O. M. Malte, Botanist, Department of Agriculture, Ottawa, Canada; P. C. Standley, Field Museum of Natural History, Chicago; C. V. Morton, Smithsonian Institution, Washington; and P. Aellen, Basel, Switzerland. Professor Aellen in correspondence pointed out that in *E. virgata* the leaves are not serrulated and that they are broadest at or below the middle while in *E. esula* they are sometimes serrulate and broadest near the apex. The involucral glands in the former are pronouncedly horse-shoe shaped but only concave in the latter.

sin and Illinois. It has been found in several counties in Nebraska, and in Colorado it has been reported from only one locality near Castle Rock. In Montana there are small patches, widely but not generally, distributed. In Idaho and Washington a few patches are known. Up to the present there appears to be no record of its presence in Oregon, Utah, Wyoming, Kansas, Missouri, Kentucky, Ohio, Virginia, Delaware, Rhode Island and Vermont. It is to be expected that sooner or later leafy spurge will

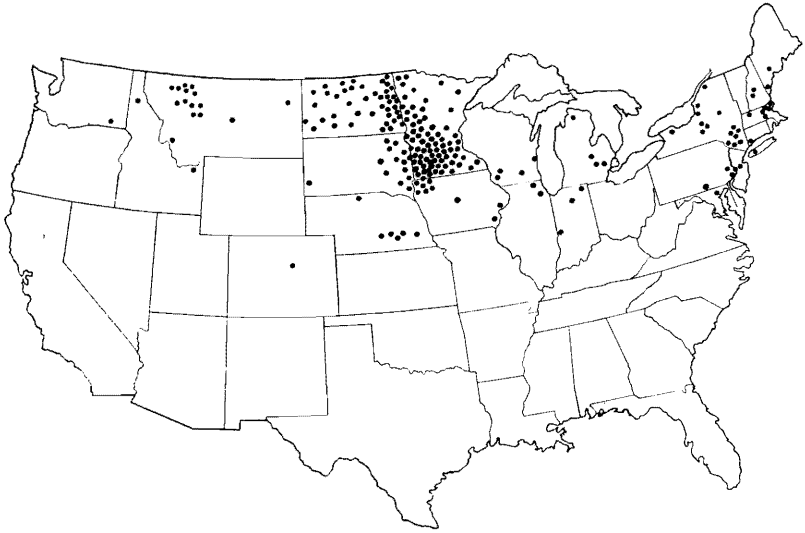

Figure 1. MAP OF THE UNITED STATES SHOWING PRESENT DISTRIBUTION OF LEAFY SPURGE
Each dot represents one or several neighboring infestations.

appear in middle-western and western states adjoining the states that now show infestations.

It is proving to be a serious weed because of the difficulty of eradication. Batho reports that it was introduced into Southwestern Minnesota in a bushel of oats brought from Southern Russia in 1890 (2). In Manitoba the weed occurs in settlements of Russian Mennonites who may have brought the seed with them from Russia. In North Dakota leafy spurge has been known since 1909. Altho a patch of leafy spurge increases in area slowly, especially when compared to such rapid spreaders as quack grass and field bindweed, leafy spurge must be considered a serious weed because of its interference with crop growth and the difficulty of eradication. On this account study of the life history and structure of leafy spurge was begun in an attempt to discover facts that would aid in its control.

DESCRIPTION

Leafy spurge is a long-lived perennial herb, somewhat woody at the base, containing milky sap. It grows to a height of 14 to

40 inches. It propagates by means of seeds and roots. Usually it occurs in clumps rather than isolated (Figure 2). Because of the

Figure 2. PHOTOGRAPH OF LEAFY SPURGE ALONG ROADSIDE NORTH OF FARGO, NORTH DAKOTA, JUNE 18, 1931

characteristic bluish-green color of the leaves and the greenish-yellow color of the flowers the clumps are conspicuous in field or pasture. In the fall many of the leaves turn to a characteristically yellowish or reddish-orange color.

FLOWERS AND FRUIT. There is no calyx nor corolla, but each individual stamen or pistil constitutes a separate flower. One pistillate flower and several staminate flowers, together forming a flower-like cluster, are surrounded by a cup-like involucre (Figure 3-A). On this are four short-horned glands which are at first yellow, gradually turning brown. The entire flower cluster is called a cyathium. As the flowers mature their pedicels elongate and the involucre splits along one side thus permitting the flowers (stamens and pistil) to protrude (Figure 3-C).

The fruit is a three-chambered capsule, explosively dehiscent usually along the line of union of the carpels. Normally each carpel contains one seed (Figures 3-D and E). Nearly 50 percent of the fruits produce only one mature seed, about 35 percent produce two and only 15 to 20 percent produce three. In the vicinity of Fargo the fruits begin to ripen about July 10 and continue into September.

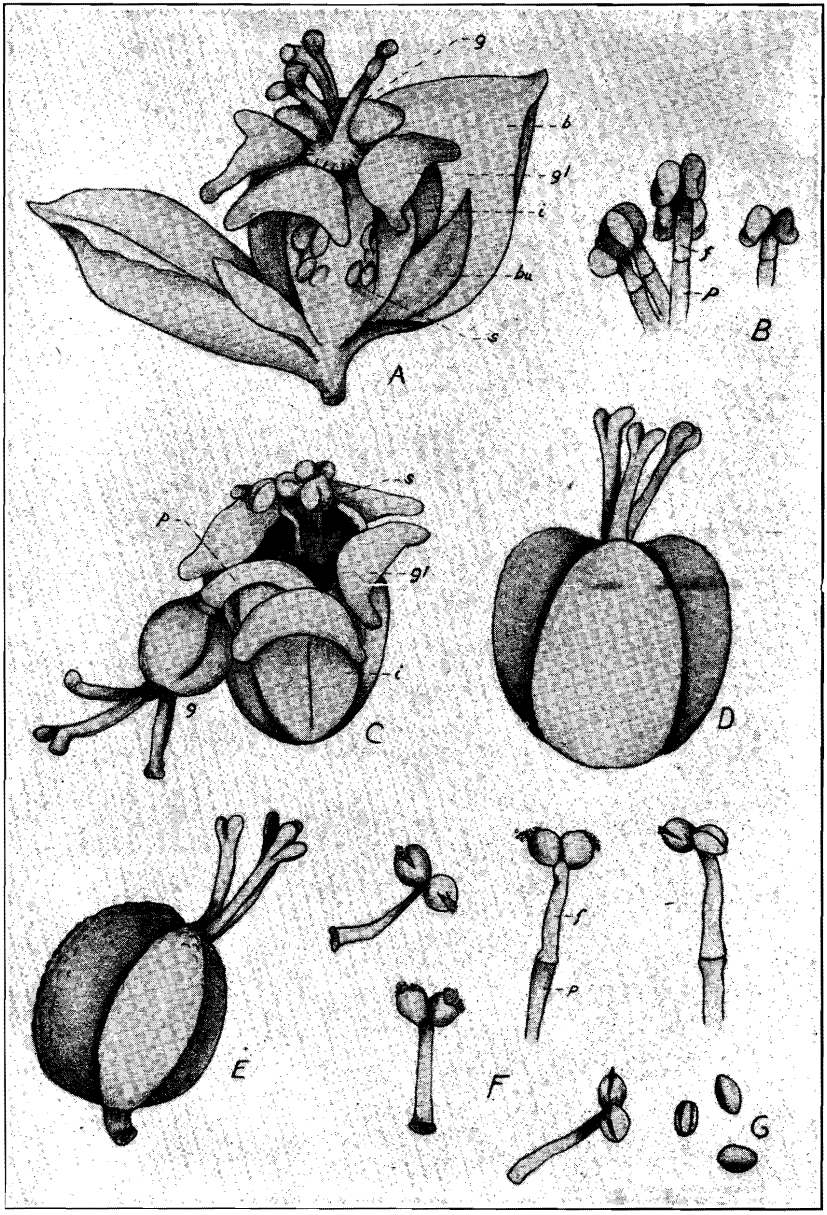

Figure 3. DRAWING OF FLORAL PARTS AND FRUIT OF LEAFY SPURGE

A, the cyathium or flower cluster surrounded by involucre; B, cluster of immature staminate flowers; C, mature flower cluster showing pistillate flower extruding from involucre; D, mature fruit with all three carpels developed; E, mature fruit with only one carpel developed; F, stamens with anthers dehiscing; G, pollen grains; b, bract; bu, flower bud; f, filament; g, gynoecium; gl, involucral gland; i, involucre; p, pedicel; s, stamen.

There is considerable variation in the seeds. The most typical color is light gray, tinged with purple. The less mature seeds are purplish-brown with very little of the gray tinge. A large number of the seeds are light gray mottled with purplish brown. There is a prominent yellowish tubercle, the caruncle, at the narrow end and a brown line extends from this to the opposite end of the seed. The most typical outline of the seeds is oblong but the shorter seeds are usually oval to obovate. Many of the seeds are broadly wedge-shaped. The surface of the seeds shines and is faintly reticulated under magnification. Most of the seeds are between 2 and 2½ millimeters in length and about 1½ millimeters in width or almost as large as the seed of yellow pigeon grass. The seeds are easily crushed.

THE LEAF. In structure the leaves show certain drouth-resistant characteristics (Figure 4). The epidermis has a fairly thick

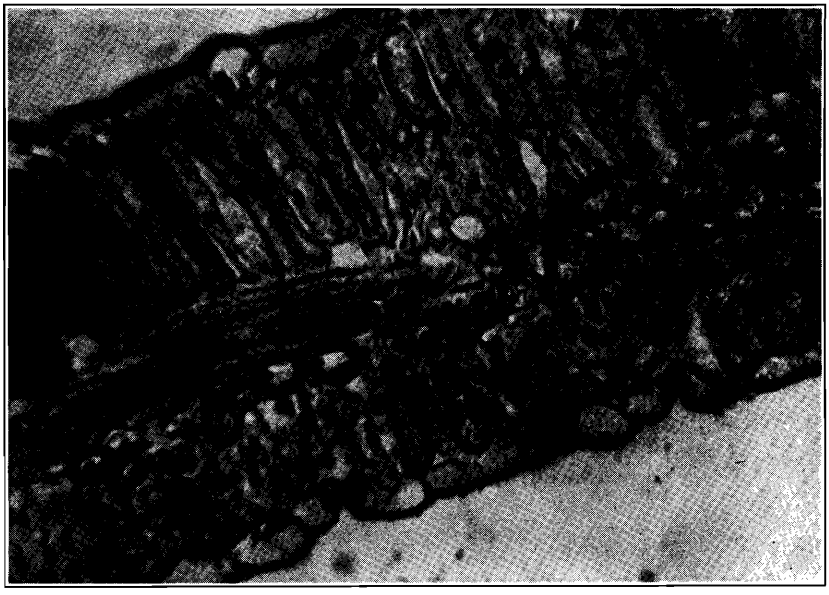

Figure 4. CROSS SECTION OF LEAF OF LEAFY SPURGE

Beginning at the upper side of the photograph note the thick layer of cutin on the upper epidermis, double row of palisade cells, latex cells in cross section (light-colored, round cells in center of picture), longitudinal view of part of vein, palisade-like parenchyma cells in lower portion of leaf, lower epidermis, and stomata with sunken guard cells (dark in color)

layer of cutin, especially toward the margins of the leaf. The stomata are numerous on both surfaces (Figure 5). On the lower surface there is an average of 108 per square millimeter; on the upper surface where they are slightly larger there is an average of 77 per square millimeter. On both upper and lower epidermis

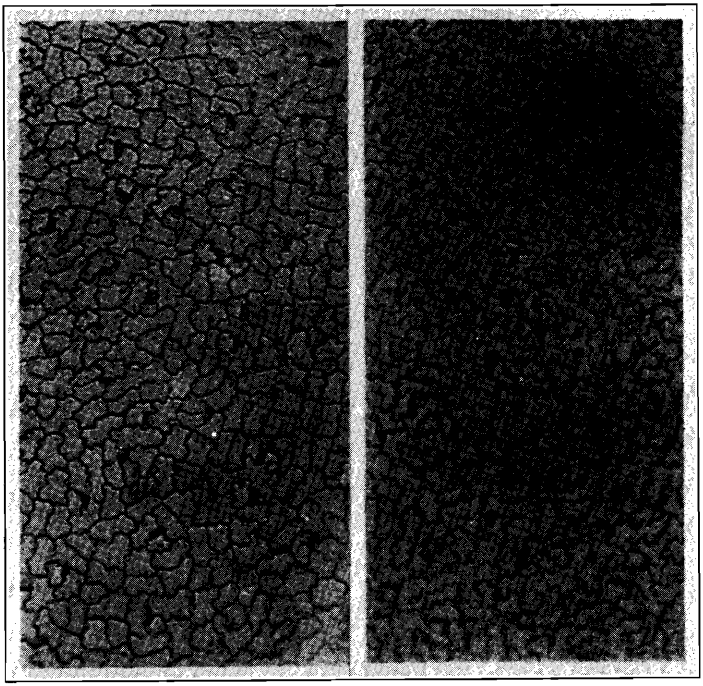

Figure 5. PHOTOGRAPH OF EPIDERMIS OF LEAF OF LEAFY SPURGE
Upper surface of leaf is shown at left. Lower surface is shown at right.

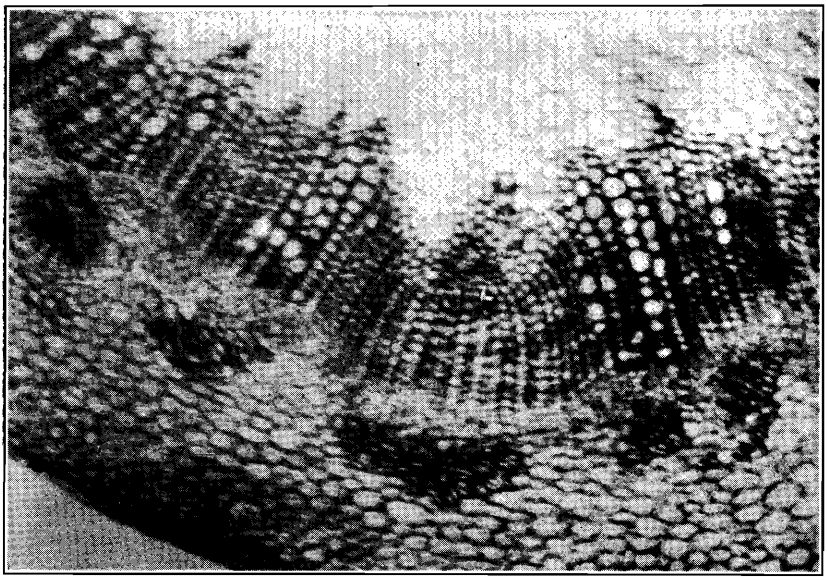

Figure 6. PHOTOGRAPH OF A PORTION OF A CROSS SECTION OF A MATURE LEAFY SPURGE STEM SHOWING XYLEM CYLINDER (DARK) AND SCATTERED BUNDLES OF PHLOEM FIBERS

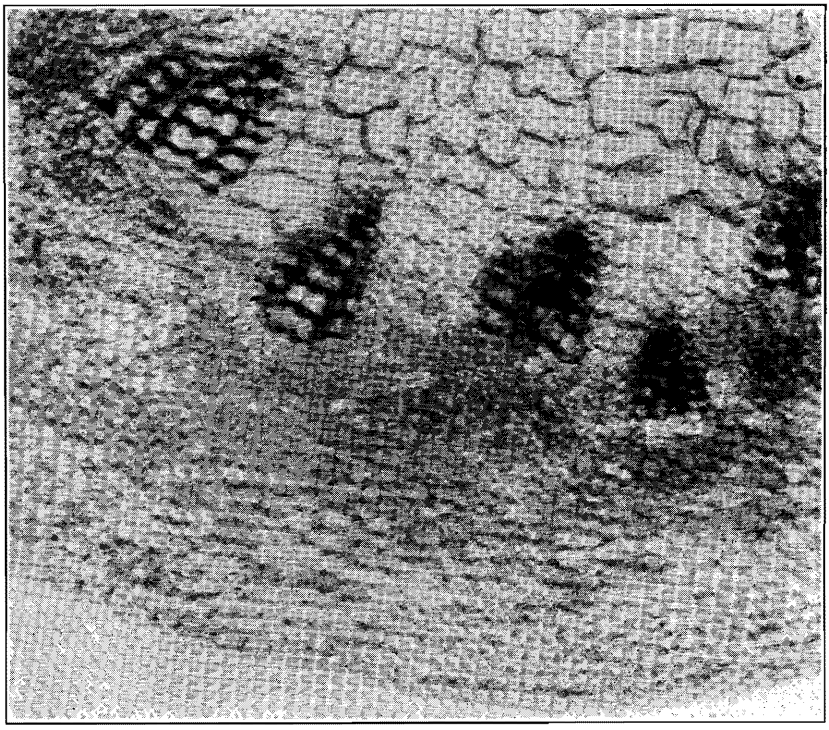

Figure 7. PHOTOGRAPH OF A PORTION OF A CROSS SECTION OF A YOUNG LEAFY SPURGE STEM

Dark areas comprise the xylem. Cambium layer is immediately below.

the stomata are sunken below the surface (Figure 4). The mesophyll is characterized by two rows of long, narrow, compactly arranged palisade cells adjacent to the upper epidermis. One or two rows of irregular palisade cells also occur adjacent to the lower epidermis. In the middle of the leaf is a narrow layer of compactly arranged small sponge cells. Both palisade and sponge cells contain numerous, rather small, chloroplasts. The air spaces are small. The latex tubes are small and numerous.

THE STEM. Usually several erect unbranched stems arise from the base (Figures 2 and 9). The stems become fairly woody toward the base. Axillary branches develop frequently when the stem tip has been injured.

The structure of the mature stem is characterized by a continuous, relatively wide cylinder of xylem, resembling that of a woody

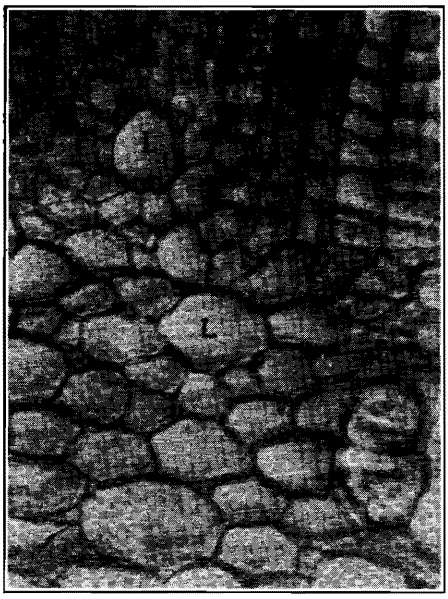

Figure 8. PHOTOGRAPH OF LATEX CELLS (L) containing MILKY SAP, IN LEAFY SPURGE STEM

plant (Figure 6). The outer margin of the xylem is wavy. The inner margin is very irregular and jagged. As in many plants containing latex the phloem is inconspicuous. Phloem fibers occuring in groups are well developed in mature stems but are lacking in young stems (Figure 7). Latex cells occur irregularly in the phloem and cortex (Figure 8). The cortex consists of thin-walled, rather small parenchyma cells, most of which contain chloroplasts (Figures 6 and 7). There are one to three rows of chlorenchyma cells adjacent to the epidermis. The large amount of xylem makes the older stems woody and tough.

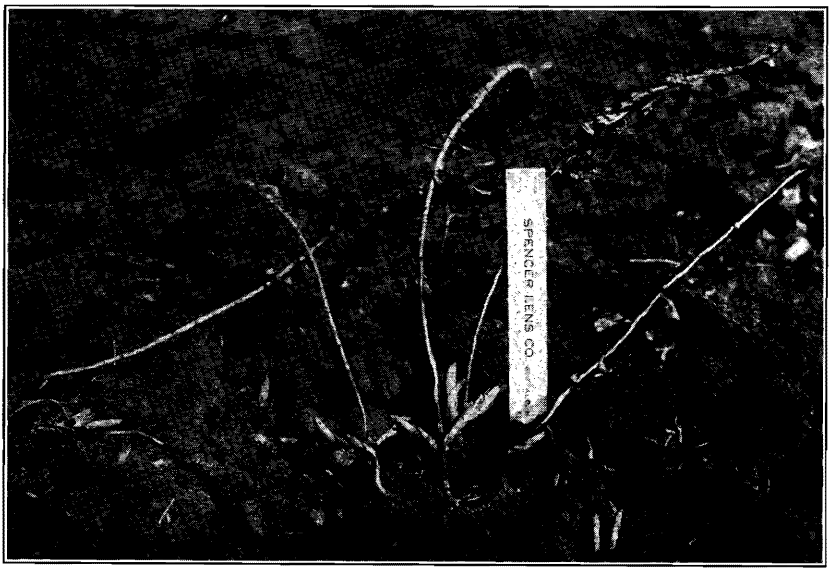

Figure 9. PHOTOGRAPH OF SHOOTS OF LEAFY SPURGE AT BEGINNING OF SECOND SEASON

A large number of buds developed at the base of the old stalk. April 10, 1932.

RATE OF SHOOT GROWTH. The shoots from the largest pieces of roots grew most rapidly and became tallest while the shoots from the shortest pieces grew less rapidly and did not become as tall (Figure 10).

In the following spring vigorous shoot growth began early. As many as 19 buds were found at the base of a single stalk. From six to eight stalks usually grew from each plant (Figure 9), but one plant had 15 stalks. On April 5 the average height

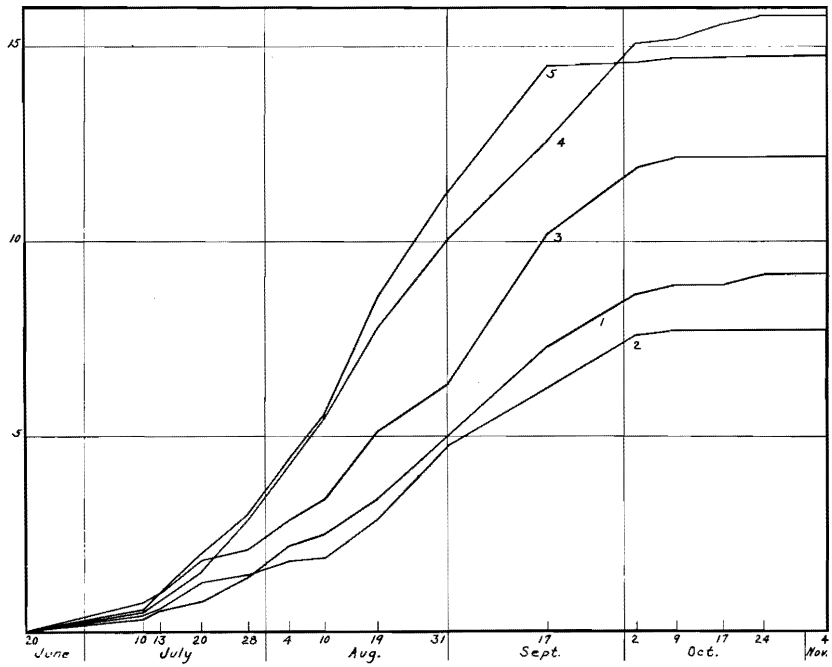

Figure 10. RATE OF SHOOT GROWTH

The graph shows the first season's growth in length of leafy spurge shoots from root pieces transplanted on June 20, 1931: 1, shoots from pieces ½-inch long; 2, ¾-inch long; 3, 1-inch long; 4, 3½-inches long; 5, 4-inches long.

of 20 shoots was ½ inch. On April 19 the average height was 1 1/5 inches. From then on growth was rapid. On April 23, the average height was 3½ inches, and on April 30 it was 12½ inches. This rapid early growth gives leafy spurge a great advantage over most crop plants, even alfalfa and sweet clover. By the end of May flowers began to appear.

THE ROOT. The most formidable part of the plant is its root system. This is because of its numerous coarse and fine roots, which occupy a large volume of soil. They are woody and tough in structure. There are numerous buds. New shoots are readily produced by small pieces of roots.

The root system of mature plants was studied in the heavy Fargo clay soil near Fargo. The trench method was used. The root system of a representative plant is shown in Figure 11. One of the chief characteristics of the root system was the extreme development of fine, white roots both in the upper 2 feet of soil and at greater depths where conditions were favorable. The maximum depth to which the root systems of several plants extended was at the water-table, 8 feet below the surface. In the first foot the roots were brown and woody and often as much as ½ inch in diameter. In the first foot the tap root forked into two or more branches, each about ¼ inch in diameter, gradually tapering to about ⅛ of an inch below 4 feet. At 6 feet the roots were frequently 1-16 of an inch in diameter. With decrease in size the roots became more yellowish in color. The smallest ones were white and brittle. The smaller roots frequently followed a zig-zag course thru the soil. Often they formed dense mats in the moist cracks in the columnar clay.

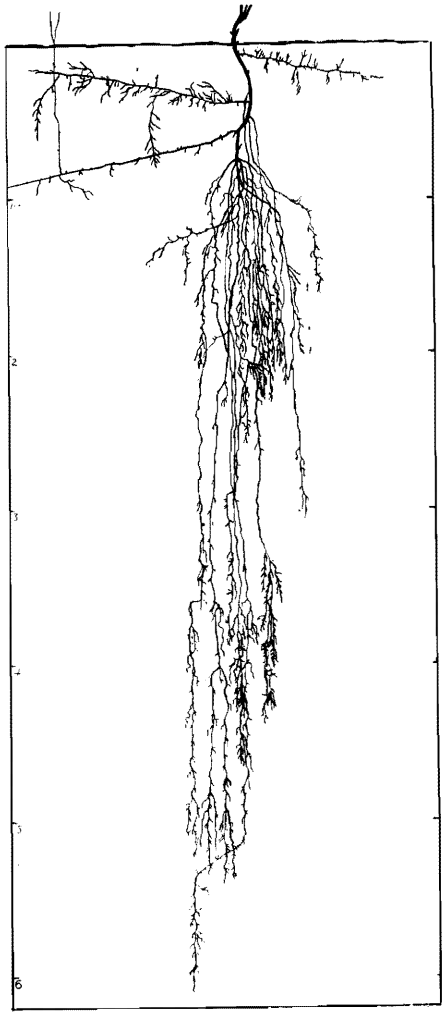

Figure 11. DRAWING OF A ROOT SYSTEM OF A MATURE LEAFY SPURGE PLANT GROWING IN FARGO-CLAY SOIL

Note prominent buds on horizontal root. Buds were found on vertical roots to a depth of 40 inches.

Large branch roots, extending more or less horizontally from the main vertical roots were found down to a depth of 20 inches. They were found most frequently at about one foot. These roots usually gave rise to one or more shoots at distances between 1 to 3½ feet from the parent plant. In a dense patch of leafy spurge these propogative roots and their shoots form an intricately interlaced network in the soil. Together with the numerous fine roots the mass of roots in the soil is enormous.

In view of this it is not surprising that other species cannot compete with leafy spurge.

Pink-colored buds were numerous on most of the larger roots in the first foot of soil. As depth increased the buds became smaller and less numerous. At 16 inches the buds were occasionally ⅛ inch long. The maximum depth at which buds were found was 42 inches. Experimental work in the greenhouse showed that the roots grew downward about twice as fast in sandy soil as in clay. The roots in the latter were, however, more branched.

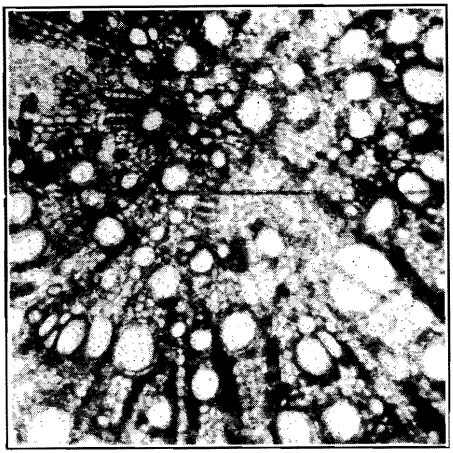

Figure 12. PHOTOGRAPH OF A PORTION OF A CROSS SECTION OF LEAFY SPURGE ROOT

The numerous, large tracheal tubes make the root efficient in transferring water to the stem.

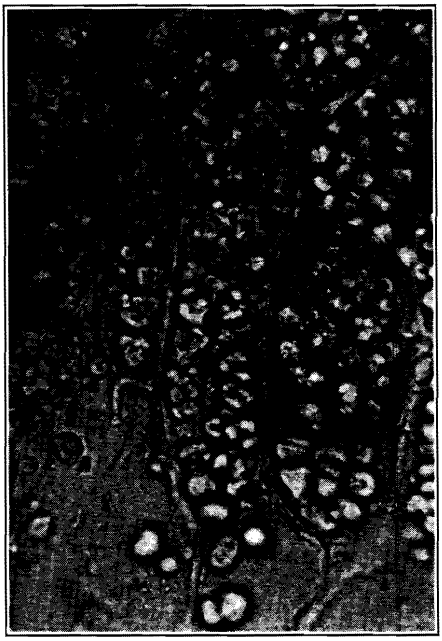

Figure 13. PHOTOGRAPH OF STARCH GRAINS IN PARENCHYMA CELLS OF LEAFY SPURGE ROOT

It is largely on account of the abundance of starch that a long period of fallow is required to starve the roots.

In cross section the roots showed an irregular arrangement of the stele (Figure 12). The triarch arrangement was most common altho tetrarch, pentarch and polyarch arrangements occurred also. The tracheal tubes were numerous and large thruout the root system (Figure 12). The wood fibers were not very thick-walled. The medullary ray cells were small and contained starch. The parenchyma cells of the cortex and the ray cells were filled with compound and simple starch grains (Figure 13). These cells were filled with starch in the late fall as well as in early spring. Latex cells were found in the phloem region and in the cortex in the same position as in the stem. The periderm was well developed (Figure 14).

Figure 14. CROSS SECTION OF A PORTION OF LEAFY SPURGE ROOT SHOWING CORK CELLS IN UPPER PART OF PHOTOGRAPH

Note starch grains in parenchyma cells of cortex in lower part of photograph.

The stems of leafy spurge may extend underground a foot or more before the transition region is reached. Externally they are difficult to distinguish from the roots except that small branch roots are infrequent or lacking and pinkish buds are numerous down to a depth of about 15 inches. These buds produce shoots very readily, especially if the upper part of the stem has been injured or killed either by cutting or by chemical spray (Figure 15). Cultivation of the soil also stimulates the development of the buds (Figure 16). Lateral branches may arise from the main root or from the underground portion of the stem and run horizontally for several feet, sending up shoots at irregular intervals. Frequently these horizontal roots follow the plow line, 4 to 6 inches below the surface. In structure they are transitional between roots and rhizomes. A periderm (Figure 14) formed from the outer cortical cells, overlaid by a brown, corky layer, gives the roots a brown color. Like the normal roots, they contain an abundance of starch.

THE LATEX. The entire plant, from the roots to the inflorescence, yields, when injured, a ready flow of white, sticky latex. Characteristic cigar-shaped starch grains, 18 to 40μ long and 4 to 6μ wide, which stained readily with iodine were found in it (Figure 17). Their shape is very different from the starch grains found in the parenchyma of the roots. The walls of the latex cells were very thin. When unstained these cells could not always be distinguished from the adjacent parenchyma cells. The walls reacted to safranin if strongly stained. In a thin cross-section of the stem the cells just below the surface were more conspicuous because of their seeming emptiness in contrast to the other cells which were filled with starch. No characteristic markings were noticed in the longitudinal section. Apparently leafy spurge is similar to most other species of Euphorbia in having

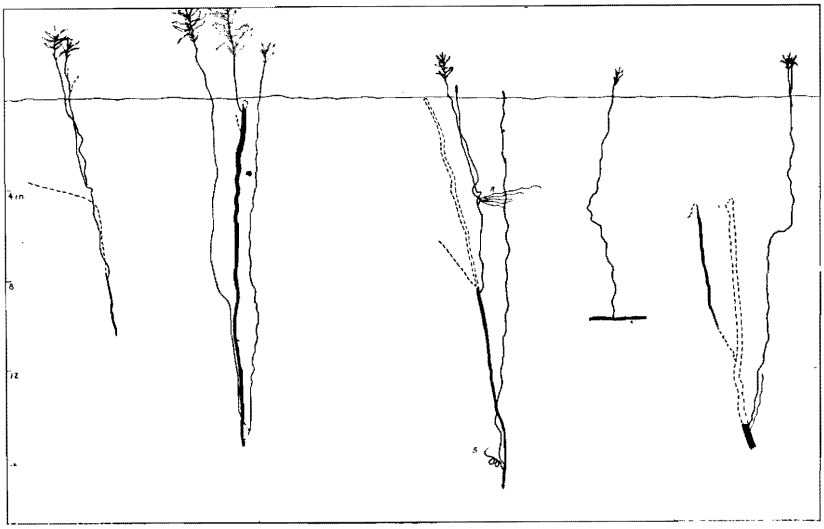

Figure 15. DRAWING OF SHOOTS OF LEAFY SPURGE ARISING FROM ROOTS TREATED WITH SODIUM CHLORATE
Dotted lines indicate killed parts. Note new roots produced on new shoot at R.

Figure 16. EFFECT OF CULTIVATION ON PRODUCTION OF NEW SHOOTS
As many as 12 new shoots may arise from depths of 8 to 21 inches on roots whose tops have been cut off. Photograph was taken on October 17, 1931. This seemingly strong aspect of the weed is actually a weak one because the food supply in roots is used up more rapidly. New shoots are very brittle. Ice pick is at depth of 21 inches.

latex tubes which are structurally one cell, originating in the embryo. The latex tubes "exhibit continued apical growth and send ramifications into each new portion of the tissue in which they occur" (15, vol. 2, p. 45).

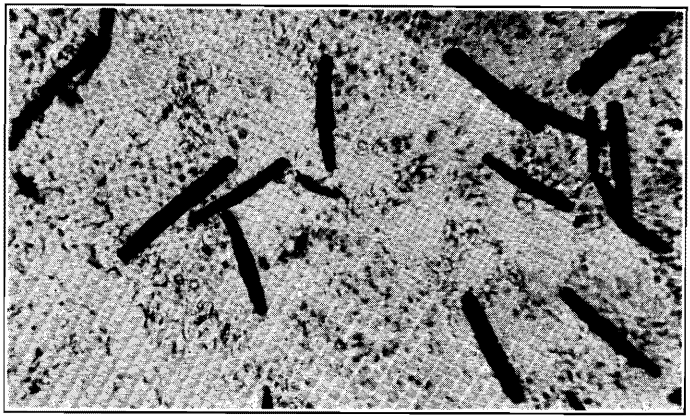

Figure 17. PHOTOGRAPH OF STARCH GRAINS IN LATEX OF LEAFY SPURGE (x 500)

DISSEMINATION OF LEAFY SPURGE

Leafy spurge is disseminated very readily by seeds and by roots. The original infestation in a new area is probably in most cases by seed. That this occurs relatively infrequently in the sowing of crop seeds is indicated by Crowley in a report given at the 1931 meeting of the Seed Analysts of America. For the year beginning July 1, 1930, the seeds of leafy spurge were not found in any of the 11,171 samples received at the Minnesota Laboratory for testing. The probable reason given for this was that the seeds fall soon after they ripen and before the grain is cut. It has been reported that the seeds are carried by birds and thus reach new fields. New patches usually appear in abandoned fields and along roadsides.

Once a patch is started the roots appear to be the more important in spreading the weed because the percentage of seedlings surviving appears to be very low. Observation indicates that a patch increases in area slowly but surely.

THE SEEDS. The seeds of leafy spurge are discharged from the ripe, dry capsules by a sudden septicidal dehiscence. In order to determine the distance to which the seeds were shot measurements were taken of fruit drying indoors and of those ripening naturally out-of-doors.

Stalks with ripe fruit were set up indoors so that the tops projected about 11 inches above the floor. After 24 hours most of the capsules had burst. Rugs had been placed on the floor to prevent the rolling of the seed. The maximum distance to which the seeds had been shot was 13 feet and 3 inches. Several seeds were found between 12 and 13 feet and a large number were found around 9 feet. A few were found within the first foot. The largest number was from 2 to 4 feet from the bottle.

An experiment was performed out-of-doors from July 18 to 21, 1931, by isolating a group of nine fruiting stalks. All fruit-bearing spurge stalks within a radius of 50 feet were cut. Canvas was then spread over an area of about 480 square feet with the stalks near the center. Observations were made for 4 days on the number and location of seeds found and the number of capsules that burst. On the last 2 days hourly records were taken of temperature, humidity, wind direction and velocity, to determine what part, if any, these factors played in the dissemination of the seeds. In all, 54 seeds were located. The maximum distance to which they were shot was 13½ feet. This was, however, the greatest radius of the canvas so there was a possibility that some of the seeds went even farther. Only one seed fell in the first foot, so it seems that it is unusual for the capsules not to shoot the seeds. The distribution of the seed between 1 and 13 feet was fairly uniform. Most of the fruits opened after 2:00 p.m.

No relationship could be found between the opening of the capsules and temperature, humidity and sunshine. During the experiment it was mostly sunny. The temperature from 9:00 a.m. to 5:00 p.m. ranged between 74 and 96° F., the relative humidity 64 to 23 percent. The wind was from the northwest. Of the 54 seeds, 23 went with the wind, 20 at right angles to it and 11 against it. The wind, then, probably had some influence on the direction of dissemination.

Germination of the Seed. Tests were made of seed germination in the North Dakota State Seed Laboratory and outdoors under natural conditions. On July 23, 1931, a quantity of seeds were put thru a blower and sorted, according to weight, into three lots: heavy, in which the average weight per seed was 3.65 milligrams; medium, 3.00 milligrams; and light, 2.25 milligrams.

Samples of each of these, as well as unsorted samples of 1930 and 1931 seed were placed in a germinator at temperatures of 20° C. for 18 hours, alternating with 30° C. for 6 hours. Each sample

consisted of 100 seeds. The number of seeds that germinated was counted at intervals until August 22 when no additional germination occurred and the seeds became moldy. The results are given in Table 1.

On February 22, 1932, seven months after ripening, three lots of 100 heavy-weight 1931 seeds were placed in germinators at various temperatures. One lot was subjected to a continuous temperature of 20° C., another lot to a continuous temperature of 30° C., and the third lot to alternating temperatures of 18 hours at 20° C. and 6 hours at 30° C. The results as given in Table 2 show that better germination is secured at higher and at alternating temperatures than at lower ones.

Table 1. PERCENTAGE OF GERMINATION OF LEAFY SPURGE SEED PLACED IN GERMINATOR ON JULY 23, 1931

Description of sample	July		August							
	27	30	1	3	5	7	10	13	17	22
Heavy, 1931	10	28	47	56	61	61	66	69	69	70
Medium, 1931	8	28	41	47	51	54	55	58	60	60
Light, 1931	4	18	28	34	38	40	43	46	47	51
Unsorted, 1930	17	47	53	59	62	63	63	63	63	63
Unsorted, 1931	6	16	36	42	50	52	53	54	54	55

Figure 18. LEAFY SPURGE SEEDLINGS PHOTOGRAPHED IN THE FIELD

Seedlings are easily recognized because color is frequently more or less pink and when stem is broken the milky sap exudes. April 15, 1932.

In the summer of 1931, 400 seeds that had just ripened were planted in the field about ½ inch below the surface. Two hundred of these were planted in soil in a shallow pan with a perforated bottom and then placed in the ground so the top was level with the soil surface. The other 200 seeds were planted directly in the soil. The germination within the following few days was about 3 percent. In the following spring 69 percent of the lot in the pan appeared. Only 50 percent of those in the soil germinated. Very few, if any, of the seedlings could reach maturity because by May 15 less than 10 percent were alive. It has been observed in fields near Fargo where leafy spurge plants are numerous that very many seedlings appear about April 15 (Figure 18) and that most of these seedlings soon die.

The root system of the seedlings develops rapidly. Two months after the cotyledons had appeared the root system of the most vigorous seedlings had penetrated to a depth of 24 inches (Figure 19). Branch roots were not numerous. The tops at this time were about 5 inches high.

In germination, the two cotyledons are pressed closely together as the hypocotyl elongates and drags the rather long and narrow cotyledons above the surface (Figure 18). The seedlings are easy to identify because

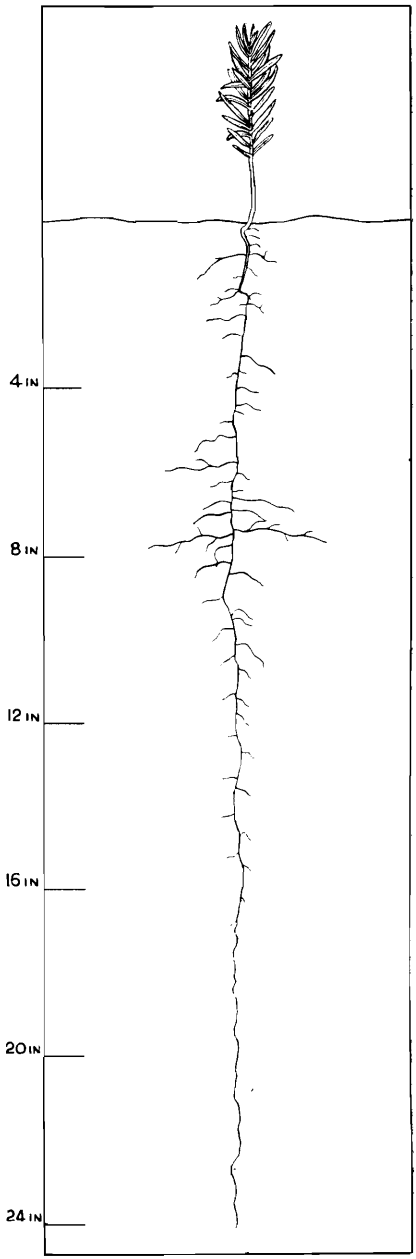

Figure 19. ROOT SYSTEM OF SEEDLING

Drawing was made of a plant growing in Fargo-clay soil. June 16, 1932.

of the shape of the cotyledons, the reddish-colored stem and the abundant latex that exudes when the tissue is broken.

Table 2. PERCENTAGE OF GERMINATION OF LEAFY SPURGE SEED 7 MONTHS AFTER RIPENING, PLACED IN GERMINATORS ON FEBRUARY 22, 1932

Temperature of Germinator	February 28	March 1	March 5	March 13
20°C.	4	4	4	4
30°C.	17	20	21	74
Alternating 20°C. & 30°C.	67	73	84	84

THE ROOTS. Because of the large numbers of buds and shoots produced by the roots, experiments were performed on the effect of size of piece on shoot production, on the degree of drying that the roots could endure, and on the depth of planting portions of the roots.

SIZE OF PIECE. On June 20, 1931, 100 root pieces, ⅛ to 3/16 inch in diameter, were planted 2 to 3 inches deep, 4 inches apart in the row, in moist, clay soil out-of-doors. These pieces were divided into 10 lots, each lot varying in length from ¼ inch to 4 inches. Three weeks after planting it was noted that all of the pieces in each lot produced shoots except in the ½-inch and ¼-inch lots. No shoots were produced from the ¼-inch pieces but 60 percent

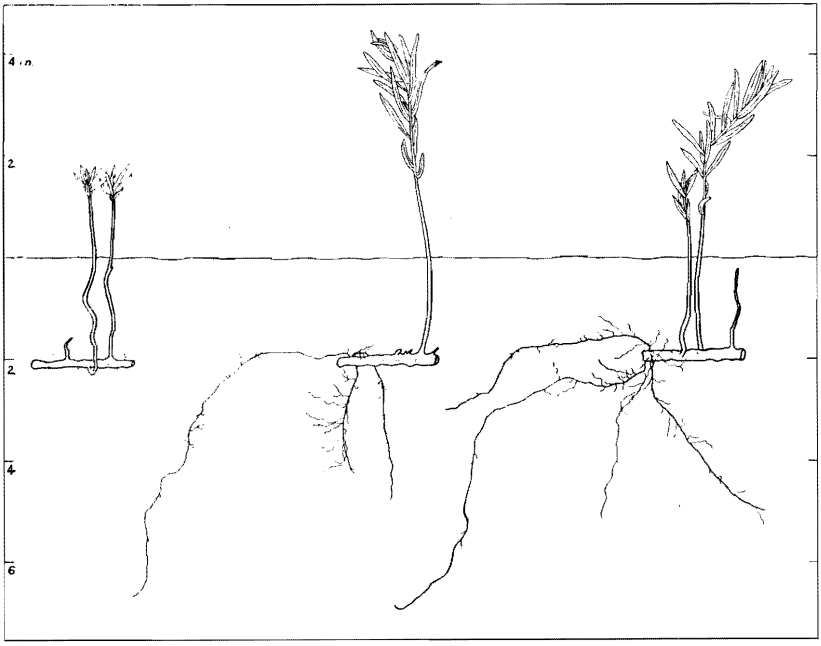

Figure 20. LEAFY SPURGE PLANTS, 1 MONTH OLD
Drawing was made of plants that had grown from 2-inch pieces of roots. July 25, 1931.

of the ½-inch pieces produced new shoots. The rate of growth was rapid. About a month after planting (July 25) the 2-inch pieces had roots down to 8 inches and tops up to 4 inches (Figure 20). On September 15, about 3 months after planting, the roots penetrated down to 43 inches, horizontally about 12 inches, and the tops had grown to about 10 inches in height (Figure 21). Branches were numerous on the roots.

On June 20, 1931, four lots of 10 pieces each were planted. These were all 2 inches long but ranged in diameter from 1/16-inch to ⅜-inch. All of the pieces except one produced vigorous shoots.

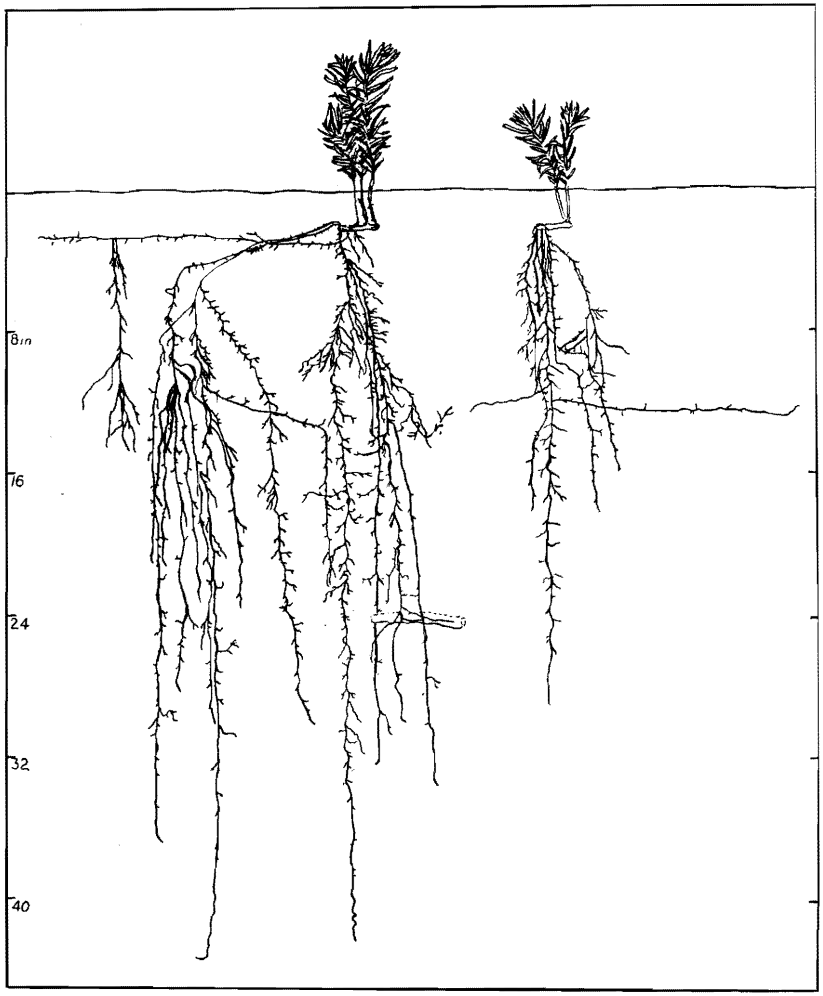

Figure 21. LEAFY SPURGE PLANTS, 3 MONTHS OLD
Drawing was made of plants that had grown from 2-inch pieces of roots. September 15, 1931.

DEPTH OF PLANTING. Root pieces 3 inches long and ¼-inch in diameter were planted in clay soil out-of-doors at depths ranging from the surface to 24 inches. There were 10 pieces at each depth. The roots were kept moist from the time they were dug until they were planted. The results were as follows: none of those planted on the surface or at the ½-inch depth produced shoots, 7 of those planted at the 1-inch depth produced shoots, 9 from the 2-inch depth, 5 from the 4-inch depth, and 7 from the 6-inch depth, none from the 10-, 14- and 24-inch depths. The pieces planted on the surface and ½ inch deep failed to grow because of the lack of moisture in the surface soil.

DURATION OF DRYING. In July, 1931, an experiment was performed to determine the resistance of the roots to drying. The roots were cut into pieces 4 inches long. They were uniformly ⅛- to 3/16-inch in diameter. The average moisture content (dried at 100-110°C.) of three samples of ten 4-inch roots taken directly from the soil was 61 percent. For each duration of time 20 pieces of roots were placed on the dry soil out-of-doors. At the end of the drying period 10 pieces were used to determine their moisture content and the other 10 were then planted under optimum conditions. The results are given in Table 3.

Table 3. SHOOTS PRODUCED FROM ROOT PIECES AFTER DRYING
Ten pieces were planted in each exposure period.

Exposure period	Moisture content after drying	No. of pieces producing growth
	Percent	
Fresh from ground	61.3	10
15 minutes	58.6	10
30 minutes	52.1	10
1 hour	52.9	9
2 hours	43.2	6
4 hours	45.3	0
10 hours	13.4	1
24 hours	7.8	0

In another experiment pieces of roots, 1 to 2 feet in length, as cut by the cultivator and brought to the surface in the field were dried in the hot sun from 3:00 p.m. to 6:00 p.m. None of these grew when planted. During this period the relative humidity was about 45 percent, the air temperature at about 3 feet was 30°C., and the temperature on the surface of the soil where the root-pieces were ranged from 41°C. to 48°C.

The well-developed cork (Figure 14) on the surface of the roots and the large amount of latex within the tissues make them fairly resistant to drying. A hot, dry day is ideal for plowing or cultivating leafy spurge because the roots will then be killed in about 3 hours. On cooler, moister days a longer time is required for killing the roots and the spreading of the plants by root pieces is more likely to occur.

CONTROL OF LEAFY SPURGE

Experiments in the control of leafy spurge were started in 1931. They have not yet been carried over a long enough period of time to yield sufficient data upon which to base definite conclusions. It appears, however, that cultivation must be continued at frequent intervals thruout at least two growing seasons in order to destroy an infestation. Dense stands have been destroyed by the use of sodium chlorate. It appears that a total of at least 6 to 8 pounds per square rod are necessary. The applications were distributed thruout the season beginning July first. Common dairy salt has also been used successfully in destroying the weed. The detrimental effects of common salt are more severe and lasting upon the soil than sodium chlorate. Since this weed spreads slowly, but eradication is difficult, it is particularly important to find and destroy it when it first appears.

SUMMARY

Leafy spurge is a perennial herb containing latex. It occurs in fields, pastures, roadsides, abandoned fields and other waste places. It has a wide distribution in northern United States, occurring from Maine to the state of Washington and as far south as Colorado and Nebraska. It also occurs in Canada.

The leaves are moderately thick, firm and drouth-resistant in structure. The stem structure is simple. Xylem is abundant but other supportive cells are scarce or lacking.

The root system is well developed. The large tap root begins to branch into a number of large, woody, brown-colored branches near the surface. The fine roots are numerous, especially near the surface and where suitable conditions occur in the deeper soil. The maximum depth at which roots were found in heavy clay soil was at the water-table at 8 feet. The maximum lateral spread was 3½ feet. In structure the root consists chiefly of xylem. Pith is not present. The cortex and periderm are also well developed. The parenchyma cells in the cortex and in the medullary rays are well filled with starch grains. The phloem region is small.

Latex is found in all of the organs. Cigar-shaped starch grains occur in it. In the stem and root the latex cells were found in the phloem and cortex.

Leafy spurge spreads readily by seeds and roots. Seeds are forcibly discharged from the capsules up to a distance of at least 13 feet from the parent plant. The percentage of seed germinating in the laboratory ranged between 50 and 80 percent; in soil in the field about 70 percent. The seedlings are tender and small. Most of them soon die.

Pieces of roots as small as ½ inch long and about ⅛ inch in diameter produced new shoots which grew very rapidly. Pieces of roots, 3 inches long by ¼ inch in diameter produced new

shoots from at least 6 inches deep. Small or large pieces of the roots will withstand up to 2 to 3 hours of drying in the hot sun before they are killed.

The growth rate of shoots of leafy spurge is rapid in early spring giving the weed an advantage over crop plants.

Experiments are under way on the control of leafy spurge. The data accumulated so far indicate that it may be killed by means of sodium chlorate or by two seasons of frequent and careful cultivation. Since eradication is extremely difficult it is particularly important to find and destroy leafy spurge when it first appears.

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GLOSSARY

CARUNCLE. A wart-like swelling.

CHLORENCHYMA. A group of cells in the leaf containing chloroplasts.

CHLOROPHYLL. The green pigment in plants.

CHLOROPLASTS. Small bodies in cells containing the green pigment called chlorophyll.

CORTEX. The outer tissue of stems and roots composed chiefly of parenchyma cells, between the epidermis and stele.

COTYLEDON. A seed-leaf, as each half of a lima bean seed.

CUTIN. The outer water-proof layer of the epidermis of leaves, stems, etc.

DEHISCENCE. Splitting into definite parts.

EPIDERMIS. The skin or covering of a plant.

LATEX. Milky sap found in some kinds of plants.

MEDULLARY RAY. A strand of thin-walled tissue extending between pith and cortex and separating the woody tissue into more or less V-shaped regions.

MESOPHYLL. The interior tissue of the leaf exclusive of veins.

PALISADE CELLS. The perpendicularly elongated cells in the leaf.

PARENCHYMA. The soft, succulent tissue commonest in plants, composed of thin-walled cells.

PEDICEL. The stalk of a single flower.

PENTARCH. The arrangement of the xylem and phloem in 5 strand found in some young stems and roots.

PERIDERM. The outer layer of bark.

PHLOEM. The thin-walled cells in which foods, as sugar, are transported in plants.

POLYARCH. The arrangement of xylem and phloem in many strands found in some young stems and roots.

SEPTICIDAL. At or along the partition of a pod.

SPONGE CELLS. Loosely arranged cells of irregular shape in the leaf.

STELE. The central portion of stems and roots composed of phloem, cambium, xylem and pith.

STOMA, plural STOMATA. Small openings in leaves which permit exchange of gases.

TETRARCH. The arrangement of xylem and phloem in four strands found in some young stems and roots.

TRACHEAL TUBE. A water-conducting tube in plants.

XYLEM. Cells in veins of leaf or central cylinder of stems and roots whose walls are thick and woody.