

permitting leafy spurge to take over by utilizing the advantages of shooting seeds and invading roots.

History: It was initially believed that leafy spurge was introduced to this continent in the early nineteenth century and spread westward through USA and Canada. The first herbarium specimen was collected in Newbury, Massachusetts in 1827. Examination of more recently collected samples from across North America has shown that leafy spurge is not a single species but an aggregate of closely related variants suggesting that multiple strains were imported at different times from Europe and Asia, probably in grass or cereal seed or in ship ballast. It appears that leafy spurge of European origin is found along the east coast and that areas of the Great Plains are infested with leafy spurge imported from Russia. Studies are in progress to determine if different control measures are required for plants in various areas.

Growth and Development: The vigorous and extensive growth of long roots capable of regeneration provides leafy spurge with the extraordinary capability to invade, colonize and persist. North America is essentially free of the pests and diseases that control this plant in its native European habitat. Furthermore, leafy spurge is toxic to some animals and unpalatable to most, so it thrives in areas where competitive plants are heavily grazed.

Reproduction: The female flowers of leafy spurge develop prior to the male, minimizing self pollination. The pollen and nectar are important food sources for insects, and their avid feeding results in high rates of pollination. Seed production is high even when leafy spurge is grown in competition with perennial grasses. Seed maturation often coincides with hay harvest, aiding in the widespread dissemination of the noxious weed. Viability of seed varies with depth of burial; in one representative experiment, more than 50% of the seeds recovered from a depth of 8" germinated, but seed closer to the surface did not survive as well. In addition to very efficient reproduction by seed, leafy spurge spread occurs by crown and root buds.

Response to Herbicides: Herbicides are commonly used to control or limit the spread of leafy spurge, but this practice is far from a complete answer. Numerous selective and non-selective herbicides in various combinations or sequences applied with specialized equipment have been evaluated over the years. Some formulations do a good job of controlling top growth but do not effectively kill roots; all are expensive.

Control of leafy spurge in established forage grasses can usually be accomplished by spraying with maximum labeled doses of selective herbicides such as 2,4-D, dicamba and picloram, followed by fertilizing to encourage the growth of the forage grasses. Spraying should be done when leafy spurge is between the early bud and first bloom stage and again usually in the fall, when the leafy spurge regrowth is 4-6 inches high. This routine must be repeated each year until the weed is eliminated.

On smaller areas, such as homesites, leafy spurge can be managed with the application of 2,4-D and dicamba when flowers and seed are developing or with glyphosate alone in midsummer or after fall regrowth, taking care to avoid non-target plants.

Response to Cultural Methods: Intensive cultivation and the planting of competitive crops are useful methods for the control of leafy spurge in cultivated fields, but with heavy infestations on rangeland, the addition of chemicals, grazing sheep or goats is usually necessary to further diminish weed growth.

Biocontrol Potentials: The high cost, relative inefficiency and environmental impact of herbicides have all contributed to a strong interest in natural control systems, such as insects, interspecific competition and grazing animals. Studies nearly 50 years ago reported that three or more years of continuous sheep grazing significantly reduced the density of established leafy spurge growth. More recently, interest has shifted to the Angora goat, which may provide a good level of weed suppression at less cost than sheep. The major drawback to the approach is the difficulty maintaining sufficient number of sheep or goats to consume spurge plants before they seed but not let the animals overgraze the grass. Low cost electrical fencing, llamas as sheep herders, and new methods of range weed management are among the many innovations currently being evaluated.

Numerous insects and specimens of fungi have been collected from leafy spurge growing in Europe, Asia and North America and are being evaluated as potential biocontrol agents. The studies are promising. The USDA selected and released in test plots, five species of insects which attack different parts of the leafy spurge plant; some feed on leaves or stems, others on root crown, shoot tip or deep secondary roots. Among the insects selected for first round of testing is the feramblyiid long horned beetle, imported from Hungary and Italy, *Oberea erythrocephala*. The adult feeds on the outside of the plant and girdles the stem. The larvae bore into the stem and root crown and consume the inside of the plant. Three species of chrysomelid flea beetles, from central Europe, *Aphthona flava*, *Aphthona czwalinea* and *Aphthona cyparissiae* are in the study group. The adult stage of these beetles feed on leaves for about three months and then the females produce about 250 offspring each, which mine the roots and eat the fine root hairs of the succulent spurge plant. The final member of this voracious quintet is the ceridomyiid midge, a species of *Bayeria*, a tiny fly whose natural home was Italy. The adult flies live only a day or two but during this time, each generation of females lay about 6 dozen eggs, which yield larvae that feed on new shoots causing the formation of galls where flowers would normally appear.

Together this array of ravenous eaters weaken and destroy the undesirable weed. Research scientists are trying to identify the combination of spurge enemies that achieves maximum control in their experimental plots and then test that recipe on a large scale.

It is not expected that biocontrol by itself will lead to the elimination of leafy spurge. The plan is to make biocontrol part of an integrated weed management effort which will include competitive planting, cultivation, herbicides and selective grazing. Leafy spurge is not a problem in its native lands. We should be able to create an environment in North America that restores that noxious weed to its proper place in the plant kingdom.

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