Picloram Translocation in Leafy Spurge

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Leafy spurge (*Euphorbia esula* L.) is an introduced deep-rooted perennial weed that infests over 1.2 million acres in North Dakota (7). Leafy spurge is primarily found in untilled non-cropland habitats such as abandoned cropland, pasture, rangeland, woodland, roadsides, and waste areas (9).

Leafy spurge causes economic losses due to both reduced forage production and avoidance of weed-infested areas, especially by cattle. In North Dakota, cattle used 20 and 2 percent of the forage available in zero- and low-density (less than 20 percent cover) leafy spurge infestation by mid-season (2). Moderate and high-density infestations were avoided until early fall when the milky latex in leafy spurge disappeared. Herbage production was reduced 17 and 33 percent on land that was 50 and 100 percent infested, respectively (4). Leafy spurge causes an annual economic loss of $14.4 million in North Dakota due to decreased herbage production and carrying capacity (8). This loss results in an estimated $75 million in foregone business activity each year in North Dakota.

Leafy spurge is difficult to eradicate, but topgrowth control and a gradual reduction in the underground root system are possible. Picloram (Tordon)® is the most effective herbicide for leafy spurge control (4). Generally, picloram is most effective when applied during the true-flower growth stage in mid-June or during regrowth in the fall from late August until a killing frost occurs in October (Figure 1). However, control from picloram can be inconsistent as picloram has given from 100 percent to less than 5 percent control two months after application, even when properly applied at the maximum labeled use rate (3).

Occasional poor leafy spurge control by picloram may be due to poor herbicide absorption and translocation caused by unfavorable weather conditions or limited carbohydrate movement within the plant. Since both picloram and carbohydrate movement in leafy spurge are weather dependent and roots must be killed for long-term control, the purpose of this study was to determine the leafy spurge growth stage and weather conditions that maximize picloram movement to roots.

METHODS

Radiolabeled picloram (^{14}C-picloram) was applied weekly from mid-May until mid-October for two years to leafy spurge plants grown in pots in the field. Plants were harvested 72 hours after treatment and were sectioned into treated leaf, remaining stem and leaves, and roots. Roots were subdivided by depth from 0- to 3- and 3- to 6-inches and were washed and frozen immediately. The amount of picloram absorbed and translocated was determined and correlated with various environmental conditions 96 hours before to 96 hours after treatment. Leafy spurge root carbohydrate content was determined for two growing seasons at two depths and the relationship between root carbohydrate and picloram content was estimated.

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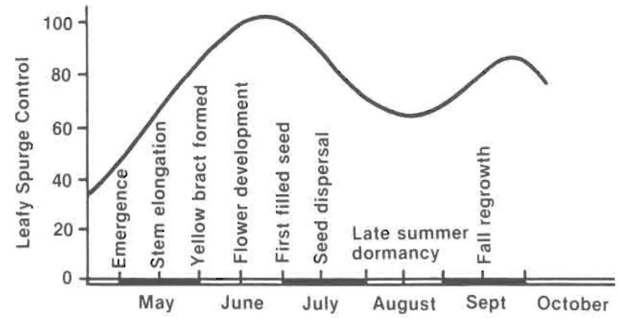

Figure 1. General pattern of leafy spurge control with picloram as affected by growth stage at application.

RESULTS AND DISCUSSION

Variable herbicide absorption due to changes in the environment or plant growth stage can result in inconsistent weed control. However, picloram absorption was similar throughout most of the growing season and averaged 36 percent of applied picloram except during summer dormancy in August when absorption declined to 14 percent (Figure 2). Maximum absorption was 52 percent and occurred during the vegetative growth stage in May. In growth chamber experiments, picloram absorption increased as the relative humidity increased during treatment but was not affected by the air temperature before or after treatment (data not shown). Thus, to maximize picloram absorption in leafy spurge, plants should be treated when growing rapidly and during periods of high humidity such as early morning or late evening.

Picloram concentration in the leafy spurge topgrowth was greatest when the herbicide was applied during the vegetative growth stage in the spring (Figure 3). Picloram concentration in the topgrowth declined rapidly when the plant began to flower in late May and June. Very little picloram

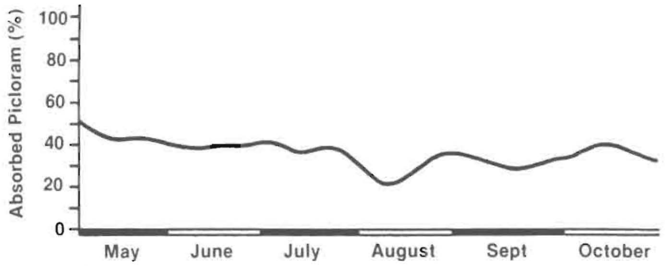

Figure 2. Picloram absorption by leafy spurge averaged over two growing seasons.

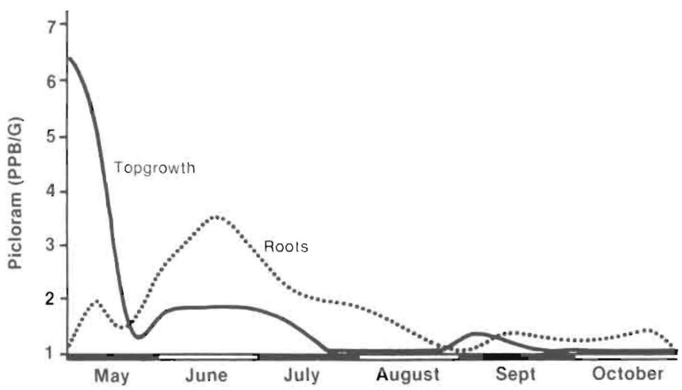

Figure 3. Picloram translocation to leafy spurge topgrowth and roots averaged over two growing seasons.

was present in the topgrowth during the rest of the growing season except for a small increase around early September when picloram was applied to the young fall regrowth of leafy spurge. In growth chamber experiments, the amount of picloram in the topgrowth was not influenced by temperature or relative humidity before or after treatment (data not shown). Since leafy spurge topgrowth is easily killed by relatively economical herbicide treatments such as 2,4-D, variability in picloram concentration in the topgrowth is only important if it leads to more picloram in the roots.

Picloram concentration in leafy spurge roots was influenced more by leafy spurge growth stage than by relative humidity, temperature, or herbicide concentration in the topgrowth. Picloram movement to the roots correlated directly with the percent control achieved in the field during the growing season (Figures 1 and 3). Maximum translocation occurred during the late-flowering and seed-set growth stages in June and early July (Figure 3). Picloram concentration in the root declined steadily during summer dormancy but then increased slightly during fall regrowth. Although about one-third of the picloram applied to leafy spurge was absorbed throughout the growing season, the maximum translocated to the roots occurred during flower development. The increased translocation was hypothesized to be due to increased flow of carbohydrates to the roots during the late-flowering growth stage; this hypothesis was evaluated in subsequent experiments.

Leafy spurge roots contain two predominate types of carbohydrates, water soluble (mostly sucrose) and water insoluble (starches). The carbohydrate concentration varied over the growing season and by root depth (Figure 4). Water-soluble and -insoluble carbohydrates were present in similar amounts (by depth) in the early spring during vegetative regrowth, but insoluble carbohydrates predominated after flowering, especially for the 3- to 6-inch depth (Figure 4). Water-soluble carbohydrate content increased sharply in the 3- to 6-inch depth during the true-flower growth stage, was lowest during mid-summer, but then increased steadily during the fall when the water-insoluble carbohydrate concentration declined. High water-soluble carbohydrate concentration that reduces the freezing point of cells may be important for winter survival of leafy spurge. Leafy spurge plants went into winter with approximately 15 percent sucrose (soluble) and 20 percent starches (insoluble) in the roots to supply energy over winter and for initial spring growth.

Picloram translocation evaluated over the entire growing season did not correlate with either the water-soluble or -insoluble carbohydrate concentration (Table 1). Auxin herbicides often are considered to flow with plant sugars (1). This hypothesis apparently is not valid with leafy spurge over the growing season, but picloram translocation may be aided by carbohydrate flow during peak movement of picloram to the root system during flowering.

Picloram and carbohydrate content within the true-flower and fall regrowth stages were correlated separately (Table 1). Picloram content and the water-soluble fraction both increased during the true-flower growth stage with a correlation of 78 and 95 percent at the 0- to 3-inch and 3- to 6-inch depths, respectively.

Despite a large increase in carbohydrate movement to the roots in fall, picloram translocation did not increase (Figures 3 and 4, Table 1). This was unexpected since the hypothesis was that herbicides move with sugars when sugars are stored for overwintering. This was not true with picloram in leafy spurge and may not be true for other auxin herbicides or perennial weeds. Although some herbicides such as glyphosate (Roundup)® follow patterns similar to sucrose in plants, phenoxy herbicides such as 2,4-D and picloram differ from sucrose in both rate and pattern of movement (6).

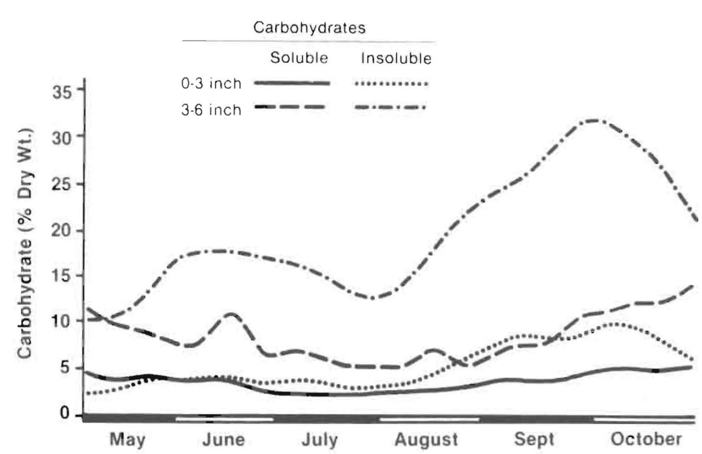

Figure 4. Water-soluble (mostly sucrose) and -insoluble (starch) carbohydrate concentration in leafy spurge roots at two depths averaged over two growing seasons.

Optimum timing of picloram application for maximum translocation to the roots is during the true-flower growth stage and to a lesser degree during fall regrowth. Within these growth stages picloram should be applied during periods of high humidity. Air temperature is less important than relatively humidity in determining picloram translocation to the roots. However, previous research has shown that application during cool weather immediately following several days of hot weather may increase picloram translocation to the roots and thus increase control slightly (5).

Table 1. Correlation of concentrations of water-soluble and water-insoluble carbohydrates and picloram in leafy spurge roots 72 hours after treatment.

Growth stage and root depth	Carbohydrate type	
	Water-soluble	Water-insoluble
	Correlation (%)	
All season		
0 to 3 inches	0	0
3 to 6 inches	0	0
True-flower		
0 to 3 inches	78	60
3 to 6 inches	95	56
Fall-regrowth		
0 to 3 inches	0	0
3 to 6 inches	0	0

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