THE INFLUENCE OF GROWTH STAGE AND APPLICATION SITE ON CALIFORNIAN THISTLE CONTROL BY GLYPHOSATE

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SUMMARY

Glyphosate was applied at different growth stages and to different parts of Californian thistle (*Cirsium arvense*) plants grown in a glasshouse. Destruction of the root system occurred more consistently following post-flowering applications, probably because herbicide translocation was predominantly to the roots at this time. At earlier growth stages, most herbicide movement appeared to be towards developing daughter shoots. More root damage occurred when glyphosate was applied to lower rather than upper parts of the stem. No differences in effectiveness were detected when glyphosate was applied to stem rather than leaf tissue.

INTRODUCTION

Californian thistle overwinters by virtue of its extensive creeping root system from which numerous new shoots develop in spring. If long-term control is to be obtained, it is important that herbicide moves into this root system. Glyphosate (Roundup) is commonly believed to move through plants with photoassimilates (Sprankle *et al* 1975), though some apoplastic movement has also been detected (Gotttrup *et al* 1976). Translocation of assimilates to the roots of Californian thistle occurs more readily at certain growth stages, but the relationship between growth stage and translocation of glyphosate to the roots is not fully understood, and the presence of several stems along one section of root can complicate this relationship (Vanden Born 1980).

Assimilates, and thus phloem-mobile herbicides, move predominantly toward the stem apex from leaves growing on the upper part of a plant and to the roots from basal leaves (Sagar *et al* 1977). As glyphosate applied by a ropewick applicator is wiped mainly onto upper leaves, translocation to the roots could be less than if lower leaves were treated.

Verity (unpublished) found that ropewick applicators apply glyphosate mainly to the stems and lower surfaces of leaves of Californian thistles. Little is known about the relative ability of glyphosate to move to the roots from stems and leaves, or from upper and lower leaf surfaces.

An investigation was therefore undertaken to examine the effects of glyphosate applied to Californian thistles at different growth stages and to different plant parts to investigate how such differences might affect control by ropewick applicators.

METHOD

Californian thistle plants were grown, from seed germinated in early September, in No. 10 Planta Bags (140 x 140 x 420 mm) in a glasshouse at 18-22 °C. A potting mixture of peat, sand and perlite was used and nutrients were supplied by a controlled release fertilizer. The bags were kept on wet felt mats from which the plants obtained water.

Growth stage experiment

Applications of 0, 1.5, 6.2, 25 or 100 mg ai of glyphosate per plant were made at the vegetative (early December), early bud (mid December), late bud (early January), flowering (mid January) or post-flowering (early February) growth stage. Mother stems treated in early December had an average height of 50 cm and 4.7 daughter stems taller

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than 20 cm, compared with 151 cm and 8.6 daughter stems in February. The glyphosate was applied to the upper parts of the mother stem of each plant using a small paint brush for the larger doses and a micropipette for the smaller amounts. (The stem that developed originally from the seed is termed the mother stem. Stems that later developed vegetatively are termed daughter stems).

Plant parts experiment

Glyphosate was applied to the mother stem of plants (25 mg ai/plant) with a paint brush to the stem and leaf tissue in the (i) upper, (ii) middle, or (iii) lower thirds of the stem; or to (iv) leaves of axillary branches; (v) the stem; (vi) the flower buds; or (vii) the leaves on one side of the main stem only. These plants were compared with (viii) untreated plants, and (ix) plants with all parts of the mother stem treated. Plants were treated at the early flowering stage.

In both experiments, the commercial form of glyphosate (360 g ai/litre as the isopropylamine salt) was used at a dilution of two parts water to one part of product, the concentration recommended for use in ropewick applicators (Monsanto 1982). Thus 25 mg ai was equivalent to 0.21 ml of glyphosate solution. All treatments in each experiment were replicated five times and the replicates were arranged in a completely randomised design.

Approximately 3 months after treatment, the plants were removed from their bags and the roots and stem material were dried and weighed separately. Decomposition of root material was used as a measure of glyphosate effectiveness. Due to large variations in plant size, shoot:root ratios were used rather than just root weights. Aerial plant parts dried out without decomposing after death whereas the roots rotted away, resulting in a significant increase in shoot:root ratio. Shoot:root ratios were log transformed (logarithms to the base 10) for statistical analysis. Log shoot:root ratios above 1.00 indicated that appreciable decomposition of the root system had occurred.

RESULTS AND DISCUSSION

Growth stage experiment

The application of 100 mg ai of glyphosate per plant resulted in a highly significant increase in shoot:root ratio compared with all other treatments, whereas the other three dosage levels resulted in no significant increase over the untreated plants. Table 1 shows the log shoot:root ratios of all plants treated with 100 mg of glyphosate. Because of the large variation in results, no significant difference was detected between growth stage treatments. However, the post-flowering treatment was the only one in which all plants had values above 1.00. So although root death occurred occasionally at most growth stages, consistent results were obtained only with the post-flowering application.

TABLE 1: The log shoot:root ratios of individual plants treated with 100 mg of glyphosate.

Replicate	Growth stage at treatment				
	Vegetative	Early bud	Late bud	Flowering	Post Flowering
1	0.35	0.64	0.84	0.72	1.54
2	0.76	0.54	1.64	0.50	1.26
3	1.87	0.77	0.71	1.13	1.48
4	2.20	0.31	1.10	2.41	1.54
5	0.18	0.16	0.41	0.55	1.04
Mean	1.07	0.48	0.94	1.06	1.37

LSD 5% (means) = 0.97

The shoot and root dry weights of untreated plants from both experiments are shown in Fig. 1 for all harvests. From March to June the stem dry weight remained fairly constant, there being no significant increase in stem growth following flowering. However, the root dry weight increased significantly during this period (from 39 to 146 g), suggesting that storage of reserves in the roots was occurring. The vegetative plants were treated in early December and the post-flowering plants in early February. As assimilate movement into the roots apparently occurred mainly in autumn, and as glyphosate is thought to move with assimilates, it would seem that glyphosate applied in February would be more likely to move into the roots than when applied in December.

Fig. 1: Mean shoot and dry weights of untreated plants harvested during autumn. Each point is the mean of five replicates.

Treatment of the mother stem at all stages up to flowering resulted in substantial chlorosis, necrosis, distortion and growth inhibition in untreated daughter stems. However the daughter stems were much less affected by treatment at later growth stages.

These observations suggested that, at earlier growth stages, glyphosate was moved through the root system to developing daughter stems without affecting the roots. At later growth stages it probably moved to the root system as storage of root reserves for overwintering of the plant became more important than development of daughter stems.

All stems of plants which were killed completely by glyphosate became severely water-stressed 3-4 weeks after treatment and died about 1 week later. This indicated that decomposition of the root system was probably the cause of death.

Plant parts experiment

Fig. 2 shows the mean log shoot:root ratios of plants treated on different parts of the mother stem. Again, due to the large variation in results, treatment means were not significantly different. The sub-optimal rates of herbicide used and the fact that plants were not treated at the most susceptible stage may also account for this lack of significance. However, there was some indication from these results and from observations of the plants that more glyphosate was translocated both into the roots and to daughter stems the closer the herbicide was applied to the base of the plant.

Other results from this experiment suggest that the effectiveness of glyphosate will not be reduced if it is applied to only one side of a stem, as would occur with a single pass of a ropewick applicator, or to stem rather than leaf tissue. Another experiment has shown that plants treated on the upper surfaces of leaves are affected to the same extent as plants treated on lower surfaces (Harrington 1983). As glyphosate applied to Californian thistle by ropewick applicators is deposited mainly on the stem and lower leaf surfaces (Verity unpublished), the effectiveness of a given dose of the herbicide will apparently be no less than if applied to the upper surfaces of leaves by more conventional spraying techniques.

Fig. 2: Average log shoot : root ratios of plants treated on different parts of the mother stem. LSD 5% = 0.65.

CONCLUSIONS

Results from these experiments suggest that glyphosate should be applied to Californian thistle once flowering is complete, and should be applied as far down the stem as possible. However, because these experiments were conducted in the glasshouse and as large variation was obtained in the results, field trials are needed to confirm these findings.

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