Glyphosate translocation in lucerne

Stephen Davies[1], Phil Eberbach[2] and Mark Peoples[1]

[1] CSIRO Plant Industry, GPO Box 1600, Canberra, ACT 2601. www.pi.csiro.au Email stephen.davies@csiro.au
[2] School of Agriculture, Charles Sturt University, PO Box 588,Wagga Wagga, NSW 2678. www.csu.edu.au/faculty/sciagr/sag/ Email peberbach@csu.edu.au

Abstract

Successful and reliable termination of a lucerne phase prior to cropping using herbicide can be difficult to achieve. Previous field studies have shown that herbicide efficacy varies with the stage of lucerne regrowth. Radiolabelled ^{14}C-glyphosate was applied to lucerne plants at various stages during a regrowth cycle to determine when lucerne is more susceptible to herbicide. This approach enabled the extent and direction of herbicide translocation from the site of application to be visualised using autoradiography. Results show that herbicide efficacy during flowering (7 weeks regrowth in this study) is likely to be poor as applied herbicide was translocated directly and solely to the flowers. Herbicide applied during the 4-5 week regrowth period was more likely to be translocated to the roots and crown, while herbicide applied after 1, 2 or 3 weeks regrowth was translocated both upwards and downwards from the site of application.

Key Words

Lucerne, regrowth, ^{14}C-glyphosate, translocation, autoradiography

Introduction

In order to kill a perennial plant such as lucerne using systemic herbicides it is necessary to achieve a lethal dose in the perenniating organs, in this instance the crown of the lucerne plant. Herbicides always kill the existing lucerne shoots, but new shoots regrow from buds in the crown enabling the plant to survive. Previous field experiments have shown that herbicide efficacy was greatest when lucerne was sprayed with systemic herbicides in early to mid spring and had been allowed to regrow for 3-5 weeks following complete defoliation through either grazing or hay cutting (1). Systemic herbicides such as glyphosate and the group I auxinic herbicides are mostly translocated in the phloem and hence tend to become concentrated in those parts of the plant that have a high demand for photosynthate (2,3). We hypothesise that application of herbicide at this stage in the regrowth cycle coincides with the downward movement of photosynthates from the shoots to replenish reserves in the taproots.

Methods

This hypothesis was tested using radiolabelled ^{14}C-glyphosate applied to glasshouse grown plants at various stages during a lucerne regrowth cycle. Prior to applying the radiolabelled herbicide the plants were sprayed with commercial glyphosate in an automated spray cabinet at a rate equivalent to that commonly used in field experiments (675g a.i./ha). Radiolabelled glyphosate (20µg a.i./leaf) was then applied to one of the uppermost expanded leaves (which had been covered while the rest of the plant was sprayed) on one of the elongated shoots of a lucerne plant. After 3 days the treated plants were harvested. Treated plants were divided into treated shoot, untreated shoot and roots (incorporating crown, taproot, lateral and fibrous roots) which were then pressed between paper for 6-12 hours. Autoradiography film was then placed on top of the pressed plant samples which were then wrapped in aluminium foil and stored in a freezer for 4-5 weeks. The presence of radiolabelled herbicide in the plant tissues exposed the film giving a visual indication of where herbicide had been translocated from the treated leaf (Figs. 1,2).

Results and discussion

Autoradiography was successfully used to show the movement of radiolabelled glyphosate from the treated leaf and into the treated shoot. After 1 weeks regrowth (Fig. 1A,B) radiolabelled herbicide was translocated up into the shoot meristem and down the length of the stem. Other leaves received little of the labelled herbicide.

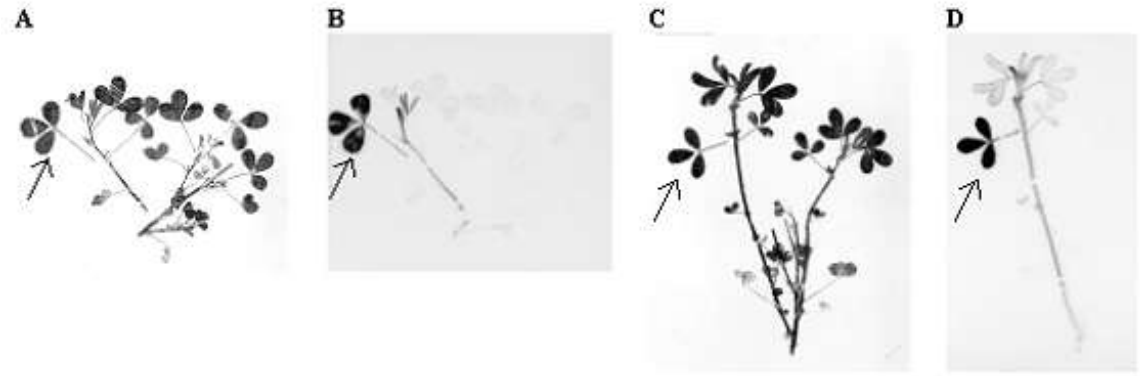

Figure 1. Layout of the treated leaf and shoot (A,C) and ^{14}C-glyphosate translocation pattern (B,D) after 1 (A,B) and 2 (C,D) weeks regrowth. (Arrow shows leaf treated with ^{14}C-glyphosate).

After 2 weeks regrowth (Fig. 1C,D) radiolabelled glyphosate was again translocated from the treated leaf up into the shoot meristem and down the stem. However, more was present in other leaves of the treated shoot than there had been after 1 weeks regrowth. This visual pattern remained similar after 3 and 4 weeks regrowth (images not shown) with some translocation of herbicide both above and below the treated leaf within the treated shoot.

Figure 2. Layout of the treated leaf and shoot (A,C) and ^{14}C-glyphosate translocation pattern (B,D) after 5 (A,B) and 7 (C,D) weeks regrowth. (Arrow shows leaf treated with ^{14}C-glyphosate).

After 5 weeks regrowth (Fig. 2A,B), however, the pattern changed with no herbicide being found above the treated leaf despite the close proximity of the shoot meristem. Herbicide could only be detected in the stem of the treated shoot with none present in the untreated leaves of the treated shoot or in the untreated shoots. This suggests that there may have been a strong sink for photosynthate and hence systemic herbicide at the base of the shoots (i.e. crown or taproot) resulting in predominantly downward transfer of herbicide. By 7 weeks regrowth (Fig. 2C,D) the plants were flowering and the radiolabelled herbicide moved predominantly upwards into the inflorescences only translocating down as far as the inflorescence at the node below the treated leaf. Clearly no glyphosate was translocated from the treated leaf to the crown or taproot at this time. At no regrowth stage was any radiolabelled glyphosate present in the untreated shoots indicating little transfer of assimilates and herbicide between shoots.

Conclusion

The translocation pattern of the systemic herbicide glyphosate in lucerne varies with the stage of regrowth. Glyphosate translocation to the crown is improved when herbicide is applied after there has been 4-5 weeks regrowth. Herbicide application to the plant before this time (ie.< 3 weeks regrowth) is likely to be unsuccessful due to lower herbicide interception and poor translocation to the crown. Herbicide translocation to the crown when the plant is flowering will also be poor.

Acknowledgements

This research was supported by the Grains Research and Development Corporation. The authors gratefully acknowledge the technical assistance of John Broster (Charles Sturt University). The additional assistance of Tim Jones and Megan Lindsay (CSIRO Plant Industry) is also acknowledged.

References

(1) Davies S.L., Peoples M.B., Storrie A.M., Cook T.S. and Latta R.A. 2001. Proceedings 10th Australian Agronomy Conference, www.regional.org.au/au/asa/2001/index.htm

(2) Dewey S.A. and Appleby A.P. 1983. Weed Sci., 31: 308-314.

(3) Kirkwood R.C. 1983. Pest. Sci., 14: 453-460.