STUDIES ON THE UPTAKE AND TRANSLOCATION OF 2,4,5-T AND PICLORAM IN YOUNG GORSE PLANTS

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Summary

The uptake and translocation of 2,4,5-T and picloram, applied singly or in combination, in young plants of gorse (*Ulex europaeus*) was investigated. A small increase in 2,4,5-T uptake was found in the presence of picloram but the uptake of both herbicides was limited. Picloram translocated freely to sites of active growth, principally the root nodules in vegetative plants and floral organs in reproductive plants, whereas 2,4,5-T was poorly translocated to active growth sinks but accumulated in stem and mature roots. The application of the two herbicides in combination did not improve their translocation.

INTRODUCTION

The efficient chemical control of gorse demands a herbicide that will translocate freely and accumulate at toxic concentrations in roots and stem crown tissues. The extent of accumulation of herbicide in these tissues is of prime importance in the control of potential shoot regrowth.

Although 2,4,5-T is the major herbicide used in chemical control of gorse there have been very few studies concerned with its uptake and translocation by the plant (Leonard and Yeates 1959; Schicke and Linden 1963). The addition of picloram to commercial herbicide formulations has been reported to improve control (Moffat 1973) but there is only one report on picloram uptake and translocation (Rolston and Robertson 1975) and one dealing directly with its effect on the uptake and translocation of 2,4,5-T (Phung and Field 1979). The spiny morphology and thick, waxy cuticle of gorse are major barriers to effective herbicide uptake, as demonstrated for picloram by Rolston and Robertson (1975) and for 2,4,5-T by Phung and Field (1979). These studies also showed that the two herbicides are chemically stable in gorse, a distinct advantage in uptake and translocation studies. This paper is concerned primarily with the translocation of 2,4,5-T and picloram, the primary sites of herbicide accumulation and any interactive effects when the two herbicides are applied simultaneously.

METHODS

A more detailed outline of the methods used in this study can be found in Phung and Field (1979).

Plant material and experimental conditions

Single plants of gorse were established from 10 cm long stem cuttings. Rooted and nodulated cuttings were grown in soil until they

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reached 25 cm in height, possessed approximately 10 lateral branches and were about 6 months old. All cuttings were raised in a glasshouse but transferred to a controlled environment cabinet (continuous illumination at 20 klux, 70% relative humidity and temperature of 18°C) for several days prior to treatment.

Herbicides

In the translocation studies a solution of 2,4,5-T- ^{14}C of specific activity 6.17 mCi/mM and concentration 6.47×10^{-5} M was used whereas in the uptake experiment the corresponding values were 0.27 mCi/mM and 7.32×10^{-5} M. Carboxyl- ^{14}C labelled picloram with a specific activity of 1 mCi/mM was used in all experiments, the concentration in the uptake experiment was 1.91×10^{-5} M and in the translocation studies 4×10^{-4} M. Where solutions contained both herbicides the 2,4,5-T and picloram were mixed in the ratio of 4:1 by weight. Both herbicides were used in free acid form with solutions at pH 4-4.2 containing 0.1% v/v Tween 20 as surfactant.

Application and extraction of herbicides

In uptake experiments with single spines the cut surface of each spine was sealed with paraffin wax before immersion in 5 ml of herbicide solution. On completion of incubation the spines were surface washed with distilled water (containing 0.01% Tween 20) before combustion in a sample oxidizer and assay of radioactivity by scintillation counting. Application of herbicide solutions to intact plants was achieved by severing a central branch, sealing a small piece of glass tube to the cut branch, injecting a known volume of herbicide (usually 50 μl) into the glass tube and finally sealing the open end of the tube. After the translocation period of 48 h the plants were fractionated before herbicide extraction in 70% ethanol for 4 days at 5°C. Aliquots of the extract were taken for scintillation counting and chromatographic analysis to check for possible metabolites.

Statistical Analysis

For analysis of distribution of radioactivity between tissue fractions Duncan's New Multiple Range Test was used on log or arcsine-transformed data. To determine changes in distribution of radioactivity following different application treatments it was necessary to use Student's t-test. A minimum of four replicates was used in each experiment.

TABLE 1: Uptake of herbicides by single, detached spines

Incubation time (h)	Number of nano Moles of the labelled herbicide per spine			
	picloram ^{14}C	picloram ^{14}C + 2,4,5-T	2,4,5-T ^{14}C	2,4,5-T ^{14}C + picloram
3	0.32 a	0.28 a	4.74 c	4.74 c
6	0.32 a	0.34 a	6.26 b	7.13 b
12	0.42 a	0.46 a	8.44 a	9.57 a
24	0.50 a	0.49 a	8.69 a	10.11 a

A t-test used horizontally between each pair of treatments (picloram ^{14}C or 2,4,5-T ^{14}C) was not significant.

RESULTS AND DISCUSSION

The uptake of 2,4,5-T into isolated gorse spines proceeded rapidly during the first 3 hours of incubation, increased with time and reached a

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apparent equilibrium state after 12 h (Table 1). The addition of picloram to the incubation solution did not significantly increase uptake although there was a marginal improvement with its addition. The corresponding data for picloram possibly show a more rapid establishment of equilibrium but no advantage by the addition of 2,4,5-T. Further investigations with branches, that have a larger sink capacity than isolated spines, have demonstrated that 2,4,5-T uptake continued to increase for several days provided a wetted spine surface was maintained (Phung 1977).

In the translocation experiments no attempt was made to investigate uptake of herbicide, the placement of herbicide solution in contact with a cut branch ensured maximum entry of chemical into the plant. The retention of 60-80% of applied chemical in the treated branch fraction compared with a figure of 85-90% when application was through an intact spine (Phung 1977).

The pattern of picloram distribution in a vegetative plant (Table 2) showed a marked basipetal translocation to the root tissues. There was no accumulation in untreated branches and only a small percentage of herbicide retained in the stem material. The quantitative distribution of picloram was not changed by the addition of 2,4,5-T. The root nodules represented about two per cent of the total root weight in these plants but accumulated approximately half the picloram associated with the total root fraction. There were a number of significant contrasts in the translocation of 2,4,5-T, (with or without added picloram). Slightly less herbicide was exported from the treated branch but even after correcting for this difference there was a greater percentage of 2,4,5-T accumulated in the stem tissue than in the case of picloram. However the most notable difference in distribution pattern was the almost total lack of 2,4,5-T in the root nodules. The lack of 2,4,5-T in root nodules is at variance with the observations of Colldrake (1970) who reported that nodules of the leguminous plant, *Acacia harpophylla*, accumulated a significantly higher amount of 2,4,5-T than the general root mass. In the present study the results obtained with picloram were more consistent with the observations of Colldrake (1970) and it is conceivable that the addition of picloram to herbicide formulations may rapidly reduce the vigour of the gorse plant by preventing nitrogen fixation.

TABLE 2: Translocation of herbicides in vegetative plants

	Percentage distribution of total radioactivity			
	picloram ^{14}C	picloram ^{14}C + 2,4,5-T	2,4,5-T ^{14}C	2,4,5-T ^{14}C + picloram
treated branch	73.5 a	72.9 a	77.5 a	79.3
untreated branches	0	0	0	0
stem	2.9 c	2.4 c	7.2 c	5.7 bc
roots	10.0 b	12.9 b	14.0 b	13.6 b
root nodules	13.6 b	11.8 b	1.3 d	1.4 c

¹⁴C A *t*-test used horizontally between each pair of treatments (picloram - ¹⁴C or 2,4,5-T - ¹⁴C) was not significant.

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When similar experiments were carried out using plants bearing flowers and maturing seed pods the distribution of both herbicides was changed, (Table 3). Again picloram showed a significant mobility and accumulated in the floral organs, apparently diverting herbicide from the roots and root nodules. In contrast relatively little 2,4,5-T was accumulated by the floral organs themselves although the subtending branches contained considerably more herbicide than in the vegetative plants (Table 2). The difference in degree of mobility demonstrated by the two herbicides was marked, of the tissue fractions analysed the most active sinks were likely to be the floral organs and root nodules. These two fractions accounted for 23.2% of the total picloram but only 2.4% of the 2,4,5-T. Rolston and Robertson (1975) made reference to the accumulation of picloram in floral organs; the confirmation demonstrated in this work and the additional observation that there may be a significant but more limited diversion of 2,4,5-T in reproductive plants suggests that the translocation of herbicide is most likely to be effective when sprayed onto vegetative plants.

TABLE 3: Translocation of herbicides in reproductive plants

Percentage distribution of total radioactivity		
	picloram ¹⁴ C	2,4,5-T ¹⁴ C
treated branch	56.6 a	62.4 a
untreated branches	9.4 bc	8.6 b
stem	5.2 bc	15.8 b
floral organs	21.0 b	1.1 c
roots	5.6 bc	10.8 b
root nodules	2.2 c	1.3 c

CONCLUSION

The results obtained did not demonstrate a clear advantage in herbicide uptake or translocation by application of 2,4,5-T and picloram in combination. Any benefit derived by the addition of picloram to a formulation containing 2,4,5-T is likely to be due to the intrinsic herbicidal activity of picloram. Whereas picloram moved to sites of active growth such as root nodules and floral organs the translocation of 2,4,5-T was more restricted, was confined to stem tissue and the general root mass and unlike picloram did not correlate with the expected pattern of assimilate distribution. A line for further investigation is the possible inactivation of the nitrogen-fixing capability of root nodules as a result of picloram accumulation. The limited translocation of 2,4,5-T in gorse may explain its lack of efficiency in controlling regrowth from stem crowns and the necessity for total spray coverage to ensure a total burning off of aerial shoots. If the basic premise is followed, that high herbicide concentrations in subterranean tissues are necessary for effective control then this study offers confirmatory evidence that spraying reproductive plants with 2,4,5-T or picloram leads to an unnecessary diversion of herbicide to these structures and away from the roots.

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