2,4,5-T UPTAKE BY GORSE — DEPENDENCE ON FOLIAR DEVELOPMENT AND HERBICIDE FORMULATION

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SUMMARY

¹⁴C-2,4,5-T butyl ester formulation was applied to mature gorse (*Ulex europaeus*) spines, aged less than 3 to more than 12 months, on plants grown under controlled environment conditions. Radioactivity uptake was found to be dependent on time and spine age. With the oldest spines, 17% was incorporated within 30 minutes and only 45% after 24 h. The youngest spines incorporated 44% within 30 min and 82% within 24 h. Addition of diesel oil reduced the uptake differences between spines of differing ages and improved uptake by older spines. The results are discussed in relation to previously reported uptake and effectiveness data of 2,4,5-T on gorse.

INTRODUCTION

It has been recognised that interactions between plant development, environmental conditions, and herbicide formulation can result in very variable herbicide effectiveness. On gorse, 2,4,5-T is most effective if applied to new rapidly expanding shoots and foliage (Balneaves and Zabkiewicz 1981). However this is not always possible in practice and most of the applied spray may land on more mature foliage. Uptake is further influenced by environmental factors such as temperature, light intensity, soil water availability and humidity. Balneaves (1980) observed that 2,4,5-T butyl ester was most effective when applied shortly before natural or simulated rain. Schicke and Linden (1963), however, stated that maximal 2,4,5-T uptake by gorse occurred within 5 minutes of application. These findings implied that environmental or developmental factors strongly influenced uptake.

The work described in this paper was aimed at elucidating and quantifying 2,4,5-T uptake into gorse tissue of different ages under similar controlled environment conditions.

METHODS AND MATERIALS

Growth room plants and conditions

Suitable gorse plants (ca 1 m tall) were dug up in August 1979 and re-planted into soil in large polythene bags (40 litre capacity). The plants were allowed to grow in the FRI Nursery until mid-February 1980 when they were transferred to the FRI growth rooms. Conditions were set at: 18°/13°C day/night temperature; 85% RH; 16 h photoperiod (6 am start); 12 h photosynthesis period (8 am start; light intensity 300 W/m²). In the time-course trial, herbicide treatments were applied in mid-March, when plants were 1.5-2 m tall, to foliage of three age classes described as "Previous" (more than 1 year old); "Current" (more than 3 months old), "New" (less than 3 months old). In the formulation trial, treatments were applied in early July when plants were more than 2 m high.

Treatment

Butyl ester of 2,4,5-T (commercial 36% formulation) was diluted with water to 0.44 kg 2,4,5-T/300 litres together with 2.98 μ Ci 2-¹⁴C-2,4,5-T butyl ester to give a final concentration of 4.7×10^{-3} M. Two further formulations were made with 0.1% Nuodex (dodecyl dimethylbenzyl ammonium salt of naphthenic acid) and 16% diesel oil (plus 2% Triton X-45 surfactant) respectively for comparison of additive effects.

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Shoots were selected with sufficient spines of each age category, well separated from one another. Ten spines from each of the three age classes were selected on individual shoots on three separate plants. Subsequent measurements of cuticle thickness (Bollmann, unpublished) on representative spines from each age class gave the following mean values: "New" 3.3 μm ; "Current" 5.7 μm ; "Previous" 6.95 μm . Treatments were applied between 10.30 am and 2 pm at intervals of 0.5, 1, 4, and 24 h before harvesting. Herbicide solutions were painted on to selected spines with a fine brush, taking care not to contaminate other parts of the plants. Treated spine plus stem section, as well as sections 5 cm above and below the treated zone, were harvested at the stated times, separated into treated spines, untreated stem, and upper and lower stem portions. Each lot of 10 treated spines was bulked, washed in diethyl ether to recover herbicide still on the spine surface, then freeze dried. After weighing, the samples were ground in a Wiley mill to pass through a 60 mesh screen. Portions were combusted in a Micro-Mat 5080 combustion apparatus and the $^{14}\text{CO}_2$ released absorbed by phenethylamine solution. Scintillant solution (11 g Permablend I + 300 ml MeOH made up to 2 litres with toluene) was added and the samples were counted in a Packard 3320 scintillation counter. Wash solutions were concentrated, transferred to scintillation vials and counted in the usual manner (Steele and Hobbs, unpublished). Radioactivity incorporated into the gorse tissue samples was calculated subsequently.

Plants in the formulation trial were treated similarly. Three plants were selected per treatment, such that ten "New" and "Current" spines were present on each shoot with a minimum of 15 cm between them. Cuticle thickness in these plants was determined as: "New" 4.6 μm ; "Current" 6.0 μm . Butyl ester solutions of 2,4,5-T alone or with Nuodex or Diesel (containing 2% Triton X-45), were painted on to these selected spines as before (between 8 am and 9.30 am). Plants were left to metabolise for 48 h then harvested. They were sectioned, washed, and dried as before, then aliquots combusted and counted for radioactivity in the usual manner.

RESULTS

The results from the treatment of spines of different age classes with 2,4,5-T ester are presented in Table 1. It appears that a considerable time period is needed before substantial uptake occurs. These results support earlier findings (Zabkiewicz and Gaskin 1979) of variable uptake which was not always substantial even after 1-2 days.

TABLE 1: Percentage incorporation of 2- ^{14}C -2,4,5-T butyl ester formulation into "New", "Current" and "Previous" age classes of foliage over 0.5, 1, 4 and 24 h.

	Clonal plant No.	Treatment duration (h)			
		0.5	1	4	24
"New" foliage	1	35	27	66	85
	5	56 (44.0) ^c	23 (26.3) ^d	57 (61.1) ^b	80 (81.6) ^a
	15	41 (± 10.4)	28 (± 2.7)	60 (± 4.9)	80 (± 3.3)
"Current" foliage	1	18	22	33	72
	5	27 (21.1) ^{ef}	- (17.6) ^{ef}	33 (33.1) ^d	67 (64.8) ^b
	15	19 (± 4.8)	13 (± 6.8)	33 (± 0.2)	56 (± 7.8)
"Previous" foliage	1	16	12	20	44
	5	20 (17.0) ^f	29 (25.0) ^{def}	16 (18.1) ^f	44 (45.1) ^c
	15	15 (± 2.6)	34 (± 11.8)	18 (± 1.8)	48 (± 2.1)

All values for each plant/foliage class are the means of duplicate analyses. Mean total result shown in brackets ($\pm$ SD) and superscript letters indicate similarities or differences between treatments.

The present results indicate that high uptake only occurred consistently in "New" or "Current" spine classes. The older spines only took up 45% of the applied herbicide over 24 h compared with 82% and 65% for the other categories. This reduced incorporation by older spines was evident at other sampling intervals, even after as little as 0.5 h. Hence this result endorses the need to spray gorse when most new growth is present.

Analysis of radioactivity distribution within the plants showed that almost without exception more than 95% of the incorporated label remained within the treated spines at all times, again confirming earlier findings (Zabkiewicz and Gaskin 1979).

In the formulation trial only "New" and "Current" spines were treated and the results are presented in Table 2. After 48 h all "New" spines showed good uptake, regardless of the additive used. However, the "Current" spines showed good uptake only with the treatment containing diesel oil (89%) and very much reduced uptake by 2,4,5-T alone or with Nuodex (43% and 34% respectively). As before, more than 97% of the applied labelled material remained in the treated gorse spine region, regardless of the formulation used.

TABLE 2: Percentage incorporations over 48 h of 2-¹⁴C-2,4,5-T butyl ester formulation into "New" and "Current" age classes of foliage, with and without additives.

Formulation	Clonal plant No.	Foliage type	
		"New" foliage	"Current" foliage
2,4,5-T butyl ester	1	80	41
	9	81	(75.6) ^b 51
	15	66	(± 7.9) 36
	1	76	25
2,4,5-T butyl ester + 0.1% Nuodex	9	81	(74.3) ^b 42
	15	67	(± 7.0) 36
	1	79	87
	9	76	(80.0) ^b 93
2,4,5-T butyl ester + 16% diesel oil	15	85	(± 4.7) 88
			(89.2) ^a (± 3.3)

All values for each plant/foliage class are the means of duplicate analyses. Mean total result shown in brackets (± SD) and superscript letters indicate similarities or differences between treatments.

DISCUSSION

Schicke and Linden (1963) concluded on the basis of washing trials that 2,4,5-T amyl ester incorporation into gorse plants was completed within 5 minutes after application. Since 2,4,5-T esters are not appreciably water soluble (Anon 1967), one must conclude from the consistency of their results (52-48% recovery) that they were only removing excess herbicide and emulsifier from the leaf surface and it does not provide a credible estimate of herbicide incorporation.

The subsequent results reported by Balneaves (1980) also cast doubt upon Schicke and Linden's conclusion. If all incorporation was completed within 5 minutes, then subsequent rainfall should not markedly affect herbicidal effectiveness. Conversely, if the applied herbicide was water soluble, then the worst results would have been expected when precipitation occurred shortly after application. Since neither was the case, there must be an alternative explanation for Balneaves' results. From the current results, it is clear that incorporation is time and plant age dependent. A recent review (Bukovac 1976) lists the factors which affect herbicidal effectiveness due to the plant's reaction. In

particular, high humidity increases spray droplet drying time, favours stomatal opening, enhances transport, and may increase membrane permeability. Rewetting of spray residues is also known to enhance penetration. Rain shortly after spraying would fulfill these requirements, reducing plant moisture stress and enhancing uptake of herbicide without washing off any significant amount. By this rationalisation, improved herbicidal effectiveness is always to be expected if plants are sprayed shortly after rainfall, or in early morning.

Since plant growth and environmental conditions are normally beyond control, a practical solution would be to use more appropriate herbicide formulations such that differential absorption by foliage of different age classes is minimised as demonstrated by the results in Table 2.

CONCLUSIONS

The rate of incorporation of 2,4,5-T butyl ester into gorse was time and spine age dependent, being greatest with the youngest spines. At least 24 h was required for older foliage to absorb substantial amounts of herbicide. Addition of suitable surfactants or emulsifiers can increase the penetration of herbicide into older foliage.

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