SURFACTANT EFFECTS ON ACTIVITY OF GLYPHOSATE AND HALOXYFOP IN PAMPAS GRASS

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SUMMARY

The uptake and translocation of glyphosate and haloxyfop in young pampas grass was determined radiochemically, along with measurements of wetting by, and phytotoxicity of, the formulations. Glyphosate was well absorbed (88%) and translocated (46%). Nonionic surfactant addition significantly enhanced uptake but dramatically reduced translocation. Haloxyfop uptake and translocation was considerably less (35% and 16% respectively) and surfactant addition had little effect on either process. Uptake was independent of, but translocation was inversely correlated with, wetting and phytotoxicity.

INTRODUCTION

Pampas grass (*Cortaderia spp*) is an important forest weed in New Zealand. Effective herbicidal control can be achieved using glyphosate, but its lack of plant selectivity limits its forestry use to preplant control and spot spray application. A new, selective, post-emergence grass herbicide is haloxyfop, which has demonstrated good activity against pampas and to which radiata pine (*Pinus radiata*) is tolerant (Saville *et al* 1986).

There is no information on the factors influencing uptake and translocation of these herbicides in pampas grass. Plant development and the nature and quantity of adjuvants in a spray formulation can affect uptake and translocation (Hull 1970; Norris 1982). This paper reports the effects of two nonionic surfactants on the wetting, absorption, movement and phytotoxicity of glyphosate and haloxyfop in young pampas grass.

MATERIALS AND METHODS

Cortaderia selloana was grown from seed in a glasshouse for 3 months and transferred to a controlled environment cabinet (24 °/17 °C day/night temperature, 70% RH, 14 h photoperiod, 300-340 $\mu\text{mol}/\text{m}^2/\text{s}$) for 3 weeks prior to treatment, by which time the plants were approximately 0.6m tall.

Glyphosate (33ml of Roundup/litre of water) was applied alone or in combination with Silwet L-77 (Union Carbide) or Triton X-45 (Rohm and Hass). Haloxyfop (20 ml of XRM 4638/litre of water) was applied with the same adjuvants. ^{14}C -glyphosate and ^{14}C -haloxyfop were added to their respective formulations (10 $\mu\text{Ci}/\text{ml}$). Spray formulations were applied as droplets ($20 \times 0.5 \mu\text{l}$) to both abaxial and adaxial surfaces over the middle 5 cm length of the fourth-youngest leaf (five plant replicates). This leaf was approximately 1 month old at the time of treatment.

Five days after application the treated leaf was excised and the treated portion washed to remove unabsorbed herbicide residues (glyphosate with 3ml 0.05% v/v aqueous Tween 80, then 3ml chloroform; haloxyfop with 3ml dichloromethane, then 3ml chloroform) and the washes assayed for radioactivity in a Packard Model 300 C liquid scintillation counter. The roots were washed free of soil and all tissues were dried and totally combusted in a Packard Tricarb Oxidiser B306 prior to assay for radioactivity. Uptake was calculated as the radioactivity recovered within the plant (% of applied) and translocation as the radioactivity recovered from the untreated tissues (% of absorbed).

The contact angles (CA) of all treatment solutions were determined on films of *Proc. 41st N.Z. Weed and Pest Control Conf.*

pampas wax as described by Zabkiewicz *et al* (1985).

Phytotoxicity was quantified as electrolyte leakage from pampas leaves after immersion in the spray formulations for 24 h (Gaskin and Kirkwood 1986). The conductivity was measured after 24 h of immersion, the treatments were then boiled, cooled and remeasured. Each treatment was replicated six times on three 9 cm leaf portions. Electrolyte leakage was expressed as a percentage of total leakage after boiling.

RESULTS AND DISCUSSION

Recoveries of radio-labelled herbicides ranged from 81–97% of total ^{14}C applied. Table 1 summarises the results obtained. Uptake of ^{14}C -glyphosate exceeded 88% from all treatments, but was still significantly enhanced by the addition of surfactant. In contrast, the uptake of ^{14}C -haloxyfop was much lower (35%) and the only significant increase occurred with the addition of the higher rate of Silwet. Triton had a detrimental effect on absorption of haloxyfop. Glyphosate translocation (46%) was significantly reduced by the addition of surfactant. Conversely, the translocation of haloxyfop (15.5%) was unaffected by surfactant addition.

TABLE 1: Effect of formulation on uptake, translocation, wetting and phytotoxicity of glyphosate¹ and haloxyfop² in pampas grass

Formulation	Uptake of ^{14}C -herbicide (% of applied)	Translocation of of ^{14}C -herbicide (% of absorbed)	Contact angle (θ°)	Electrolyte leakage (% of total)
glyphosate (12g ai/litre)	88.4b	45.6a	84.9e	25.4a
+ 0.1% Silwet L-77	94.0a	20.9b	66.1d	75.8c
+ 0.2% Silwet L-77	94.6a	20.9b	58.6b	80.8d
+ 0.25% Triton X-45	93.8ab	14.3bc	64.5d	75.1c
+ 0.5% Triton X-45	95.4a	9.9c	48.4a	51.2b
haloxyfop (5 g ai/litre)	35.3de	15.5bc	60.1bc	85.7e
+ 0.05% Silwet L-77	37.4cd	16.0bc	58.9b	90.4h
+ 0.1% Silwet L-77	42.1c	16.1bc	56.4b	86.5ef
+ 0.25% Triton X-45	25.8f	16.2bc	63.8c	87.4fg
+ 0.5% Triton X-45	29.7ef	16.7b	59.7bc	87.8g

Means sharing common column postscripts are not significantly different at $P=0.05$ (Duncans Multiple Range Test).

1 Roundup (36% ai)

2 XRM 4638 (24% ai)

As anticipated from the CA results which reflect foliar wetting, all treatments dried rapidly upon application to the leaf except the glyphosate formulation in the absence of added surfactant. This remained on the surface as discrete droplets and took up to 30 min to dry (24°C, 70% RH). This treatment was the poorest wetting of all formulations tested with a CA of 85°, in contrast to the others which ranged from 48–65°. Uptake of radio-labelled herbicide was independent of wetting and the poor uptake from haloxyfop formulations was not attributable to high CA. In contrast, translocation was inversely correlated with wetting ($R^2 = 0.829$, $P = 0.001$). It is possible that the consistently poor uptake and translocation of ^{14}C -haloxyfop was due to the phytotoxicity of its formulation, which contained a large amount of xylene to solubilise the herbicide. Cuticular penetration takes place by passive diffusion (Hull 1970) and occurs regardless of cell membrane integrity. However, if cells are severely damaged and transport processes halted, the chemical will accumulate in the apoplast and alter the diffusion gradient across the cuticle, ultimately affecting uptake.

Electrolyte leakage has been used as an indicator of herbicide injury (Vanstone and Stobbe 1977; O'Donovan *et al* 1985). It was found the Silwet L-77 and Triton X-45 solutions alone caused little damage to tissue; even the highest rates of 0.2% and 0.5%

gave only 8% and 16% leakage respectively. The glyphosate spray formulation caused moderate leakage (25%), but addition of the surfactants increased this 2 to 3-fold. In contrast, haloxyfop caused severe damage (86%) and little increase in electrolyte leakage was evident on the addition of surfactants.

A degree of increased cell membrane permeability (as evidenced by electrolyte leakage) may improve short-distance transport and symplast loading of phloem-mobile herbicides, resulting in more efficient translocation of these compounds to active sinks (Wyrill and Burnside 1977). However, loss of membrane integrity due to excessive quantities or high toxicity of compounds may reduce herbicide performance, as symplast loading could stop. In the present work there was an inverse correlation between translocation and electrolyte leakage ($R^2 = 0.485$, $P = 0.05$). The lower leakage caused by the glyphosate spray formulation may be evidence of membrane permeability sufficient to promote glyphosate translocation in pampas. The increased leakage following surfactant addition may indicate excessive phytotoxicity of these modified formulations to the young foliage. An increased rate of absorption with surfactant addition may have been responsible for the reduced translocation of the herbicide. Increasing the rate of entry (and therefore, quantity) of chemical into a leaf may increase phytotoxicity, damaging the mechanisms associated with translocation.

Whereas the addition of a nonionic surfactant may improve efficacy of glyphosate and haloxyfop on mature pampas, these results indicate it may not improve herbicidal control when applied to seedling or very young pampas plants.

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