Rainfastness of phenoxy herbicide formulations on four pasture weeds

Trevor K. James[1], Anis Rahman[1] and Alan Cliffe[2]
[1] AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton 3240, New Zealand
[2] Nufarm NZ, PO Box 22-407, Otahuhu Auckland 1640, New Zealand
Email: trevor.james@agresearch.co.nz

Summary Glasshouse experiments were carried out to evaluate the rainfast interval of four phenoxy herbicides using simulated rainfall with four pasture-weed species. Nodding thistle, Scotch thistle, ragwort and hairy buttercup plants were grown in pots for 4–6 weeks prior to treatment with 2,4-D amine, 2,4-D ester, MCPA and an MCPA/MCPB combination product. After spraying some pots were set aside and received no simulated rainfall while others were placed under the rainfall simulator (9 mm rain over 20 minutes) at 1, 2, 4 or 6 h after application. Plants were visually assessed for herbicide efficacy at regular intervals. All four herbicides produced typical auxin-like damage in the target species within 48 h of treatment. At the assessments made 9–11 days after treatment, the activity of all the herbicides evaluated was reduced when rain was applied 1 h after application. For most herbicide/species combinations this only delayed efficacy as in most cases the plants were killed by the end of the experiment. The two exceptions were 2,4-D amine where both 1 and 2 h rainfall events significantly reduced herbicide efficacy on ragwort; and 2,4-D ester where the 1 h rainfall significantly reduced efficacy on hairy buttercup.

Keywords Herbicide, rainfast, 2,4-D, MCPA, MCPB, nodding thistle, Scotch thistle, ragwort, hairy buttercup.

INTRODUCTION

Although 2,4-D and other phenoxy herbicides have been used to control broadleaf weeds in New Zealand pastures for the past 50 years, some aspects of their behaviour are not well documented. The rainfast period for a herbicide is the minimum period that must elapse after application and before rain occurs for herbicide efficacy not to be compromised (James and Rahman 2005, Molin and Hirase 2005). For 2,4-D and other phenoxy herbicides there is little quantitative data available on the rainfast period when used on common pasture species (Loux *et al*. 1993). Many of the phenoxy products on the market have rainfree periods documented on their labels which were probably inserted as safety nets rather than an experimentally determined rainfast period (O'Connor 2003). For the products reported in this paper, Agritone (MCPA amine) and Baton (2,4-D amine) both had rainfree periods of 6 h while Relay (2,4-D ester) and Thistrol (MCPA/MCPB amine) had no rainfree period on their labels. However, another MCPB/MCPA combination product, Tropotox Plus, stipulates a 12 h rainfree period.

The aim of this work was to determine more accurately the rainfree periods for certain phenoxy herbicides on some common pasture weeds.

MATERIALS AND METHODS

Herbicides used in these rainfastness studies were: Agritone 720, a soluble concentrate containing 720 g L^{-1} MCPA as the dimethylamine salt; Baton, a water dispersible granule containing 800 g kg^{-1} 2,4-D as the dimethylamine salt; Relay, an emulsifiable concentrate containing 520 g L^{-1} 2,4-D as the ethylhexyl ester and Thistrol Plus, a soluble concentrate containing 25 g L^{-1} MCPA plus 375 g L^{-1} MCPB, both as dimethylamine salts.

The test species included ragwort (*Senecio jacobaea* L.), hairy buttercup (*Ranunculus sardous* Crantz), nodding thistle (*Carduus nutans* L.) and Scotch thistle (*Cirsium vulgare* (Savi) Ten.).

Seeds were germinated on vermiculite prior to transplanting at the cotyledon stage. For each species, four plants were transplanted into 5 L plastic containers filled with a Horotiu silt loam soil with 6.8% organic carbon and a pH of 5.2. All plants were grown in the glasshouse at Ruakura Research Centre without supplementary light and were watered by sub-irrigation as required. Average temperatures during this time were 12–15°C during the night and 20–25°C during the day. The plants were grown for 4–6 weeks and ranged from small rosettes up to 35 cm in diameter, depending on species, when treated.

The treatments (Tables 1–4) were applied with a CO_2 powered, moving belt sprayer fitted with a single TeeJet 8001E nozzle and operated at 200 kPa to apply 100 L ha^{-1} of spray mix.

Plants were subjected to simulated rainfall at various intervals between 1 and 6 h after the herbicide application, while other plants received no wetting of the foliage at all. The rainfall was applied for 20 min via an oscillating, overhead irrigation system and was equivalent to approximately 9 mm of precipitation.

When the plants had dried after the simulated rainfall the pots were laid out on the glasshouse bench in a randomised block layout with four replications. They were maintained there until all the plants had either died or showed signs of regrowth.

The growth of plants was visually assessed relative to the untreated control plants on several occasions. The unmodified data were subjected to analysis of variance excluding the untreated controls from the analysis to avoid bias. The least significant difference (LSD) was calculated (P = 0.05) for the means.

RESULTS

The plants of all four test species used in these experiments were small to medium rosettes between four and six weeks old and as such were quite susceptible to herbicides when treated. Therefore much of the herbicide would need to be washed from the plant during the simulated rainfall to avoid the plant being severely affected or killed.

All four herbicides evaluated produced typical auxin-like damage symptoms in the target species within 48 h of treatment. Reduced activity due to rainfall soon after treatment was evident in some cases at that time. By 9–11 days after treatment (DAT), simulated rainfall at 1 or 2 h after application significantly reduced the activity of all three herbicides (Tables 1–4). In addition the activity of MCPA (Table 1) was reduced by rainfall after 4 h and 2,4-D ester (Table 2) by rainfall after both 4 and 6 h.

At 24 DAT, the impact of the simulated rainfall on herbicide efficacy was less evident than at 9–11 DAT. However, most plant/herbicide combinations demonstrated reduced activity from rainfall after both 1 and 2 h (Tables 1–3). The exceptions were MCPA on nodding thistle (Table 1) which showed significantly reduced activity from the 2 h rain but not the 1 h rain, 2,4-D ester (Table 3) on nodding thistle where there was no longer any rainfall effect and MCPA+MCPB (Table 4) where all plants were dead by 20 DAT irrespective of rainfall time.

By the time of the final assessment at 47 DAT all the buttercup and nodding thistle plants had died despite the earlier signs of reduced activity but, many ragwort plants survived in treatments that were subjected to rainfall soon after application. By this time, most plants that were not dead were showing signs of regrowth from the crown. The activity of 2,4-D amine on ragwort was significantly reduced by simulated rain applied both 1 and 2 h after application while the activity of 2,4-D ester was reduced only by rain applied 1 h after application.

Table 1. Damage to nodding thistle and hairy buttercup from MCPA (1.44 kg a.i. ha^{-1}) with rainfall 1–6 h after application.

Rain after (h)	Percent damage[A]			
	Nodding (DAT)		Buttercup (DAT)	
	11	24	11	24
1	40	95	43	81
2	49	90	50	85
4	55	95	64	89
6	68	99	81	98
No rain	64	100	83	100
LSD	8.1	8.7	9.3	12.0

[A] By 47 DAT all treated plants were dead.

Table 2. Damage to nodding thistle and ragwort from 2,4-D amine (1.6 kg a.i. ha^{-1}) with rainfall 1–6 h after application.

Rain after (h)	Percent damage[A]				
	Nodding (DAT)		Ragwort (DAT)		
	11	24	11	24	47
1	39	79	44	55	63
2	50	73	49	58	73
4	68	93	50	66	95
6	65	88	58	74	100
No rain	73	91	60	73	100
LSD	9.7	10.2	8.2	11.9	5.2

[A] By 47 DAT all treated nodding thistle plants were dead.

Table 3. Damage to nodding thistle and ragwort from 2,4-D ester (1.3 kg a.i. ha^{-1}) with rainfall 1–6 h after application.

Rain after (h)	Percent damage[A]				
	Nodding (DAT)		Buttercup (DAT)		
	11	24	11	24	47
1	53	99	38	54	60
2	60	100	39	73	98
4	66	98	39	79	100
6	69	98	46	78	100
No rain	86	100	59	76	100
LSD	4.0	3.7	7.3	13.4	4.2

[A] By 47 DAT all treated nodding thistle plants were dead.

DISCUSSION

The amine formulations of the phenoxy herbicides are considerably more water soluble than the ester formulations (Table 5) and as such are more prone to being washed from the plants if rain occurs soon after application. Modern adjuvant technology can improve herbicide uptake and help protect herbicides

Table 4. Damage to nodding thistle and hairy buttercup from MCPA + MCPB (75 + 1125 g a.i. ha^{-1}) with rainfall 2–6 h after application.

Rain after (h)	Percent damage[A]			
	Nodding (DAT)		Buttercup (DAT)	
	9	15	9	15
2	81	98	68	100
4	82	98	68	100
6	83	99	73	100
No rain	87	100	63	97
LSD	5.6	2.8	4.3	1.5

[A] By 20 DAT all treated plants were dead.

Table 5. Water solubility of some phenoxy herbicides (Tomlin 2003).

Water solubility (mg L^{-1})			
2,4-D		MCPA/MCPB	
amine	ester	amine	ester
5000,000	113	270,000	5

from loss of activity due to rainfall (Thompson *et al*. 1996, Green and Beestman 2007). The formulations of some older herbicides, however, have remained unchanged for many years and there is little incentive for the proprietors to do research on further development of these products.

The experiments reported here have demonstrated that the rainfree period specified on product labels for several phenoxy herbicides can be shortened without compromising the efficacy of the herbicide. Based on this study new recommendations on the product label of the herbicides evaluated here are Agritone 720 (MCPA amine), Relay (2,4-D ester) and Thistrol Plus (MCPA/MCPB amine) a rainfree period of 2 h. Baton (2,4-D amine) remains unchanged at 6 h (Young 2007).

ACKNOWLEDGMENTS

We wish to thank Nufarm NZ for funding this study and Michael Trolove and Erin Carney for providing technical assistance.

REFERENCES

Green, J.M. and Beestman, G.B. (2007). Recently patented and commercialized formulation and adjuvant technology. *Crop Protection* 26, 320-7.

James, T.K. and Rahman, A. (2005). Efficacy of several organic herbicides and glyphosate formulations under simulated rainfall. *New Zealand Plant Protection* 58, 157-63.

Loux, M.M., Stachler J.M. and Harrison, S.K. (1993). Weed control guide for Ohio field crops. p. 112. (Ohio Cooperative Extension Service, Ohio State University, Dept. of Agronomy).

Molin, W.T. and Hirase, K. (2005). Effects of surfactants and simulated rainfall on the efficacy of the Engame formulation of glyphosate in Johnsongrass, prickly sida and yellow nutsedge. *Weed Biology and Management* 5, 123-7.

O'Connor, B. (2003). Novachem manual. 444 p. (Novachem Services Limited, Palmerston North, New Zealand).

Thompson, W.M., Nissan S.J. and Masters, R.A. (1996). Adjuvant effects on imazethapyr, 2,4-D and picloram absorption by leafy spurge (*Euphorbia esula*). *Weed Science* 44, 469-75.

Tomlin, C. (2003). The pesticide manual: a world compendium. British Crop Protection Council, Alton. 1344 p.

Young, S. (2007). New Zealand Novachem agrichemical manual. p. 652. (AgriMedia, Christchurch, New Zealand).