RAGWORT AND NODDING THISTLE CONTROL WITH NOVEL 2,4-D MIXTURES

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ABSTRACT

For 50 years 2,4-D has been the predominant chemical used for weed control on New Zealand farms but there is regulatory pressure to reduce application rates. Pot and field experiments investigated the efficacy of lower rates of 2,4-D when used in combination with either chlorsulfuron or mesotrione, for control of ragwort (*Senecio jacobaea*) and nodding thistle (*Carduus nutans*). Experiments on potted plants evaluated herbicide combinations at several growth stages from small rosettes to pre-bolting while field trials were on weeds at bolting. Ragwort was well controlled by the half-rate of 2,4-D plus either chlorsulfuron or mesotrione. For nodding thistle, mesotrione was a better additive. In the field trials, control of both ragwort and nodding thistle from the half-rate of 2,4-D plus either chlorsulfuron or mesotrione was equal to or significantly better than that from the full-rate of 2,4-D alone. However, in some instances there was also significant pasture damage.

Keywords: nodding thistle, *Carduus nutans*, ragwort, *Senecio jacobaea*, 2,4-D, mesotrione, chlorsulfuron.

INTRODUCTION

The herbicide 2,4-D has been used for controlling broad-leaved weeds in New Zealand pastures since 1945 (Ward 1949). It was the first herbicide to show good grass tolerance while controlling most common broad-leaved weeds (Matthews 1956). It was widely researched from 1949–1959 with more than half of all the papers on 2,4-D published in the New Zealand Plant Protection Conference proceedings appearing in this period. During this period there were seven different formulations of 2,4-D available in 30 propriety brands, reflecting the importance of this herbicide at the time (Matthews 1956).

The advantages of the new hormone type herbicides would probably not have been fully realised were it not for the parallel development of precise, low-volume, hydraulic nozzles that allowed more accurate application of pesticides over a wide area (Brodie 1949). However, these sprayers were not suitable for rolling and hill country farms and two formulations were specifically formulated for use in these situations. These were the 2,4-D dust (1% sodium salt) and the hormonised superphosphate fertiliser (0.5–1% 2,4-D) (Muller 1952). With the advent of helicopters, which were better suited for spray application in hill country, and improved ground applicators in the early 1970s these two formulations and their application methods ceased. However, 2,4-D remains the most widely used herbicide in New Zealand's pastoral sector (Manktelow et al. 2005), albeit now with improved formulations with reduced volatility.

2,4-D is effective in controlling many major weeds of pasture, including ragwort (*Senecio jacobaea*) and nodding thistle (*Carduus nutans*) (Martin et al. 1986; James et al. 1995). Despite this there is pressure from several sources to reduce the amount of 2,4-D applied to pasture. The Ministry for the Environment has formulated a policy for pesticide risk reduction with reduced pesticide usage one of the aims (Anon. 2002). Also, farmers are wanting to reduce or avoid the use of 2,4-D due to concerns with herbicide drift and off-target damage or because of problems with herbicide resistance

in the target weed (James et al. 1995). As a result of this, various sulfonylurea herbicides have been evaluated as alternative or combination herbicides for control of ragwort and nodding thistle (Martin et al. 1988; James et al. 1995, 1997). This paper reports on both glasshouse and field investigations of using low rates of sulfonylurea and other herbicides in combination with reduced rates of 2,4-D for control of ragwort and nodding thistle, with the aim of reducing the total amount of herbicide used in pasture.

MATERIALS AND METHODS

Field trials

Two field trials were carried out over the summer months of 2006/07 to evaluate the use of certain herbicides below their recommended application rates (spikes) in combination with 2,4-D for the control of ragwort and nodding thistle. The active ingredients used as spikes were chlorsulfuron (Glean[®]), flumetsulam (PresideTM) and mesotrione (CallistoTM). Urea was also used as an inorganic adjuvant in the nodding thistle trial. All spikes and adjuvants were evaluated with the ethylhexyl ester formulation of 2,4-D (Pasture-KleenTM). Chlorsulfuron was also used with the dimethylamine salt formulation (Baton[®]) (Tables 1 & 2). Both formulations were used alone at the highest recommended rates and at half label rates in combination with the spikes and adjuvants. A lower rate of chlorsulfuron was used in the ragwort trial in an attempt to reduce pasture damage from this mixture. The new herbicide, aminopyralid (Tordon Max[®]), was also included for comparison.

Trial 1 was laid down on 26 October 2006 on a property in South Waikato where nodding thistle was the problem weed. Nodding thistle plants ranged from large rosettes to pre-bolting plants (300–500 mm in diameter). Trial 2 was laid down on 28 November 2006, also in South Waikato, where ragwort was the problem weed. The ragwort plants ranged in size from rosettes to pre-bolting plants (100–300 mm in diameter). Both trials had a plot size of 3 × 10 m with four replicates. All treatments were applied with a CO₂ powered back pack sprayer with a 3 m boom fitted with four TeeJet 11003 nozzles to apply 200 litres/ha at 210 kPa. Visual assessments of weed control and damage to ryegrass and clover were carried out at approximately monthly intervals for 3 months after treatment. At the time of the final assessments plant counts of nodding thistle and ragwort were also carried out.

Outdoor pot experiments

Nodding thistle was planted on 9 May 2007 and ragwort on 7 June 2007. Pre-germinated seeds were planted into potting mix (Daltons Premium Mix) in 150 mm diameter plastic pots and grown outside with regular watering and nutrient supplements. Over the next 5 months, four plants were randomly selected and the treatments applied. All treatments were applied with a CO₂ pressurised, moving belt sprayer fitted with a single, even spray nozzle (TeeJet 8003E) to apply 200 litres/ha at 210 kPa. In an attempt to achieve greater efficacy the rate of chlorsulfuron used in the ragwort pot trial was increased to be the same as used for nodding thistle. The average size of the plants at treatment is presented in Table 1. After treatment the plants were assessed every 2 weeks until they had either died and the crown decayed or they began to regrow.

All the data were subjected to ANOVA to separate treatment means and the LSD was calculated.

TABLE 1: Average size of potted plants at treatment.

Nodding thistle (planted on 9.5.07)			Ragwort (planted on 7.6.07)		
Treatment date	No. of leaves	Diameter (mm)	Treatment date	No. of leaves	Diameter (mm)
5.6.07	8.8±1.0 ¹	146±27	13.7.07	8.1±1.8	123±12
23.6.07	10.5±1.2	215±26	3.8.07	14.3±3.8	188±26
6.7.07	15.2±2.3	261±28	24.8.07	30.6±6.7	285±35
3.8.07	19.0±3.6	298±43	28.9.07	46.4±7.5	379±47
31.8.07	23.8±3.9	327±25	31.10.07	51.3±8.8	388±36
28.9.07	32.1±4.0	350±82	-	-	-

¹ ± 1 standard deviation.

RESULTS AND DISCUSSION

Field trial – nodding thistle

The results for Trial 1 on nodding thistle are presented in Table 2. The large plants in this trial generally were not well controlled with the 2,4-D treatments. Both the ester and amine formulations at full rate only achieved 20–48% control while the half rate only resulted in slight damage. However, when the half rate of 2,4-D was combined with either chlorsulfuron or mesotrione the level of control was significantly improved over both the half and full rate of 2,4-D alone. Flumetsulam and urea as additives to 2,4-D had little impact on this weed. Aminopyralid, used alone in this trial, resulted in 100% control of the nodding thistles present at treatment.

TABLE 2: Control of nodding thistle (% remaining number of nodding thistle plants per plot) and damage to white clover (%) from herbicide combinations applied on 26.10.06, with measurements made on 21.11.06 (Nov), 18.12.06 (Dec) and 26.1.07 (Jan).

Treatment (rate: g ai/ha)	Nodding thistle			White clover		
	Nov	Dec	Jan	Nov	Dec	Jan
Untreated	0	0	0	0	0	0
2,4-D ester (1040)	13	15	20	8	13	0
2,4-D ester (2080)	28	20	30	13	20	0
Ester (1040)+chlorsulfuron (4)	68	68	69	30	33	18
Ester (1040)+flumetsulam (20)	21	25	24	5	0	0
Ester (1040)+mesotrione (20)	68	65	84	38	13	15
Ester + urea	10	5	5	5	0	0
2,4-D amine (1200)	31	20	20	10	0	0
2,4-D amine (2400)	48	28	40	18	30	5
Amine(1200)+chlorsulfuron (4)	74	75	80	23	35	0
Aminopyralid (60)	89	99	100	100	100	100
LSD(P<0.05)	13.7	16.5	24.9	14.2	18.8	13.0

Unfortunately the treatments that offered the best weed control also resulted in the most pasture damage, particularly to the white clover (*Trifolium repens*) (Table 2). However, the damage to ryegrass and white clover from the 2,4-D mixtures was not significantly different from the full rate of 2,4-D alone. Aminopyralid was extremely

damaging to white clover, removing it completely for the duration of the trial. Damage to perennial ryegrass (*Lolium perenne*) was minimal in the trial with only 2,4-D plus chlorsulfuron causing damage. For the 2,4-D ester plus chlorsulfuron this was assessed as 18% and 5% for November and December respectively and no damage was observed in January. Corresponding figures for 2,4-D amine plus chlorsulfuron were 5%, 5% and no damage.

Field trial – ragwort

The results for ragwort (Trial 2, Table 3) were similar to those from nodding thistle in that most of the herbicide spikes used with the half rate of 2,4-D showed efficacy equal to the full rate of 2,4-D and significantly better than the half rate alone. The rates of chlorsulfuron used in this trial were lower than in Trial 1 and pasture damage was considerably less. No clover damage persisted through to the January assessment, except for aminopyralid, which remained at 100%. No damage to ryegrass was observed during any of the assessments.

TABLE 3: Control of ragwort (% remaining number of ragwort plants per plot) and damage to white clover (%) from herbicide combinations applied on 28.11.06, with measurements made on 18.12.06 (Dec), 26.1.07 (Jan) and 21.2.07 (Feb).

Treatment (rate: g ai/ha)	Ragwort (%)			White clover ¹	
	Dec	Jan	Feb	Dec	Jan
Untreated	0	0	0	0	0
2,4-D ester (1040)	15	30	43	0	0
2,4-D ester (2080)	25	60	67	0	5
Ester (1040)+chlorsulfuron (1)	58	75	75	0	0
Ester (1040)+chlorsulfuron (3)	63	86	87	0	8
Ester (1040)+flumetsulam (20)	48	46	43	0	0
Ester (1040)+mesotrione (20)	55	73	85	0	0
Ester (1040)+aminopyralid (3)	28	78	75	12	23
2,4-D amine (1200)	20	65	75	0	0
2,4-D amine (2400)	30	84	92	0	5
Amine (1200)+chlorsulfuron (3)	70	94	95	0	0
Aminopyralid (60)	80	100	100	60	100
LSD(P<0.05)	10.1	17.0	22.2	15.1	9.8

¹No clover damage was observed during the February assessment except for aminopyralid, which remained at 100%.

Outdoor pot experiments – impact of stage of growth

Results from the pot trials are presented in Table 4 (nodding thistle) and Table 5 (ragwort). These show that nodding thistle was readily killed when the plants were less than 150 mm diameter or about 1 month old (Table 1). After this time the efficacy began to decline, particularly for the low rates of 2,4-D. Of the treatments applied on 31 August 2007, only the high rate of 2,4-D (both formulations) plus mesotrione resulted in greater than 95% control while the high rate of 2,4-D alone and the mixture with chlorsulfuron resulted in 80–90% control (data not presented). In the earlier assessments 2,4-D plus mesotrione performed significantly better than the other treatments, but no significant differences existed at the final assessment. This shows that the knockdown of the mesotrione mixture was significantly faster. For the treatments applied on

29 September 2007, the 2,4-D plus mesotrione mixture again provided faster knockdown but by the time of the final assessment (8 weeks after treatment) there were no significant differences between the treatments and control was only 50–80% for the highest rates evaluated (data not shown). Overall, with the application rates chosen mesotrione was a superior additive to 2,4-D than chlorsulfuron for control of nodding thistle but effective control could only be achieved on plants smaller than 300 mm in diameter or under 3 months old with the low rates of herbicide evaluated.

TABLE 4: Visual assessment of damage (%) to potted nodding thistle plants, planted on 9.5.07, and sprayed at four different stages of growth.

Treatment ¹	Rate ai ² (g/ha)	5.6.07 ³		23.6.07 ³		6.7.07 ³		3.8.07 ³	
		4Wk ⁴	12Wk	4Wk	10Wk	4Wk	11Wk	4Wk	10Wk
2,4-D ester	260	85	99	55	100	43	81	40	63
	520	93	100	63	100	55	100	50	99
	1040	98	100	88	100	73	100	65	100
2,4-D amine	300	85	100	55	98	43	89	55	86
	600	90	100	75	100	73	99	78	100
	1200	99	100	88	100	78	100	88	100
Ester+Chlor	130	95	100	48	55	38	45	58	78
	260	98	100	53	75	55	65	60	84
	520	100	100	85	100	50	78	68	86
Amine+Chlor	150	99	100	45	65	53	53	48	68
	300	99	100	55	70	58	70	60	80
	600	99	100	78	96	65	85	68	95
Ester+Meso	130	100	100	63	98	70	89	70	65
	260	100	100	78	100	86	100	80	95
	520	100	100	93	100	94	100	88	98
Amine+Meso	150	100	100	73	100	68	65	68	63
	300	100	100	84	100	73	100	85	93
	600	100	100	96	100	81	100	93	100
Untreated	-	0	0	0	0	0	0	0	0
LSD (P<0.05)		4.1	0.5	12.4	8.6	10.8	14.0	15.9	12.2

¹Ester=2,4-D ester, Amine=2,4-D amine, Chlor=chlorsulfuron, Meso=mesotrione.

²Rate of chlorsulfuron was 4 g ai/ha, rate of mesotrione was 83 g ai/ha.

³Treatment date.

⁴Wk = weeks after treatment.

Ragwort proved more difficult to control than nodding thistle, with few of the treatments achieving a 100% kill (Table 5). Again size was a critical factor, with ragwort plants up to 120 mm in diameter (5 weeks old, Table 1) being readily controlled by most treatments. However, after this time the ragwort plants became more tolerant. Both mesotrione and chlorsulfuron combinations with 2,4-D provided faster knockdown compared to 2,4-D alone but only in a few instances was the final effect from these combinations significantly better than for the highest rate of 2,4-D alone. Results from the final treatment application on 31 October 2007 were similar to those for the previous application on 28 September 2007 in Table 5.

TABLE 5: Visual assessment of damage (%) to potted ragwort plants, planted on 7.6.07, and sprayed at four different stages of growth.

Treatment ¹	Rate ai ² (g/ha)	13.7.07 ³		3.8.07 ³		24.8.07 ³		28.9.07 ³	
		4Wk ⁴	12Wk	4Wk	10Wk	4Wk	11Wk	4Wk	10Wk
2,4-D ester	260	48	95	58	78	60	75	30	60
	520	60	100	55	78	75	92	40	65
	1040	63	100	63	91	70	100	60	93
2,4-D amine	300	55	93	53	78	50	58	30	50
	600	63	93	63	85	73	90	40	68
	1200	68	100	60	93	80	95	70	92
Ester+Chlor	130	96	99	89	90	60	55	63	81
	260	100	100	100	97	83	90	70	90
	520	100	100	96	89	81	97	70	84
Amine+Chlor	150	99	80	94	97	79	95	60	85
	300	99	100	96	95	95	97	58	74
	600	100	100	98	99	73	91	68	84
Ester+Meso	130	93	100	63	83	68	73	50	43
	260	96	100	63	86	75	90	58	68
	520	97	100	80	95	85	100	60	81
Amine+Meso	150	90	100	73	90	70	55	65	64
	300	96	100	75	98	85	80	65	80
	600	98	100	78	100	83	95	61	69
Untreated	-	0	0	0	0	0	0	0	0
LSD (P<0.05)		10.1	9.2	18.9	13.5	21.6	16.9	13.4	13.4

¹Ester=2,4-D ester, Amine=2,4-D amine, Chlor=chlorsulfuron, Meso=mesotrione.²Rate of chlorsulfuron was 4 g ai/ha, rate of mesotrione was 83 g ai/ha.³Treatment date.⁴Wk = weeks after treatment.

CONCLUSIONS

These results demonstrate that the application rate of 2,4-D could be halved and effective control of both nodding thistle and ragwort still be achieved if low doses of either chlorsulfuron or mesotrione are used as additives in a treatment mix. Mesotrione would be the preferred choice as this mixture was more effective on nodding thistle and also resulted in less pasture damage. As well as being able to halve the rate of 2,4-D applied, the additives also significantly improved the speed of knockdown or brownoff of the weeds. The data presented here could also be used to more accurately match 2,4-D use rates to plant size, although, in practice, it is very rare to find naturally occurring populations of uniform size.

Both nodding thistle and ragwort have been reported as difficult to control weeds albeit for differing reasons. Multicrown ragwort plants especially are very difficult to control (Martin et al. 1986). However, as the mixtures evaluated here performed only equal to or slightly better than the higher rate of 2,4-D alone and did not perform well on the older plants in the pot trial, it is unlikely that these would be effective on multicrown ragwort plants. Nodding thistle plants in many locations in New Zealand have become resistant to the phenoxy herbicides and additives to 2,4-D have been successfully used to control

these resistant plants (James et al. 1995), although some of these mixtures have proved quite damaging to the pasture (James et al. 1993; Rahman et al. 1993). The herbicide combinations evaluated here were not tested on phenoxy-resistant nodding thistles but due to their possible greater pasture safety this would be the logical next step.

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