THE EFFECT OF HERBICIDES ON *LOTUS CORNICULATUS* ESTABLISHMENT IN DRYLAND CENTRAL OTAGO

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SUMMARY

Herbicides were applied in either autumn or winter and followed by glyphosate, paraquat/diquat or no herbicide in early spring, to control weeds and grasses prior to direct drilling *Lotus corniculatus* (birdsfoot trefoil) into dry hill country. Successful weed control resulted in increased numbers and production of *L. corniculatus*. Establishment was greatest in the paraquat/diquat sub-treatment but plant survival in the first 7 months was best in glyphosate treated sub-treatments. Dry matter production over two seasons was greatest in winter applied carbetamide and propyzamide treatments combined with the spring applied glyphosate treatment.

Keywords: *Lotus corniculatus*, herbicides, weeds

INTRODUCTION

Lotus corniculatus L. shows potential as a productive and persistent legume of dry hill country areas of low to medium fertility (Scott and Charlton 1983) and is seen as an alternative to lucerne (*Medicago sativa* L.) on more acid and low fertility soils. *L. corniculatus* is, however, slow to establish from seed and this factor may limit its use (Scott and Charlton 1983). It can be sown as a single crop or in combination with non-competitive grasses.

Problems associated with successful establishment of either *Lotus corniculatus* or lucerne are very similar. Musgrave (1982) found that the success of lucerne establishment by oversowing or direct drilling depended on the use of herbicide to reduce competition during the establishment phase. Brash (1982) showed lucerne establishment to be greatly improved by applying glyphosate 6 weeks before drilling and that failure to control sheep's sorrel (*Rumex acetosella*) could be a major factor in poor lucerne establishment. Chapman *et al.* (1989) also considered it essential to remove weed competition using either herbicides or cultivation before sod-seeding *L. corniculatus*. Weed competition in drier environments is considered to be the main reason for failure of *L. corniculatus* establishment in trials evaluating techniques for rhizobia inoculation (W.L. Lowther pers. comm.).

This paper reports the findings from a single trial where herbicides were applied to resident weeds and grasses before direct drilling *L. corniculatus*.

MATERIALS AND METHODS

The investigation was carried out on an extensive dry land sheep grazing property near Alexandra in a semi-arid inland basin with a mean annual rainfall of 350–500 mm, subject to very hot summers and cold winters with severe frosts. The property had been top-dressed with sulphur superphosphate every 3 years and the trial area had not been cultivated for at least 50 years. Soil type was a Conroy brown-grey earth with a pH of 5.7 and 2.1% organic carbon.

The main herbicide treatments (Table 1) were applied on either 23 March or 14 July 1988 to plots measuring 15 x 1.5 m arranged in four randomised blocks. On 15 August 1988, 4.5 m wide strips of either glyphosate (Roundup) at 2.1 kg/ha or paraquat/diquat (Preeglone) at 0.48/0.24 kg/ha were sprayed at right angles across each replicate. An unsprayed strip, also 4.5 m wide was included as the control. All

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herbicides were applied with a modified Oxford Precision sprayer fitted with Tee-jet Spraying Systems 8002 fan nozzles in 250 litres water/ha. On 17 August the trial was direct drilled with 4 kg/ha of pelleted inoculated (at 5 times the recommended rate) *L. corniculatus* seed using a Duncan 730 multi-seeder triple disc drill. The soil was moist with a temperature at 10 cm depth of 6°C. The trial was protected by a rabbit proof fence but was opened for sheep grazing for 1 week in April 1989 and for 5 weeks in November/December 1989.

Weed cover was visually assessed in spring and autumn 1988-89 and again in November 1989. Plant numbers were counted along ten 0.75 m lengths of drill row in each sub-plot in November 1988, March 1989 and March 1990.

L. corniculatus production was assessed by cutting the herbage to 1 - 2 cm above ground level from ten 0.75 m lengths of drill row in each sub-plot in April and November 1989 and February 1990.

Analyses of variance accounting for the criss-cross trial design were performed on plant numbers and dry matter production figures. Mean percentage weed cover showed gross differences, and is presented without analysis.

RESULTS

Weed and grass control

Ground cover of weeds and grasses before the autumn herbicide application on 23 March 1988 was mainly sheep's sorrel and haresfoot trefoil (*Trifolium arvense*) (40-60% cover) with lesser amounts (20-30%) of downy brome (*Bromus tectorum*), *Festuca* spp., woolly mullein (*Verbascum thapsus*), storksbill (*Erodium cicutarium*) and various flatweeds.

By the time of the August 1988 herbicide application, downy brome comprised 90% of the annual weeds present in the dicamba, metsulfuron and clopyralid treatments. In the carbetamide and propyzamide treated plots, sheep's sorrel was the dominant weed (Table 1) and only fescue and downy brome showed visible signs of herbicide damage. Seedlings of woolly mullein and storksbill were the only weeds present in the glyphosate treatment.

By October 1988 (10 weeks after drilling [WAD]), downy brome and haresfoot trefoil were the major weeds in the sub-treatment which received nil herbicide in spring (Table 1) except for where amitrole and glyphosate had been applied in autumn. Here, the main weeds were speedwell (*Veronica* spp.) and forget-me-not (*Myosotis arvensis*) with haresfoot trefoil and storksbill appearing in mid-summer.

Immediately before the harvest in November 1989 (64 WAD), woolly mullein was prominent in the glyphosate sub-treatment with sheep's sorrel, grasses, haresfoot trefoil, speedwell and forget-me-not covering most area of the paraquat/diquat and nil herbicide sub-treatments. Annual weed and grass cover had increased overall from an average of 20% at 30 March 1989 (Table 1) to 36%, with greater increases in the glyphosate and paraquat/diquat sub-treatments than in the nil treatment. Carbetamide and propyzamide in association with spring applied glyphosate had maintained the best weed control.

Plant numbers

In November 1988 (11 WAD), the highest numbers of *L. corniculatus* plants were recorded in the paraquat/diquat sub-plots ($P < 0.01$) (Table 2). Of the main treatments, metsulfuron and glyphosate treated plots had the lowest numbers ($P < 0.05$). Plants varied between 1 and 10 cm in height and having 1 to 3 shoots. Plant numbers decreased between November 1988 and March 1990 (Table 2). Plant survival overall was best in the glyphosate sub-treatment.

Yield

In April 1989 (30 WAD), *L. corniculatus* yields from carbetamide plus glyphosate and propyzamide plus glyphosate treatments were significantly ($P < 0.05$) higher than the yields from any other treatment (Table 3). When glyphosate was applied in autumn and repeated in spring the yield was lower than either of the single applications of glyphosate and when glyphosate was used in combination with paraquat/diquat.

TABLE 1: Percentage cover of weeds.

Main treatment (kg ai/ha) (Trade name)	Sub treatment	15.8.88			27.10.88			30.3.89		
		W ¹	S	Ann	W	S	Ann	W	S	Ann
amitrole (1) ² (2.0) (Weedazol 4L)	glyphosate para/diq ³ nil	29	-	1	24 14 0	1 15 9	0 6 16	58 38 15	10 18 36	0.1 0.1 10
dicamba (1) (0.5) (Shell Dicamba)	glyphosate para/diq nil	-	3	40	18 11 0	18 26 2	2 3 55	33 31 2	21 21 22	3 1 59
metsulfuron (1) (0.015) (Escort)	glyphosate para/diq nil	5	-	45	8 8 0	0 0 0	0 3 50	66 60 6	0 0 0	0.1 7 93
carbetamide (2) (3.0) (Carbetamex)	glyphosate para/diq nil	-	70	10	0.5 0.3 0	0 0.1 0.1	1 16 35	6 3 0	0 5 5	1 33 55
propyzamide (2) (1.25) (Kerb 50W)	glyphosate para/diq nil	-	75	5	0.3 0.3 0	0.3 10 0.1	3 10 43	3 3 0.1	5 15 14	3 20 62
glyphosate (1) (2.1) (Roundup)	glyphosate para/diq nil	48	-	2	15 14 0	0.3 2 0	3 3 28	65 48 20	1 3 6	2 1 33
clopyralid (1) (0.5) (Versatil)	glyphosate para/diq nil	-	0.1	50	14 8 0	3 31 0.1	0 1 62	48 30 10	10 28 20	0.1 0.1 38
untreated control	glyphosate para/diq nil	65	10	10	8 3 0	1 52 2	5 13 62	35 4 1	4 40 28	0.1 6 43

¹W = woolly mullein; S = sheep's sorrel; Ann = annuals - storks-bill, hares-foot trefoil, speedwell, downy brome

²(1) = applied 23.3.88; (2) = applied 14.7.88; sub treatments applied 15.8.8

³para/diq = paraquat/diquat

TABLE 2: *L. corniculatus* plant numbers/10 m of row and percent plant survival from initial counts.

Treatments applied autumn or winter 1988	10.11.88			31.3.89			29.3.90		
	Gly ¹	P/d	Nil	Gly	P/d	Nil	Gly	P/d	Nil
amitrole	117	147	91	68	73	33	49	45	23
% survival				58	50	36	42	31	25
dicamba	124	157	33	68	71	0	41	57	0
% survival				55	45	0	33	36	0
metsulfuron	86	130	22	47	51	0	24	32	4
% survival				55	40	0	28	25	18
carbetamide	126	178	98	89	60	4	51	49	4
% survival				71	34	4	40	28	4
propyzamide	99	163	93	72	73	4	39	59	3
% survival				73	45	4	39	36	3
glyphosate	84	106	64	47	77	34	39	47	30
% survival				56	73	37	46	44	47
clopyralid	89	155	30	56	67	2	38	51	3
% survival				63	43	7	43	33	3
untreated control	125	179	38	88	63	0	57	41	1
% survival				70	36	0	46	23	3
Mean plant numbers:	106	152	59	67	69	10	42	48	8
Mean % plant survival:	-	-	-	63	46	11	40	32	13
LSD 5%. Same level of:									
August treatment		54			29			18	
Main treatment		55			35			22	

¹Gly = glyphosate; P/d = paraquat/diquat

In the second growing season, the combined total dry matter yield from each treatment was generally slightly higher than that taken from the single cut of the previous autumn. In the amitrole and glyphosate treatments the yield increases from the sub-treatment combinations were comparatively high. Although plant numbers remained slightly higher in the paraquat/diquat sub-treatment than in the glyphosate sub-treatment, yields were higher in the latter (Table 3).

DISCUSSION

In this investigation *L. corniculatus* appeared to be extremely sensitive to weed competition in the early stages of development. It was noticeable after *L. corniculatus* had become established that plant growth was stronger and more vigorous in areas where weeds had been controlled. Once established, the plant develops a long tap-root with numerous lateral and fibrous secondary roots which enables it to cope more successfully with weed competition and dry conditions, and the results of this investigation reflect this.

TABLE 3: Dry matter yield (kg/ha) of *L. corniculatus*.

Treatment	April 1989			November 1989 February 1990 combined yields		
	Gly ¹	P/d	Nil	Gly	P/d	Nil
amitrole	220	190	120	620	570	240
dicamba	165	260	0	220	390	0
metsulfuron	200	200	2	270	280	30
carbetamide	950	250	20	1030	550	20
propyzamide	750	370	7	1000	620	13
glyphosate	190	470	230	500	780	490
clopyralid	250	190	8	500	270	0
untreated control	430	130	0	560	180	3
LSD 5%						
Same level of treatment:						
August treatment		200			450	
Main treatment		210			440	

¹Gly = glyphosate; P/d = paraquat/diquat

Rainfall over the 4 months following drilling was 25% less than the 20 year average in the area (N.Z. Meteorological Service summaries) and this, coupled with normal high temperatures, affected weed and *L. corniculatus* growth. All plants were visibly suffering from moisture stress as early as November 1988. *L. corniculatus* survival between November 1988 and March 1989 was lower in areas where fibrous shallow rooting weeds such as annual grasses, haresfoot trefoil and to a lesser degree sheep's sorrel were dominant. *L. corniculatus* plants were noticeably larger in those sub-plots where woolly mullein was the main weed, due possibly to less competition for moisture at establishment as woolly mullein, like *L. corniculatus*, develops a tap root.

L. corniculatus plant numbers were lowest following a spring application of glyphosate. Herbicide application was carried out only 2 days before drilling and it seems probable that germinating or emerging *L. corniculatus* seedlings contacted root or leaf tissue which held toxic residues of glyphosate. There is evidence of this occurring in Western Australia where cereal grain yields declined significantly with a decreasing time between glyphosate spraying and direct drilling (Madin 1989). In New South Wales, Campbell (1976) showed that glyphosate reduced the establishment of legumes and attributed this to seed coming into contact with the herbicide residue.

In this investigation, the best treatments gave final plant numbers of 34-42 plants/m² with a survival rate since establishment of over 40%, which follows the trend recorded for lucerne (Wyn-Williams 1982). The production of *L. corniculatus* over two growing seasons was directly influenced by the level of weed competition during its establishment period. Where weed cover exceeded 20% by late October 1988, subsequent *L. corniculatus* production was reduced ($P < 0.05$). There was no direct relationship between plant numbers and dry matter yields.

Brash (1982), suggested that early spring was not the optimum time for glyphosate application, and reported low establishment rates of lucerne where glyphosate control of sheep's sorrel was poor. In this investigation, however, conditions were apparently more favourable, resulting in successful *L. corniculatus* establishment and good control of sheep's sorrel. In an extreme environment such as this, the timing of spraying and sowing to suit ground and weather conditions can be critical.

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