

Control of Weeds, and Particularly White Clover (*Trifolium repens* L.), in Lucerne (*Medicago sativa* L.) Grown For Seed Production

M. Askarian¹, J.G. Hampton^{1,2} and K.C. Harrington²

ABSTRACT

Hand removal of weeds, predominantly white clover but also *Poa annua* L. and broad leaved species increased seed yield in a second year lucerne crop from 0.7 to 21.3 g m⁻² mainly because racemes increased from 89 to 1230 m⁻². Increases in pods per raceme and seeds per pod were also recorded. Hexazinone applied at 1.0 kg ai ha⁻¹ during active vegetative growth in early spring eliminated white clover from the lucerne plots and increased seed yield to 14.3 g m⁻². However this treatment did not control *Rumex obtusifolius* L. Simazine plus paraquat (2.25 kg ai plus 0.6 kg ai ha⁻¹) applied in winter before active spring growth controlled many annual weeds but, although initially checking white clover, did not control it. As a consequence, seed yield did not differ from that of the untreated control. Although hexazinone effectively removed white clover from a second year lucerne seed crop, it is recommended for use only on mature stands. White clover removal from first year stands still requires investigation. Harvested lucerne seed viability did not differ among treatments, but hand weeding and herbicide treatments significantly reduced the percentage of hard seed.

Additional index words: alfalfa, competition, hand weeding, hard seed, hexazinone, paraquat, seed yield, simazine.

INTRODUCTION

Weed control in forage lucerne (*Medicago sativa* L.) in New Zealand is well documented (Butler, 1982; Palmer, 1982; O'Connor, 1990), but there is a dearth of research on weed control in crops grown for seed (Dunbier, Wynn-Williams and Purves, 1983). However a limited number of reports from other countries have shown that weed competition can significantly reduce lucerne seed yield. For example Waddington (1985) reported that control of primarily smooth brome (*Bromus inermis* Leyss.) increased seed yield by 68%, while Dawson and Rincker (1982) found that by keeping lucerne weed free, seed yield was 820 kg ha⁻¹ compared with 45 kg ha⁻¹ for the unweeded control.

While a large number of weed species can be present in lucerne seed crops in New Zealand, many can be successfully controlled by pre-sowing treatment with trifluralin (Butler, 1982) and inter-row cultivation (Dunbier et al., 1983). However, two problem weeds are red clover (*Trifolium pratense* L.) and white clover (*Trifolium repens* L.), the former because seed size similarities can make this species difficult to clean from lucerne seed lots, and the latter because of the large plant population that can establish from volunteer buried seed (Hampton, Clifford and Rolston, 1987), leading to intense competition with the lucerne plants (Askarian, 1993).

A second year lucerne seed crop contained a heavy contamination from established white clover plants, and also a number of weed species including *Poa annua* L., dandelion (*Taraxacum officinale* Weber), twin cress (*Coronopus didymus* (L.) Sm.), annual mouse-ear chickweed (*Cerastium glomeratum* Thuill) and broad leaved dock (*Rumex obtusifolius* L.) (Askarian, 1993). Simazine

plus paraquat is commonly used for weed control in lucerne forage crops (Atkinson and Meeklah, 1980), while Waddington (1985) reported that hexazinone could be successfully used for selective weed control in established lucerne seed crops. In New Zealand, this herbicide is registered for use in established lucerne forage stands (O'Connor, 1990) for the control of a number of weeds including white clover. In this paper we report the effects of chemical and non-chemical control of white clover and other weeds on lucerne seed yield and quality.

MATERIAL AND METHODS

The experiment was conducted at Massey University, Palmerston North, New Zealand (40°S 170°E) on an Ohakea silt loam soil classified as an aeriofragiaqualf (gleyed yellow-grey earth) with a pH of 5.2. The stand of lucerne cv. Grasslands Oranga had been established in 30 cm rows using a sowing rate of 3 kg ha⁻¹ in 1991 (Askarian and Hampton, 1993) and a seed harvest taken in March 1992 (Askarian, 1993). The stand was grazed to 7 cm on 30 July 1992. Honey bees (9 colonies ha⁻¹) were introduced to the trial area on 24 December 1992 to facilitate pollination.

A control (weeds undisturbed), two herbicide treatments and a hand weeding treatment were each replicated three times in a complete randomised block design. Plot size was 1.5 x 2 m. Simazine (2.25 kg ai ha⁻¹) plus paraquat (0.6 kg ai ha⁻¹) was applied on 30 August 1992 before active vegetative lucerne growth, while hexazinone (1.0 kg ai ha⁻¹) was applied on 30 September 1992 during active weed growth (O'Connor, 1990). Herbicides were applied via a small gas pressure sprayer in 400 litre water ha⁻¹ at 200 kPa. Hand weeding was begun on 30 September 1992 and

continued at two weekly intervals until February 1993.

Treatment effects were assessed by visual assessment of percentage ground cover on 1 November 1992 and 1 February 1993. Botanical analysis to measure dry matter production of lucerne and weeds was taken from a randomly selected 0.1 m² quadrat in each plot on 21 March 1993. Plants were cut at ground level, separated into lucerne and weeds and dried at 65°C for 96 hours. Lucerne seed yield and its components were also recorded on 21 March 1993 by removing all plant material from two randomly allocated 0.25 m² quadrats per plot. Lucerne racemes were hand separated from this material and left to dry at ambient temperature for four weeks. The racemes were then counted and pods per raceme determined from 50 randomly selected racemes per plot. Seeds per pod were then counted from 50 randomly selected pods per plot. Seed was then removed from the pods by hand rubbing (Askarian, 1993) and cleaned using 1.0 -1.7 mm sieves and then a Burrows portable blower set at 50 km h⁻¹ air speed for three minutes. Seed moisture content, thousand seed weight and seed viability were determined using internationally standardised methodology (ISTA, 1985). Seed yields were expressed at 7% seed moisture content.

Data were analysed by analysis of variance using the SAS programme (SAS, 1987). Any data recorded as percentages were transformed (Steel and Torrie, 1987) to

an angular scale ($\arcsin \sqrt{y}$) before analysis. Regression analysis was used to examine the relationship between seed yield, its components and weed dry matter.

RESULTS

At 1 November 1992 total percentage ground cover was greatest for the unweeded control, followed by the two herbicides treatments, with the hand weeding treatment having only just over one third ground cover (Table 1). However for the control, only 13% of this cover was lucerne with white clover constituting 60% and other weed species 26% of the cover. Hand weeding and the herbicide treatments significantly increased the percentage of lucerne as plant ground cover (Table 1), and significantly decreased the percentage of white clover compared with unweeded plots, although hexazinone and hand weeding were more effective than simazine plus paraquat (Table 1).

By 1 February 1993, both of the herbicide treatments and hand weeding had increased ($P < 0.05$) the percentage of lucerne in the plant cover (Table 1). The hexazinone application and hand weeding had eliminated white clover from the plant cover but there was no significant difference in the white clover cover of the unweeded plots and those treated with simazine and paraquat (Table 1). Other weeds (Table 1) still present included twin cress, dandelion, broad leaved dock and annual mouse-ear chickweed.

Table 1: Effect of herbicides and hand weeding on percentage plant ground cover and its components, on 1 November 1992 and 1 February, 1993.

Treatment	% ground cover 1 November ¹				% ground cover 1 February ¹			
	ground cover	lucerne	white clover	other weeds ²	ground cover	lucerne	white clover	other weeds ²
Unweeded	90.0 ³ a ⁴	13.3b	60.5a	25.7a	90.0a	27.8c	38.4a	37.0a
Hand weeding	36.4c	36.3a	3.3c	0.0b	90.0a	90.0a	0.0b	0.0b
Hexazinone	69.2b	42.1a	13.8c	22.7a	90.0a	70.7ab	0.0b	19.3ab
Simazine + Paraquat	82.4ab	36.8a	31.9b	34.3a	90.0a	54.8b	28.6a	16.1b
LSD $P < 0.05$	16.79	12.52	12.35	12.39	0.0	25.79	19.91	20.77
Significance	* ⁵	*	*	*	NS	*	*	*
CV %	12.0	19.5	22.5	26.8	0.0	21.2	39.4	37.4

¹ transformed data. ² included twin cress, dandelion, annual mouse-ear chickweed, broad leaved dock. ³ 100% for non transformed data. ⁴ means within columns with the same letters are not significantly different at $P < 0.05$. ⁵ significant at $P < 0.05$.

At final harvest both herbicide treatments and hand weeding had produced more lucerne dry matter ($P < 0.05$) than the unweeded control, and had also significantly decreased the dry matter of weeds. However, hexazinone and hand weeding had less weed dry matter ($P < 0.05$) than simazine plus paraquat (Table 2). For the hexazinone treated plots the major weed species present was broad

leaved dock, while broad leaved dock, twin cress, dandelion, and annual mouse-ear chickweed were present in simazine plus paraquat treated plots.

Hexazinone and hand weeding increased ($P < 0.05$) the number of harvestable racemes m² and pods per raceme (Table 3) but there was no significant difference between simazine plus paraquat and the unweeded control for these

two parameters (Table 3). Hand weeding significantly increased the number of seeds per pod, but the herbicide treatments did not. Neither herbicide treatments nor hand weeding had any effect on thousand seed weight (Table 3).

Hand weeding and hexazinone increased ($P < 0.05$) seed yield, but simazine plus paraquat had no significant effect on seed yield (Table 3).

Table 2: Effect of herbicides and hand weeding on lucerne and weed dry matter (gm^{-2}) at final harvest on 25 March 1993.

Treatment	Dry matter of lucerne	Dry matter of weeds ¹
Unweeded	75.2b ²	374.1a
Hand weeding	410.4a	6.4c
Hexazinone	509.7a	45.0c
Simazine + Paraquat	405.6a	202.8b
LSD $P < 0.05$	178.8	70.8
Significance	*	*
CV %	26.9	24.0

¹ major species were white clover, broad leaved dock, *Poa annua*, twin cress, dandelion.

² means within columns with the same letters are not significantly different at $P < 0.05$.

Table 3: Effect of herbicides and hand weeding on lucerne seed yield and its components.

Treatment	Racemes m^{-2}	Pods raceme ⁻¹	Seeds pod ⁻¹	TSW (g)	Seed yield (g m^{-2})
Unweeded	89.3b ¹	3.5b	2.57b	1.79a	0.72c
Hand weeding	1230.8a	5.5a	3.68a	1.62a	21.3a
Hexazinone	956.0a	6.0a	3.49ab	1.84a	14.3ab
Simazine + Paraquat	370.6b	4.5ab	3.27ab	1.75a	7.23bc
LSD $P < 0.05$	296.64	1.65	0.962	0.22	7.92
Significance ²	*	*	*	NS	*
CV %	22.1	16.9	14.8	6.1	22.0

TSW = thousand seed weight.

¹ means within columns with the same letters are not significantly different at $P < 0.05$.

² * significant at $P < 0.05$. NS - not significant

Seed yield was significantly and positively correlated with racemes m^{-2} ($r = 0.97$, $P < 0.001$) and pods per raceme ($r = 0.62$, $P < 0.05$) and negatively correlated with weed dry matter at final harvest ($r = -0.91$, $P < 0.001$).

Seed viability did not differ among treatments (Table 4). However hand weeding and herbicide treatment significantly increased germination by reducing hard seed levels. This response was greatest for the hexazinone treatment (Table 4).

DISCUSSION

Competition from weeds resulted in an 82% reduction in total lucerne dry matter production because when compared with hand weeded plots, racemes m^{-2} were reduced by over 90%. The net effect of this for seed produc-

tion was a 97% reduction in seed yield due to the presence of weeds, a result very similar to the 95% reduction reported by Dawson and Rincker (1982). Initially at this site, most of this weed competition came from white clover (Table 1), but as the season progressed other weed species including dandelion, broad leaved dock, twin cress and annual mouse-ear chickweed also became important. However by final harvest the major weed component was still white clover. White clover plants reached their maximum height in January and began to lodge, forcing the lucerne plants to lodge as well. This occurred during lucerne flowering, and it is possible that in addition to the competition for light, nutrients and water provided by the weeds, lodged lucerne flowers were less accessible to pollinators.

Table 4: Effect of herbicides and hand weeding on lucerne seed germination

Treatment	% Normal seedlings	% Hard seed	% Viable seed
Unweeded	23.0c ¹	75.0a	99.0a ³
Hand weeding	32.4b	63.0b	99.5a
Hexazinone	53.0a	41.5c	98.5a
Simazine + Paraquat	37.0b	59.0b	99.0a
LSD P < 0.05	6.54	9.18	2.26
Significance ²	*	*	NS
CV %	11.1	9.6	1.4

¹ means within the columns with the same letters are not significantly different at P < 0.05.

² * significant at P < 0.05. NS - not significant

³ differences between % viable seed and the sum of % normal seedlings and hard seed are accounted for by abnormal seedlings (ISTA, 1985).

Hexazinone successfully removed white clover from the lucerne stand and as a result, seed yield was significantly increased. Concern has been expressed about the use of hexazinone in lucerne. Wilson (1981) reported initial injury to lucerne following its application, but found that forage yield was not reduced, and Waddington (1985) also reported damage to young lucerne shoots present at the time of treatment, but that recovery was rapid and no delay in reproductive development was observed. A similar result was recorded in the present trial - slight yellowing of lucerne foliage occurred after hexazinone application, but plants recovered after two weeks, and total dry matter did not differ from that of the hand weeded plots. Hexazinone at 1.0 kg ai ha⁻¹ also eliminated grass weeds, but did not control *Rumex obtusifolius*, which grew to a height of over one metre in hexazinone treated plots. It is possible that the reason the seed yield from hexazinone treated plots was lower (but not significantly different) than that from the hand weeded plots was because of the presence of *Rumex obtusifolius*, but this was not determined conclusively.

Hexazinone is an effective herbicide for control of white clover in lucerne, but can not be used in stands less than twelve months old (O'Connor, 1990) because of the risk of damage to young lucerne plants. This poses a problem for first year lucerne seed crops where volunteer white clover is likely to be present. Chlorimuron is also registered for use in lucerne in New Zealand to control red and white clovers amongst other weeds (Hare and Rolston, 1990), but like hexazinone can only be applied to established crops. Hare and Rolston (1990) reported that chlorimuron increased seed yield of *Lotus uliginosus* Schkr. through reducing white clover vegetative growth, but that white clover regrew in late spring. If white clover is likely to be a problem for lucerne seed production, the advice of Dunbier et al., (1983) should be followed i.e. sow in rows wide enough to facilitate inter-row cultivation. Any white clover plants not controlled by cultivation could then be

removed by hexazinone application in spring of the second year. It would also be useful, however, for further trial work to establish whether the damage caused by hexazinone application to a first year lucerne crop would outweigh the loss in seed yield caused by white clover competition.

Simazine plus paraquat did not significantly increase seed yield, primarily because of the failure of this treatment to control white clover. The white clover was checked initially by simazine plus paraquat, but recovered quickly, so that by the end of flowering of the lucerne crop, the white clover content did not differ from that of the control.

An unexpected result from this experiment was the effect of the treatments on hard seed levels. Viability did not differ among treatments, yet both complete and partial removal of weeds significantly reduced hard seed levels. Hard seed development is strongly influenced by environmental factors (Rolston, 1978) particularly relative humidity and temperature. It is possible that the environment during seed maturation differed between the unweeded plots, where lucerne seed pods were overgrown and smothered by weeds, and plots where weeds were absent or partially removed. However this was not recorded. Factors affecting hard seed levels in forage legumes require further investigation.

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