Weed control in chickpeas (*Cicer arietinum*)

J. N. Plew, G. D. Hill and F. Dastgheib

Plant Science Department, P.O. Box 84, Lincoln University, Canterbury

Abstract

Kabuli chickpeas (*Cicer arietinum* L.) were sown on 10 December 1993 and subjected to a range of treatments for weed control. There were 7 pre-emergence treatments, 10 post- emergence treatments and three controls: unweeded, hand weeded and hoed. Chemicals tested were known to be selective on field peas, (*Pisum sativum* L.), including the grass controlling herbicides clethodim and haloxyfop, and the broadleaf controlling herbicides bentazone, cyanazine, MCPB, metribuzin, and terbuthylazine. The herbicides were applied at the recommended dose rate for field peas, twice the recommended dose rate and in several combinations at the recommended rate for each herbicide.

Best control of weeds and greatest dry matter production of chickpeas was obtained from pre-emergence treatment with cyanazine at 1.0 kg a.i./ha, terbuthylazine at 1.0 kg a.i./ha, the combination of cyanazine at 1.0 kg a.i./ha with metribuzin at 0.25 kg a.i./ha, and hand weeding. The chickpeas were seriously damaged by post-emergence application of cyanazine, bentazone, and their combination.

Additional key words: *Weed competition; herbicide toxicity.*

Introduction

Chickpeas (*Cicer arietinum*) are planted on about 8.7 million hectares worldwide. Of this area, 24% is found in the West Asia and North Africa (WANA) region. They account for 14% of the total world area sown to pulses (Anon, 1992). Chickpeas are a good source of carbohydrates and protein, which together constitute about 80% of the total seed dry weight (Williams and Singh, 1987). The average chickpea seed yield is low, about 713 kg/ha (Anon, 1992), because chickpeas are usually grown as a spring sown, rainfed crop on soils with marginal fertility (Hernandez, 1986), or in the cooler season of the year, when days are short in the Indian subcontinent.

Chickpeas are not yet grown commercially in New Zealand. The suitability of the crop for production in New Zealand has been assessed by Logan (1983), Farnsworth (1985), Hernandez (1986), and Kosgey (1994). Yields obtained to date in New Zealand trials of 1.7 to 4.3 t/ha are considerably higher than those obtained in traditional chickpea growing regions (Hernandez, 1986; Kosgey *et al.*, 1994; Verghis *et al.*, 1994). The major consumer of New Zealand produced chickpea seed is expected to be the local health food market (Farnsworth, 1985). However, there is a potential for exports, particularly of the large seeded *Kabuli* type.

Chickpea yield losses due to weed competition have been estimated to range between 40 and 87% depending on weed species and density (Bhan and Kukula, 1987). High yield losses occur because chickpeas have a slow initial growth rate (Knott and Halila, 1988). Weed flora is dependent on climate, crop rotation and time of sowing (Knott and Halila, 1988). In general, chickpeas are more sensitive to herbicides than cereals (Kumar *et al.*, 1989). Results from experimental work conducted in India, Italy, and Australia indicate that pre-emergence herbicides generally gave better weed control than post-emergence herbicides and did not cause plant damage (Mahoney, 1981; Ramakrishna *et al.*, 1992; Mittal and Singh, 1983; Yadav *et al.*, 1983; Mahoney, 1984a, 1984b; Calcagno *et al.*, 1987; Kumar *et al.*, 1989).

To date there has been little work conducted on selective herbicides that will provide adequate weed control for chickpea in the New Zealand environment. The purpose of this experiment was to identify the problem weed species in chickpea crops in the Canterbury region of New Zealand and to evaluate several pre- and post-emergence herbicides for selective weed control.

Materials and Methods

Locally grown *Kabuli* chickpea seed, mean seed weight 295 mg and with a germination of 50%, was sown to obtain a plant population of 45 plants/m^2. The crop was drilled in 15 cm rows at a depth of 5 cm with an Øyjord cone seeder into a Wakanui silt loam soil at the Lincoln University research farm on 10 December 1993. A maintenance fertilizer dressing of 200 kg/ha of superphosphate was applied at sowing. Prior to sowing all seed was treated with Apron C 70 SD (metalaxyl/captan) and inoculated with *Rhizobium* strain CC1192 at 480 g/100 kg of seed. Environmental conditions during the experimental period are shown in Table 1. The experiment had a randomised complete block design with twenty treatments and four replicates. Each plot was 10 m by 2 m.

The herbicides chosen for evaluation were all selective towards field peas (Anon, 1993). Herbicides used and their dose rates are shown in Table 2. All herbicides were applied at 300 l/ha at 95 KPa with a portable battery powered Smoggi sprayer with a 2 metre boom. Two controls were established, a hand-weeded, weed free control and an unweeded control. In addition, a single hand hoeing at 42 days after sowing (DAS) was included as a mechanical weed control treatment. Pre-emergence herbicides were applied at 6 DAS and post-emergence herbicides were applied at 24 DAS.

Two 0.1 m^2 quadrat cuts at ground level were taken from each plot at 45, 60, 90 and 120 DAS. All weed species present in the samples were identified. Chickpea and weed samples were dried in a forced air oven at 70^{o}C to constant weight and weighed.

Once crop senescence was complete (130 DAS) all chickpea plants in a 1m^2 quadrat were counted and harvested by hand. A five-plant sub-sample was removed and weighed, the number of pods counted and threshed to determine yield components. After equilibration to constant moisture level, the remaining sample was weighed and mechanically threshed. The seed recovered was weighed to calculate final seed yield and harvest index for each treatment.

All data were analyzed using the general linear model (GLM) in Minitab version 9 and SAS and appropriate contrasts determined. Chickpea and weed biomass data collected at 45, 60, 90 and 120 DAS were transformed by $\log_x+1$ prior to analysis to ensure normal distribution. For back-transformed values, confidence interval limits at the P=0.05 level, and, for original values, standard error of the mean (SEM) are given.

Table 1. Weather data for Lincoln University from December 1993 to April 1994.

Month	Rain (mm)	T_{max}[1] (°C)	T_{min}[1] (°C)
December	99.8 (91.93)	17.7 (20.2)	9.2 (10.2)
January	50.3 (35.57)	22.6 (23.0)	11.7 (11.5)
February	37.8 (55.89)	21.7 (21.6)	11.7 (11.3)
March	81.0 (57.88)	18.1 (19.7)	8.6 (9.2)
April	17.5 (41.67)	18.5 (17.4)	6.0 (6.5)

[1] Mean of average daily values.
Figures in parenthesis indicate 9 year averages.

Results

Climate

The growing season for 1993/94 was slightly cooler and wetter than normal (Table 1), hence delaying crop maturity.

Weed species present

The dominant broadleaf weed species identified were fathen (*Chenopodium album* L.), black nightshade (*Solanum nigrum* L.), speedwell (*Veronica arvensis* L.) and wireweed (*Polygonum aviculare* L.). Other broadleaf weed species present included spurrey (*Spergula arvensis* L.), scarlet pimpernel (*Anagallis arvensis* L.), hedge mustard (*Sisymbrium officinale* L.), shepherd's purse (*Capsella bursa-pastoris* L.), broad-leaved dock (*Rumex obtusifolius* L.), white clover (*Trifolium repens* L.), scentless chamomile (*Matricaria inodora* L.), henbit (*Lamium amplexicaule* L.), sow thistle (*Sonchus oleraceus* L.), wart cress (*Coronopus squamatus* L.), chickweed (*Stellaria media* L.), field bindweed (*Convolvulus arvensis* L.), and storksbill (*Erodium cicutarium* L.). Grass species present included *Phalaris aquatica* L., lesser canary grass (*Phalaris minor* L.), annual poa (*Poa annua* L.), and perennial ryegrass (*Lolium perenne* L.), and they comprised only a minor portion of the weed population.

Chickpea and weed dry matter production

Weed competition was detrimental to chickpea dry matter production. Chickpea biomass in the weedy control showed significant reductions of 70 and 42% at the second and third harvests, respectively, when compared with the weed-free control (Table 2).

Chickpeas were tolerant to pre-emergence applications of cyanazine, metribuzin, terbuthylazine, and cyanazine plus metribuzin (Table 2). These herbicides provided good weed control for most of the growing season. This is indicated by the lower amount of weed biomass in these treatments compared with the weedy control at 45 and 60 DAS. Reduction in weed biomass was significant even up to 120 DAS with cyanazine, the higher rates of terbuthylazine and metribuzin, and the combination of cyanazine and metribuzin.

Chickpeas were very sensitive to post-emergence applications of cyanazine, bentazone and combinations containing either of these two herbicides (Table 2).

These herbicides caused severe damage to the crop, which was still visible at 45 DAS. While there was some recovery, the total dry matter production from these plants was consistently lower than the weed-free control. In general, these treatments provided poor weed control at all sampling dates, except cyanazine at 2 kg a.i./ha and bentazone at 1.5 kg a.i./ha at 45 DAS, and cyanazine plus haloxyfop at 45, 60, and 90 DAS (Table 2).

Table 2. Effect of herbicides on *Kabuli* chickpea and total weed dry matter production (values are back transformed).

Herbicide	Rate (kg a.i./ha)	45 DAS[1] Chickpea (g/m^2)	45 DAS[1] Weed (g/m^2)	60 DAS Chickpea (g/m^2)	60 DAS Weed (g/m^2)	90 DAS Chickpea (g/m^2)	90 DAS Weed (g/m^2)	120 DAS Chickpea (g/m^2)	120 DAS Weed (g/m^2)
Pre-emergence									
Cyanazine	1.0	151	5.4	339	21.5	862	30.6	784	7.4
	2.0	111	1.9	325	2.6	1067	1.4	751	7.6
Metribuzin	0.25	115	16.9	372	31.5	823	43.4	608	45.5
	0.50	122	4.9	314	57.1	934	10.7	742	11.0
Terbuthylazine	0.75	111	25.8	408	34.3	814	30.8	726	32.9
	1.0	159	2.9	245	15.6	1022	13.2	762	3.7
Cyanazine + metribuzin	1.0 + 0.25	100	2.3	98	22.1	937	12.0	742	9.8
Post-emergence									
Cyanazine	1.0	32	89.6	110	293.8	234	373.8	262	123.4
	2.0	3	11.2	0	92.9	22	93.8	54	68.6
Bentazone	1.0	26	25.5	240	140.1	337	258.9	251	103.7
	1.5	5	13.2	50	151.6	89	299.6	13	189.42
Clethodim	0.06	118	56.9	59	188.4	272	141.8	525	96.6
	0.12	140	57.1	409	108.1	506	159.4	484	86.4
Haloxyfop	0.15	122	56.8	240	104.1	720	88.3	469	74.5
	0.30	87	83.7	321	140.9	694	116.5	473	122.4
Bentazone + MCPB	1.0 + 1.2	6	18.5	2	145.4	25	171.5	41	226.9
Cyanazine + haloxyfop	1.0 + 0.15	6	0.2	3	3.4	134	9.9	11	28.3
Control									
Weed free control		124	0.0	473	0.0	1125	0.0	878	0.0
Weedy control		99	38.1	139	123.6	650	85.2	623	54.3
Single hoe control		107	10.9	269	35.6	598	67.4	701	54.1
Confidence Interval [2]		0.64-1.57	0.55-1.83	0.50 -1.99	0.59-1.71	0.50-1.99	0.42-2.35	0.46-2.16	0.43-2.33
CV%		21%	40%	29%	26%	24%	43%	28%	44%
Contrasts									
Pre- vs. post-		**	**	**	**	**	**	**	**
Broadleaf vs. grass		**	*	**	NS	**	NS	**	NS
Cyanazine pre- vs. post-		**	**	**	**	**	**	*	**

[1] DAS = Days after sowing * $P < 0.05$; ** $P < 0.01$

[2] Confidence interval is the mean multiplied by the upper and lower limits (ratios) given.

Post-emergence applications of clethodim and haloxyfop provided poor weed control at all harvest dates due to the dominance of broadleaf weeds. Chickpea biomass showed a reducing trend with clethodim and haloxyfop treatments, although differences from the weed-free control were only significant in a few cases.

The orthogonal contrasts indicated that chickpea biomass was affected by time of herbicide application (i.e., pre-emergence vs. post-emergence) and type of herbicide (i.e., grass vs. broadleaf) (Table 2). Biomass of weeds was also influenced by timing of application, but not by the type of herbicide applied.

Controlling weeds with a hand hoe was only successful during early crop growth. Weed biomass was reduced by 71% at 45 and 60 DAS compared with the weedy control. However, there was a resurgence of weeds later on in the season, and weed biomass from the hand-hoe treatment was similar to the weedy control (Table 2). Hoeing caused a trend toward reduction in chickpea dry matter at all harvest dates compared to the weed-free control, but this was not statistically significant.

Total dry matter, seed yield and harvest index

Comparison between pre-emergence and post-emergence herbicides showed that the total plant biomass, seed yield and harvest index were all reduced by post-emergence herbicide application (Table 3, contrasts). This effect was also observed for post-emergence applications of cyanazine regardless of the rate. Values obtained for total plant biomass and seed yield were all reduced for plants treated with broadleaf herbicides compared with plants treated with grass herbicides.

Seed yield in the weedy control showed a significant reduction of 30% compared with the weed-free control (Table 3). All post-emergence herbicides and pre-emergence applications of metribuzin at 0.25 kg a.i./ha reduced seed yield and plant dry matter at final harvest. The highest seed yield, of 375 g/m^2, was obtained from plots which received pre-emergence application of cyanazine at 1.0 kg a.i./ha. In comparison, the lowest seed yield, of 45 g/m^2, was obtained from plants sprayed with cyanazine plus haloxyfop. Harvest index was increased by pre-emergence applications of cyanazine at the low rate and was reduced by post-emergence applications of cyanazine at the high rate, bentazone at both rates and cyanazine plus haloxyfop (Table 3).

Components of yield

The number of pods/plant was only reduced by post-emergence applications of cyanazine at 1.0 kg a.i./ha (15.9 compared with 38.0 for the weed-free control, Table 4). Weed control method had no effect on the number of seeds/pod with most pods containing on average slightly more than one seed. Mean seed weight was relatively constant, with the mean seed weight for most treatments falling between 220 and 300 mg. Plants treated with terbuthylazine at 1.0 kg a.i./ha, haloxyfop at 0.15 kg a.i./ha and clethodim at both rates did produce significantly larger seeds than the weed free control (Table 4).

The orthogonal contrasts indicate that only the number of pods/plant was affected by application of post-emergence herbicides (Table 4). The number of pods/plant was not affected by grass versus broadleaf herbicide. However, mean seed weight was reduced by the broadleaf herbicides. Post-emergence application of cyanazine reduced the number of pods/plant and increased the number of seeds/pod, but had no effect on mean seed weight compared with cyanazine applied pre-emergence.

Discussion

The results illustrate that in the absence of weed control, there was a dramatic reduction in plant weight (Table 2) and seed yield (Table 3). Similar reductions by weed competition have been reported by Malik *et al.* (1982), Yadav *et al.* (1983), and Mahoney (1984a; 1984b).

Hoeing resulted in an increase in chickpea seed yield, dry matter accumulation, and total plant dry matter compared with the weedy control. However, the increase was not as great as in the weed-free control. This may have been due to mechanical damage by the hoe or competition from weeds present in the crop before hoeing. In addition, hoeing disturbed the seed bed, stimulating the germination of a second flush of weeds (Table 2). Better weed control would have been obtained if the plots had been hoed more than once. Bhan and Kukula (1987) reported that chickpea crops are normally hoed two to three times during the early stages of crop growth. Frequent hoeing as well as hand weeding is a labour intensive exercise and usually uneconomic. If weeds are to be controlled by mechanical means the crop should be planted in rows greater than 15 cm, but this would increase the time to canopy closure.

Application of pre-emergence herbicides cyanazine, metribuzin, terbuthylazine, and cyanazine plus metribuzin provided good control of weeds without causing crop damage (Table 2). Similar control of weeds in chickpeas and lentils (*Lens culinaris* L.) has been reported by Bhan

Table 3. Effect of herbicides on chickpea seed yield, total dry matter and harvest index.

Herbicide	Rate (kg a.i./ha)	Total plant dry matter (g/m^2)	Seed yield (g/m^2)	Harvest index (%)
Pre-emergence				
Cyanazine	1.0	612	375	63
	2.0	573	276	48
Metribuzin	0.25	521	267	51
	0.50	607	280	46
Terbuthylazine	0.75	553	286	51
	1.0	651	341	52
Cyanazine + metribuzin	1.0 + 0.25	650	319	49
Post-emergence				
Cyanazine	1.0	253	125	48
	2.0	137	51	34
Bentazone	1.0	181	50	34
	1.5	151	71	36
Clethodim	0.06	450	238	53
	0.12	482	262	54
Haloxyfop	0.15	524	289	56
	0.30	461	257	56
Bentazone + MCPB	1.0 + 1.2	282	110	40
Cyanazine + haloxyfop	1.0 + 0.15	196	45	22
Controls				
Weed free control		726	360	50
Weedy control		523	249	49
Single hoe control		661	350	53
SEM			30.3	3.7
CV%		26%	26%	16%
Contrasts				
Pre- vs. post-		**	**	**
Broadleaf vs. grass		**	**	**
Cyanazine pre- vs. post-		**	**	**

* $P < 0.05$; ** $P < 0.01$

and Kukula (1987) and Knott and Halila (1988) for cyanazine and metribuzin. There are no published data on the effect of terbuthylazine on chickpea crops. Butler and Alexander (1987) reported that lentils tolerated low application rates of terbuthylazine. For most herbicides the higher application rates provided better weed control. All the pre-emergence herbicides exhibited adequate weed control for the period of crop growth. This resulted in production of seed yields not significantly different from the weed-free control. Highest grain yield and harvest index were obtained by the application of cyanazine at 1.0 kg a.i./ha.

Chickpea response to post-emergence herbicides differed depending on the selectivity of the herbicide. Chickpeas tended to be tolerant to the grass herbicides, haloxyfop and clethodim. However, these herbicides did not provide good weed control (Table 2) as the dominant weed population was comprised of broadleaf species. This resulted in reductions in chickpea dry matter accumulation and yield.

Table 4. Effect of herbicide treatments on chickpea yield components.

Herbicide	Rate (kg a.i./ha)	Number pods/plant	Number seeds/pod	Mean seed weight (mg)
Pre-emergence				
Cyanazine	1.0	28.5	1.0	275
	2.0	43.8	1.0	263
Metribuzin	0.25	29.4	1.1	276
	0.50	39.1	1.0	265
Terbuthylazine	0.75	32.4	1.1	272
	1.0	33.3	1.1	307
Cyanazine + metribuzin	1.0 + 0.25	33.2	1.0	251
Post-emergence				
Cyanazine	1.0	15.9	1.1	263
	2.0	29.8	1.2	211
Bentazone	1.0	30.4	1.1	253
	1.5	23.4	1.1	209
Clethodim	0.06	22.4	1.0	309
	0.12	26.5	1.0	297
Haloxyfop	0.15	22.7	1.0	310
	0.30	26.1	1.1	303
Bentazone + MCPB	1.0 + 1.2	29.9	1.0	213
Cyanazine + haloxyfop	1.0 + 0.15	38.1	1.2	188
Controls				
Weed free control		38.0	1.0	236
Weedy control		20.6	1.0	259
Single hoe control		35.3	1.0	275
SEM		6.73	0.07	17.89
CV%		44%	13%	14%
Contrasts				
Pre- vs. post-		*	NS	NS
Broadleaf vs. grass		NS	*	**
Cyanazine pre- vs. post-		*	*	NS

* $P < 0.05$; ** $P < 0.01$

The broadleaf herbicides, cyanazine and bentazone, caused severe damage and death to the chickpea crop when applied post-emergence. Similar results have been reported for post-emergence applications of cyanazine to lupins (*Lupinus albus* L.) (Adamczewski and Paradowski, 1987 and Penner *et al.*, 1993) and bentazone to chickpeas (Mahoney, 1981; Yadav *et al.*, 1983; Mahoney, 1984a; 1984b), and peas (*Pisum sativum* L.) (Adamczewski and Paradowski, 1987). Cyanazine and bentazone provided good weed control during the early period of crop growth. However, during the later stages, the amount of weed growth in these treatments was greater than in the weedy control. This was due to reduction or removal of competition from the chickpea plants. The dominant weeds present in these treatments were the grass weeds which had clumped distribution.

The phytotoxicity of post-emergence application of bentazone plus MCPB was greater than when bentazone was applied alone. Plants treated with this combination also exhibited epinastic bending characteristic of hormone damage. Cyanazine plus haloxyfop provided good weed control but there was severe damage to the crop.

There was some compensation in yield components in chickpea plants treated with the broadleaf herbicides. In general, these plants had slightly more seeds/pod than the other treatments. However, final yield was reduced due to low harvest indexes and reduced plant growth.

It seems chickpeas are more sensitive to herbicides than other grain legume crops. This emphasizes the need for experiments to find selective herbicides if an economic crop is expected. The degree of weed control obtained from any herbicide is affected by seasonal and environmental influences. For example, Verghis *et al.* (1994) obtained poor weed control in early sown chickpeas in Canterbury with metribuzin. More work is required to extend the findings of the present study to different areas with potential for growing chickpeas.

Conclusion

Chickpeas have the potential to yield well in the Canterbury environment with yields of up to 3.75 t/ha provided there is adequate weed control during the initial period of crop growth. Under the conditions of the present study, the major problem weeds were fathen, nightshade, wireweed, and speedwell. If these weeds are not controlled then large reductions in yield can be expected.

Chickpeas showed tolerance to pre-emergence applications of cyanazine, metribuzin, terbuthylazine, and cyanazine plus metribuzin in combination and post-emergence applications of haloxyfop and clethodim. Haloxyfop and clethodim only control grass weeds and therefore, crop losses due to competition from broadleaf weeds can be expected. Chickpeas did not tolerate post-emergence applications of cyanazine or bentazone, or combinations of cyanazine plus haloxyfop and bentazone plus MCPB.

Acknowledgements

J.N.P. wishes to thank the Plant Protection Research Unit of Lincoln University for the award of a summer scholarship under which this work was conducted. Thanks are due to Dr D.L. McNeil for statistical advise.

References

Adamczewski, K. and Paradowski, A. 1987. Annual and perennial grass weed control in oilseed rape, peas and lupins with post-emergence gramicides. *Proceedings of the 1987 British Crop Protection Conference - Weeds*, 845-850.

Anon. 1992. *FAO Production Yearbook* ***46***, 113.

Anon. 1993. The New Zealand agrichemical & plant protection manual 1993. Agpress: Palmerston North.

Baylan, R.S., Malik, R.K. and Bhan, V.M. 1988. Screening of herbicides for weed control in chickpea (*Cicer arietinum* L.). *Harayana Journal of Agronomy* ***4***, 22-27

Bhan, V.M. and Kukula, S. 1987. Weeds and their control in chickpea. *In:* The Chickpea (eds. M.C. Saxena and K.B. Singh), pp. 319-328. CAB International, Wallingford.

Butler, J.H.B. and Alexander, R.T. 1987. Tolerance of lentils to pre-emergence herbicides. *Proceedings of the New Zealand Weed and Pest Control Conference*, 75-77.

Calcagno, F., Verona, G. and Gallo, G. 1987. Chemical weed control for chickpea in Sicily, Italy. *International Chickpea Newsletter* ***7***, 34-35.

Hernandez, L.G. 1986. Study of the agronomy of chickpea (*Cicer arietinum* L.) in Canterbury. Ph.D. Thesis. Lincoln College, University of Canterbury.

Farnsworth, T. 1985. Chickpea, "poor man's meat" may be useful for NZ. *New Zealand Farmer* June 13, 18-19.

Kosgey, J.R. 1994. Nodulation Growth and Water use of Chickpeas (*Cicer arietinum* L.). M.Agr.Sc. Thesis. Lincoln University, Canterbury.

Kosgey, J.R., McKenzie, B.A. and Hill, G.D. 1994. The effect of nitrogen on the nodulation and growth of autumn and spring sown chickpea in Canterbury, New Zealand. *International Symposium on Pulse Research, New Delhi, April 1994*. (In press)

Knott, C.M. and Halila, H.M. 1988. Weed in food legumes: problems, effects and control. *In:* World Crops: Cool Season Food Legumes (ed. R.J. Summerfield), pp. 535-548. Kluwer Academic Publishers, Dordrecht.

Kumar, Y., Gupta, O.P. and Gill, O.P. 1989. Weed control studies in irrigated chickpea in Rajasthan, India. *International Chickpea Newsletter* ***21***, 28-30.

Logan, L.A. 1983. Crop production and utilization in New Zealand. *Crop Research Division. Department of Scientific and Industrial Research Report No. 81*, 82-83.

Mahoney, J.E. 1981. Herbicide tolerance in chickpeas. *International Chickpea Newsletter* ***5***, 7-8.

Mahoney, J.E. 1984a. Broadleaf weed control in chickpeas. *International Chickpea Newsletter* ***10***, 8-10.

Mahoney, J.E. 1984b. Chemical weed control in chickpeas (*Cicer arietinum* L.). *Australian Weeds* ***3*** ***(4)***, 125-127.

Malik, B.A., Hussain, S.A. and Haqqani, A.M. 1982. Efficacy of herbicides in chickpeas. *International Chickpea Newsletter* ***6***, 15.

Mittal, M. and Singh, O.P. 1983. Effect of different weed control methods on growth and dry weight of associated weeds in chickpea (*Cicer arietinum* L.). *Legume Research* ***6***, 91-93.

Penner, D., Leep, R.H., Roggenbuck,F.C. and Lempke, J.R. 1993. Herbicide efficacy and tolerance in sweet white lupin. *Weed Technology* ***7***, 42-46.

Ramakrishna, A., Rupels, O.P., Reddy, S.L.N. and Sivaramacrishna, C. 1992. Promising herbicides for weed control in chickpeas. *Tropical Pest Management* ***38***, 398-399.

Verghis, T.I., Hill, G.D. and McKenzie, B.A. 1994. Effect of nitrogen and sowing dates on yield of chickpea in Canterbury, New Zealand. *International Symposium on Pulses Research, New Delhi, April 1994.* (In press).

Williams, P.C. and Singh, U. 1987. The chickpea - nutritional quality and the evaluation of quality in breeding programmes. *In:* The Chickpea (eds. M.C. Saxena and K.B. Singh), pp. 329-356. CAB International, Wallingford.

Yadav, S.K., Singh, S.P. and Bhan, V.M. 1983. Weed control in chickpea. *Tropical Pest Management* ***29***, 297.