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Chemical weed control in pigeonpea (*Cajanus cajan*) intercropped with short-duration grain legumes

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 1988 and 1989, having intercropping systems and weed-control treatments in randomized block design. Intercrop cowpea [*Vigna unguiculata* (L.) Walp.] effectively suppressed weed growth, arrested nutrient depletion and resulted in significant increase in yield attributes and yield of pigeonpea [*Cajanus cajan* (L.) Millsp.] in both the years. The effect of greengram (*Phaseolus radiatus* L.) was slightly lower than of cowpea in wet year but minor in drought year. Hand-weeding and tank mix of imazethapyr + pendimethalin effected significant decrease in weed population, weed dry weight and nutrient depletion and conspicuous increase in yield attributes and yield of pigeonpea in both years. Their application resulted in higher net return, net return/rupees and benefit : cost ratio. Intercropping systems generated higher return than sole cropping in both the years.

Prolonged, early slow crop growth, wider row spacing and adequate soil moisture provide unique opportunity to weeds to ensconce and exploit the pigeonpea [*Cajanus cajan* (L.) Millsp.] habitat. The weeds not only divest the crop of vital growth factors nutrients and water but also hangup germination and growth, resulting in yield loss varying from 30 to 40% (Balyan *et al.*, 1988). Thus it is imperative to device effective control measures to combat weed minence to enable the crop plant to make use of their habitat effectively.

Growing short-duration grain pulse intercrops between pgeonpea rows attenuates weed threat, improves soil health and gives additional yield and returns (Ali, 1988). But these intercrops also suffer from weed competition owing to inadequate canopy in early stage (Moody, 1978). Herbicides are potent means of controlling weeds from early stage. However, very little work has been done on their use in various forms in intercropping systems. The aim of the present study was to evaluate the effect of herbicides and their mixtures on weeds and productivity of pigeonpea intercropped with cowpea [*Vigna unguiculata* (L.) Walp.] and greengram (*Phaseolus radiatus* L.).

MATERIALS AND METHODS

An experiment with 21 treatment combinations of 3 intercropping systems (C_1, sole crop of pigeonpea; C_2, pigeonpea + cowpea; and C_3, pigeonpea + greengram) and 7 weed-control treatments (W_1, unweeded control; W_2, hand-weeding 20 and 40 days after sowing (DAS); W_3, imazethapyr @ 0.075 kg a.i./ha; W_4, fluchloralin, @ 1.0 kg/ha; W_5, pendimethalin @ 1.0 kg a.i./ha; W_6, imazethapyr @ 0.05 kg a.i./ha + fluchloralin @ 0.5 kg a.i./ha; W_7,

imazethapyr @ 0.05 kg a.i./ha + pendimethalin @ 0.5 kg a.i./ha) was conducted in randomized block design with 3 replications at New Delhi, during the rainy (*kharif*) season 1988–89 and 1989–90. Pigeonpea variety 'Pusa 33', cowpea 'Pusa 779' and greengram 'PS 16' were sown on 20 July and 17 July in 1988 and 1989 respectively. Fluchloralin was applied as pre-plant and others as pre-emergence using a volume spray of 600 litres/ha with the help of knapsack sprayer fitted with flat-fan nozzle. Nitrogen and phosphorus @ 20 kg N/ha and 40 kg P_2O_5/ha were applied at the time of sowing.

The soil of the experimental was sandy loam with pH 8.2–8.5 and organic carbon 0.33–0.32. The available P and K in 1988 were 11.1 and 11.8 kg/ha, whereas 10.1 and 117 kg/ha in 1989 respectively. The data on weed population and their dry weight was subjected to square-root transformation $\sqrt{X+0.5}$ to normalize their distribution. The climate of this area is semi-arid and sub-tropical type with dry and hot summer months and cold winter. A total rainfall of 978 mm being 50% higher than normal rainfall was received during 1988–89. The rainfall during 1989–90 was, however, quite low (208 mm which was 68% lower than normal).

RESULTS AND DISCUSSION

Weed population and weed dry weight

Trianthema portulacastrum L. and *Digera arvensis* Forskaal were dominant among the dicots, whereas *Cyperus rotundus* L. and *Dactyloctenium aegyptium* (L.) Willd. among monocots in both the years. *Tribulus terrestris* L., *Physalis minima* L., *Eclipta alba* (L.) Hassk. and *Eichinochloa colonum* Link. were also present in small numbers. In both the years weed population was significantly lower under intercropping systems than that under sole cropping (Table 1). In 1988, both intercrops cowpea and greengram caused identical decrease, whereas in 1989 cowpea resulted in significantly higher decrease than greengram due to greater crop canopy. As the cowpea tolerates drought, its growth was not affected considerably even during low-rainfall year. The lower population under cropping system may be attributed to higher crop canopy than sole cropping system. Tiwari *et al.* (1989) and Ali (1988) also reported effect of intercrops on weed population.

Weed-control treatments significantly decreased the weed population. Hand-weeding caused the maximum decrease and proved statistically superior to all other treatments. The finding confirms the results of Balyan *et al.* (1988). Tank-mix of imazethapyr + pendimethalin resulted in higher decrease than other herbicide treatments. Though differences existed among herbicide treatments, these were not found conpicuous. In 1988, efficacy of herbicides was lower than that in 1989. This may be due to leaching of herbicides from upper layers due to frequent rainfall. Singh and Singh (1977) reported similar results. Intercrops arrested weed dry matter significantly in both the years. In 1988 both cowpea and greengram caused identical decrease, whereas in 1989 former proved significantly superior to latter in arresting weed biomass. Dhingra *et al.* (1984) recorded lower dry matter of weeds under intercrops.

All the weed-control treatments lowered significantly weed dry weight. Hand-weeding caused maximum decrease and proved statistically superior to all other treatments. Herbicide treatments varied among themselves in decreasing the dry-matter accumulation by weeds. Imazethapyr + pendimetha-

Table 1. Effect of cropping systems and weed-control treatments on weed and nutrient depletion at 45 days after sowing

Treatment	Weed popuation		Weed dry weight		Nutrient depletions (kg/ha)					
	1988	1989	1988	1989	N		P		K	
					1988	1989	1988	1989	1988	1989
Cropping system										
C_1	11.6 (154)	8.5 (81)	9.9 (108)	16.8 (260)	16.2	41.9	2.8	7.5	16.5	40.5
C_2	10.4 (112)	5.7 (42)	8.8 (86)	14.5 (227)	13.5	36.4	2.1	6.0	13.0	32.7
C_3	10.5 (113)	7.5 (60)	8.9 (92)	14.3 (230)	13.4	35.8	2.4	6.1	12.6	34.9
CD (P = 0.05)	0.34	0.8	1.0	1.5	1.2	4.7	0.2	6.7	1.7	3.1
Weed-control treatment										
W_1	13.2 (187)	10.2 (114)	13.7 (218)	22.5 (372)	31.2	56.3	5.1	9.5	30.6	54.5
W_2	7.6 (165)	4.3 (23)	5.1 (26)	5.4 (30)	2.4	5.9	0.4	0.9	2.3	5.3
W_3	10.2 (115)	8.0 (69)	9.2 (104)	16.1 (260)	15.8	44.3	2.6	8.2	14.1	42.2
W_4	12.7 (164)	7.4 (57)	10.3 (99)	17.8 (371)	15.6	51.3	2.6	8.8	15.6	49.6
W_5	11.5 (148)	7.4 (59)	8.8 (77)	15.6 (290)	12.7	37.6	2.3	6.6	12.4	34.6
W_6	12.4 (154)	7.0 (57)	9.7 (60)	17.0 (294)	15.7	49.6	2.5	7.9	14.8	45.0
W_7	8.6 (76)	6.5 (45)	7.8 (59)	12.2 (150)	8.3	21.6	1.5	3.8	8.3	20.2
CD (P = 0.05)		1.3	1.7	2.3	1.8	7.2	0.3	1.1	2.5	4.8

Details of treatments are given in text

lin combination resulted in maximum decrease due to inhibition of weed growth better than other. Hand-weeding and imazethapyr + pendimethalin lowered the weed dry weight up to 92.7 and 72% in 1989 and 91.9 and 60% in 1989 respectively. Fluchloralin, pendimethalin and their combinations with imazethapyr caused identical decrease to that of imazethapyr + pendimethalin.

Depletion of N, P and K

Intercrops and weed-control treatments significantly decreased N, P and K depletion (Table 1). Depletion was higher under sole cropping and under unweeded control. Maximum decrease was caused by hand-weeding, followed by imazethapyr + pendimethalin. Effect of these treatments was found almost identical.

Depletion under other weed-control treatments was alike but significantly lower than weedy check. Lower depletion in weed control may be attributed to hangup of weed germination and reduced crop–weed competition in early stage.

Yield attributes and yield

Pods/plant were significantly more under intercropping than under sole cropping (Table 2). In 1988 pods/plant were significantly more under pigeonpea + cowpea system than that under pigeonpea + greengram, but no such difference existed in 1989. Weed-control treatments significantly increased the pods/plant. In 1989, hand-weeding, pendimethalin, and imazethapyr + fluchloralin caused identical increase. Effect of other treatments was homogenous. In 1989, effect of hand-weeding and imazethapyr + pendimethalin was identical but significantly higher than the rest of the treatments owing

Table 2. Effect of cropping and weed control on yield attributes and yield of pigeonpea and grain equivalent

Treatment	Pods/plant		1,000-grain weight		Grain yield (q/ha)		Grain equivalant	
	1988	1989	1988	1989	1988	1989	1988	1989
Cropping system								
C_1	43.1	40.1	66.2	62.6	12.7	5.7	12.7	5.8
C_2	68.2	46.6	71.7	67.3	15.0	7.8	18.5	10.0
C_3	60.8	40.0	67.0	67.9	13.7	6.9	16.1	7.7
CD (P = 0.05)	5.1	2.7	1.9	0.5	1.1	0.7	0.8	0.5
Weed control								
W_1	35.8	21.7	61.9	64.9	9.6	3.5	11.1	4.2
W_2	68.4	59.8	67.6	64.6	18.5	9.4	10.7	
W_3	54.6	37.7	65.1	67.2	11.5	5.5	13.5	6.6
W_4	55.6	24.8	63.2	67.1	12.6	4.7	14.4	5.5
W_5	62.5	54.5	70.8	67.5	13.6	8.2	15.4	9.4
W_6	56.7	51.0	72.0	63.5	12.9	7.0	15.8	7.8
W_7	67.9	57.2	77.6	66.9	17.6	9.3	19.2	10.5
CD (P = 0.05)	7 7	4.2	2.96	2.4	1.6	9.0	1.3	0.8

Details of treatments are given in text

to effective control of weeds at the critical periods of crop–weed completion. In both the years, 1,000-grain weights varied significantly under different cropping systems. In 1988, it was in order of pigeonpea + cowpea > pigeonpea + greengram > sole crop of pigeonpea, whereas in 1989, the former proved statistically superior to latter systems. In 1988 imazethapyr + pendimethalin caused maximum increase and proved statistically superior to other treatments, whereas in 1989 hand-weeding and imazethapyr + pendimethalin resulted in almost similar increase. Increase due to other treatments was almost alike.

In both the years grain yield was significantly higher under intercropping systems (Table 2). Intercrop cowpea significantly increased the grain yield in both the years, whereas effect of greengram was only palpable in 1989. Beneficial effect of intercrop on yield of pigeonpea may be attributed to lower crop–weed competition, increased nutrients availability and marked increase in pods/plant and 1,000-grain weight. Ali (1988) also found increase in the yield of sole crop owing to better utilization of nutrients and water due to suppression of weed growth.

Balasubramanium and Subramanium (1989) reported increased yield due to increase in yield attributes. Lower yield of sole crop may be attributed to severe crop–weed competition, which resulted in poor crop expression. Similar was the observation of Ali (1988). Intercrop cowpea caused higher increase than greengram in the both years owing to its better suppressive ability both under adequate and inadequate soil-moisture conditions. Shetty (1980) found greengram inferior to cowpea as companion crop because of its poor weed-suppressive ability due to it its tendency to shed mature leaves much earlier than cowpea.

Weed-control treatments significantly increased grain yield of pigeonpea. Hand-weeding and imazethapyr + pendimethalin caused higher increase and proved superior to all other treatments in both the years. Effect of other treatments was not alike in both the years. In 1989, fluchloralin, pendimethalin, and imazethapyr + fluchloralin caused similar increase. Differences among other treatments were non-significant. In 1989, pendimethalin resulted in significantly higher yield than imazethapyr + fluchloralin. The latter proved statistically superior to imazethapyr and fluchloralin. Higher productivity under hand-weeding and tank mix of imazethapyr + pendimethalin was due to better weed control, higher dry matter production, higher nutrient uptake and improvement in yield-attributing characters, viz. pods/plant and 1,000-grain

Table 3. Yield of pigeonpea (q/ha) as affected by interaction between intercropping systems and weed-control treatments in 1989

Intercropping system	Weed-control treatment						
	W_1	W_2	W_3	W_4	W_5	W_6	W_7
C_1	2.8	7.1	4.9	4.0	6.0	6.2	8.2
C_2	4.3	12.9	5.5	5.1	9.2	7.7	9.5
C_3	3.6	8.2	5.8	4.9	8.5	6.9	10.5
CD (P = 0.05)	1.8						

Details of treatments are given in text

Table 4. Pigeonpea-grain equivalent (q/ha) as affected by interaction effect between intercropping systems and weed-control treatments in 1989

Intercropping system	Weed-control treatment						
	W_1	W_2	W_3	W_4	W_5	W_6	W_7
C_1	2.8	7.1	5.0	4.0	6.9	6.3	8.3
C_2	5.6	15.5	3.2	7.1	11.8	9.7	11.9
C_3	4.2	9.3	6.7	5.4	9.5	9.5	11.7
CD (P = 0.05)	1.4						

Details of treatments are given in text

weight.

Interaction between intercropping and weed control was significant only in 1988. Hand-weeding in pigeonpea + cowpea system caused the maximum increase and proved statistically superior to all other treatments (Table 3). This may be attributed to better weed control and greater crop canopy. Balyan *et al.* (1988) found hand-weeding more efficient than chemical weeding. Effect of pendimethalin in both pigeonpea + cowpea and pigeonpea + greengram systems was identical but statistically higher than that on pigeonpea sole cropping.

Grain equivalents

Significant variation existed in pigeonpea-grain equivalents under different cropping systems and the grain equivalents were in order of pigeonpea + cowpea > pigeonpea + greengram > sole pigeonpea in both the years (Table 2). Weed-control treatmens significantly increased pigeonpea-grain equivalents compared with weedy check in both the years. Hand-weeding and imazethapyr + pendimethalin were statistically alike but resulted in significantly higher grain equivalent than the rest of the treatments in both the years. This confirms the finding of Prusty *et al.* (1987).

Interaction effect of intercropping and weed-control treatments on pigeonpea-grain equivalent was significant only in 1989 (Table 4). Grain equivalent was highest under cowpea intercropping and hand-weeding (15.5 q/ha). Under sole cropping, hand-weeding, pendimethalin and imazethapyr + pendimethalin caused similar increase, whereas under pigeonpea + cowpea cropping system hand-weeding and under pigeonpea + green–gram cropping system imazethapyr + pendimethalin resulted in significantly higher increase than the rest of the combinations.

Economics

Net return varied with intercropping systems and weed-control treatments in both the years. In 1988, intercropping with cowpea and greengram gave additional return of Rs 4,185 and Rs 2,006, whereas in 1989 the additional returns were only Rs 3,588 and Rs 1,508 over sole cropping. Net return/rupees invested and the benefit : cost ratios were higher under intercropping than sole under cropping.

In 1988 all the weed-control treatment increased the return, whereas in 1989 imazethapyr and fluchloralin showed loss. In both the years hand-weeding and tank-mix of imazethapyr + pendimethalin gener-

Table 5. Economics of intercropping as affected by weed-control treatments

Treatment	Net return (Rs/ha)		Net return/rupee		Benefit : cost ratio	
	1988	1989	1988	1989	1988	1989
Cropping system						
C_1	5,318.8	-831.9	1.04	-0.14	2.05	0.86
C_2	9,504.3	2,756.0	1.81	0.42	2.72	1.11
C_3	7,325.6	676.7	1.34	0.10	2.33	0.67
Weed control						
W_1	4,537.4	-1,863.4	0.94	-0.33	1.94	0.67
W_2	10,094.4	3,195.0	1.96	0.49	2.96	1.49
W_3	5,477.1	-141.0	1.00	-0.03	2.01	0.98
W_4	6,830.8	-1,217.7	1.28	-0.20	2.27	0.80
W_5	7,242.0	2,224.3	1.33	0.35	2.34	1.36
W_6	6,695.1	7,68.6	1.22	0.12	2.22	1.12
W_7	10,414.9	3.102.5	1.89	0.49	2.29	1.49

Details of treatments are given in text

ated higher net return. Benefit : cost ratio and net return/rupees were also higher under these treatments (Table 5).

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