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Research Paper

Performance of herbicide on yield and economic returns of pigeonpea [*Cajanus cajan* (L.) Millsp.] in Bihar

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ABSTRACT

The research was carried out during kharif season of 2012-13 to find out the cost-effective weed management practices with special focus on fine tuning the dose and time of herbicide application and its impact on growth and yield of pigeonpea at Bihar Agricultural University, Sabour, Bhagalpur. The result of the study revealed that uncontrolled growth of weeds led to 40.53% reduction in pigeonpea yield in comparison with the other treatments. However, the highest seed yield (2,725 kg/ha) was obtained in weed free treatment but not cost-effective due to high cost in manual weed operation. Among the herbicide treatments, lower weed index (7.25%) was recorded in T_2 (imazethapyr @ 40 g a.i./ha at 15 DAS), which resulted in higher seed yield (2,526 kg/ha), net returns (₹ 71,059/ha) and benefit : cost ratio (2.74).

Key words : *Benefit :Cost ratio, Herbicide, Pigeonpea, Weed index, Yield.*

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is a short-lived perennial shrub that is traditionally cultivated as an annual crop in Asia, Africa, Caribbean region and Latin America. In India it is grown in an area of 3.86 M ha with production of 2.65 MT but low productivity of 686.5 kg/ha (FAO STAT, 2012). Since the scope of increasing pigeonpea area in the country is limited, increasing its productivity is the only viable option through managing various biotic and abiotic factors.

Among the biotic factors which limit the productivity of pigeonpea, weeds are major impediments. Considered a *kharif* season crop, the intermittent rains provide congenial environment for growth to all types of weeds including the narrow and broad-leaved weeds. Weeds are the leading constraints in pigeonpea production through their ability to compete for resources and their adverse impact on product quality. Due to wider row spacing and initial slow growth of pigeonpea, weeds pose a major problem to its productivity which may lead to its yield reduction of up to 80% (Talnikar *et al.*, 2008). Timely weed control is very essential for realization of yield potential of pigeonpea (Goyal *et al.*, 1991). Manual and mechanical methods of weed control are quite effective, but they are costly and time consuming (Ram *et al.*, 2011). In addition, due to frequent rains it becomes difficult to do hand weeding at proper time. Under given circumstances farmers need alternate production system using weed management that are most efficient, less labour intensive and cost-effective. Recognizing the importance of controlling weeds in enhancing growth and yield up to a considerable extent, the present research work was undertaken to find out the cost-effective weed management practices in pigeonpea under Bihar condition.

MATERIALS AND METHODS

The experiment was conducted in sandy loam soil at Bihar Agricultural University, Sabour (Bhagalpur) during 2012-2013 cropping season. Pusa-9, a long duration (250-260 days) variety of pigeonpea, was selected because it is suitable for flood prone areas of Gangetic basin and widely grown in agro-climatic zone 3A of Bihar as a *kharif* season crop.

The research comprises of 12 treatments (**Table 1**) with three replications and was laid out in randomized block design covering an area of 1000 m^2. Specification for each treatment consist of five rows of 6 m length with a row to row distance of 67.5 cm and plant to plant distance of 30 cm. Treatments consist of herbicides of two pre-emergence (metribuzin and pendimethalin) and two post-emergence (quizalofop-ethyl and imazethapyr); intercropping with black gram; weed free; and weedy check (control). Pre-emergence herbicides (pendimethalin @ 750 g/ha and metribuzin 250 g/ha) were applied one day after sowing. Post-emergence herbicides (imazethapyr and quizalofop-ethyl) were sprayed at 15 DAS

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Table 1. Weed management treatments

Treatment	Particulars
T_1	Imazethapyr (POE) @ 20 g a.i./ha at 15 DAS
T_2	Imazethapyr (POE) @ 40 g a.i./ha at 15 DAS
T_3	Imazethapyr (POE) @ 60 g a.i./ha at 15 DAS
T_4	Imazethapyr (POE) @ 20 g a.i./ha at 30 DAS
T_5	Imazethapyr (POE) @ 40 g a.i./ha at 30 DAS
T_6	Imazethapyr (POE) @ 60 g a.i./ha at 30 DAS
T_7	Pendimethalin (PE) @ 750 g a.i./ha
T_8	Pendimethalin (PE) @ 750 g a.i./ha + Quizalofop-ethyl (POE) @ 50 g a.i./ha
T_9	Pigeonpea+ blackgram intercropping
T_{10}	Metribuzin (PE) @ 250 g a.i./ha
T_{11}	Weedy check
T_{12}	Weed free (control)

Note :
POE : Post-emergence PE : Pre-emergence
GAI. : Gram active ingredient ha : Hectare
DAS : Days after sowing

using flat fan nozzle. Hand weeding was carried out in weed free plot. The recommended fertilizer rate of 100 kg/ha of DAP was applied. Other cultural management practice was undertaken to ensure good crop growth.

Weed data were taken using a quadrate of 0.25 m^2 and multiplied by four and were subjected to square root transformation by using the formula $\sqrt{x + 0.5}$ (Chandel 1984). The data (weeds; and yield and yield attributes) were subjected to analysis of variance techniques (ANOVA) as prescribed by Cochran and Cox (1963) for testing the significant difference among various treatments at 5% level.

Net returns were calculated by subtracting the total farm expenditure from the gross income. The basis for estimating the net returns is by using the net yield derived from the estimated yield at harvest. The principle behind in estimating the benefit-cost ratio is to determine the investment incurred for every rupee invested during the cropping season (Mula *et al.*, 2010).

RESULTS AND DISCUSSIONS

Effect on weed population : The major weed flora observed in the study at 60 DAS included grass weeds (*Cynodon dactylon, Dactyloctenium aegyptium, Echinochloa colona, Echinochloa crussgulli, Eleusine indica and Digitaria sanguinalis);* sedges (*Cyperus rotundus, Cyperus iria, Cyperus difformis);* and broad-leaved weeds (*Ageratum conyzoides, Digera arvensis, Physallis minima, Trianthema portulacastrum, Boerrhivia diffusa, Euphorbia hirta, Phyllanthus niruri, Commelina benghalensis* & *Bidens biternata).* The population percentage of these three types of weeds are almost equal in each treatment except in T_{12} (**Table 2**). The highest percent population of grass weeds were noted in T_6 (39.27), broad-leaved weeds in T_{11} (35.67) & sedges in T_1 (39.97).

Table 2. Weed population at 60 DAS

Treatment	Grass		Broad-leaves		Sedges	
	No./m^{-2}	%	No./m^{-2}	%	No./m^{-2}	%
T_1	3.39 (11.01)	29.66	3.41 (11.27)	30.36	3.89 (14.84)	39.97
T_2	3.35 (10.92)	33.83	3.24 (10.08)	31.23	3.42 (11.27)	34.93
T_3	3.20 (9.87)	32.79	3.14 (9.38)	31.16	3.34 (10.85)	36.04
T_4	4.82 (22.82)	34.50	4.01 (15.61)	28.70	5.14 (25.97)	36.8
T_5	4.59 (20.58)	37.25	3.46 (11.81)	28.08	4.27 (17.85)	34.66
T_6	4.58 (20.51)	39.27	3.42 (11.78)	29.33	3.66 (13.09)	31.40
T_7	5.26 (27.93)	33.14	5.09 (25.48)	32.07	5.52 (30.03)	34.78
T_8	5.06 (25.83)	34.70	4.13 (18.30)	28.32	5.39 (28.84)	36.97
T_9	5.41 (29.47)	33.39	4.75 (22.05)	29.32	6.04 (36.05)	37.28
T_{10}	5.46 (29.40)	34.38	4.87 (23.45)	29.91	5.55 (30.38)	35.71
T_{11}	7.34 (53.41)	35.87	7.30 (53.48)	35.67	5.82 (37.42)	28.45
T_{12}	0.71 (0.00)	0	0.71 (0.00)	0	0.71 (0.00)	0
SEm±	0.30		0.40		0.48	
CD at 5%	0.90		1.19		1.42	

Note : Figure in parenthesis indicate the original value.

Moreover, the study also showed that during 60 DAS, all the treatments significantly reduced the weed population except in T_{11}. However, T_1, T_2 and T_3 performed effectively in controlling all type of weeds. But among these three treatments, T_3 was best because it registered least weed count of grassy (3.20), broad-leaves (3.14) and sedges (3.34) while the highest was recorded in T_{11} for grass (7.34), broad-leaves (7.30) and sedges (5.82) as shown in Table 2.

Effect on weeds : Among all the weed management options, application of post-emergence herbicide imazethapyr @ 60 g a.i./ha at 15 DAS (T_3) recorded significantly lower weed dry matter (5.04 g/m^2 and 4.89 gm^2) and weed control efficiency (80.38% and 83.36%) at 60 and 90 days after sowing, respectively (**Table 3 and Fig. 1**). However, imazethapyr @ 40 g a.i./ha at 15 DAS (T_2) was found statistically at par with T_3 in terms of weed control efficiency (Fig. 1) and dry matter (Table 3) which is in conformity with the findings of Reddy *et al.* (2008).

In contrast to the other treatments, weedy check (T_{11}) recorded higher weed density, dry matter and weed index which agrees to the findings of Dhonde *et al.* (2009). Among pre-emergence herbicides, at 60 DAS, pendimethalin @ 750 g a.i./ha (T_7) resulted in significantly higher weed control efficiency (75.03%) than T_{10} - metribuzin 250 g a.i./ha (62.20%)

Table 3. Weed dry matter, weed control efficiency and weed index as influenced by weed management practices

Treatment	Weed dry matter at 60 DAS (g/m^2)	Weed control efficiency at 60 DAS (%)	Weed index (%)
T_1	6.09 (36.6)	71.17	21.84
T_2	5.06 (25.2)	80.16	7.25
T_3	5.04 (24.9)	80.38	8.59
T_4	5.33 (28)	77.94	27.21
T_5	5.22 (26.8)	78.80	12.50
T_6	5.23 (26.9)	78.88	11.20
T_7	5.67 (31.7)	75.03	24.21
T_8	5.36 (28.3)	77.72	18.68
T_9	7.61 (57.5)	54.72	22.13
T_{10}	6.96 (48)	62.20	21.88
T_{11}	11.29 (127.0)	0.00	40.53
T_{12}	0.71 (0.00)	100.00	0.00
SEm±	0.08	0.69	3.49
CD at 5%	0.24	2.03	10.23

Note : Figure in parenthesis indicate the original value.

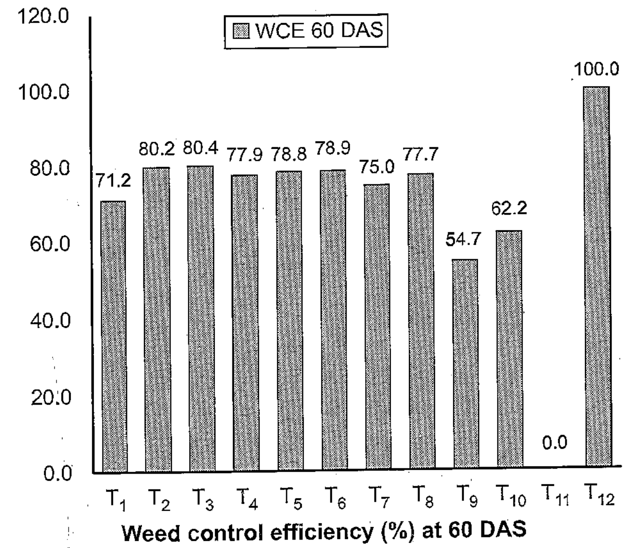

Fig. 1. Weed control efficiency of different treatments at 60 DAS

but lesser than T_2. This might be due to effective control of weeds at an early stage and residual effect of imazethapyr resulting in direct killing or suppression of germinated weeds.

Weed index differed significantly due to different weed control treatments (Table 3). Uncontrolled growth of weeds (T_{11}) led to 40.53% reduction in pigeonpea yield in comparison with weed free condition. Among the herbicidal treatments significantly lower weed index (7.25%) was recorded in application of imazethapyr @ 40 g a.i./ha at 15 DAS (T_2) but remained statistically at par with T_3 (8.59%).

Effect on yield and yield attributes : The weed free plot (T_{12}) recorded more number of pods/plant (170.5), higher grain yield/plant (63.2 g), and number of seeds/pod (3.7) as shown in **Table 4**. This attributes was mainly due to no crop-weed competition of nutrient which enable better plant growth allowing more primary and secondary branches.

Among the herbicide treatments, significantly higher number of primary and secondary branches/plant (14.6 and 27.1, respectively), pods/plant (165.3), seeds/pod (3.6), grain yield/plant (59.2 g), and higher seed yield of 2,526 kg/ha was recorded in T_2, but not significantly different with T_3 (Table 4). Moreover, T_2 obtain higher stalk yield (8,589 kg/ha) which was at par with T_3 (8,457 kg/ha). The increased yield and yield attributes under treatments of imazethapyr was due to effective control of grassy and broad-leaved weeds. These results were found in close conformity with the findings of Jadhav (2013) and Kelly *et al.* (1998) in soybean.

Table 4. Yield and yield attributes of pigeonpea as influenced by weed management

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)	Plant height (cm)	Pods/Plant (no)	Seeds/pod (no)	Grain yield/ plant (g)	Primary branches/ plant (no)	Secondary branches/ plant (no)
T_1	2129.0	7338.6	254.7	141.6	3.2	50.5	12.6	23.0
T_2	2526.0	8589.3	259.0	165.3	3.6	59.2	14.6	27.1
T_3	2492.6	8457.0	257.8	162.8	3.5	58.2	14.5	26.0
T_4	1982.0	6735.0	257.2	143.5	3.3	46.5	12.0	21.0
T_5	2383.0	8100.3	248.1	158.0	3.5	55.5	13.9	24.4
T_6	2425.0	8245.0	242.5	163.0	3.5	46.4	14.0	25.6
T_7	2065.0	7018.0	236.2	153.3	3.5	46.4	12.6	20.2
T_8	2210.0	7514.0	251.0	147.0	3.5	50.5	12.4	23.1
T_9	2124.0	7219.0	233.7	146.3	3.5	49.2	13.0	21.4
T_{10}	2130.0	7274.6	238.8	136.0	3.4	49.8	14.2	22.4
T_{11}	1623.3	5850.3	216.7	127.0	3.1	37.4	9.8	16.9
T_{12}	2725.0	9264.0	261.7	170.5	3.7	63.2	14.8	27.8
SEm±	94.9	297.9	8.24	4.07	0.08	1.60	0.89	1.89
CD at 5%	278.4	873.7	NS	11.95	0.23	4.69	2.63	5.56

Table 5. Economics of pigeonpea as influenced by weed management

Treatment	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio	Seed yield (kg/ha)
T_1	25620	81853.6	56233.6	2.19	2129.0
T_2	25940	96999.3	71059.3	2.74	2526.0
T_3	26260	95700.3	69440.3	2.64	2492.6
T_4	25620	76105.0	50485.0	1.97	1982.0
T_5	25940	91505.3	65565.3	2.53	2383.0
T_6	26260	93120.0	66860.0	2.55	2425.0
T_7	26425	79293.0	52868.0	2.00	2065.0
T_8	28125	84864.0	56739.0	2.02	2210.0
T_9	29650	81559.0	51909.0	1.75	2124.0
T_{10}	25943	81824.6	55881.7	2.15	2130.0
T_{11}	25000	62667.0	37667.0	1.51	1623.3
T_{12}	40000	104639.0	64639.0	1.61	2725.0
SEm±	-	3580.7	3580.7	0.13	94.9
CD at 5%	-	10501.93	10501.9	0.39	278.4

Effect on economics

Total cost of cultivation : Prevailing market prices during the cropping period were used to determine the estimates on costs of inputs used in this research. The analysis includes land, labour and capital utilization costs. The cost of cultivation differed due to different weed management practices. Total cost of cultivation of each treatment was calculated by adding the common cost of cultivation with treatment cost according to herbicide used. Higher cost of cultivation was involved in weed free plot (₹ 40,000/ha) followed by pigeonpea + blackgram intercropping (₹ 29,650/ha) while T_{11} is having the least cost (₹ 25,000/ha) as revealed in **Table 5**.

Gross returns : The highest gross returns was noted in T_{12} at ₹ 104,639/ha while the lowest recorded was T_{11} at ₹ 62,667/ha (Table 5). Among the herbicide treatments, post-emergence application in T_2 has significantly higher gross return (₹ 96,999/ha) than the other treatments (T_1 and T_4) but do not differ significantly with T_3 (₹ 95,700/ha).

Net returns and B:C ratio : The economic analysis revealed that higher net returns is recorded in T_2 (₹ 71,059/ha) and T_3 (₹ 69,440/ha) with higher benefit cost ratio of 2.74 and 2.64, respectively as compared to the other treatments (**Table 5**). These results collaborate to the findings of Gupta *et al.* (2013) and Padmaja *et al.* (2013).

CONCLUSION

Based on the findings of present study, it can be concluded that weed can be a limiting factor in reducing pigeonpea yield as uncontrolled growth of weeds resulted in 40.53% reduction in yield. Weed free treatment recorded highest grain yield of 2,725 kg/ha but have the highest rate of cultivation at ₹ 40,000/ha due to operational cost of hand weeding. Moreover, among the herbicide treatments, the higher grain yield and as well as economic efficiency can be obtained through the application of imazethapyr @ 40 g a.i./ha at 15 DAS (T_2) or imazethapyr @ 60 g a.i./ha (T_3). However, T_2 performed better due to higher seed yield (2,526 kg/ha) and registering higher net return (₹ 71,059/ha) and B:C ratio (2.74).

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