Impact of weed management practices and phosphorus levels on nutrient uptake and quality of Clusterbean (*Cyamopsis tetragonoloba* L.)

Abstract

A field experiment was conducted during *Kharif* 2013 at Agronomy farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) to evaluate the impact of weed management practices and phosphorus levels on nutrient uptake and quality of clusterbean crop. The treatments comprising 6 weed control treatments (Weedy check, one HW at 20 DAS, two HW at 20 and 40 DAS, pendimethalin at 0.75 kg/ha, imazethapyr at 100 g/ha and fenoxoprop-p-ethyl at 70 g/ha and four levels of phosphorus (0, 20, 40 and 60 kg/ha) assigned to main and sub plots of spilt plot design, respectively and replicated thrice. Hand weeding twice at 20 and 40 DAS, imazethapyr at 100 g/ha, and one HW at 20 DAS were found statistically similar and significantly better treatments in enhancing nutrient concentration in grain and stover, protein content in grain, and reduction in nutrient depletion by weeds but in enhancing of nutrient uptake by crop, two hand weeding at 20 and 40 DAS was found significantly better treatment over rest of the treatments. Application of 60 kg P/ha in clusterbean recorded the highest N, P, and K concentration in weeds and nutrient depletion by weeds at the harvest stage. Every increase in the level of P to 40 kg/ha resulted significant improvement in N, P and K uptake by grain and stover, protein content and phosphorus use efficiency.

Keywords: Hand weeding, pre-emergence, phosphorus, uptake and protein.

Introduction

"Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] commonly known as guar, is an important drought-hardy leguminous crop of arid and semiarid areas. It is grown for various purposes viz., vegetable, green fodder, green manuring and seed. Now-a-days, it has acquired the status of the industrial crop because of high galactomanan content (gum) in the endosperm of its seed (28-33%) which has multiple industrial uses viz. textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling, etc. uses, thus making it a main foreign exchange earner. India accounts for more than 80 percent of the total world clusterbean production. This crop has occupied sizable areas in arid and semi-arid regions encompassing Rajasthan, Gujarat, Haryana and Punjab state. Rajasthan has emerged as a major clusterbean growing state of India and it ranks first with respect to both area and production of clusterbean" [1].

"Cluster bean is a poor competitor with weeds. As a guar is a rainy season crop and due to frequent rains the weed population increases tremendously which compete for nutrients, moisture, and space with main crop causing considerable yield reduction. Critical crop weed competition is from 20-30 DAS" [2]. "Guar crop is infested with both grass and broadleaved weeds. Season long competition with weeds in Cluster bean causes severe yield reduction ranging from 29-48 percent and severity may even be higher (70-98%) depending on the weed infestation" [3]. According to Saxena *et al.* [4] observed "53.7 percent reduction in guar yield due to weed infestation. Among different weed management practices, hand weeding is traditional and effective option but unavailability of labor at peak weeding periods and increasing labor costs impose major limitations on economical feasibility of manual weeding".

"Amongst agronomic factors known to augment crop production, appropriate weed and nutrient management are considered to be the most important. Being a rainy season crop, clusterbean suffers badly due to severe competition by mixed weed flora. These weeds utilize natural resources more efficiently than crop plants to achieve a fast and vigorous growth which results in they provide a tough competition to the crop plants. Initial 30 days of sowing is very critical and the presence of weeds beyond this results in yield reduction up to 93.22 per cent" [5]. "Phosphorus application led to an increase in plant height [6,7], extensive root growth [8], total dry weight [9], and leaf area of clusterbean. Phosphorus also influences the symbiotic nitrogen fixation, yield and quality of clusterbean pods. Phosphorus has a positive effect on nodulation [10,11] and the activity of rhizobia present in root nodules of leguminous plant" [12]. Keeping these factors in view, the present investigation was planned with objective to study the effect of weed management practices and phosphorus levels on nutrient uptake and quality of clusterbean.

Materials and Methods

The experiment was conducted during *Kharif* season in 2013 at Agronomy farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan), research area was in semi- to arid (26°06' 56" N latitude and 75°28' 29" E longitude). Summer temperatures range from 26 to 48.5 ^{0}C, and winter temperatures varied from -4.5 to 32 ^{0}C. The majority of the yearly rainfall is anticipated during the monsoon season (July to September) and ranges from 400 to 660 mm on average. In the soil, the water is around 90–100 m below the surface. The soil of the experimental field was loamy-sand in texture, alkaline in reaction (pH 8.10), poor in organic carbon (0.19 %), low in available nitrogen (126.30 kg/ha), medium in phosphorus (19.23 kg/ha) and potassium (150.26 kg/ha). The treatments comprising six weed control treatments (Weedy check, one HW at 20 DAS, two HW at 20 and 40 DAS, pendimethalin at 0.75 kg/ha, imazethapyr at 100 g/ha, and fenoxoprop-p-ethyl at 70 g/ha and four levels of P (0, 20, 40 and 60 kg/ha), phosphorus was applied through DAP and assigned to main and sub plots of spilt plot design, respectively and replicated thrice. Clusterbean variety RGC-1003 was used as a test crop. After recording dry matter accumulation by weeds at harvest, samples were ground for estimation of N, P and K contents in weeds. Representative samples of clusterbean grain and stover taken at the harvest stage were oven dried, ground in Willey mill and analysed for their N, P and K concentrations. Estimation of N was done by colorimetric method using Nessler's reagent to develop colour [13]. P content was determined by Vanadomolybdo phosphoric acid yellow colour method [14] while K was by flame photometer method [15].

The depletion of these nutrients by weeds at the harvest stage was estimated by using the following formula.

$$\text{Nutrient depletion (kg/ha)} = \frac{\text{Nutrient concentration in weeds (\%)} \times \text{Weed dry matter at harvest stage (kg/ha)}}{100}$$

The total uptake of nitrogen, phosphorus and potassium was computed from N, P and K concentration in grain, and stover at harvest using the following relationship:

$$\text{Total nutrient uptake (kg/ha)} = \frac{\text{Nutrient conc. in grain (\%)} \times \text{grain yield (kg/ha)} + \text{Nutrient conc. in stover (\%)} \times \text{stover Yield (kg/ha)}}{100}$$

Protein content in grain was calculated from the percent N in the grain multiplied by the factor 6.25 [16] and expressed as per cent protein content.

Result and Discussion

Nutrient depletion by weeds

All the treatments evaluated for their efficacy of controlling weeds resulted in significantly lower depletion of N by weeds in comparison to weedy check treatment at harvest stage of the crop. Two HW (Table 1) at 20 and 40 DAS registered the lowest depletion of 11.10 kg N/ha. Thus it reduced the N depletion by the magnitude of 1.93, 3.09, 3.18, 6.85 and 26.31 kg/ha than imazethapyr @ 100 g/ha, one HW at 20 DAS, pendimethalin @ 0.75 kg/ha, fenoxoprop-p-ethyl @ 70 g/ha and weedy check treatments, respectively. Application of phosphorus at 60 kg/ha in clusterbean resulted in the highest depletion of 21.39 kg N/ha by weeds which was 25.1 and 57.3 percent more than obtained under 20 kg/ha and control, respectively. Data presented in Table 2 indicated that weedy check treatment observed significantly higher N depletion by weeds up to the highest level of 60 kg P/ha. Whereas, in the rest of the weed control treatments, increase in N depletion by weeds with increasing levels of P was found significant up to 20 kg/ha.

The data presented in Table 1 revealed that the lowest depletion of phosphorus 1.70 kg/ha was recorded under two HW at 20 and 40 DAS treatment. Pre-emergence application of imazethapyr at 100 g/ha and pendimethalin at 0.75 kg/ha and one HW at 20 DAS were observed as the next superior and equally effective treatments in reducing P depletion by weeds. The maximum depletion of 3.24 kg P/ha obtained at this level of P was higher by 0.24, 0.67 and 1.24 kg/ha than obtained under 40 and 20 kg/ha, and control, respectively. Weedy check treatment recorded significantly higher P depletion (Table 3) by weeds when combined with increasing levels of phosphorus up to 60 kg/ha. Unfertilized plots of two HW at 20 and 40 DAS, imazethapyr at 100 g/ha and one HW at 20 DAS (W_3P_0, W_5P_0 and W_2P_{20}) and two HW at 20 and 40 DAS combined with 20 kg P/ha (W_3P_{20}) attained significantly lower P depletion of 1.26, 1.48, 1.62, and 1.62 kg /ha, respectively than most of the treatment combinations.

Results indicated (Table 1) that two HW at 20 and 40 DAS led to the significantly lowest depletion of potassium 10.38 kg /ha by weeds thereby reducing it to the extent of 13.9, 19.9, 20.6, 36.4 and 68.8 percent in comparison to imazethapyr at 100 g/ha, one HW at 20 DAS, pendimethalin at 0.75 kg/ha, fenoxoprop-p-ethyl at 70 g/ha and weedy check treatments, respectively. Every increase in P level from 0 to 60 kg/ha brought about significantly higher K depletion over preceding levels. This level of P fertilization resulted in the highest K depletion by weeds (19.57 kg/ha) which was 6.7, 21.6 and 60.6 per cent more than recorded under 40 and 20 kg/ha and control, respectively. The drastic reduction in nutrient depletion by weeds under these treatments might be directly associated with the corresponding reduction in dry matter production by weeds due to effective control and suppression of weed growth by crop. Nutrient uptake is the product of percent nutrient content and biomass, thus similarity in the trend of uptake and total weed biomass production was an expected outcome. Reduced nutrient uptake by weeds under the influence of different weed control measures had been also reported by [17,18,1].

Nutrient uptake by clusterbean

The total uptake of N by crop was significantly improved due to all the weed control treatments and phosphorus levels (Table 4). Two HW at 20 and 40 DAS was the most superior treatment. It represented the N uptake of 85.15 kg/ha and thus increased it by 14.8, 25.5, 37.1, 63.5, and 121.6 per cent over imazethapyr at 100 g/ha, one HW at 20 DAS, pendimethalin at 0.75 kg/ha, fenoxoprop-p-ethyl at 70 g/ha and weedy check treatments, respectively. Total N uptake increased significantly with progressively increasing levels of P. The highest uptake of 81.22 kg N/ha was obtained with 60 kg P/ha which was 5.8, 33.3 and 136.8 percent more than obtained with 40 and 20 kg/ha and control, respectively.

Results (Table 5) reflected that all the measures evaluated for weed control in clusterbean recorded a substantial increase in total uptake of P by crop than weedy check. Two HW at 20 and 40 DAS excelled rest of the treatments by obtaining the highest uptake of 22.93 kg N/ha thereby increasing it by a margin of 115.7 percent over weedy check. Every addition in the level of P also significantly increased the P uptake by crop up to 60 kg/ha over preceding levels. It provided the highest P uptake of 22.58 kg/ha which was 6.0, 35.0 and 158.4 percent more than recorded at 40 and 20 kg/ha and control, respectively.

The maximum K uptake (Table 5) of 54.11 kg/ha was obtained with two HW at 20 and 40 DAS which was 18.6, 29.9, 42.1, 67.7, and 112.6 percent more than recorded with imazethapyr @ 100 g/ha, one HW at 20 DAS, pendimethalin at 0.75 kg/ha, fenoxoprop-p-ethyl at 70 g/ha and weedy check treatments, respectively. It was followed by imazethapyr @ 100 g/ha and one HW at 20 DAS. Results further revealed that every increase in the level of phosphorus resulted significant improvement in K uptake by crop up to it's the highest level of 60 kg/ha over lower levels and control. It witnessed K uptake of 50.50 kg/ha thereby registering a quantum increase of 2.6, 13.14 and 28.12 kg/ha over 40 and 20 kg/ha and control, respectively. Increase in dry matter and grain yield production with a concomitant an increase in nutrients concentration seemed to be directly responsible for higher uptake of nutrients by crops under these treatments [19,20]. Increased accumulation of nutrient especially N, P and K in vegetative plant parts concomitant with improved metabolism led to greater translocation of these nutrients in reproductive structures.

Phosphorus use efficiency

The data presented in Table 6 revealed that the two HW at 20 and 40 DAS represented the significantly highest agronomic efficiency (24.61 kg grain/kg P) and apparent recovery of P (41.64%) than most of the weed control treatments. It was closely accompanied by imazethapyr @ 100 g/ha which also recorded 70 .5 and 91.9 percent higher agronomic efficiency and apparent recovery of P over weedy check treatment, respectively. The highest agronomic efficiency (26.90 kg grain/kg P), apparent recovery (39.93%), and physiological efficiency of P (68.15 kg grain/kg P uptake) were obtained when the level of phosphorus fertilization was raised from 0 to 20 kg/ha. Thereafter, an increase in P level resulted progressive decline in all the efficiencies of P.

Protein content in Grain

Data about the effect of different weed control treatments and phosphorus levels on protein content in grain presented in Table 4 showed that the highest protein content of 18.05 percent was recorded with twice HW at 20 and 40 DAS was higher by 12.7 and 20.0 percent as compared to fenoxoprop-p-ethyl at 70 g/ha and weedy check treatments, respectively. However, it showed statistical equivalence with imazethapyr at 100 g/ha (17.50%), one HW at 20 DAS (17.13%) and pendimethalin at 0.75 kg/ha (16.94%). Application of graded levels of 40 and 60 kg P/ha increased the protein content in grain by a margin of 6.8 and 4.2 percent over 20 kg/ha, and 13.2 and 10.4 per cent over control, respectively. The protein content of grain is essentially the manifestation of N content, higher concentration of N in grain due to P fertilization might have increased the protein content [21,22,1].

Conclusion

It can be inferred from the present investigation that hand weeding twice at 20 and 40 DAS, imazethapyr at 100 g/ha, and one HW at 20 DAS were found statistically similar and significantly better treatments in enhancing nutrient concentration in grain and stover, protein content in grain and significant reduction nutrient depletion by weeds but in enhancing of nutrient uptake by crop, two hand weeding at 20 and 40 DAS was found significantly better treatment over rest of the treatments. Application of 60 kg P/ha in clusterbean recorded the highest N, P, and K concentration in weeds and nutrient depletion by weeds at the harvest stage. Every increase in the level of P to 40 kg/ha resulted in significant improvement in N, P and K uptake by grain and stover, protein content, and phosphorus use efficiency.

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Table 1. Effect of weed management practices and phosphorus levels on nutrient depletion by weeds at the harvest stage of the crop

Treatments	Nutrient depletion (kg/ha)

	N	P	K
A. Weed control			
Weedy check	37.41	5.44	33.27
One HW at 20 DAS	14.20	2.19	12.96
Two HW at 20 & 40 DAS	11.10	1.70	10.38
Pendimethalin @ 0.75 kg/ha (PE)	14.26	2.13	13.07
Imazethapyr @ 100 g/ha (PE)	13.03	2.01	12.05
Fenoxoprop-p-ethyl @ 70 g/ha (POE)	17.95	2.71	16.33
SEm±	0.54	0.08	0.47
CD (P = 0.05)	1.70	0.25	1.48
CV (%)	10.41	9.99	9.98
B. Phosphorus levels (kg/ha)			
0	13.60	1.99	12.19
20	17.10	2.57	15.35
40	19.88	3.00	18.26
60	21.39	3.24	19.57
SEm±	0.41	0.05	0.36
CD (P = 0.05)	1.08	0.14	0.96
Interaction (WXP)	Sig.	Sig.	Sig.
CV (%)	9.59	8.01	9.39

Sig.= Significant

Table 2. Combined effect of weed management practices and phosphorus levels on N depletion by weeds (kg/ha) at the harvest stage of the crop

Treatments	P_0	P_{20}	P_{40}	P_{60}

W_1 - Weedy check	28.28	35.55	41.33	44.47
W_2 - One HW at 20 DAS	10.73	13.49	15.69	16.88
W_3 - Two HW at 20 & 40 DAS	8.39	10.55	12.26	13.20
W_4- Pendimethalin @ 0.75 kg/ha (PE)	10.78	13.55	15.75	16.95
W_5 - Imazethapyr @ 100 g/ha (PE)	9.85	12.38	14.40	15.49
W_6 - Fenoxoprop-p-ethyl @ 70 g/ha (POE)	13.57	17.06	19.83	21.34
For P at same level of W				
SEm$\pm$				1.00
CD (P=0.05)				2.86
For W at same or different levels of P				
SEm$\pm$				0.72
CD (P=0.05)				2.05

Table 3. Combined effect of weed management practices and phosphorus levels on P depletion by weeds (kg/ha) at the harvest stage of the crop

Treatments	**P_0**	**P_{20}**	**P_{40}**	**P_{60}**

W_1 - Weedy check	4.01	5.17	6.04	6.52
W_2 - One HW at 20 DAS	1.62	2.09	2.44	2.63
W_3 - Two HW at 20 & 40 DAS	1.26	1.62	1.89	2.04
W_4- Pendimethalin @ 0.75 kg/ha (PE)	1.58	2.03	2.37	2.56
W_5 - Imazethapyr @ 100 g/ha (PE)	1.48	1.91	2.23	2.41
W_6 - Fenoxoprop-p-ethyl @ 70 g/ha (POE)	2.00	2.58	3.01	3.25
For P at same level of W				
SEm±				0.12
CD (P=0.05)				0.36
For W at same or different levels of P				
SEm±				0.09
CD (P=0.05)				0.27

Table 4. Effect of weed management practices and phosphorus levels on total N uptake by crop and protein content in grain

Treatments	Total N uptake	Protein

	(kg/ha)	content (%)
A. Weed control		
Weedy check	38.43	15.04
One HW at 20 DAS	67.85	17.13
Two HW at 20 & 40 DAS	85.15	18.05
Pendimethalin @ 0.75 kg/ha (PE)	62.10	16.94
Imazethapyr @ 100 g/ha (PE)	74.15	17.50
Fenoxoprop-p-ethyl @ 70 g/ha (POE)	52.07	16.02
SEm±	2.16	0.43
CD (P = 0.05)	6.82	1.36
CV (%)	11.84	8.91
B. Phosphorus levels (kg/ha)		
0	34.30	15.63
20	60.91	16.56
40	76.74	17.25
60	81.22	17.69
SEm±	1.12	0.24
CD (P = 0.05)	2.98	0.65
Interaction (WXP)	Sig.	NS
CV (%)	7.53	6.19

Sig.= Significant NS= Non significant

Table 5. Effect of weed management practices and phosphorus levels on total P and K uptake by crop

Treatments	Total P uptake (kg/ha)	Total K uptake (kg/ha)
A. Weed control		
Weedy check	10.63	25.45
One HW at 20 DAS	18.59	41.65
Two HW at 20 & 40 DAS	22.93	54.11
Pendimethalin @ 0.75 kg/ha (PE)	17.04	38.08
Imazethapyr @ 100 g/ha (PE)	20.37	45.64
Fenoxoprop-p-ethyl @ 70 g/ha (POE)	14.45	32.26
SEm±	0.59	1.31
CD (P = 0.05)	1.86	4.13
CV (%)	11.81	11.49
B. Phosphorus levels (kg/ha)		
0	8.74	22.38
20	16.72	37.35
40	21.31	47.90
60	22.58	50.49
SEm±	0.41	0.92
CD (P = 0.05)	1.09	2.43
Interaction (WXP)	Sig.	Sig.
CV (%)	10.02	9.83

Sig. = Significant NS= Non significant

Table 6. Effect of weed control and phosphorus levels on phosphorus use efficiencies

Treatments	AEp (kg grain/kg P)	REp (%)	PEp (kg grain/kg P)
A. Weed control			
Weedy check	12.93	19.28	66.21
One HW at 20 DAS	21.16	33.77	61.80
Two HW at 20 & 40 DAS	24.61	41.64	58.25
Pendimethalin @ 0.75 kg/ha (PE)	19.71	30.97	63.04
Imazethapyr @ 100 g/ha (PE)	22.05	36.99	60.84
Fenoxoprop-p-ethyl @ 70 g/ha (POE)	17.27	26.22	66.70
B. Phosphorus levels (kg/ha)			
0	0.00	0.00	0.00
20	26.90	39.93	68.15
40	18.65	31.43	60.86
60	13.32	23.07	59.40

AEp=Agronomic efficiency-P (kg grain/kg P)

REp = Apparent recovery of P (%)

PEp = Physiological efficiency of P (kg grain/kg P)