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Effect of integrated phosphorus management on growth, yield and quality of Cowpea (*Vigna unguiculata* L.)

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Abstract

A field experiment was carried out during *kharif* season 2021 to study the “Effect of integrated phosphorus management on growth, yield and quality of cowpea (*Vigna unguiculata* L.)” at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The experiment was laid out in a factorial randomized block design with three replications and twelve treatment combinations comprising three phosphorus levels, namely 20, 30 and 40 kg P₂O₅/ha, two organic manure sources, namely castor cake @ 0.5 t/ha and FYM @ 2.5 t/ha, and two biofertilizer treatments, namely seed inoculation with PSB and without biofertilizer. Among different levels of phosphorus results showed that an application of 40 P₂O₅/ha kg, castor cake @ 0.5 t/ha and seed inoculation of PSB recorded significantly plant height, higher number of branches/plant, number of pods/plant, pod length, number of seeds/pod, seed yield (kg/ha) and stover yield (kg/ha), while protein content was remain unaffected.

Keywords: Cowpea (*Vigna unguiculata* L.), integrated phosphorus management, phosphorus levels

Introduction

Pulses play an important role in Indian agriculture and India is the largest producer and consumer of pulses in the world. Pulses occupy a strategic position in Indian agriculture because they provide dietary protein, improve soil fertility through biological nitrogen fixation and contribute to the sustainability of cropping systems. In predominantly vegetarian diets, pulses serve as an economical source of protein, vitamins and minerals. They are also valued in crop rotations because their root systems, biological nitrogen fixation and crop residues help improve soil physical and biological properties. Pulses are therefore important not only as food crops but also as soil-restoring crops in diversified farming systems. Cowpea (*Vigna unguiculata* L.) is an important *kharif* and summer pulse crop cultivated for grain, green pods, fodder and green manuring. The crop is known for its adaptability to warm conditions, drought tolerance and multipurpose utility. The high content of protein in pulses makes the diet more nutritive. Pulses are popularly known as “Poor man’s meat” and “Rich man’s vegetable” (Singh and Singh, 1992)^[1]. Fertilizer is an important factor which increases agriculture production. The importance of phosphorus application to cowpea has been recognized since long. Phosphorus is a major plant nutrient next to nitrogen in augmenting the plant metabolic activity ultimately reflecting on the crop yield. Phosphorus is particularly important in pulses because it supports root growth, nodulation, energy transfer, flowering, seed formation and biological nitrogen fixation. Organic manures such as FYM and castor cake can improve soil physical, chemical and biological properties while supplying nutrients over a longer period. Biofertilizers, particularly phosphorus solubilizing bacteria (PSB), help mobilize insoluble forms of phosphorus into plant-available forms through organic acid production.

Materials and Methods

A field experiment was carried out during *kharif* season 2021 to study the “Effect of integrated phosphorus management on growth, yield and quality of cowpea (*Vigna unguiculata* L.)” at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Twelve treatment combinations comprising

of three levels of phosphorus viz., 20 kg P_2O_5 /ha (P_1), 30 kg P_2O_5 /ha (P_2) and 40 kg P_2O_5 /ha (P_3) and two levels of organic manure viz., castor cake @ 0.5 t/ha (O_1) and FYM @ 2.5 t/ha (O_2) and two levels of bio fertilizers with seed inoculation (B_1) and without seed inoculation (B_2) with PSB. The experiment was laid out in a randomized block design with factorial concept (FRBD) with three replications. The soil of the experimental plot was loamy sand in texture, slightly alkaline in reaction and free from any kind of salinity hazard. The soil was low in organic carbon and available nitrogen and medium in available phosphorus and potassium status. The experimental field was cultivated by tractor drawn cultivator and it was followed by harrowing and planking to obtain fine seedbed. The experiment was laid out as per layout plan and plots were levelled manually. A recommended dose of Nitrogen @ 20 kg/ha was applied as a basal dose in ploughed furrows before sowing as some part through DAP and remaining through urea. As per treatment, the crop was fertilized with phosphorus @ 20, 30 and 40 kg/ha before sowing the crop in furrows in form of DAP, Organic manure castor cake @ 0.5 t/ha and FYM @ 2.5 t/ha before sowing the crop in furrows. The require quantity of healthy cowpea seed treatment with and without PSB before sowing. Cowpea variety GC 6 was used for sowing. Before sowing, the required quantity of seeds was treated uniformly with phosphorus solubilizing bacteria culture @ 5 ml/kg seeds, were used for sowing of all inoculated treatments. Whereas, uninoculated seeds were sown in respective uninoculated treatments. Sowing was done under dry condition on 22th July, 2021 by hand sowing method keeping inter-row spacing of 45 cm. The first light irrigation was given to the crop immediately after sowing the seeds for uniform germination. The second irrigation was given to the crop to the ten days after first irrigation. Thinning and gap filling were done at 12 days after sowing to maintain intra row spacing of about 10 cm between two plants in all experimental plots. Observations were recorded on plant height, number of branches per plant, number of pods per plant, pod length, number of seed per pod, seed yield, straw yield and protein content were recorded.

Results and Discussion

(A) Effect of Phosphorus on growth, yield and quality of cowpea

Effect of different levels of phosphorus on plant height an application of 40 kg P_2O_5 /ha (P_3), recorded significantly higher plant height at harvest (57.87 cm), which is remaining statically at par with 30 kg P_2O_5 /ha (P_2). The lower plant height at harvest were recorded with treatment 20 kg P_2O_5 /ha (P_1). This might be due to acceleration of various metabolic process, internodes elongation and synthesis of higher photosynthates due to adequate supply of phosphorus through chemical fertilizer. These results are in conformity with the findings of Kumar *et al.* (2000) [2], Jat *et al.* (2013) [3], Gajera *et al.* (2014) [4], Kokani *et al.* (2015) [5], Kadam and Khanvilkar (2015) [6], Sipai *et al.* (2016) [7], Heisnam *et al.* (2017) [8], Chaudhari (2018) [9] and Yadav (2018) [10]. Significantly higher number of branches per plant (8.33) were found at harvest under treatment 40 kg P_2O_5 /ha (P_3), which is remained statistically at par with the application of 30 kg P_2O_5 /ha (P_2). Whereas, significantly lower number of branches/plant (7.37) were noticed with the treatment 20 kg P_2O_5 /ha (P_1). Increase in number of branches/plant due to phosphorus could be ascribed to the overall improvement in plant growth, vigour and production of sufficient photosynthetic. These results are in conformity with the findings of Kumar *et al.*

(2000) [2], Jat *et al.* (2013) [3], Kokani *et al.* (2015) [5], Kadam and Khanvilkar (2015) [6], Heisnam *et al.* (2017) [8] and Chaudhari (2018) [9]. The significantly the highest number of pods/plant (21.67) and seeds/pod (12.87) were recorded under the application of 40 kg P_2O_5 /ha (P_3), which is at par with 30 kg P_2O_5 /ha (P_2). Significantly the lowest number of pods/plant (18.07) and seeds/pod (11.90) were recorded under the treatment 20 kg P_2O_5 /ha (P_1). The favourable effect of phosphorus application on number of pods/plant and seeds/pod was mainly due to its primary role in photosynthesis by way of rapid energy transfer and there by increased photosynthetic efficiency and thus, increased in total biomass production and translocation in plant parts. These all together resulted in to overall increase in above characters. These results are in close conformity with those of Patel *et al.* (2003) [11], Jat *et al.* (2013) [3], Kokani *et al.* (2015) [5], Chaudhari *et al.* (2016) [9], Heisnam *et al.* (2017) [8] and Yadav (2018) [10]. Significantly higher length of pod (13.59 cm) was recorded with application of 40 kg P_2O_5 /ha (P_3), which remaining at par with application of 30 kg P_2O_5 /ha (P_2). Significantly lower length of pod (12.54 cm) was noted with application of 20 kg P_2O_5 /ha (P_1). This increment was attributed due to supply of phosphorus, resulted in amplified photosynthetic activity and helps to develop a ramified root system and thus empowers the plant to withdraw extra water and nutrient from deeper layers, resulted in better growth and yield attributes and ultimately increase pod length. Present result is similar with the finding of Patel *et al.* (2013) [11], Jat *et al.* (2013) [3] and Kokani *et al.* (2015) [5]. Significantly the highest seed yield (1294 kg/ha) was recorded under application of 40 kg P_2O_5 /ha (P_3), but it was found at par with 30 kg P_2O_5 /ha (P_2). Significantly lower seed yield (1158 kg/ha) was observed under application of 20 kg P_2O_5 /ha (P_1). Treatment 40 kg P_2O_5 /ha (P_3) and 30 kg P_2O_5 /ha (P_2) recorded 11.7% and 5.0% higher seed yield over 20 kg P_2O_5 /ha (P_1) respectively. Seed yield was significantly higher with treatment 40 kg P_2O_5 /ha (P_3) might be due to the fact that, excess assimilates stored in the leaves and later translocate into seeds at the time of senescence, ultimately led to higher seed yield. Second probable reason for increasing seed yield might be due to phosphorus application not only plays important role in root development and proliferation, but also improves nodulation and N fixation by supplying assimilates to the roots. Third reason for higher seed yield by phosphorus application might be due to increase in photosynthetic activity of plant and root system and thus enables plants to extract more water and nutrients from the soil depth, resulting into better development of plant growth, yield attributes and ultimately the higher seed yield. The results are in close agreement with the findings of Kumar *et al.* (2000) [2], Patel *et al.* (2013) [11], Kokani *et al.* (2015) [5], Chaudhari *et al.* (2016) [9], Sipai *et al.* (2016) [7], Yadav (2018) [10] and Singh *et al.* (2019) [12]. Significantly the highest stover yield (2502 kg/ha) found with application of 40 kg P_2O_5 /ha (P_3), but it was found at par with application of 30 kg P_2O_5 /ha (P_2). Significantly the lowest stover yield (2167 kg/ha) was recorded under application of 20 kg P_2O_5 /ha (P_1). Increase in stover yield was might be due to increase in growth and development in terms of plant height, branches and dry matter accumulation by improved nutritional environment in rhizosphere and plant system. The results are in close agreement with the findings reported by Patel *et al.* (2013), Jat *et al.* (2013) [3], Kokani *et al.* (2015) [5], Chaudhari *et al.* (2016) [9] and Yadav (2018) [10]. green gram crop. Differences in protein content (%) in seed due to application of phosphorus was to be non-significant.

Table 1: Effects of different levels of phosphorus, Organic manure and biofertilizers on plant height, number of branches per plant, number of pods per plant, pod length, number of seed per pod

Treatment			Plant height (cm) at harvest	Number of branches per plant at harvest	Number of pods per plant at harvest	Pod length (cm)	Number of seeds per pod
A	Phosphorus (P)						
	P ₁	20 kg P ₂ O ₅ /ha	53.40	7.37	18.07	12.54	11.90
	P ₂	30 kg P ₂ O ₅ /ha	56.01	7.92	19.26	13.04	12.31
	P ₃	40 kg P ₂ O ₅ /ha	57.87	8.33	21.67	13.59	12.87
	S.Em. ±		1.19	0.21	0.52	0.28	0.26
	C.D. at 5%		3.48	0.62	1.53	0.83	0.75
B	Organic manure (O)						
	O ₁	Castor cake @ 0.5 t/ha	57.20	8.14	20.62	13.18	12.44
	O ₂	FYM @ 2.5 t/ha	54.32	7.61	18.71	12.93	12.27
	S.Em. ±		0.97	0.17	0.43	0.24	0.21
	C.D. at 5%		2.84	0.51	1.25	NS	NS
C	Biofertilizer (B)						
	B ₁	With biofertilizer	57.18	8.13	20.29	13.12	12.41
	B ₂	Without biofertilizer	54.34	7.62	19.04	12.99	12.31
	S.Em. ±		0.97	0.17	0.43	0.24	0.21
	C.D. at 5%		2.84	0.51	1.25	NS	NS
Interactions (P × C, P × B, C × B, P × C × B)							
C.D. at 5%			NS	NS	NS	NS	NS
C.V.%			7.37	9.39	9.30	7.75	7.17

(B) Effect of organic manure on growth, yield and quality of cowpea

The plant height recorded significantly higher plant height at harvest (57.20 cm) were observed in treatment castor cake @ 0.5 t/ha (O₁) over FYM @ 2.5 t/ha (O₂) treatment. It might be attributed over to multifarious role of castor cake in terms of nutrients supply as well as improvement in physical, chemical and biological properties of soil which finally reflected on growth of plant. These results are in conformity with the findings of Gohil *et al.* (2017) ^[13] and Yashraj (2021). Significantly higher number of branches per plant (8.14) were observed with treatment castor cake @ 0.5 t/ha (O₁). This might be due to the crop accumulates more amount of constituent and nutrients from organic manures like castor cake. Significantly the lower number of branches per plant (7.61) were observed with treatment FYM @ 2.5 t/ha (O₂). significantly higher number of pods per plant (20.62) produce under treatment castor cake @ 0.5 t/ha (O₁). The significantly lower number of pods per plant (18.71) were noted with treatment FYM @ 2.5 t/ha (O₂). Increase in pods per plant might be due to availability and optimum supply of nutrients from castor cake to plants favorably influenced the flowering and seed formation which ultimately increased the pods per plant and seeds per pod. These findings are in agreement with findings of Shukla *et al.* (2013) ^[15], Gohil *et al.* (2017) ^[13] and Yashraj (2021). Different sources of organic manure were found non significant on length of pod. This indicated that uniform length of pod was found under all treatments. Effect of different sources of organic manure on

number of seeds per pod was found non significant. This indicated that uniform number of seeds per pod were found under all treatments. Significantly higher seed yield (1268 kg/ha) produce under treatment castor cake @ 0.5 t/ha (O₁). Significantly lower seed yield (1177 kg/ha) was noted with treatment FYM @ 2.5 t/ha (O₂). Treatment castor cake @ 0.5 t/ha (O₁) produced 7.17% higher seed yield over FYM @ 2.5 t/ha (O₂). Application of castor cake increase the supply of easily assimilated major as well as micronutrients to plant, besides mobilizing unavailable nutrients into available form. It is needed mostly by young, fast growing tissue and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrates. The results are in close agreement with the findings of Shukla *et al.* (2013) ^[15], Gohil *et al.* (2017) ^[13] and Yashraj (2021). Significantly higher stover yield (2453 kg/ha) produce under treatment castor cake @ 0.5 t/ha (O₁). Significantly lower seed yield (2248 kg/ha) was noted with treatment FYM @ 2.5 t/ha (O₂). Addition of organic manure might have resulted into increased uptake of nutrients, release of phytohormones and organic acids which provided food for the beneficial bacteria. In addition of castor cake seems balance supply of nutrients over a longer time and also due to its pivoted role in enhancing physico-chemical and biological properties of soil which would have resulted into favourable soil atmosphere and ultimately higher yield. The results are in close agreement with the findings of Shukla *et al.* (2013) ^[15], Gohil *et al.* (2017) ^[13] and Yashraj (2021).

Table 2: Effects of different levels of phosphorus, Organic manure and biofertilizers on Protein content, seed yield and stover yield

Treatment		Protein content (%)	Seed yield (kg/ha)	Stover yield (kg/ha)
A	Phosphorus (P)			
	P ₁	20 kg P ₂ O ₅ /ha	19.69	1158
	P ₂	30 kg P ₂ O ₅ /ha	20.19	1216
	P ₃	40 kg P ₂ O ₅ /ha	21.32	1294
	S.E.m. ±		0.53	36.15
	C.D. at 5%		NS	106.03
B	Organic manure (O)			
	O ₁	Castor cake @ 0.5 t/ha	20.80	1268
	O ₂	FYM @ 2.5 t/ha	20.00	1177
	S.E.m. ±		0.43	29.52
	C.D. at 5%		NS	86.57

C	Biofertilizer (B)			
B ₁	With biofertilizer	20.62	1267	2436
B ₂	Without biofertilizer	20.18	1179	2265
	S.E.m. $\pm$	0.43	29.52	55.93
	C.D. at 5%	NS	86.57	164.04
Interactions (P $\times$ C, P $\times$ B, C $\times$ B, P $\times$ C $\times$ B)				
	C.D. at 5%	NS	NS	NS
	C.V.%	8.96	10.24	10.10

(C) Effect of Biofertilizers on growth, yield and quality of cowpea

Biofertilizer had significant influence on plant height at harvest. Seed inoculation with PSB produced significantly taller plant at harvest (57.18 cm). Whereas, the shorter plant at harvest (54.34 cm) were registered under without seed inoculation. The increase in plant height with PSB is quite obvious because nitrogen obtained from biological nitrogen fixation influenced favourably the meristematic activity, which increased the number and length of internodes ultimately resulting in better growth. These results are in conformity with Jain and Singh (2003) ^[16], Parmar and Thanki (2007) ^[17], Wagadre *et al.* (2010) ^[18], Mahetele and Kushwaha (2011) ^[19]. Seeds inoculated with PSB had shown their significant effect on number of branches/plant. Significantly the highest number of branches/plant (8.13) were recorded under treatment with biofertilizer (B₁) over treatment (without biofertilizer) (B₂). The increase in number of branches/plant might be due to the reason that, phosphobacteria dissolved insoluble phosphorus in the soil, making it available to the crop plants for profuse root and vegetative growth and produced growth promoting substances. Similar results have been reported by Jain and Singh (2003) ^[16], Kumawat *et al.* (2009) ^[20] and Heisnam *et al.* (2017) ^[8]. Number of pods/plant were significantly influenced due to phosphorus solubilizing bacteria treatment. Significantly the highest number of pods/plant (20.29) were recorded under the treatment with biofertilizer (B₁) over without biofertilizer (B₂). Inoculation of seed with PSB liquid biofertilizer might have helped in reducing phosphorus fixation by its effect and also solubilizing the unavailable form of phosphorus leading to more uptake of nutrient and reflected in better yield attributes. These results are similar with Ghosh and Joseph (2008) ^[21], Wagadre *et al.* (2010) ^[18] and Pargi *et al.* (2018) ^[22]. Length of pod of cowpea did not vary due to PSB treatments. Number of seeds per pods of cowpea did not vary due to PSB treatments. The application of PSB had significant influence on seed yield of cowpea. Differences in protein content (%) in seed due to application of biofertilizer was found to be non-significant. Significantly the highest seed yield (1267 kg/ha) was recorded under treatment with biofertilizer (B₁) over treatment (B₂) without biofertilizer (1179 kg/ha). On an average, the application with PSB increased 7.46% seed yield over without biofertilizer. The increase in seed yield due to PSB liquid biofertilizer inoculation may be attributed to solubilization of native (insoluble) or applied phosphorus in soil by bacteria and thus, making it available for plant use which in turn helps to put forth profuse growth and produced more seed yield. Other reason might be due to inoculation of PSB, increased availability of phosphorus and favoured higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of phosphorus and other plant nutrients and ultimately positive resultant effect on growth and yield attributes, which led to increase the seed yield. The results are in close agreement with the findings reported by Parveen *et al.* (2002) ^[23], Kumar and Kumar (2003) ^[24], Gupta and Sharma (2006) ^[25], Jarande *et al.* (2006) ^[26],

Kumawat *et al.* (2009) ^[20], Wagadre *et al.* (2010) ^[18], Mahetele and Kushwaha (2011) ^[19] and Pargi *et al.* (2018) ^[22]. Stover yield (kg/ha) of cowpea significantly influenced by seed treatment with PSB. Significantly the highest stover yield (2436 kg/ha) recorded with inoculation of PSB liquid biofertilizer over uninoculation of PSB liquid biofertilizer. Significantly the lowest stover yield (2265 kg/ha) was recorded under without PSB application. Increase in stover yield might be due to inoculation with PSB, which increased availability of phosphorus and favoured higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of P and other plant nutrients and ultimately positive resultant effect on growth and yield attributed, which led to increase the stover yield. The results are in close agreement with Balyan *et al.* (2002) ^[27] and Wagadre *et al.* (2010) ^[18]. Differences in protein content (%) in seed due to application of biofertilizer was found to be non-significant.

(D) Effect of interaction

The interaction of different levels of phosphorus, organic manure and biofertilizers were found non-significant for plant height, number of branches, number of pods per plant, number of seed per pod, pod length, seed yield, stover yield and protein content in cowpea.

Conclusion

In light of the results obtained, from the present investigation, it is concluded that for securing higher yield and net return of cowpea grown on loamy sand, the crop should be fertilized with 30 kg P₂O₅/ha, 0.5 t/ha castor cake and seed inoculation with PSB @ 5 ml/kg along with recommended dose of nitrogen (20 kg/ha).

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