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Effect of biofertilizers and phosphorus on growth and yield of blackgram (*Vigna mungo* L.)

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Abstract
A field experiment was carried out during Kharif, 2021 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) on sandy loam soil to assess the effect of phosphorus levels (30, 40 and 50kg/ha) and biofertilizers (VAM, PSB and VAM + PSB) on growth parameters and yield of Blackgram (*Vigna mungo L.*). The design of field experiment was Randomized block design consisting of nine treatments each replicated thrice. Experimental results showed significant increase in growth parameter and yield. Application of VAM + PSB+50 kg P /ha (Treatment 9) recorded maximum plant height (37.46cm), number of nodules (12.38 per plant), dry weight (10.82 g per plant), Crop growth rate (g/m^2/day)(13.02 g/m^2/day), Relative growth rate (mg/g/day)(0.1067 mg /g/day) and number of pods (25.46/plant), number of grains (6.92 per pod), test weight (45.23g), grain yield (2.41 t/ ha), stover yield (6.47 t /ha) and harvest index (33.52 t/ha). Maximum gross return (INR 1,44,600 /ha), net return (98,986.68 INR /ha) and B:C ratio (2.17) were also recorded with application VAM + PSB + 50 kg P /ha (Treatment 9).

Keywords: Biofertilizers, phosphorus, growth, yield and blackgram

Introduction
Blackgram (*Vigna mungo* L.) commonly known as urdbean is a deep rooted drought hardy crop. The word pulse is derived from the Latin word pulse means pottage, *i.e.* seed boiled to make porridge or thick soup (Patel, 2017). Pulses provide 25% of protein requirements of predominantly vegetarian population. The World Health Organization (WHO) recommends a per capita consumption of pulses at 80 gram per day and the Indian Council of Medical Research (ICMR) has recommended a minimum consumption of 47 g. Pulse crops are one of the most sustainable crops a farmer can grow. It is mostly cultivated on marginal lands in mono/mixed cropping system without any fertilizers under rainfed conditions with results in generally low yield gap can be maintained through adequate and balance supply of plant nutrients (Rathore *et al.*, 2010) [1]. Advantage of optimum spacing under irrigated conditions is due to reduced competition for light because when the moisture is lacking, light is no longer limiting factor and the advantage of uniform spacing is lost (Ihsanullah *et al.*, 2002). Phosphorus stimulates the symbiotic nitrogen fixation because in presence of phosphorus bacterial cell becomes mobile which is pre requisite for migration of bacterial cell to root hair for nodulation (Charel 2006) [2]. Phosphorus helps in proper root development which increases root nodules and consequently increases nitrogen fixation. It also plays an important role in the process of photosynthesis, energy conservation and transportation, cell division and meristematic growth in living tissues, grain quality and most of physico-bio-chemical activities. Phosphate Solubilizing Bacteria (PSB) plays an important role in solubilization of soil P through secretion of various organic acids (formic, acetic, butyric, propionic, citric, glucomic, succinic, oxalic, malic, maleic and lactic acids) and make it available to plant (Gaur 1991) [3]. Many fungi, bacteria and actinomycetes are potential solubilizers of bound phosphates in soil. More over use of PSB also reduce the environmental pollution caused by the heavy use of chemical fertilizers.

Materials and Methods
The experiment was carried out during kharif season 2021 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad (U.P.), which is located at 25.4358oN latitude, 81.8463OE longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Allahabad rewa road about 5km away from

Allahabad city. The experiment was conducted in Randomized Block Design consisting of 9 treatment combinations with 3 replications and was laid out with the different treatments allocated randomly in each replication. Experiment was laid out in randomized block design with nine treatment combinations comprised of three phosphorus levels (30, 40 and 50kg/ha) and three treatments of bio-fertilizers *viz*., (VAM, PSB and VAM + PSB). The observations on growth and yield parameters i.e. plant height (cm), plant dry weight (g/plant), crop growth rate (CGR) (g/m2/day), relative growth rate (RGR) (g/g/day), nodules/plant (No.), pods/plant (No.), test weight (g), seed yield (kg/ha), stover yield (kg/ha) and harvest index (%). The recorded data were analysed statistically by ANOVA technique (Gomez and Gomez, 1984). Significant difference among the treatment mean was verified against the critical difference at five per cent level of significance.

Results and Discussion

Observations regarding the response of different levels of Biofertilizers and Phosphorus on plant height, number of nodules plant^{-1}, dry weight (g plant^{-1}), Crop growth rate (g m^{-2} day^{-1}) and Relative growth rate (mg g^{-1} day^{-1}) of Blackgram are given in table 1. It was noticed that successive stage there was an incremental trend. 60 DAS were significant influence in plant height, number of nodules plant^{-1}, dry weight (g plant^{-1}), Crop growth rate (g m^{-2} day^{-1}) and Relative growth rate (mg g^{-1} day^{-1}) due to different treatments. At 60 DAS, there was significant difference between the treatments and maximum plant height (37.46cm) was observed the applications of VAM + PSB + 50 kg P /ha, whereas the lowest value (25.43cm) was observed in treatment PSB + 30 kg P /ha. At 60 DAS there was significant difference between the treatments and maximum number of nodules (12.38 plant^{-1}) was observed by the application of VAM + PSB + 50 kg P /ha, whereas the lowest value (5.80 plant^{-1}) in PSB + 30 kg P /ha. At 60 DAS, there was significant difference between the treatments and maximum dry weight (10.82 g plant^{-1}) was observed by the application of VAM + PSB + 50 kg P /ha, whereas the lowest value (4.59g plant^{-1}) was observed in treatment PSB + 30 kg P /ha. At 45-60 DAS the highest Crop growth rate (g m^{-2} day^{-1}) (13.02 g m^{-2} day^{-1}) was found in treatment VAM + PSB + 50 kg P /ha and lowest Crop growth rate (g m^{-2} day^{-1}) (7.41 g m^{-2} day^{-1}) at was recorded in treatment PSB + 30 kg P /ha. At 45-60 DAS the highest Relative growth rate (mg g^{-1} day^{-1}) (0.1067 mg g^{-1} day^{-1}) was recorded in treatment VAM + PSB + 50 kg P /ha and lowest Relative growth rate (mg g^{-1} day^{-1}) (0.0473 mg g^{-1} day^{-1}) was recorded in treatments PSB + 30 kg P /ha. The increase in growth attributes due to phosphorus helps in early root development and formation of lateral fibrous, healthy roots and root proliferation. P increases the metabolic activities and amount of naturally occurring phytohormones. PSB strains released greater amounts of available P and this enable the plant to absorb more P resulting in improved growth attributes. Similar results were reported by Niraj *et al.,* (2014) [5], Madholiya (2015) [8], Vidhyashree *et al.,* (2017) [7], Biswas and Patra (2007) [4] and Tomar *et al*., (2001) [6].

Observations regarding the response of different levels of Biofertilizers and Phosphorus on yield and yield attributes of Blackgram are given in table 2. The observation showed that at yield and yield attributes there was significant difference between treatments. The results revealed that there was significant difference between the treatments and maximum number of pods (25.46 plant^{-1}) was observed by the application of VAM + PSB + 50 kg P /ha, whereas the lowest value (15.73 plant^{-1}) was observed in treatment PSB + 30 kg P /ha The results revealed that there was significant difference between the treatments and maximum number of grains (6.92 pod^{-1}) was observed by the application of VAM + PSB + 50 kg P /ha, whereas the lowest value (3.35 pod^{-1}) was observed in treatment PSB + 30 kg P /ha. The results revealed that the difference between the treatments were non-significant with maximum test weight (45.23g) was observed in treatment VAM + PSB + 50 kg P /ha and minimum test weight (32.63g) was observed in treatment PSB + 30 kg P /ha. The results revealed that there was significant difference between the treatments and maximum grain yield (2.41 t ha^{-1}) was observed by the application of VAM + PSB + 50 kg P /ha, whereas the lowest value (1.06 t ha^{-1}) was observed in treatment PSB + 30 kg P /ha. The results revealed that there was significant difference between the treatments and maximum stover yield (6.47 t ha^{-1}) was observed by the application of VAM + PSB + 50 kg P /ha, whereas the lowest value (4.25 t ha^{-1}) was observed in treatment PSB + 30 kg P /ha. The results revealed that there was significant difference between the treatments and maximum harvest index (33.52 t ha^{-1}) was observed by the application of VAM + PSB + 50 kg P /ha, whereas the lowest value (23.31 t ha^{-1}) was observed in treatment PSB + 30 kg P /ha. The increased in straw yield might be due to vigorous start to plant and strength straw yield by P application. The application of P through SSP also provides S to the soil and plant which encourages vegetative plant growth, constituent of proteins and enzymes and helps in reduction oxidation system in respiration and increases root growth. Similar results were reported by Appana *et al*., (2008) [9], Patil *et al*., (2011) and Gajera *et al*., (2014) [11]. With the application of different P levels and biofertilizer increased grain yield these could be due to increased availability of photosynthates to the reproductive part during pod filling stage. These results are in conformity with the Balaguravaviah *et al.,* (1989) [12], Gupta *et al.,* (2016) [13] and Prajapati (2014) [10]. The highest gross return (₹144600), net return (₹98986.68ha^{-1}) and benefit cost ratio (2.17) were registered in treatment VAM + PSB + 50 kg P /ha. Whereas the lowest value gross return (₹63600 ha^{-1}), net return (₹21492.98ha^{-1}) and benefit cost ratio (0.051) respectively in treatment PSB + 30 kg P /ha.

Table 1: Effect of biofertilizers and phosphorus on growth parameters of Blackgram

Treatment	Treatments Combination	60 DAS				
		Plant height (cm)	Number of Nodules plant^{-1}	Dry weight (g per plant)	Crop growth rate (g m^{-2} day^{-1}) 45-60 DAS	Relative growth rate (mg g^{-1} day^{-1}) 45-60 DAS
1	VAM + 30 kg P /ha	29.37	10.32	3.05	3.48	0.0866
2	VAM + 40 kg P /ha	30.53	11.80	4.94	7.54	0.0772
3	VAM + 50 kg P /ha	32.10	9.34	5.60	9.10	0.0874
4	PSB + 30 kg P /ha	25.43	5.80	4.59	7.41	0.0473
5	PSB + 40 kg P /ha	28.09	11.46	6.58	12.27	0.0802
6	PSB + 50 kg P /ha	27.10	11.21	8.37	10.12	0.0930
7	VAM +PSB + 30 kg P /ha	33.8.0	12.43	9.04	7.09	0.0657
8	VAM + PSB + 40 kg P /ha	34.14	12.76	9.38	9.04	0.0700
9	VAM + PSB + 50 kg P /ha	37.46	12.38	10.82	13.02	0.1067
	F test	S	S	S	S	S
	S.Ed. (±)	1.313	0.731	0.444	1.305	0.011
	CD. (P = 0.05)	2.784	1.549	0.940	2.767	0.023

Table 2: Effect of Biofertilizers and Phosphorus on yield and yield attributes of Blackgram

Treatment No.	Treatments Combination	Number of Pods/ plant	Number of grains/Pod	Test weight(g)	Grain yield (t ha^{-1})	Stover yield(t ha^{-1})	Harvest index (%)
1	VAM + 30 kg P /ha	21.61	5.26	35.84	1.84	6.15	27.60
2	VAM + 40 kg P /ha	23.31	4.58	35.00	1.65	6.08	26.48
3	VAM + 50 kg P /ha	21.54	4.39	36.40	1.59	5.90	24.31
4	PSB + 30 kg P /ha	15.73	3.35	32.63	1.06	4.25	23.31
5	PSB + 40 kg P /ha	21.74	4.49	41.29	2.17	6.29	31.29
6	PSB + 50 kg P /ha	23.98	5.43	42.34	1.88	6.24	27.87
7	VAM +PSB + 30 kg P /ha	23.30	5.94	44.09	1.88	5.34	30.71
8	VAM + PSB + 40 kg P /ha	23.66	6.27	44.23	2.12	6.11	31.55
9	VAM + PSB + 50 kg P /ha	25.46	6.92	45.23	2.41	6.47	33.32
	F- test	S	S	S	S	S	S
	S.Ed (±)	0.918	0.326	1.367	0.186	0.367	2.965
	CD (P = 0.05)	1.946	0.692	2.899	0.394	0.779	6.286

Table 3: Effect of biofertilizers and phosphorus on economics of Blackgram

Treatments No	Treatment combinations	Cost of Cultivation (ha^{-1})	Gross return (ha^{-1})	Net Return (ha^{-1})	B:C ratio
1	VAM + 30 kg P /ha	42,089.32	1,10,400	68,310.68	1.62
2	VAM + 40 kg P /ha	43,839.32	99,000	55,160.68	1.26
3	VAM + 50 kg P /ha	45,589.32	95,400	49,810.68	1.09
4	PSB + 30 kg P /ha	42,107.02	63,600	21,492.98	0.51
5	PSB + 40 kg P /ha	43,857.02	1,30,200	86,342.98	1.97
6	PSB + 50 kg P /ha	45,607.02	1,12,800	67,192.98	1.47
7	VAM +PSB + 30 kg P /ha	42,113.32	1,12,800	70,686.68	1.68
8	VAM + PSB + 40 kg P /ha	43,863.32	1,27,200	83,336.68	1.90
9	VAM + PSB + 50 kg P /ha	45,613.32	1,44,600	98,986.68	2.17

Conclusion

It may be concluded that treatment VAM + PSB + 50 kg P /ha was found to be the best treatment for obtaining higher grain yield (2.41 t ha^{-1}), higher number of grains/pod observed were (6.92) and other growth and yield attributes and also higher stover yield (6.47 t ha^{-1}) while higher net returns (₹98986.68 ha^{-1}) and B:C ratio (2.17) was obtained with Blackgram variety Shekhar -2. Since the results in based on one year experiment, further trials may be done to confirm the findings.

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