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Research Article

EFFECT OF PHOSPHORUS AND BIOFERTILIZERS ON GROWTH, YIELD, NUTRIENT CONTENT AND UPTAKE BY BLACKGRAM [*Vigna mungo* (L.) Hepper]

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Abstract: The experiment was undertaken during *Kharif* 2019, 2020 and 2021 at Agricultural Research Station, S.D.Agricultural University, Aseda (Gujarat). The treatments comprised of four levels of phosphorus (P_0 : Control, P_1 : 20, P_2 : 30 and P_3 : 40 Kg P_2O_5/ha) and four levels of biofertilizers (B_0 : Control, B_1 : PSB,B_2 : VAM and B_3 : PSB + VAM. It is three replicated trials using the FRBD design. Among the different levels of phosphorus, it seems that as levels of phosphorus increase (0 to 40 kg P_2O_5/ha), the value of plant height at harvest, No. of pods per plant, No. of seeds per pod, test weight, seed yield and straw yield increases significantly over controls. In case of different bio fertilizers application significantly higher value of growth as well as yield attributes were recorded under the combined application of PSB + VAM compared to the control (no. application of bio fertilizers). The result of interaction found superior combination of 40 P_2O_5 kg/ha along with VAM and PSB bio fertilizers application and remained at par with the with 40 P_2O_5 kg/ha along with PSB bio fertilizers.

Keywords: *Blackgram, Bio fertilizers, Phosphorus, Seed yield, Economics, Agronomic efficiency, Content and Uptake*

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Introduction

In India among the pulses, Black gram is considered to the most important crop as in case of cultivated area and production. It has better quality protein content and digestibility that can minimize the malnutrition which is the serious cause of India Pulses are the main source of dietary protein particularly for vegetarians and contribute about 14 per cent of the total protein of average Indian diet. It is a self-pollinated leguminous crop containing 24% protein. The duration of the crop is very short; it fits well in various multiple and intercropping systems. After removing pods, its plant may be used as good quality green or dry fodder or green manure. Phosphorus is a key component of molecules necessary for root growth and development, respiration, photosynthesis, nucleic acid synthesis, nitrogen fixation, plant maturity, and seed production [1]. Biofertilizers are living creatures that has various microbial cells which plays crucial role in agriculture. These are preparation entities, which has microbial strains of living and latent cells that may be helpful in uptake of nutrients from root rhizosphere zone and majorly fix from atmosphere where nutrients in the gaseous form. A lot of microorganism species that are beneficial by stimulating plant growth plethora of mechanism [2]. Biofertizers can be used for treating seeds and directly applied to soil or mixed with organic manures and applied in field. As chemical fertilizers provide nutrients directly to plants when we apply in soil, but these are non eco-friendly which can cause harm to soil biota. Whereas biofertizers may be helpful in nutrients uptake by fixing them from atmosphere where most of nutrients are in gaseous form. Symbiosis between plant roots and certain soil fungi *e.g.* Vesicular Arbuscular Mycorrhiza (VAM) plays an important role in phosphorus cycling and its uptake by plants [3]. These symbiotic micro-organisms have extensive mycelial network and can increase the transport of other mineral elements such as zinc and copper.

Materials and Methods

A field experiment was conducted consecutively for three years in *kharif* season of 2019, 2020 and 2021 at the Agricultural Research Station, S.D. Agricultural University on the fixed plots. Factorial Randomized complete block design with three replications were used to study the effect of different levels of phosphorus and biofertilizer on growth and yield of blackgram. The experimental site was low in available nitrogen (178 kg N/ha), medium in available phosphorus (179 kg P_2O_5) and available potash (178 kg K_2O/ha)and normal in soil reaction (pH 7.58). The treatments comprised of four levels of phosphorus *e.g.* P_0: 0 kg P_2O_5 /ha, P_1: 20 kg P_2O_5 /ha, P_2: 30 kg P_2O_5 /ha, P_3: 40 kg P_2O_5 /ha and four levels of Bio fertilizers *e.g.* B_0: 0 (No application), B_1: PSB, B_2: VAM and B_3: PSB + VAM. The Uniform dose of nitrogen 20 kg/ha applied to all the plots by adjusting the nitrogen supplied by DAP and remaining through urea at the time of sowing. Whereas, Phosphorus applied as per treatments through DAP.PSB (1 L/ha) and VAM (5 kg/ha) applied as per treatments to the open furrow using field soil to bulk the carrier. The apparent recovery and agronomic efficiency were calculated by using following formula.

Apparent recovery(%)= Phosphorus uptake by seed of treated plot-Phosphorus uptake by seed of untreated/Phosphorus applied

Agronomic efficiency(%)= Seed yield from treated plot-seed yield of untreated/Phosphorus applied

Results and Discussion

Growth and yield attributes of black gram

Plant height at 30 DAS

Effect of phosphorus levels: The effect of different phosphorus levels on plant height at 30 DAS of black gram crop was significant in almost all the years and pooled results, except during 2019. Application of 40 kg phosphorus/ha (P_3) recorded significantly the highest plant height at 30 DAS 9.56, 9.88 and 10.37 cm and it was remain at par with 20 kg phosphorus/ha (P_1) and 30 kg phosphorus/ha (P_2). ***Effect of bio fertilizer levels:*** Significantly the highest plant height 30 DAS 9.60 cm was recorded with application of VAM (B_2) and statistically at par with all the others bio fertilizer levels.

Table-1 Effect of phosphorus and bio fertilizers on growth and yield character of black gram(Pooled of three years)

Treatments	Plant height (cm)			Number of pods per plant	Number of seed per pod	Number of nodules per plant
	30 DAS	50 DAS	At harvest			
Phosphorus levels (kg/ha)						
P_0 : Control	9.13	25.93	42.41	25.59	6.59	17.60
P_1 : 20	9.96	29.02	44.49	29.59	6.80	21.08
P_2 : 30	9.88	29.67	44.70	31.23	6.70	22.72
P_3 : 40	10.37	29.62	45.40	35.45	6.80	26.08
SEm±	0.14	0.55	0.43	1.23	0.07	0.57
CD at 5%	0.37	1.54	1.20	4.2	NS	1.62
B. Bio-fertilizer						
B_0 : Control	9.55	27.42	45.48	28.11	6.66	19.99
B_1 : PSB	9.88	28.45	44.62	30.46	6.76	21.89
B_2 : VAM	9.99	28.93	44.15	30.55	6.72	22.02
B_3 : PSB + VAM	9.90	29.45	45.75	32.79	6.77	23.58
SEm±	0.14	0.55	0.43	0.76	0.07	1.40
CD at 5%	NS	NS	1.20	2.1	NS	4.87
Interaction (P x B)						
P x B	0.75	NS	NS	NS	NS	NS
YXPXB	NS	NS	NS	NS	NS	NS
C.V(%)	8.08	11.53	5.80	15.08	5.89	18.30

Table-2 Effect of phosphorus and bio fertilizers on seed yield, straw yield, agronomic efficiency, apparent recovery, test weight and protein content (Pooled of three years)

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Agronomic Efficiency (%)	Apparent recovery (%)	Test weight(g)	Protein content
Phosphorus levels (kg/ha)						
P_0 : Control	489	1855	0.00	0.00	42.88	23.46
P_1 : 20	675	1969	13.10	4.81	44.36	23.51
P_2 : 30	802	2260	12.95	4.35	46.47	24.22
P_3 : 40	946	2527	13.31	5.57	46.16	23.38
SEm±	17	97	1.28	0.57	0.72	0.28
CD at 5%	48	336	3.59	0.40	2.02	NS
B. Bio-fertilizer						
B_0 : Control	609	1931	9.02	3.36	43.25	30.38
B_1 : PSB	764	2244	14.64	5.46	45.19	30.93
B_2 : VAM	710	2180	12.74	5.00	45.05	32.87
B_3 : PSB + VAM	829	2256	16.08	5.82	46.16	31.91
SEm±	17	55.41	1.28	1.97	0.72	0.28
CD at 5%	48	156	3.59	NS	2.02	0.79
Interaction (P x B)						
P x B	96	NS	NS	NS	NS	NS
YXPXB	NS	S	NS	NS	NS	
C.V(%)	13.59	15.44	25.60	37.48	9.59	7.53

Interaction effect: Interaction effect of phosphorus and bio fertilizer levels was significant on plant height at 30 DAS in pooled analysis.

Plant height at 50 DAS

Effect of phosphorus levels: The data revealed that effect of different phosphorus levels onplant height at 50 DAS of black gram crop was significant in almost all the years and pooled results, except during 2021. Application of 30 kg phosphorus/ha (P_2) recorded significantly the highest plant height at 50 DAS 27.88, 28.57 and 29.67 cm and it was remain at par with 40 kg phosphorus/ha (P_3) and 20 kg phosphorus/ha (P_1).

Effect of bio fertilizer levels: Effect of different bio fertilizer levels on plant height at 50 DAS of black gram crop was found non-significant in the individual years as well as in pooled analysis.

Interaction effect: Interaction effect found non-significant in individual years as well as pooled analysis.

Plant height at harvest

Effect of phosphorus levels: The effect of different phosphorus levels on plant height at harvest of black gram crop was significant in almost all the years and pooled results, except during 2019. Application of 40 kg phosphorus/ha (P_3) recorded significantly the highest plant height at harvest 50.67, 46.54 and 45.40 cm and it was remained at par with 30 kg phosphorus/ha (P_2) and 20 kg phosphorus/ha (P_1).

Effect of bio fertilizer levels: Significantly the highest plant height at harvest 51.0, 46.83 and 45.75 cm was recorded with application of PSB+VAM (B_3) and it was remain at par with VAM (B_2) and PSB (B_1).

Interaction effect: Interaction effect found non-significant in individual years as well as pooled analysis. 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 [4].

Number of nodules per plant

Effect of phosphorus levels: The effect of different phosphorus levels on number of nodules per plant of black gram crop was significant in almost all the years and pooled results. Application of 40 kg phosphorus/ha (P_3) recorded significantly the highest number of nodules per plant 17.60, 32.91, 27.73 and 26.08 during 2019, 2020, 2021 and pooled, however it remain at par with 30 kg phosphorus/ha (P_2) and 20 kg phosphorus/ha (P_1) during 2021. Effect of bio fertilizer levels: Application of PSB+VAM (B_3) recorded significantly the highest number of nodules per plant 16.22 and 23.58 during 2019 and pooled, however it remain at par with almost all the phosphorus levels in pooled analysis.

Interaction effect: Interaction effect found non-significant in individual years as well as pooled analysis [5].

Test weight

Effect of phosphorus levels: Significantly the highest test weight 46.08 and 46.47 gm was recorded with application of 30 kg phosphorus/ha (P_2) and it was remain at par with 40 kg phosphorus/ha (P_3)during 2021 and pooled results.

Effect of bio fertilizer levels: Application of PSB+VAM (B_3) significantly the highest test weight 45.67 and 46.16 during 2021 and pooled, however it remain at par with VAM (B_2) during 2021 and PSB (B_1) and VAM (B_2) in pooled.

Table-3 Effect of phosphorus and bio fertilizers on nitrogen and phosphorus content and uptake by plant after harvest of crop (Pooled)

Treatment	N content in plant (%)	N uptake by plant (kg/ha)	N content in seed (%)	N uptake by seed (kg/ha)	P content in plant (%)	P uptake by plant (kg/ha)	P content in seed (%)	P uptake by seed (kg/ha)
Phosphorus levels (kg/ha)								
P_0 : Control	0.96	17.19	3.75	18.29	0.15	2.80	0.36	1.73
P_1 : 20	0.99	19.26	3.76	25.23	0.15	3.06	0.38	2.55
P_2 : 30	1.08	24.22	3.87	30.97	0.18	3.94	0.37	2.90
P_3 : 40	0.95	23.88	3.74	35.33	0.19	5.05	0.41	3.81
SEm±	0.043	1.92	0.045	0.74	0.017	0.55	0.022	0.23
CD at 5%	NS	NS	NS	2.09	NS	NS	NS	0.80
B. Bio-fertilizer								
B_0 : Control	0.97	18.30	3.65	22.10	0.16	3.03	0.38	2.31
B_1 : PSB	0.98	22.03	3.71	28.22	0.18	4.20	0.38	2.91
B_2 : VAM	1.05	22.53	3.94	28.04	0.17	3.92	0.38	2.75
B_3 : PSB + VAM	0.97	21.70	3.83	31.47	0.16	3.71	0.37	3.02
SEm±	0.025	0.74	0.045	0.74	0.009	0.29	0.008	0.13
CD at 5%	NS	2.10	0.127	2.09	NS	NS	NS	0.45
Interaction (P x B)								
P x B	0.14	NS	NS	4.18	0.06	2.16	NS	NS
YXPXB	NS	S	NS	NS	S	NS	NS	NS
C.V(%)	18.25	26.53	7.53	16.18	17.69	25.38	14.37	20.36

Interaction effect: Interaction effect found non-significant in individual years as well as pooled analysis. Increase in test weight due to more number of heavy weighed and bold seeds with application of P and PSB [6,7].

Number of pods per plant

Effect of phosphorus levels: The effect of different phosphorus levels on number of pods per plant of black gram crop was significant in the individual years as well as in pooled analysis. Significantly highest number of pods per plant 28.21, 53.18, 24.95 and 35.45 were counted with application of 40 kg phosphorus/ha (P_3) during 2019, 2020, 2021 and pooled, however it remain at par with 30 kg phosphorus/ha (P_2) during 2021-22.

Effect of bio fertilizer levels: Significantly highest number of pods per plant 25.96 and 32.79 was recorded with PSB+VAM (B_3) over other treatment during 2019 and pooled results.

Interaction effect: Interaction effect found non-significant in individual years and pooled analysis except during 2019.

Number of seeds per pod

Effect of phosphorus levels: The effect of different phosphorus levels on number of seeds per pod of black gram crop was found non-significant in the individual years as well as in pooled analysis.

Effect of bio fertilizer levels: effect of different bio fertilizer levels on number of seeds per pod of black gram crop was found non-significant in the individual years as well as in pooled analysis.

Interaction effect: Interaction effect found non-significant in individual years and pooled analysis.

Seed yield (kg/ha)

Effect of phosphorus levels:The effect of different phosphorus levels on black gram seed yield was significant almost all the individual year as well as pooled analysis. Application of 40 kg phosphorus/ha (P_3) recorded significantly higher seed yield of 983, 1122, 881 and 946 kg/ha during 2019, 2020, 2021 and in pooled analysis, while significantly the lowest seed yield recorded under control (P_0) in all the individual year and pooled results.

Effect of bio fertilizer levels: Effect of different levels of bio fertilizer was found significant on black gram seed yield in individual year and pooled results. Application of PSB+VAM (B_3) recorded significantly higher seed yield of 818, 1049, 767 and 829 kg/haduring 2019, 2020, 2021 and in pooled, however it remain at par with PSB(B_1) during 2019 and 2020.

Interaction effect: Interaction effect of phosphorus and bio fertilizer levels was significant on seed yield in pooled analysis. Interaction P_3B_3 recorded significantly higher seed yield (1123.6 kg/ha) in pooled analysis [8-11].

Straw yield (kg/ha)

Effect of phosphorus levels: The effect of different phosphorus and bio fertilizer levels on black gram straw yield was significant in the individual years as well as in pooled analysis. Except bio fertilizer levels during 2021-22. Application of 40 kg phosphorus/ha (P_3) recorded significantly higher straw yield of 2264, 2736, 2580 and 2527 kg/ha during 2019, 2020, 2021 and in pooled analysis, but it was statistically at par with 30kg phosphorus/ha (P_2) during 2021 and pooled analysis. while significantly the lowest straw yield recorded under control (P_0) in all the individual year and pooled analysis.

Effect of bio fertilizer levels: Significantly the highest straw yield 1977, 2527 and 2256 kg/ha has been recorded under PSB+VAM (B_3) and remain at par with PSB(B_1) and VAM(B_2) during 2019, 2020 and pooled results.

Interaction effect: Interaction effect of phosphorus and bio fertilizer levels was significant on straw yield in pooled analysis[12,13].

Effect of different levels of phosphorus and bio fertilizers on protein content agronomic efficiency, apparent recovery and harvest index

Effect of different levels of phosphorus found significant on agronomic efficiency, apparent recovery and harvest index but non significantly affecting on protein content of seed. Significantly higher value of agronomic efficiency, apparent recovery and harvest index recorded (13.31,5.57 and 27.53) under the treatment of 40 kg P_2O_5 /ha and remained statistically at par with the treatment 20 and 30 kg P_2O_5 /ha. Effect of different bio fertilizers on protein content of seed , agronomic efficiency and harvest index found significant while apparent recovery remains un affected. Significantly higher value of protein content (24.65) recorded under the treatment of B_2: VAM and remained at par with the B_3 : PSB + VAM, while higher value of agronomic efficiency and harvest index recorded under the treatment B_3 : PSB + VAM and remained at par with the treatment B_1 : PSB and B_2 : VAM. The effect of interaction found non significant [14,15].

Effect of different phosphors levels and bio fertilizers on nitrogen and phosphorus content and uptake by the crop

Effect of different levels of phosphorus found non significant on nitrogen content and uptake by plant and n content in seed while uptake of nitrogen by seed affected significantly and highest value was recorded under the treatment P_3:40 kg/ha (35.33 kg/ha). Phosphorus content and uptake by plant and content in seed found non significantly affected while higher value of phosphorus uptake (381.76 kg P_2O_5 /ha) while lower value (173.82 kg/ha) was recorded under the treatment P_0 : Control Effect of different bio fertilizers found non significant on nitrogen content in plant and phosphorus content in plant, seed and uptake by plant while found significant on the nitrogen uptake by plant and content in seed (22.53 and 3.94 respectively) in B_2 : VAM while lower value was recorded under the no bio fertilizer application while highest nitrogen uptake by seed (31.47 kg N/ha). Phosphorus uptake by seed found significantly higher under the treatment B_3 : PSB + VAM and remained at par with the treatment PSB and VAM. Interaction effect of different levels of phosphorus and bio fertilizers found non significant on nitrogen uptake by plant, and nitrogen content by seed as well as phosphorus content and uptake by the seed. It shows significant effect on N content in plant, N uptake by seed, P content by seed and P uptake y seed. Higher value of nitrogen content in plant found in the treatment P_1B_2 (1.27) and remained at par with the treatment P_2B_0 an P_2B_1 while lower value was recorded under the treatment P_1B_3 (0.79). Significantly higher value of nitrogen content in seed found (40.04) under the treatment P_3B_3 and remained at par with treatment P_2B_3 while the lower value of 15.04 in P_0B_0.

Higher value of phosphorus content and uptake by plant (0.27 %and 7.48 kg/ha) found under the treatment P_3B_1 while lower value was recorded under the treatment P_3B_0 (0.10) and P_0B_1 (2.10) [16,17].

Conclusion

Urdbean is next important pulse crop after mungbean, it is used as many ways of daily healthy diet. Pulse productivity is decreasing day by day due to less care to be taken by the growers and it cultivated in poor fertile soil. As the phosphorus is second most important nutrient for the crop production point of view and very costly input for the agriculture. Phosphorus is important nutrient for the root growth of the pulses. To increase the response of soil unavailable phosphorus, we have to mobilize it with the microorganism. In this experiment, we found that the combined application of 40 kg P_2O_5 /ha along with VAM and PSB bio fertilizers application or with 40 P_2O_5 kg/ha along with PSB bio fertilizers improve yield of crops and income of farmers.

Application of research: This research is useful for the farmers growing black gram in soil having medium range in phosphorus and utilize the available phosphorus by using bio fertilizers.

Research Category: Soil science

Abbreviations: DAP: Di ammonium phosphate, C:N ratio: Carbon nitrogen ratio DAS: Days after sowing, RDF: Recommended dose of fertilizers, N: Nitrogen,

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Study area / Sample Collection: Agricultural Research Station, Aseda, 385535

Cultivar / Variety / Breed name: Blackgram GU1

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
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References

[1] Zhang Z.H. Liao, and Lucas W.J. (2014) *J. Intr. Plant Biol*., 56 (3),192-220
[2] Vessey J.K. and Heisinger K.G. (2001) *Can J. Plant Sci.,* 81(3), 361-366
[3] Biswas B.C., Das S. and Subhash K.P. (2001) *Fertilizers News*, 46, 15-24.
[4] Patil S.C., Jagtap D.N. and Bhale V.M. (2011) *Int. J. agric. Sci*., 7 (2): 348-351
[5] Niu Y.F., Chai R.S., Jin G.L., Wang H., Tang C.X. and Zhang Y.S. (2012) *Ann. Bot*., 112:391-408.
[6] Ullah A., Ali A., Waseem M., Nadeem M.A., Tahir M., Iqbal A. and Rehman H. (2010) *Int. J. of Applies Agric. Res*., 5 (5), 621-628.
[7] Verma G., Kumawat N. and Morya J. (2014) *Int. J. Curr. Microbial. App. Sci*., 6 (7), 488-493.
[8] Bhabai B., Mukhopadyay D. and Mitra B. (2019) *Journal of pharmacognosy and phytochemistry*, 8(4), 505-509.
[9] Ade U.K., Dambale A.S and Jadhav D.B. (2018) *J. Curr. Microbiol. App. Sci,* 6, 1408-1416
[10] Anvar A., Khaitov B., Toderich K. and Park K. (2019) *J Plant Nutrition* 42(20), 2703-2714.
[11] Chandra G., Gambhir L. and Lokesh R. (2020) *Current Journal of Applied Science and Technology*, 39(15), 133-139.
[12] Gupta A. and Sharma V.K. (2006) *Legume Res*., 29 (4), 278- 281.
[13] Prajapati C.K. (2014) M. *Sc. (Ag.), Thesis, B. A. College of Agriculture, Anand Agril. University, Anand*.
[14] Madane A.J., Chavan M.G., Rajemahadik V.A. and Singh J.K. (2014) *Internat.J. Sci. Engg. and Tech*. 3, 259-262.
[15] Dongare D.M., Pawar G.R., Murumkar S.B. and Chavan D.A. (2016) *Int. J. of Agril. Sci*.,12(2), 151-157
[16] Yadav M., Yadav S.S., Kumar S., Kumari H. and Tripura P. (2017) *Int.J.Curr.Microbiol.App.Sci*. 6(5), 2144-2151.
[17] Rathore D.S., Purohit H.S. and Yadav B.L. (2010) *J. Food Legumes*, 23(2),128-137.