Original Research Article

"Influence of Phosphorus and Bio-fertilizers on growth and yield of Black gram(*Phasiolus mungo*L.)"

ABSTRACT

The field experiment was conducted during *kharif* 2022 at the Crop Research Farm,DepartmentofAgronomy,NainiAgriculturalInstitute,SamHigginbottomUniversity ofAgriculture, Technology Andand Sciences, Prayagraj (U.P.) to determine the "Effect of Phosphorus and Bio-fertilizer on growth and yield of black gram***(****Phasiolus mungo* L)".The results showed that treatment -9[Phosphorus -50kg/ha+Rhizobium +PSB]significantly increasedhigher plantheight (45.69cm), higher number of nodules/plant (38.15), higher plant dry weight (6.64g),higherCrop growth rate (2.99 g/m^2/day),highernumber of pods/plant (40.8),the maximumnumber of seeds/pod(6.23), higher test weight (34.75 gm), higher seed yield (1371kg/ha) ,higher stover yield (2980kg/ha), Maximumgrossreturn (INR89,290.00/ha), and Maximumnet return (INR60,797.00/ha). Also, the maximumand highestB:C: Cratio (2.13) wasalsorecordedin treatment-9[Phosphorous phosphorous 50 kg/ha + Rhizobium (concentration)+ PSB (please mention complete words instead of abbreviate?)]as compared to other treatments

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Keywords:*Black gram, Phosphorus, Bio-fertilizers,growthparameters,yieldattributes andEconomics.*

INTRODUCTION

Pulses stand a strategic position in the agriculture economy of our country. They contain a high percentage of quality protein three times more than cereals. Pulses contain vitamin B, minerals and contain a certainfibrecertain quality fibre, which is desirable in the human diet because of medical considerationsconsideration. Pulse crops enrich the soil through symbiotic nitrogen fixation from the atmosphere.Besides being a rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil and thus, play a vital role in sustainable agriculture.

Blackgram is the third most important pulse crop grown under rainfed, rice fallow, irrigated conditions and during kharif, rabi and summer seasons, which matures in 90-100 days and it~~,~~ enriches the soil with nitrogen. India is the major producer and consumer of blackgram. It is used for the preparation of different food **Sivasubramanian *et al*. (2015),** with rice flour.

Pulses arethe "Marvel of Nature" because of their drought resistance and ability to soil erosion due to deep root structure and good ground covering**.** Which contains 24 % protein, 60 % carbohydrate, 1.3 % fat, 3.2 % minerals, 0.9 % fibre, 154 mg Ca, 385 mg P, 9.1 mg Fe and a small amount of vitamin-B complex. It is a rich source of vitamins like A, B1,and B3 and has a small amount of thiamine, riboflavin, niacin, and vitamin C. It contains 78% to 80% nitrogen in the form of albumin and globulin.

The global black gram market size reached 3.4 million Tons in 2022. Looking forward to expects the market to reach 5.0 million Tons by 2028, exhibiting a growth rate (CAGR) of 6.5% during 2023-2028. India is its primary origin and is mainly cultivated in Asian countries including Pakistan, Myanmar, and parts of Southern Asia. India is the world's largest producer as well as consumer of blackgram. It produces about 23.4 lakh~~tonnes~~tones of blackgram annually from 46.7 lakh hectares of area, with an average productivity of 501Kg per hectare in2020-21. The black~~Black~~ gram area accounts for about 15.7 per cent of India's total pulse acreage and contributes 9.09 per cent of total pulse production. The major Kharif growing states are Uttar Pradesh 6.99 lakh ha, Odisha 1.66 lakh ha, Chhattisgarh 1.3 lakh ha and Telangana 0.119 lakh ~~ha .~~ ha. According to the 4th Advance Estimates of Production of Food grains for 2021-22, all India Black gram production estimate was 2.84 million tonnes as against 2.23 million tonnes in 2020-21. (**GOI, 2021).**

Despite ~~of~~ these features, the productivity of this crop is below the average owing to several constraints. The major reason for the low productivity of black gram in the country, apart from natural constraints, is ~~due to~~ the supply imbalance use of nutrients. Proper fertilization is essential to improve the productivity of blackgram. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrient which needs attention is Phosphorus.

Phosphorus deficiency in soil is widespread and crops grown under deficient situations ~~situation~~ show a significant response to fertilizer phosphorus. At several places,the normal yield of crops could not be achieved despite the judicious use of NPK fertilizers due to deficiency of micronutrients in soil, in general, that of Zn in particular. The knowledge regarding the use of optimum dose of nutrients especially Phosphorus and Zinc is of serious concern**Rathore*et al.* (2014**).

BiofertilizerBiofertilizers deficiency is usually the most important single factor which is responsible for a poor yield of pulses on all soils. It is a major constituent of protein and nucleic acids. The cost of nitrogenous and phosphatic fertilizers is are increasing day by day hence, it is required to use some cheaper source of fertilizers like Rhizobium and phosphatic solubilizing bacteria etc. Bio-fertilizers like Rhizobium and phosphate solubilizing bacteria plays an important role in increasing the availability of nitrogen and phosphorus through the increase in biological fixation of atmospheric nitrogen and enhanced phosphorus availability to the crop**Abhishali&Debbarama, (2023**

Phosphorous is one of the most important elements significantly affecting the plant growth and metabolism. In legumes, the high requirement for P is consistent with the involvement of P in high rates of energy transfer that take place in the nodule. Phosphorous has also an enhancing impact on growth and biological yield through its importance as energy storage and transfer necessary for metabolic processes" **Singh *et al.* (2014**).

"Phosphorous addition increases the efficiency of plants photosynthesis, enhances the activity of rhizobia. Phosphorus contributes substantially to the increased yield of legumes by enhancing the physiological functions of the crop plants, root development, and nodulation. Phosphorus application not only increases the dry matter and seed yield of a black gram but also enhances the N and P content of the seed by increasing nodulation and root development.

Biofertilizers such as (PSB solubilisesolubilize insoluble soil phosphates like tri-calcium phosphates and produce plant growth substances in soil. Among various bio-fertilizers,Rhizobium rhizobium is of paramount importance. Rhizobium fixes atmospheric nitrogen symbiosis with legumes. PSBinoculation showed more available phosphorus in the soil, which favoured better root growth and resulted in a beneficial effect of nodulation with increased PSB bacterial activity. For maximizing the yield, it is essential that green gram should not suffer due to inadequate mineral nutrients,nutrient especially nitrogen and phosphorus. Since chemical fertilizers are scarce and costly, it is necessary to use them economically in combination with bio bio-fertilizers, as green gram shows a high response to bio bio-fertilizers. Phosphorus plays a key role in various physiological processes concerning root and dry matter production, nodulation and N2 fixation and also in metabolic activities, especially in protein synthesis **Bhatt et al. (2013).**

The introduction~~Introduction~~ of an efficient strain of Rhizobium in ~~the~~ poor soil ~~poor~~ in nitrogen may be helpful in boosting ~~up the~~ production through more nitrogen fixation. Phosphorus solubilizing bacteria as inoculants in the root zone of crop plants partially solubilize the insoluble phosphate and improve the phosphorus use efficiency and ~~the~~ productivity. Mineral nutrition plays a vital role not only in exploiting the realizable potential of the crop~~,~~ but also to maintain the sustainability of soil for agricultural production. Due emphasis on nutritional part is very essential. Fertilizers ~~Fertilizer~~ and their ~~its~~ management are ~~is~~ one of the important cost effective agronomic factors to augment ~~the~~ production. The degree of response of the crow to fertilizer application depends on the fertility status of the soil. Inadequate or excess supply of any plant nutrient limits ~~the~~ crop production.Keeping these points in view, the present study entitled "**Influence of Phosphorus and Bio-fertilizers on growth and yield of Blackgram (*Vigna mungo* L.)",** was conducted at Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during *Kharif* season of 2022.

MaterialsandMethods

The experiment was conducted during *Kharif*of 2022,Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology ~~And~~ and Sciences, Prayagraj, ~~Uttar~~and Uttar Pradesh. Which is located at 25.24' 42''N latitude, 81.50' 56" E longitude and 98m altitude above the mean sea level (SL). The experiment was conducted in Randomized Block Design with 10 treatments each replicated thrice. The plot size of each treatment was 3m x 3m. Factors are three levels of Phosphorus (30,40,50 kg/ha) and the Bio-fertilizers are Rhizobium -20g/kg seeds, PSB -20g/kg seeds, Rhizobium(10g) +PSB (10g)/kg seeds. The Blackgram crop was sown on 20 June 2022 by maintaining a spacing of 30 cm × 10 cm. Harvesting was done by taking ~~1m2~~ 1 m^2 area from each plot. And from it, five plants were randomly selected for recording growth and yield parameters. The treatment details ~~are~~ wereas follows, T1 –[Phosphorus (30kg/ha) + Rhizobium), T2 –[(Phosphorus (40kg/ha) + Rhizobium], T3 – [Phosphorus (50kg/ha) + Rhizobium] T4 –[Phosphorus (30 kg/ha) + PSB], T5 –[(Phosphorus (40kg/ha) + PSB], T6 –[(Phosphorus (40kg/ha) +PSB], T7 –[Phosphorus (30 kg/ha)+ Rhizobium +PSB], T8 -(Phosphorus (40 kg/ha) +Rhizobium + PSB], T9 –[Phosphorus -50 kg/ha +

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Rhizobium +PSB], and Control Plot. The observations were recorded for plant height, dry weight, number of nodules/plant, Crop growth rate, number of pods/plant, number of seeds/pod, test weight, seed yield and stover yield. The data was subjected to statistical analysis by analysis of variance method (Gomez and Gomez (1976).

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ResultsandDiscussion

Growthparameters:

Plant height–The result revealedthata significantly higherPlant plant height (45.69 cm) was recorded with the treatment-9 [Phosphorus -50kg/ha+Rhizobium+PSB] over compare tothe other treatments. However, treatments -6[Phosphorous 50 kg/ha+ PSB] and treatment -8[Phosphorus -40kg/ha+Rhizobium+PSB]were found to be statistically at par with treatment-9 [Phosphorus -50kg/ha+Rhizobium+PSB] (Table-1).significant and higher plant height was observed with the application of biofertilizer PSB and Rhizobium might be due to better uptake and translocation of plant nutrients. Similar results were reported by **Yadav *et al.* (2017).** Further, increased in plant height withthe application of phosphorous-50kg/ha. itIt might be due to the formation of new cells, which promote plant vigour and hastens leaf development, which helps help in harvesting more solar energy and better utilization of nitrogen, which helps help towards higher growth attributes. A Ssimilar result was reported by**Mir *et al*. (2013).**

The Nnumber of nodules/plant **–**The result revealed that significantly highernumber of nodules/plant(9.61) was recorded with the treatment-9 [Phosphorus -50kg/ha+Rhizobium+PSB] over the other treatments. However, treatments -6[Phosphorous 50 kg/ha+ PSB] and treatment-8[Phosphorus -40kg/ha+Rhizobium +PSB]were found to be statistically at par with treatment-9 [Phosphorus -50kg/ha+Rhizobium+Rhizobium +PSB] (Table-1). Significant and higher number of nodules/plant was recorded with the application of Rhizobium,which might be due to the more competitive availability of microbes near roots which is the site for microbial infection and a well-developed root system provides more evidence for a maximum Number number of nodules/plant. Similar results were reported by**Hussain *et al*. (2015).**Further, increase in number of nodules/plant with the application of Phosphorus (50kg/ha), may be due to influenced the protein formation that leads to increased increase number of nodules**.** Similar results were conformity with **Kachave *et al*. (2018)**

Plant dry weight(g/plant)-Theresult revealed that thetreatment-9 [Phosphorus -50kg/ha+Rhizobium(10g) +PSB(10g)] recordedsignificantly higherdry weight/plant(6.64

g/plant) However, treatment -8[Phosphorus -40kg/ha+Rhizobium+PSB]were found to be statistically at par with treatment-9 [Phosphorus -50kg/ha+Rhizobium +PSB](Table-1)it might be due to chief constituent of lipoids and nucleoproteins, an abundance of phosphorus in meristematic region might have helped in cell division and multiplication and it is also concerned carbohydrates, transformation and nitrogen fixation and hence boosted plant growth. Similar results were reported by ~~**parshar**~~ **Parshar*****et al.*** **(2020).** Further, plant dry weight increaseddue to the application of PSB may be due to strains released greater amounts of available P and this enable the plant to absorb more P resulting in improved growth attributes. A similar result was reported by **Kachave*****et al.*** **(2018).**

Crop Growth Rate(g/m^{2}day) -The result revealedthat a significantly higher Crop growth rate (2.99 g/m^2/day) wasobservedin treatment-9 [Phosphorous (50 kg/ha)+Rhizobium +PSB]. However, treatment -8[Phosphorous (40 kg/ha)+Rhizobium +PSB] (2.79 g/m^2/day) were foundstatistically par with treatment -9[[Phosphorous (50 kg/ha)+Rhizobium+ PSB](Table-2).Significant and higher crop growth rate~~was~~ recorded with~~the application~~the application of PSB might be due to better accumulation of dry matter throughout the plant's vegetative and reproductive phase, which enhances the physiological and metabolic activity and growth by assimilating the available nutrients at a higher rate ~~on~~ ofgrowth parameters and facilitating more photosynthesis, resulting in higher crop growth rate.A similar result was reported**(Gupta et al., 2006)**

YIELD ATTRIBUTES:

A number ~~Number~~ of pods/plant - Theresult revealed thata significant and higher Number of Pods/Plant (40.08) ~~were~~wasobservedin treatment -9[Phosphorus -50kg/ha+Rhizobium +PSB]. However, the treatment -8 [Phosphorus -40kg/ha+Rhizobium+PSB]~~were~~wasfound to be statistically at par with treatment-9[Phosphorous (50 kg/ha +Rhizobium+ PSB] (Table-2). The significant and higher number of pods/plant were observed with the application of rhizobium, thismight be due to enhanced nitrogen fixation, thereby increasing the availability of plant efficient growth and development, particularly number of pods/plant. A ~~S~~similar result was concluded by **Kumar *et al.* (2010).** Further,the maximumnumber of pods/plant with application of Phosphorous (50kg/ha) may be due to better root proliferation, higher root development, increased availability and uptake of nutrients energy transformation and metabolic processes in plant. Similar results lined with by **Hussain *et al.* (2011).**

Number of seeds/pod–The Significantly and higher number of seeds/pod (6.23)wererecordedin treatment-9 [Phosphorus (50kg/ha)+Rhizobium+PSB]. However, the treatment -8 [Phosphorus (40kg/ha) +Rhizobium +PSB]was found to be statistically at par with treatment-9[Phosphorous (50kg/ha)+Rhizobium+ PSB](Table-2).The significant and higher number of seeds/pod were observed with application of rhizobiummight be due to the increased nodulation, extensive root system, and the greater production of metabolites and their translocation to various sinks especially the productive structures (pods and seeds) might have helped to increase into the number of pods/ plant besides increasing the overall growth. Similar results were reported by **Ghansyam*et al*. (2010)**in green gram. Further, maximum number of seeds/pod was observed with the application of phosphorus(50kg/ha) may be due to theincrease in phosphorus fertilization in ensuring the availability of other plant nutrients which increased carbohydrate accumulation and their re-mobilization to reproductive parts of the plant, being the closest sink. Phosphorus is known to encourage flowering and fruiting which might have stimulated the plants to produce more pods/ plant and enables development of a greater number of seeds/pod. Similar findings were reported by **Shah *et al.* (2000).**

Test Weight (gm)–TheSignificantlyand higher Test Weight (34.75 g)wasobserved in treatment-9 [Phosphorus (50kg/ha)+Rhizobium +PSB] over the other treatments. However, treatment -8 [Phosphorus (40kg/ha)+Rhizobium+PSB]was were found to be statistically at par with treatment-9 [Phosphorus -50kg/ha+Rhizobium+PSB](Table-2).Significant and maximumtest weight was observed with application of PSB might be due to the yield attributing character because of the beneficial effect of PSB along with basal application of phosphorus helps in the development of extensive root system to extract more water and nutrient from the soil thus resulting in better plant growth and yield attributes similar results was reported by **Pramanik and Singh*et al.*(2003)** in cowpea. Further, the increase in testweightobserved with the application of phosphorus(50kg/ha) may be due to the increases in the symbiotic nitrogen fixation power and in turn, increased number of pods/plant, Length of pod, number of grain/ pod and test weight and ultimately grain yield. A Ssimilar result was reported by **Parashar*et al.* (2020).**

Seed Yield (kg/ha) –The significantlyand higher Seed yield (1371 kg/ha)was observedin treatment-9[Phosphorus -50kg/ha+Rhizobium+PSB]. However, the treatment -8 [Phosphorus (40kg/ha)+Rhizobium +PSB]was found to be statistically at par with treatment-9[Phosphorous(50kg/ha) +Rhizobium+PSB](Table-2).Significant and higherseed yield was observed with the applicationPhosphorous (50kg/ha)might be due to it increases the photosynthesis and translocation of assimilates to different plant parts for enhanced growth and yield attributing characters of the crop as observed in number of pods/plant and number of seeds/ pods, which later stage, the excess assimilates stored in the leaves was translocated towards sink development which ultimately contributed to higher seed yield.Similar results werereported by**Yumna*et al*.(2017).** Further, the increase in seed yield with the application of Rhizobium may be due to the bio-fertilizer have attributed to supply of moreplant hormones (auxin, cytokinin, gibberellin etc.,) by themicroorganisms inoculated or by the root resulting fromreaction to microbialpopulation.Similarresults wereconformitywith**Umamaheswari *et al*. (2001)**in green gram.

Stover Yield (t/ha)– The significantly and higher Stover yield (2980 kg/ha)was recordedin treatment -9[Phosphorus -50kg/ha+Rhizobium + PSB]. However, the treatment -8 [Phosphorus -40kg/ha+Rhizobium +PSB]was found to be statistically at par with treatment-9[Phosphorous (40 kg/ha)+Rhizobium + PSB] (Table-2).Significant and higher stover yield was observed with applicationPhosphorous (50kg/ha) might be due to the increased growth and development in terms of plant height, branchesand dry matter by improving nutritional environment of rhizosphere and plant system leading to higher plant metabolism and photosynthetic activity. Similar result was reported by **Yadav*et al*. (2017).** Further, the increase in stover yield was observed with the application of PSB and Rhizobium may be due to theowing higher dry matter accumulation and better root development through phosphorous, resulting into maximum uptake of nutrient and moisture which ultimately lead to higher stover yield. Similar results were reported by **Rajesh*et al*. (2013).**

ECONOMIC ANALYSIS:

Economics

The result revealed that Maximum gross return (89,290.00 INR/ha), Maximum net return (60,797.00 INR/ha) and highest ~~benefit~~benefit-cost ratio (2.13) wasrecorded in treatment-9 [Phosphorus (50kg/ha)+Rhizobium +PSB] as compared to other ~~treatments(~~treatments (Table-3).Higher gross Return, net return andbenefit cost ratio were ~~was~~recorded with the application of[Phosphorus (50kg/ha) +Rhizobium +PSB]it might be due to the higher growth and yield attributes resulting in more seed and stover yield withthe recommended dose of phosphorus. Similar results were reported by**Bhat*et al*. (2013)** infield pea.

CONCLUSION

Based on the above findings it can be concluded with the application of Phosphorus 50kg/ha along with Rhizobium and PSB has performed better in growth parameters and yield attributes ofand is also economically viable . viable. Since the findings are based on one season, further trials trails are needed to confirm the result

Table 1. Influence of Phosphorus and Bio-fertilizerson growth parameters of Black gram.

S. No.	Treatment combinations	Plant height	Number of nodules	Plant Dry weight	Crop Growth Rate (g/m^{2}day)
1.	Phosphorus -30kg/ha + Rhizobium	42.40	7.02	5.69	2.20
2.	Phosphorus -40kg/ha + Rhizobium	43.36	7.64	5.97	2.33
3.	Phosphorus -50kg/ha + Rhizobium	44.47	8.67	6.29	2.66
4.	Phosphorus -30kg/ha + PSB	42.81	7.27	5.78	2.26
5.	Phosphorus -40kg/ha + PSB	43.66	8.13	6.09	2.45
6.	Phosphorus -50kg/ha + PSB	44.98	8.91	6.40	2.79
7.	Phosphorus -30 kg/ha + Rhizobium + PSB	44.12	8.47	6.16	2.56
8.	Phosphorus -40 kg/ha + Rhizobium + PSB	45.41	9.36	6.46	2.87
9.	Phosphorus -50 kg/ha + Rhizobium + PSB	45.69	9.61	6.64	2.99
10.	Control (20:40:20 NPK Kg/ha)	41.52	6.75	5.44	1.93
	F test	S	S	S	S
	S Em.(±)	0.30	0.24	0.11	0.14
	CD (P=0.05)	0.88	0.70	0.32	0.41

Table 2. Influence of Phosphorus and Bio-fertilizerson yield attributes of Blackgram.

Treatments	Pods/plant	Seeds/pod	Test Weight (g)	Seed Yield (kg/ha)	Stover Yield (kg/ha)
1. Phosphorus -30kg/ha + Rhizobium	27.2	4.75	32.64	942	1853.33
2. Phosphorus -40kg/ha + Rhizobium	29.5	5.06	33.11	976	2173.33
3. Phosphorus -50kg/ha + Rhizobium	32.3	5.64	33.52	1035	2080.00
4. Phosphorus -30kg/ha + PSB	30.6	4.90	32.74	1101	2280.00
5. Phosphorus -40kg/ha + PSB	34.0	5.23	33.26	1160	2333.33
6. Phosphorus -50kg/ha + PSB	35.3	5.70	34.01	1209	2490.00
7. Phosphorus -30 kg/ha + Rhizobium + PSB	37.4	5.40	33.49	1275	2573.33
8. Phosphorus -40 kg/ha + Rhizobium + PSB	39.3	5.90	34.33	1333	2816.67
9. Phosphorus -50 kg/ha + Rhizobium + PSB	40.8	6.23	34.75	1371	2980.00
10. Control (20:40:20 NPK Kg/ha)	28.3	4.59	32.37	965	1833.33
F test	**S**	**S**	**S**	**S**	**S**
S. EM (±)	0.70	0.16	0.26	12.89	77.58
CD (P = 0.05)	2.08	0.48	0.76	38.30	230.52

Table 3. Influence ofSulphur and siliconoeconomic analysis of rice.

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	Treatments	Cost of cultivation	Gross returns	Net returns	B:C Ratio
1.	Phosphorus -30kg/ha + Rhizobium	27290	61840	34550	1.27
2.	Phosphorus -40kg/ha + Rhizobium	27842	64128	36286	1.30
3.	Phosphorus -50kg/ha + Rhizobium	28393	67929	39536	1.39
4.	Phosphorus -30kg/ha + PSB	27490	71883	44393	1.61
5.	Phosphorus -40kg/ha + PSB	28042	75759	47717	1.70
6.	Phosphorus -50kg/ha + PSB	28593	78965	50372	1.76
7.	Phosphorus -30 kg/ha + Rhizobium +PSB	27390	83025	55635	2.03
8.	Phosphorus -40 kg/ha + Rhizobium+ PSB	27942	86618	58676	2.10
9.	Phosphorus -50 kg/ha + Rhizobium +PSB	28493	89290	60797	2.13
10.	Control (20:40:20 NPK Kg/ha)	27242	63174	35932	1.32

- DATA WAS NOT SUBJECTED TO THE STATISTICAL ANALYSIS

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