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Effect of different levels of nitrogen and phosphorus without and with *Rhizobium* inoculation on growth and yield of Blackgram (*Vigna mungo* L.)

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Abstract
A field experiment was conducted to determine the effect of different levels of Nitrogen and Phosphorus without and with *Rhizobium* Inoculaton on Growth and Yield of Blackgram (var. SHEKAR- II) with 9 treatments in the Zaid 2021 with different levels of nitrogen (15 and 25 kg/ha), phosphorus (35 and 45 kg/ha) without and with *Rhizobium* inoculation (20g/kg of seed), respectively at crop research farm, department of Agronomy, Faculty of Agriculture, SHUATS, Prayagraj, Uttar Pradesh. The soil of experimental plot was sandy loam in texture, basic in soil reaction (pH 7.7), low in organic carbon (0.48%), available N (278.93 kg/ha), available P (14.1 kg/ha), available K (213.4kg/ha). The experiment was laid out in Randomized Block Design with nine treatments and each treatment replicated thrice. Maximum plant height (52.42 cm), branches/plant (8.80), plant dry weight (12.70 g/plant), pod/plants (40.80), seeds/pod (7.80), seed yield (847 kg/ha), stover yield (3566.33 kg/ha), biological yield (4413.33kg/ha), and test weight (37.21g) were recorded with application of 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed). Higher Gross returns (53361Rs./ha), Net returns (32802.2Rs./ha) and Benefit Cost Ratio (2.59) were also recorded in the same treatment.

Keywords: Nitrogen, phosphorus, *Rhizobium*, blackgram, growth and yield

Introduction
After cereals and oilseeds, pulses occupy an important place in Indian agriculture. The total world acreage under pulses is about 85.40 Mha with production of 87.40 Mt at productivity 1023 kg ha-1 production with 34 and 26% respectively with average productivity of 835 kg ha-1 (Agricultural Statistics Division, Directorate of Economics and Statistics, 2019). 70% of the total world's black gram and green gram production comes from India, of which black gram constitutes 1.65 Mt with the share of 12.4% (Elzebroek and Wind, 2008) [5]. Pulses are excellent source of high quality protein, essential amino acids, fatty acids, fibers, minerals and vitamins. Black gram (*Vigna mungo*) is one of important pulse crop. The protein level of black gram is quite high *i.e* about 24% with nutritional value of 10.9% moisture, 1.4% fats, 60.3% carbohydrates and 3.4% ash (Shroti *et al.*, 2018) [24] and contains approximately 25-28 per cent protein. It improves soil health by enriching nitrogen status and also maintains sustainability of the cropping systems. Most of its nitrogen requirement is fulfilled by symbiotic nitrogen fixation from air and substantial amount of residual nitrogen and organic matter are left behind for subsequent crops.

India is largest production of pulse in the world with 25% shares in the global production. The production is not sufficient to meet the per capita requirement. It has also been a serious concern to see a decrease in daily per capita availability of pulse from 69 g in 1961 to 37 g in 2004. To alleviate protein-energy malnutrition, a minimum of 50 g pulses/capita should be available in addition to other sources of proteins such as cereals, milk, meat and eggs (Mehta *et al.*, (2005) [16]. Proper fertilization is essential to improve the productivity of Blackgram. Availability of nitrogen is of prime importance for growing plants as it is major and indispensable constituent of protein and nucleic acid molecules. It is integral part of chlorophyll molecules, which is responsible for photosynthesis. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally lead to higher productivity. Application of nitrogen increases yield due to cumulative increase in the yield attributed characters such as number of capsules per plant, number of seeds per capsule and seed weight.

Blackgram being a pulse crop requires high amount of phosphorus. Phosphorus is among the essential macro-nutrients required for plant growth and development. It plays a key role in photosynthesis, metabolism of sugars, energy storage and transfer, cell division, cell enlargement, transfer of genetic information, root growth, nodulation and nitrogen fixation in plants. 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]. It serves as "energy currency" within plants and help in root development and grain formation. Increase in yield brought by phosphorus application is significant and economically viable owing to its widespread deficiency of soils in India in general. 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.

Rhizobium is the most well-known species of a group of bacteria that acts as primary symbiotic fixer of nitrogen. Black gram, being leguminous crop, use symbiotic nitrogen fixation which is performed with the help of bacterium called *Rhizobia* as an important source to fulfil its major part of nitrogen requirement (Pareek, 1978) [20]. This symbiotic nitrogen fixation proves to an important source of nitrogen, and around 200 to 300 kg nitrogen ha-1is often fixed by various legume crops and pasture species (Dudeja and Duhan, 2005) [4]. These microbes vary in number, effectiveness and nodulation. Although *Rhizobia* is great source of symbiotic nitrogen fixation but sometimes due to less number of *Rhizobia* and ineffective native *Rhizobia*, nodulation and nitrogen fixation does not occur properly. To ensure efficient population of effective *Rhizobia* in soil, these are introduced in soil from outside in the form of biofertilizers. Seed treatment as well as soil application is the way to apply biofertilizer. Another approach may be application of biofertilizer through organic sources.

Material and Methods

The experimental trial was carried out during *Zaid* 2021 at Crop Research Farm (CRF), Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P) located 25 ◦39″42″ North latitude, 81˚67"56" East longitude and 98 m altitude above the mean sea level. The experiment was laid out in Randomized Block Design consisting of nine treatments which are T_1: Control plot (Recommended rate of NPK 20:40:20 NPK/ha), T_2:15kg N/ha + 35kg P/ha + 20kg K/ha, T_3:15kg N/ha + 45kg P/ha + 20kg K/ha, T_4:25kg N/ha + 35kg P/ha + 20kg K/ha, T_5:25kg N/ha + 45kg P/ha + 20kg K/ha, T_6:15kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed), T_7:15kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed), T_8:25kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed), T_9:25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed). The soil of the trial plot was sandy loam in texture nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), medium in available P and K (15.2 kg/ha and 232.5 kg/ha respectively). Shekhar 2 was the variety used for experimentation and the nutrient sources were Urea, SSP, MOP to fulfill the requirement of N, P_2O_5, and K_2O. The recommended dose of 20 kg/ha potassium was applied as basal, and also nitrogen and phosphorus were applied according to the treatment details. Seeds were treated with Rhizobium at 20g/kg of seed according to treatment details. Irrigation was based on the necessity and as per the time of sowing. Thinning & Gap filling was done within 10 DAS to maintain the plant population according to treatment in order to attain recommended plant population for proper growth and yield of crop. Pre-harvest observations which include plant height(cm), number of nodules/plant, number of branches/plant, plant dry weight(g/plant), Crop Growth Rate (g/m^2/day), Relative Growth Rate(g/g/day) were observed at 15,30,45,60 DAS (Days After Sowing) and Post-harvest observations like number of pods/plant, number of seeds/plant, 100 seed weight, grain yield, Stover yield, biological yield, harvest index, gross returns, net returns and benefit cost ratio were recorded with standard process of observation. The data was statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design. (Gomez and Gomez 1984).

Result and Dissucussion

Effect on growth parameters of Blackgram

The statistical data regarding growth parameters are presented in Table 1.

Nitrogen, Phosphorus and Rhizobium inoculation significantly influenced plant height at harvest. Highest plant height (52.42 cm) was recorded with application of 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (200g/10kg of seed) which was significantly superior over rest of the treatments. The significant increase in plant height due to increasing levels of nitrogen fertilizer throughout the measurement period. The increase in plant height in response to application of N fertilizers is probably due to enhanced availability of nitrogen through fertilizer means and by SNF. The results were in accordance with Kumawat and Bansal (1996) [14]. Phosphorus encourage formation of new cells, promote plant vigour and hastens leaf development, which help in harvesting more solar energy and better utilization of nitrogen, which help towards higher growth attributes. Mir *et al.* (2013) [17]. *Rhizobium* inoculation, which may maintain favourable balance between the applied nutrients in the plant for its optimum growth while elongation and chlorophyll biosynthesis in turn, improve the branches plant-1. The result is supported by Singh and Pareek (2003) [20], Sripriya *et al.,* (2005) [25], Kumar and Elamathi (2007) [13] Bhuiyan *et al.,* (2008) [1] and Giri *et al.,* (2010) [6].

Significantly maximum number of nodules (21.66) were recorded in the treatment combination T_9 25kg N/ha + 45kg P/ha + 20kg K/ha *Rhizobium* (200g/10kg of seed). Rautela *et al.* (2001) reported that *Rhizobium* inoculation increased the nodulation and crop growth. It might have resulted due to more competitive ability of microbes near roots which is the site for microbial infection. Well-developed root system provides more evidence for infection resulting in greater number of nodules. These finding are found relevant to Hussain *et al.,* (2015) [8], Dhakal *et al.,* (2016) [3], Meena and Ram (2016) [3], Kant *et al.,* (2016) [11] and Mohammad *et al.,* (2017) [11]. When phosphorus supply is limited, the availability of phosphorus and Nitrogen to chloroplast became limited ultimately affect the photosynthetic processes as well as photosynthate supply to nodules. The effect of phosphorus could be related to the finding by that it stimulates root growth and activity and nodule formation. Mir *et al.* (2013) [17] found the similar results.

Similarly maximum number of branches (8.80) and Plant dry weight (12.70g) were recorded in the treatment combination

T_9 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed) which was significantly superior over the rest of the treatments. The number of branches were increased due to the greater availability of nutrients in soil due to increasing application of Nitrogen doses might have enhanced multiplication and elongation of cells leading to increased number of branches as reported by Kalaiselvan *et al.* (2002) [10]. The significant increase in dry weight might be due to adequate supply of Nitrogen allowed the plant tissue to grow large and increase the chlorophyll formation and stimulated rapid rate of photosynthetic activity, consequently recorded more dry matter accumulation in comparison to its lower level as stated by Hasan *et al.* (2010) [7]. *Rhizobium* inoculation, which may maintain favourable balance between the applied nutrients in the plant for its optimum growth while elongation and chlorophyll biosynthesis in turn, improve the branches per plant. The result is supported by Singh and Pareek (2003) [20], Sripriya *et al.*, (2005) [25], Kumar and Elamathi (2007) [13] Bhuiyan *et al.*, (2008) [1] and Giri *et al.*, (2010) [6]. Highest Crop growth rate (2.46 g/m^2/day) was recorded in the treatment combination T_3 15kg N/ha + 45kg P/ha + 20kg K/ha. There was no significant difference among the treatments. The increasing rate of nitrogen and phosphorous leads to increase in higher accumulation of plant biomass production which ultimately leads to increase in crop growth rate. The similar results were obtained with Kalaiselvan *et al.* (2002) [10] and Kishore *et al.* (2020) [12]. The maximum Relative growth rate were recorded in T_1 Control plot (Recommended rate of NPK 20:40:20 NPK/ha), T_2 15kg N/ha + 35kg P/ha + 20kg K/ha and T_3 15kg N/ha + 45kg P/ha + 20kg K/ha which is 0.05. There was no significant difference among the treatments.

Table 1: Effect of Nitrogen and Phosphorus on growth attributes of Blackgram

Treatments	Plant height (cm)	No. of nodules/plant	No. of branches/plant	Plant dry weight (g/plant)	CGR (g/m^2/day)	RGR (g/g/day)
1. Control plot (Recommended rate of NPK 20:40:20 NPK/ha)	44.41	9.33	5.53	8.60	2.27	0.05
2.15kg N/ha + 35kg P/ha + 20kg K/ha	44.13	9.00	5.47	8.80	2.37	0.05
3. 15kg N/ha + 45kg P/ha + 20kg K/ha	45.13	11.66	5.73	9.19	2.46	0.05
4. 25kg N/ha+ 35kg P/ha + 20kg K/ha	45.58	14.22	5.93	9.84	2.40	0.04
5. 25kg N/ha + 45kg P/ha + 20kg K/ha	48.44	17.20	6.53	10.15	2.27	0.04
6. 15kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	48.53	18.22	6.20	10.63	2.24	0.04
7. 15kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	50.55	18.89	6.73	11.14	2.19	0.03
8. 25kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	51.32	20.55	7.47	11.80	2.32	0.03
9. 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	52.42	21.66	8.80	12.70	2.39	0.03
F test	S	S	S	S	NS	NS
SEm±	0.17	0.28	0.16	0.15	0.08	0.00
CD (P = 0.05)	0.49	0.81	0.46	0.43		

Yield and yield attributes

Data presented in Table 2 indicated that the significantly maximum number of pods per plant (40.80) of blackgram were observed in the treatment combination of T_9 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed) significantly higher among all treatments and statistically at par with T_8 25kg N/ha + 35kg P/ha + 20kg K/ha *Rhizobium* (20g/kg of seed) (39.40). Application of N along with P increased the number of pods per plant might be due to the enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation and vigorous root system resulted in more branches which consequently increased the number of pod bearing branches significantly. Similar findings were observed by Parry *et al.* (2018) [21] and Singh *et al.* (2020) [12]. There was remarkable effect of Rhizobium inoculation on number of pods per plant. The yield parameter like pods per plant was significantly influenced by seed treatment with Rhizobium. This may be due to synergistic effect of inoculants. Similar results were also reported by Tahir *et al.* (2009) [26]. Similarly maximum number of seeds/pod (7.80), test weight (37.21g), seed yield (847kg/ha), stover yield (3566.33) and biological yield (4413.33) were also recorded with the application of 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed). Rhizobium culture might have helped in reducing in the N fixation by its effect and also the unavailable from of N leading to more removal of nutrient by the crop as reflected in better growth parameters *viz.* pods plant and number of grains pod. The increase in grain, straw and biological yield was due to the cumulative effect of increased growth and yield parameters. Similar results have also been reported by Hussain *et al.* 2011 [9]. The increase in yields might have resulted due to improvement in growth and yield attributing characters through better supply of nutrient as a result of *Rhizobium* inoculation. These results are in accordance with the findings of Prasad and Ram (1988), Provarov *et al.* (1998) and Mandel and Ray (1999). They also reported that nodulation was greatest with *Rhizobium* inoculation. Grain yield was increased due to application of higher doses of nitrogen, which increases the photosynthetic activity and might have increased vegetative growth and yield attributes also improved ultimately increased grain yield. Similar findings have been observed by Togay *et al.* (2005). The increase in seed yield due to phosphorus application is attributed to source and sink relationship. It appears that greater translocation of photosynthates from source to sink might have increased seed yield (Patil *et al.* 2007) [22]. Phosphorus increases yield due to its well- developed root system, increased N fixation and its availability to the plants and favourable environments in the rhizosphere (Paes *et al.* 2010) [19].

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

Treatments	No. of Pods/plant	No. of Seeds/pod	Test weight(g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
1. Control plot (Recommended rate of NPK 20:40:20 NPK/ha)	29.13	6.60	30.52	708.67	1664.67	2373.33	29.99
2. 15kg N/ha + 35kg P/ha + 20kg K/ha	29.20	6.47	30.94	782.33	1711.00	2493.33	31.38
3. 15kg N/ha + 45kg P/ha + 20kg K/ha	29.40	6.53	33.55	719.33	1950.67	2670.00	26.95
4. 25kg N/ha+ 35kg P/ha + 20kg K/ha	31.07	6.80	34.48	737.67	2199.00	2936.67	25.13
5. 25kg N/ha + 45kg P/ha + 20kg K/ha	33.07	7.27	34.93	783.33	2393.33	3176.67	24.67
6. 15kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	34.93	7.07	35.18	770.00	2960.00	3730.00	20.67
7. 15kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	37.60	7.20	36.14	807.00	3479.67	4286.67	18.84
8. 25kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	39.40	7.40	36.24	835.00	3351.67	4186.67	19.95
9. 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	40.80	7.80	37.21	847.00	3566.33	4413.33	19.19
F test	S	S	S	S	S	S	S
SEm±	0.55	0.08	0.20	2.80	66.15	66.30	0.59
CD (P = 0.05)	1.61	0.25	0.59	8.14	192.29	192.73	1.72

Economics

Data in table 3- tabulated that experimental results revealed that application of 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed) recorded highest cost of cultivation (20555.8), Maximum gross return (INR 53361/ha), net return (INR 32802.2/ha) and B:C ratio (2.59).

Table 3: Effect of Nitrogen and Phosphorus on Economics of Blackgram

Treatment Combinations	Cost of Cultivation (₹/ha)	Gross returns (₹/ha)	Net Returns (₹/ha)	B:C Ratio
1. Control plot (Recommended rate of NPK 20:40:20 NPK/ha)	20381.4	44646.21	24264.81	2.19
2. kg N/ha + 35kg P/ha + 20kg K/ha	20293.8	49286.79	28992.99	2.42
3. 15kg N/ha + 45kg P/ha + 20kg K/ha	20413.8	45317.79	24903.99	2.21
4. 25kg N/ha+ 35kg P/ha + 20kg K/ha	20349	46473.21	26124.21	2.28
5. 25kg N/ha + 45kg P/ha + 20kg K/ha	20469	49349.79	28880.79	2.41
6. 15kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	20383.6	48510	28126.4	2.37
7. 15kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	20503.6	50841	29977.4	2.46
8. 25kg N/ha + 35kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	20438.8	52605	32166.2	2.57
9. 25kg N/ha + 45kg P/ha + 20kg K/ha + *Rhizobium* (20g/kg of seed)	20558.8	53361	32802.2	2.59

*Economics not subjected to data analysis

Conclusion

On the basis of one year experimentation It was concluded that treatment 25kg N/ha + 45kg P/ha + 20Kg K/ha with Rhizobium inoculation was found to be more productive higher grain yield (847 Kg/ha), and maximum gross return (INR 53361/ha) as well as higher economic (2.59) B:C ratio also.

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