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Productivity of Blackgram (*Vigna mungo* L.) Influence by Biofertilizers and Variable Sources of Nutrients

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ABSTRACT

Background: Blackgram (*Vigna mungo* L.) is an important pulse crop with a short duration in the *kharif* and summer seasons in India. Biofertilizer application seed treatment plays a crucial role in the fixation of nitrogen, converting unavailable phosphorous to an available form, increasing nutrient uptake and reducing crop stress. Inorganic fertilizer with a combined application of organic manure to sustainable crop production and soil health.

Methods: The field experiment was conducted at Agronomy Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, during the *kharif* season 2023 and 2024 under the factorial randomized block design with three replications. The treatments (Factor A) biofertilizers *viz*. B_1: PGPR (Seed treatment @20 g kg^{-1} Seed), B_2: PSB (Seed treatment @20 g kg^{-1} Seed) and B_3: PGPR + PSB (Seed treatment each @20 g kg^{-1} Seed) and (Factor B) Variable source of nutrients *viz*. N_0: Control, N_1: 100% RDF (Inorganic Fertilizer), N_2: 75% RDF + Vermicompost @1 tonne ha^{-1}, N_3: 75% RDF + Enriched FYM @ 2 tonne ha^{-1} and N_4: 50% RDF + Vermicompost @1 tonne ha^{-1} + Enriched FYM @ 2 tonne ha^{-1}.

Result: The experimental results two years pooled values were revealed under investigation. The seed treatment with PGPR + PSB (seed treatment each @ 20 g kg^{-1} seed) was observed to have the highest plant height (24.32, 49.29 cm), number of primary branches (3.41, 5.90 $plant^{-1}$), leaf area index (3.33, 4.70) and dry matter accumulations (3.10, 7.76 g $plant^{-1}$) at 45 DAS and 60 DAS. Yield attributes *viz*. no. of pods (32.87 $plant^{-1}$), pod length $plant^{-1}$ (5.93 cm), no. of seeds (5.31 pod^{-1}), grains weight pod^{-1} (0.239 g), grain yield (1,365.71 kg ha^{-1}), stover yield (2,690.94 kg ha^{-1}) and harvest index (33.61%) respectively. The application of 50% RDF + vermicompost @ 1 tonne ha^{-1} + enriched FYM @ 2 tonne ha^{-1} was observed to achieve the highest plant height (24.51, 51.93 cm), number of primary branches (3.57, 6.52 $plant^{-1}$), leaf area index (3.46, 4.93) and dry matter accumulations (3.19, 8.27 g $plant^{-1}$) at 45 DAS and 60 DAS. Yield attributes *viz*. no. of pods (33.87 $plant^{-1}$), pod length $plant^{-1}$ (6.05 cm), no. of seeds (5.57 pod^{-1}), grains weight pod^{-1} (0.251 g), grain yield (1,492.68 kg ha^{-1}), stover yield (2,921.82 kg ha^{-1}) and harvest index (33.80%) respectively.

Key words: Biofertilizers, Enriched FYM, Grain yield, Plant growth-promoting rhizobacteria (PGPR), Vermicompost.

INTRODUCTION

Blackgram (*Vigna mungo* L.) is one of the important pulse crop grown in India which belong to the family "Leguminoseae". Blackgram is reported as originated in the India (De Candolle, 1886). It is commonly referred to by various regional names, including 'urad bean', 'black gram', 'minapapappu' and 'udad dal'. Blackgram is a protein rich food. It contains 48.0% carbohydrates, 22.3% protein, 154 mg calcium, 9.1 mg iron, 1.4 g fat, 0.37 g riboflavin and 0.42 mg thiamine in per 100 g (Asaduzzaman *et al.,* 2010; Narayanan *et al.,* 2017; Selvakumar *et al.,* 2012). Black gram (*Vigna mungo* L.), is a highly nutritious legume that offers a wealth of health benefits and integral part of human diets, particularly in South Asia. This pulse is rich in essential nutrients, making it a valuable source of protein, dietary fiber, vitamins and minerals (Raveena *et al.,* 2024). In India, it is mostly grown in summer and rainy seasons, covering an area of 4.2 million hectares with total production of 2.34 million tonnes and average productivity of 557 kg ha^{-1} during 2020-21. Madhya Pradesh is the largest producer of blackgram, accounting nearly for 21 per cent of the total national production, followed by Andhra Pradesh (15%), Uttar Pradesh (13%) and Maharashtra (11%) (2020-21). In the case of area, the share of Madhya Pradesh was 24 per cent, followed by Uttar Pradesh (10%) and Maharashtra (7%) area shares of major blackgram growing states during 2020-21. Among the major producing states, productivity is highest in Andhra Pradesh (915 kg ha^{-1}), followed by Jharkhand (879 kg^{-1}) during 2020-21

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(Anonymous, 2021). Black gram's roots lie in the Indian subcontinent; its cultivation has now extended to various parts of the world. The crop is extensively grown in countries like India, Bangladesh, Sri Lanka, Myanmar and Thailand, where it forms an essential part of the diet. Additionally, its popularity is spreading to regions in Africa, the Americas and even Australia due to its adaptability to diverse agro-climatic conditions.

Blackgram is a legume crop, which means that it can form a symbiotic relationship with Rhizobium bacteria to fix atmospheric nitrogen (Das *et al.,* 2014; Sadiq *et al.,* 2023; Yamini and Anilkumar, 2023). However, if the soil does not contain the right strain of Rhizobium bacteria, blackgram plants will not be able to fix nitrogen efficiently. They are living microorganisms that can fix atmospheric nitrogen, solubilize phosphorus and promote plant growth (Kumar and Patil, 2024; Choudhary *et al.,* 2025; Gautam *et al.,* 2022). Biofertilizers can help to ensure that blackgram plants have the necessary Rhizobium bacteria to fix nitrogen and grow well (Hepsibha *et al.* 2024; Kavitha and Srimathi 2022; Patel *et al.* 2022). Biofertilizers play an important role in blackgram (*Vigna mungo* L.) cultivation (Vinutha *et al.*, 2023; Tiwari *et al.,* 2017). In addition to Rhizobium bacteria, other biofertilizers that can be used for blackgram include phosphate-solubilizing bacteria (PSB) and plant growth-promoting rhizobacteria (PGPR) (Kumar *et al.,* 2022; Satyanandam *et al.,* 2022). PSB can help to make phosphorus in the soil more available to blackgram plants (Tyagi and Singh, 2019; Porpavai *et al.,* 2022). PGPR can promote plant growth by producing plant hormones, suppressing pests and diseases and improving nutrient uptake.

MATERIALS AND METHODS

The experiment was conducted at Agronomy Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India, during *Kharif* season 2023 and 2024. The field was well levelled, having good soil conditions. Geographically, Ayodhya (Kumarganj) falls in a subtropical climate and is situated at 26°47″ North latitude and 82°12″ East longitude with an altitude of 113 meters above mean sea level. Soil of the experiment field was classified as silt loam in texture with alkaline reaction (pH 8.1) low in organic carbon (0.25%) and available nitrogen (190 kg ha^{-1}), medium in phosphorus (14.5 kg ha^{-1}) and potash (238.1 kg ha^{-1}). The experiment was laid out in a factorial randomized block design, two factors (biofertilizers and variable source of nutrients) with three replications. The three treatments of biofertilizers are *viz.* B_1: PGPR (Seed treatment @20 g kg^{-1} Seed), B_2: PSB (Seed treatment @20 g kg^{-1} Seed) and B_3: PGPR + PSB (Seed treatment each @20 g kg^{-1} Seed). The levels variable source of nutrients *viz.* N_0: Control, N_1: 100% RDF (Inorganic Fertilizer), N_2: 75% RDF + Vermicompost @ 1 tonne ha^{-1}, N_3: 75% RDF + Enriched FYM @ 2 tonne ha^{-1} and N4: 50% RDF+ Vermicompost @ 1 tonne ha^{-1} + Enriched FYM @ 2 tonne ha^{-1}. The recommended dose of NPK was 20:60:30 kg ha^{-1}. Sources of nitrogen, phosphorus and potassium were urea, single superphosphate and muriate of potash, respectively. The blackgram variety "Shekhar-2" was sown at a spacing of 30 cm × 10 cm with a seed rate of 25 kg ha^{-1}. The growth characteristics and yield attributes were recorded as per the different stages of the crop growth. The seed and stover yield (kg ha^{-1}) was recorded from the net plot area of each treatment. All the observations are statistically analyzed, following Gomez and Gomez's (1984) method, with the significance tested at $p<0.05$. Standard error of the mean (SEm±) and critical differences (CD) values were provided for computing mean differences.

RESULTS AND DISCUSSION

Growth characters

The pooled data over two years clearly indicated that the growth parameters of black gram were significantly influenced by the application of biofertilizers and different sources of nutrient at 45 and 60 days after sowing (DAS) (Table 1). Among the treatments, seed treatment with PGPR + PSB (@ 20 g kg^{-1} seed each) consistently recorded superior plant growth, reflected in greater plant height (24.32 cm at 45 DAS and 49.29 cm at 60 DAS), a higher number of primary branches (3.41 and 5.90 per plant), Leaf Area Index (3.33 and 4.70) and dry matter accumulation (3.10 and 7.76 g plant^{-1}) compared to other biofertilizer treatments.

Similarly, the use of variable nutrient sources also exhibited significant effects on plant growth. The treatment comprising 50% RDF+ Vermicompost @1 tonne ha^{-1} + Enriched FYM @ 2 tonne ha^{-1} outperformed other nutrient combinations, particularly at 60 DAS, where it resulted in maximum plant height (51.93 cm), number of primary branches (6.52 plant^{-1}), leaf area index (4.93) and dry matter accumulation (8.27 g plant^{-1}). At 45 DAS, the highest plant height (25.05 cm) was observed under 100% RDF (inorganic fertilizer) alone, though the combined organic treatment proved more effective at later stages of growth. However, number of primary branches (3.57 plant^{-1}), leaf area index (3.46) and dry matter accumulation (3.19 g plant^{-1}) were observed highest at 45 DAS in 50% RDF+ Vermicompost @1 tonne ha^{-1} + Enriched FYM @ 2 tonne ha^{-1}.

Overall, the results suggest that integrating biofertilizers with organic nutrient sources enhances black gram growth, potentially reducing the reliance on full doses of inorganic fertilizers while sustaining plant vigor and biomass accumulation. Biofertilizer is crucial work in soil solubilized nutrients, uptake and increased nutrient use efficiency; similar results were found (Meena *et al.,* 2021; Sarwade *et al.,* 2023; Sangothari and Radhamani 2024). These findings underscore the importance of integrating biofertilizers in agricultural practices to enhance soil fertility and crop yield. Future studies should explore the long-

term effects of these treatments on soil health and sustainability.

Yield attributes and seed yield

The pooled results over two years clearly demonstrate the beneficial effects of biofertilizers and variable source of nutrients on the yield attributes and yield of blackgram (Table 2). Significant improvements were recorded in key yield components such as the number of pods per plant, pod length, number of seeds per pod, grain weight per pod, grain yield, stover yield and harvest index.

Seed treatment with a combination of PGPR + PSB (Seed treatment each @ 20 g kg^{-1} seed) showed remarkable enhancement in plant performance, leading to a higher number of pods (32.87 $plant_{-1}$), pod length (5.93 cm), seeds per pod (5.31) and grain weight (0.239 g). This

Table 1: Growth characters (Pooled two years) at different growth stages as affected by biofertilizers and variable source of nutrients of blackgram (*Vigna mungo* L.).

Treatments	Plant height		Number of primary branches ($plant^{-1}$)		Leaf area index		Dry matter accumulations (g $plant^{-1}$)	
	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
Bio-fertilizers								
PGPR (Seed treatment @20 g kg^{-1} seed)	23.12	46.28	2.96	5.60	3.12	4.46	2.97	7.38
PSB (Seed treatment @20 g kg^{-1} seed)	22.44	44.71	2.72	5.34	2.98	4.27	2.76	6.82
PGPR + PSB (Seed treatment each @ 20 g kg^{-1} seed)	24.32	49.29	3.41	5.90	3.33	4.70	3.10	7.76
SEm±	0.38	0.76	0.05	0.09	0.05	0.07	0.05	0.12
C.D. (P=0.05)	1.10	2.19	0.15	0.27	0.15	0.21	0.14	0.35
Variable source of nutrients								
Control	20.80	40.66	2.47	4.65	2.83	4.03	2.59	5.46
100% RDF (Inorganic Fertilizer)	25.05	43.52	2.85	5.23	3.01	4.31	2.88	7.42
75% RDF+Vermicompost @1 tonne ha^{-1}	22.71	46.61	3.05	5.64	3.16	4.49	3.02	7.65
75% RDF+Enriched FYM @ 2 tonne ha^{-1}	23.38	47.57	3.21	6.05	3.25	4.64	3.03	7.78
50% RDF+ Vermicompost @1 tonne ha^{-1} + Enriched FYM @ 2 tonne ha^{-1}	24.51	51.93	3.57	6.52	3.46	4.93	3.19	8.27
SEm±	0.49	0.99	0.06	0.12	0.07	0.09	0.06	0.16
C.D. (P=0.05)	1.42	2.83	0.19	0.35	0.21	0.27	0.18	0.46

Table 2: Yield attributes and yield (Pooled two years) as affected by biofertilizers and variable source of nutrients of blackgram (*Vigna mungo* L.).

Treatments	No. of pods $plant^{-1}$	Pod length $plant^{-1}$ (cm)	No. of seeds (pod^{-1})	Grains weight pod^{-1} (g)	Grain yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	Harvest index (%)
Bio-fertilizers							
PGPR (Seed treatment @20 g kg^{-1} seed)	31.34	5.54	5.05	0.228	1,202.08	2,457.99	32.74
PSB (Seed treatment @20 g kg^{-1} seed)	29.10	5.39	4.80	0.214	1,043.37	2,117.60	32.83
PGPR + PSB (Seed treatment each @ 20 g kg^{-1} seed)	32.87	5.93	5.31	0.239	1,365.71	2,690.94	33.61
SEm±	0.51	0.09	0.08	0.004	22.69	45.26	0.60
C.D. (P=0.05)	1.47	0.27	0.24	0.011	65.74	131.09	NS
Variable source of nutrients							
Control	27.57	4.71	4.56	0.200	856.16	1,823.44	31.87
100% RDF (Inorganic Fertilizer)	30.59	5.65	4.87	0.216	1,110.97	2,292.78	32.61
75% RDF+Vermicompost @1 tonne ha^{-1}	31.69	5.77	5.04	0.227	1,218.79	2,432.71	33.35
75% RDF+Enriched FYM @ 2 tonne ha^{-1}	31.80	5.92	5.23	0.239	1,340.00	2,640.15	33.65
50% RDF+ Vermicompost @1 tonne ha^{-1} + Enriched FYM @ 2 tonne ha^{-1}	33.87	6.05	5.57	0.251	1,492.68	2,921.82	33.80
SEm±	0.65	0.12	0.11	0.005	29.30	58.43	0.78
C.D. (P=0.05)	1.89	0.35	0.31	0.014	84.87	169.24	NS

treatment also translated into superior grain yield (1,365.71 kg ha^{-1}) and stover yield (2,690.94 kg ha^{-1}) along with an improved harvest index (33.61%). These findings align with the observations reported by Kumar and Kumar (2022) and Menariya *et al.* (2024), highlighting the synergistic role of biofertilizers in improving nutrient uptake and plant productivity.

Furthermore, the combined application of 50% RDF+ Vermicompost @1 tonne ha^{-1} + Enriched FYM @ 2 tonne ha^{-1} outperformed other nutrient treatments. This integrated approach resulted in the highest recorded values for number of pods (33.87 plant^{-1}), pod length (6.05 cm), seeds per pod (5.57), grain weight (0.251 g), grain yield (1,492.68 kg ha^{-1}), stover yield (2,921.82 kg ha^{-1}) and harvest index (33.80%). The improvement under this treatment can be attributed to the combined effect of balanced nutrient supply from both chemical and organic sources, leading to better soil health and sustained crop growth. This might be due to enhancement in growth and yield parameters as well as uptake of nutrients by the crop. Obviously, the cumulative effects of these parameters might have contributed to the increased grain yield potential of the crop. Similar findings might be due to Geetha and Velayutham, 2016; Rekha *et al.,* 2013; Kumar *et al.,* 2023). Therefore, with regard to *kharif* black gram cultivation, PGPR + PSB (seed treatment each @ 20 g kg^{-1} seed) were found to be the most promising treatment in order to increase the black gram yield. These organic sources, such as enriched farmyard manure and vermicompost provided a substantial amount of nutrients to the soil. This increased nutrient availability led to a higher conversion of carbohydrate into protein, subsequently contributing to the elaboration of protoplasm and cell wall materials, thereby increasing cell size. This morphological expression was evident in terms of plant height, the number of branches plant^{-1} and ultimately, greater dry matter accumulation. It is noted that cellulose, being a highly persistent component, requires an extended period for the decomposition of blackgram crop. As a result, the blackgram crop benefited from the residual nutrients, leading to improved growth and increasing the yield of blackgram. The results were in confirmation with the findings of Sangothari and Radhamani (2024); Rohan *et al.* (2022); Ramesh *et al.* (2016).

CONCLUSION

On the basis of experimental results (pooled two-year values), it was concluded that the application of bio-fertilizers (PGPR + PSB) was found to better the growth and yield of blackgram, remarkable increase in plant height, number of primary branches, leaf area index, plant dry weight, yield attributes, seed yield and stover yield. Among the variable sources of nutrients, the application of 50% RDF + vermicompost @ 1 tonne ha^{-1} + enriched FYM @ 2 tonne ha^{-1} (N4) was found better to achieve higher growth, yield attributes and yield of blackgram. Therefore, with regard to *kharif* black gram cultivation. PGPR + PSB (seed treatment each @ 20 g kg^{-1} seed) with the application of 50% RDF + vermicompost @ 1 tonne ha^{-1} + enriched FYM @ 2 tonne ha^{-1} was found to be the most promising treatment combination in order to increase the black gram yield.

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Disclaimers

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Informed consent

All experimental procedures and handling techniques were approved by Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced for conducting study, data collection, analysis, decision to publish, or preparation of the manuscript.

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