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Effect of Bio Fertilizers and Micro Nutrients on Growth and Yield of Black Gram (*Vigna mungo* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted during *ZAID* season, 2023 at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. In the present study, effect of bio fertilizers and micro nutrients on growth and yield of black gram. The treatments consist of three levels of bio fertilizers i.e, AMF – 25 g/kg seeds, *Pseudomonas* - 10 g/kg seed, *Rhizobium* – 20g/ kg seeds along with three different micro nutrients i.e, Zinc - 0.5 %, Iron - 0.5% and Molybdenum - 0.4%. There are 10 treatments each replicated thrice. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.9), available in medium nitrogen (138.700 kg/ha) medium phosphorus (17.5 kg/ha) and medium potassium (157.9 kg/ha). Results revealed that maximum plant height (44.40cm), plant dry weight (9.53 g/plant), number of nodules/ plant (27.20), no of branches (18.43), number of pods (10.07), number of seeds/pod (9.67), test weight (39 g), grain yield (1213.33 kg/ha), stover yield (2233.33kg/ha) was recorded in T_8 (*Rhizobium* – 20g/kg

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seed + Iron - 0.5 %). Maximum gross return (INR 63,350.00), net return (INR 41,900.00) and B:C ratio (1.95) which was significantly superior over other treatment (*Rhizobium* – 20g/kg seed + Iron - 0.5 %). It is concluded that the application of *Rhizobium* -20g/kg seed along with foliar spray Iron-0.5% (T_8) produce higher yield and benefit cost ratio in Black gram.

Keywords: Iron; molybdenum; pseudomonas; rhizobium; zinc.

1. INRTODUCTION

Black gram (*Vigna mungo L.)* is one of the important pulse crop. It is grown throughout India. Black gram is widely cultivated legume crop which belongs to the family “Leguminosae” . It is known as urad bean, urad dal or urad. It also acts as cover crop and its deep root system protects the soil from erosion. Black gram shows high nutritional properties. It fixes atmospheric nitrogen into the soil and improves soil fertility. Biofertilizers are selected strains of beneficial soil microorganisms cultured in the laboratory and packed in an appropriate carrier. Biofertilizers improves soil quality and protects the plants from pathogens, and avoids environmental pollution, destruction of harmful substances present in the soil. Biofertilizers Increases the availability of plant nutrients and help in maintenance of soil fertility. Seed treatment with biofertilizers increases 20-30% crop yield.

Rhizobium is a biofertilizer which increases symbiotic nitrogen fixation and plays a major role in promoting growth. The application of *Rhizobium* as bio fertilizer ensures success in crop productivity and reduce the need of artificial fertilizer that are expensive and cause environmental problems. Seed treatment with *Rhizobium* protects the seedlings from seed borne pathogens, root-rot and seedlings diseases. AMF (*Arbuscular Mycorrhizal Fungi*) is a beneficial fungus that plays an important role in soil nutrient dynamics and improves soils physical, chemical and biological properties. It improves the nutrient status of plants and increases growth and development, protects plant against pathogen and resist to drought and salinity. VAM involves in multistep colonization process, and mycorrhizal mechanism and pathways involved in phosphorus availability.

Pseudomonas belong to Plant Growth Promoting Rhizobacteria (PGPR), the important group of bacteria plays a major role in the plant growth promotion, induced systemic resistance, biological control of pathogens etc. Many strains of *Pseudomonas* are known to enhance plant growth and improves the soil permeability and protects the plant from wilting, soft rot. The efficacy of bacterial antagonists in controlling fungal diseases. [1] Ganeshan and Kumar [2,3].

Micronutrients are required in small quantity but plays a crucial for plant growth and development process such as flowering and it plays important role in photosynthesis. Zinc is one of the micronutrient, It is essential for the formation of auxins, which helps in growth regulation and stem elongation of the plant. Growth parameters are increased by application of zinc. Iron plays a significant role in various physiological and biochemical pathways in plants. In plants, iron is involved in the synthesis of chlorophyll and it is essential for the maintenance of chloroplast structure and function. Iron increases the photosynthetic activity, root length, number of branches and it’s developing structure leads to increase number of pods per plant.

Molybdenum is regarded as a critical micronutrient and it’s lack causes low seed yield in pulses. It is a structural component of nitrogenase and nitrate reductase enzymes which brings about oxidation- reduction reaction in plant cells. (Anand *et al.,*2022) Soni and Kushwaha, [4].

2. MATERIALS AND METHODS

The field experiment was conducted during *zaid* season 2023 at the Crop Research Farm, Department of Agronomy, (SHUATS), Prayagraj U.P. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 6.9) medium in available nitrogen (138.700kg/ha) medium phosphorus (17.5 kg/ha) and medium potassium (157.9kg/ha). The experiment was laid out in Randomized Block Design with 10 treatments replicated thrice *viz.,* $T_{1,}$- AMF-25g/ kg seed+Zinc-0.5%;T_2-AMF-25g/kgseed+Iron-0.5%; T_3-AMF-25g/kg seed+ Molybdenum- 0.5% T_4-*Pseudomonas-10g/kgseed*+Zinc-0.5%;T_5 *Pseudomonas-10g/* kgseed+Iron-0.5%;T_6 *Pseudomonas*-10g/kg seed Molybdenum-0.4%;T_7-*Rhizobium*-20g/kg seed+ Zinc-0.5%;T_8-*Rhizobium*-20g/kgseed+ Iron-0.5%; T_9 *Rhizobium*-20g/kg seed+ Molybdenum-0.4%; T_{10} Control - (RDF) NPK-20 – 40 - 20 kg/ha. The observations was recorded for plant height (cm), dry weight (g/plant), number of nodules, number of branches. Where as yield attributes are

recorded after the harvest of the crop. crop growth rate (g/m^2/day), relative growth rate (g/g/day), number of pods /plant, no of seeds/pod, Test weight (g), seed yield (t/ha), stover yield (t/ha), harvest index (%). The data was subjected to statistical analysis by analysis of variance method (Gomez and Gomez, 1976).

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height: Plant height was observed at 15,30,45,60 DAS. Significantly highest plant height (44.40 cm) was recorded at 60 DAS with seed treatment *Rhizobium*-20g/kg seed and foliar spray of Iron-0.5%. However, T_4 (*pseudomonas* 10g/kg+ Zinc 0.5%) was found to be statistically at par with T_8 (Rhizobium-20g/kg seed+.Iron-0.5%). The better supplement of nutrients increase to the plant stimulates the metabolic and enzymatic activities in crop and involves in the synthesis of chlorophyll and it is essential for the maintenance of chloroplast structure and function which helps in the increase growth of the plant. *Rhizobium* inoculation helps in the optimum growth of plant. Seed treatment with *Rhizobium* protects seeds from seed borne pathogen, root rot. Iron increases the photosynthetic activity, root length, number of branches and its developing structure leads to increase in pod per plant. Similar findings were reported by [5] in chickpea, Subha *et al.,(*2021) in black gram and [6] in green gram.

Plant dry weight: Plant dry weight was observed at 15,30,45,60 DAS. Significantly highest plant dry weight (9.53 g/plant) was recorded at 60 DAS with the T_8 (*Rhizobium* 20g/kg seed + Iron - 0.5%).

However, T_5 was found to be statistically at par with T_8. It is due to application of *Rhizobium* and iron. *Rhizobium* inoculation, helps in optimum growth and chlorophyll biosynthesis, which results in better growth that is plant height and number of branches/plant, and results in higher dry matter accumulation. The increase in the availability of iron to plant stimulates the metabolic and enzymatic activities and influences the plant vigour through absorption of nutrients at critical stages that enhance the physiological activity of crop and increase the assimilation of photosynthates. Similar finding were reported by Dobariya and Patel [7], Suman *et al*.,(2021), [8] in chickpea.

Number of root nodules: Number of Root nodules was observed at 15,30,45,60 DAS. Significantly highest number of root nodules (27.20) was recorded at 45 DAS in T_8 (Rhizobium – 20g/kg seed + Iron - 0.5%), However, T_5, T_6, T_7, was statistically at par with T_8. The increase of root nodule number is due to better compatibility and efficiency of inoculated *Rhizobium.* It results in more competitive ability of microbes near roots. Well-developed root system provides more evidence results in greater number of root nodules. Iron is important in nitrogen fixation. Similar findings were reported by [9], [5] subha *et al.,* (2021) in black gram. Geetanjali *et al*.,(2020) Kumar *et al*., (2020) in chickpea.

Number of branches: Number of branches was observed at 15,30,45,60 DAS. Significantly highest number of branches (18.43) was recorded at 60 DAS in T_8 (*Rhizobium*-20g/kg seed+Iron-0.5%), However, T_5, T_6, was statistically at par with T_8. This enhancement could be attributed to the promotional effect of iron on vegetative growth and ultimately increase photosynthetic activity. Additionally, it results in the availability of required quantity of essential plant nutrients at various growth stages, accelerating plant metabolic processes and consequently leading to the production of more number of branches [10] Rawat *et al*.,(2023) in chickpea.

3.2 Yield Attributes

Pods/plant: Significantly highest number of pods/plant (10.07) was recorded with the T_8 (*Rhizobium* – 20g/kg seed + Iron - 0.5%). How ever T_5, T_7 which was found to be statistically at par with T_8. These micronutrients and *Rhizobium* led to greater photosynthates production and vigorous growth.

Further with efficient partitioning of accumulated photosynthates results in more bud and flower initiation. which might be also responsible for efficient translocation of photosynthates from source to sink, and cause higher number of pod formation [11] and [4].

Seeds/pod: Significantly highest number of seeds/pod (9.67) was recorded with the T_8 (*Rhizobium* - 20 g/kg seed + Iron - 0.5%). However, T_2, T_4, T_7 was found to be statistically at par with T_8. which is due to greater availability of nutrients. Iron and *Rhizobium* inoculation was easily absorbed by the crop that significantly increases the rate of photosynthesis. The translocation and accumulation of photosynthates in the economic sinks results in increase number of seeds/ pod. Similar findings were reported by [5] and Veer *et al.,(*2022) .

Table 1. Effect of biofertilizers and micronutrients on growth and yield of black gram

		At 60 DAS		45 DAS	
	S. No. Treatment combination	**Plant height (cm)**	**Dry weight (g/plant)**	**No of branches**	**No of Root nodules**
1.	VAM-25g/kg seed+Zinc-0.5%	39.14	8.13	17.03	23.93
2.	VAM-25g/kg seed+Iron-0.5%	39.87	7.13	17.13	23.77
3.	VAM-25g/kg seed+Molybdenum-0.4%	38.86	7.97	17.17	24.60
4.	*Pseudomonas*-10g/kg seed+Zinc-0.5%	41.00	8.07	17.10	24.60
5.	*Pseudomonas*-10g/kg seed+Iron-0.5%	40.53	8.23	18.13	25.50
6.	*Pseudomonas*-10g/kg seed+ Molybdenum-0.4%	40.11	8.23	18.27	25.27
7.	*Rhizobium*-20g/kg seed+Zinc-0.5%	37.48	8.50	17.17	25.27
8.	*Rhizobium*-20g/seed+Iron-0.5%	44.40	9.53	18.43	27.20
9.	*Rhizobium*-20g/kg seed+Molybdenum-0.4%	39.53	9.77	17.37	24.37
10.	Control (RDF)-20-40-20 NPK Kg/ha	35.93	8.40	16.13	21.13
	SFm(±)	1.33	0.18	0.35	0.75
	CD(p=0.05)	3.96	0.54	1.07	2.25

Table 2. Response of bio fertilizers and micro nutrients on yield attributes and yield of black gram

	At Harvest					
S.no Treatment Combinations	**Pods/plant**	**Seed/ pod**	**Test weight (g)**	**Seed yield (Kg/ha)**	**Stover yield (kg/ha)**	**Harvest index (%)**
1. VAM-25g/kg seed+Zinc-0.5%	9.07	7.80	39.00	980.00	1836.67	34.74
2. VAM-25g/kg seed+Iron-0.5%	8.87	8.73	39.00	990.00	1933.33	33.88
3. VAM- 25g/kg seed+Molybdenum-0.4%	9.47	8.33	38.00	970.00	2050.00	32.14
4. *Pseudomonas*-10g/kg seed+Zinc-0.5%	8.93	8.73	38.00	976.33	2123.33	31.48
5. *Pseudomonas*-10g/kg seed+Iron-0.5%	9.67	8.73	38.00	1150.00	2183.33	34.65
6. *Pseudomonas*-10g/kg seed+Molybdenum-0.4%	8.80	8.27	38.33	963.00	2126.67	31.14
7. *Rhizobium*-20g/kg seed+Zinc-0.5%	9.53	8.80	36.33	1016.67	2166.67	32.03
8. *Rhizobium*-20g/kg seed+Iron-0.5%	10.07	9.67	39.00	1213.33	2233.33	34.91
9. *Rhizobium*-20g/kg seed+Molybdenum-0.4%	9.27	7.80	38.67	976.67	2126.67	30.84
10. Control (RDF)- 20-40-20 N PK Kg/ha	9.47	7.87	38.33	945.67	1996.67	31.18
S. Em (±)	0.18	0.37	0.50	28.92	83.77	1.05
CD (p = 0.05)	0.56	1.10	1.50	85.92	248.9	3.12

Table 3 Response of bio fertilizers and micro nutrients on economics of black gram

S.no	Treatment combination	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C
1.	VAM-25g/kg seed+Zinc-0.5%	20,730.00	51,605.00	30875.00	1.49
2.	VAM-25g/kg seed+Iron-0.5%	20,830.00	52,400.00	31570.00	1.52
3.	VAM-25g/kg seed+Molybdenum-0.4%	23,430.00	51,575.00	28145.00	1.20
4.	*Pseudomonas*-10g/kg seed+Zinc-0.5%	20,800.00	51,851.67	31051.67	1.49
5.	*Pseudomonas*-10g/kg seed+Iron-0.5%	20,900.00	59,916.67	39016.67	1.87
6.	*Pseudomonas*-10g/kgseed+Molybdenum-0.4%	23,500.00	51,190.00	27690.00	1.18
7.	*Rhizobium*-20g/kg seed+Zinc-0.5%	21,350.00	54,083.33	32733.33	1.53
8.	*Rhizobium*-20g/kg seed+Iron-0.5%	21,450.00	63,350.00	41900.00	1.95
9.	*Rhizobium*-20g/kg seed+Molybdenum-0.4%	24,050.00	50,523.33	26473.33	1.10
10.	Control (RDF)- 20-40-20 NPK Kg/ha	22,550.00	48,328.33	25778.33	1.14

**Data not subjected to statistical analysis*

Test weight : The data present in table 2 shows that significantly highest test weight (39.00 g) was recorded with the T_8 (Rhizobium - 20g/kg seed + Iron - 0.5%) (AMF –25 g /kg seed+ Zinc-0.5%), (AMF-25g/kg seed+Zinc-0.5%), However T_5, T_6, T_9 was found to be statistically at par with T_8. Increase in Seed index is to greater mobilization of photosynthesis. Application of iron is the reason for increase in seed weight. *Rhizobium* helps in enzyme activation, membrane integrity, chlorophyll formation, stomatal balance. which enhance the accumulation of grains resulting in heavier grains. [6] and [12] Veer *et al.,(*2022)

Seed yield (kg/ha): Significantly highest seed yield (1213.33 kg/ha) was recorded in T_8 (*Rhizobium* - 20g/kg seed + Iron - 0.5%). In the process of tissue differentiation from somatic to reproductive, meristematic activity the development of floral primordial increases *Rhizobium* inoculation and this method results in more flowers and pods formation and increases the grain yield. However, combined effect of iron and *Rhizobium* provides sufficient nutrients to the plant and thereby more yield attributes and higher yield was recorded. Similar finding was reported by [6] and [13] Tripathi *et al*.,(2021).

Stover yield (kg/ha): Significantly highest stover yield (2233 kg/ha) was recorded in T_8 (*Rhizobium* - 20g/kg seed + Iron - 0.5%) *Rhizobium* inoculation results in increase of leaf photosynthetic activity, improves nutrient uptake and metabolism, increase efficiency of other nutrients through the translocation of photosynthate. Iron application helps in better vegetative growth in plant, which helps in increase in the yield. Subha *et al*.,(2021).

Harvest index (%): Significantly highest harvest index (34.91%) was recorded in T_8 *(Rhizobium* - 20g/kg seed +Iron-0.5%), However, treatments T_1, T_2, T_5 was found to be statistically at par with T_8. Harvest index is directly corelated to the seed yield. Increased harvest index was due to better crop growth from early stage to harvest stage. It is the result of reduced vegetative growth in the plants, which in turn results in a lower biological yield and raises the harvest index percentage. Comparable results were by Kumar *et al*.,(2020) [5].

3.3 Economic

Gross returns: The data table 3 shows that significantly highest gross return (63,350.00 INR/ha) was recorded in T_8 (Rhizobium-20g/kg seed+Iron-0.5%)

Net returns: Significantly highest net return (41.900.00INR/ha) was recorded in T_8 (*Rhizobium* - 20g/kg seed + Iron - 0.5%).

Benefit-cost ratio: Significantly highest benefit-cost ratio (1.95) was recorded in T_8 (*Rhizobium* – 20g/kg seed + Iron - 0.5%).

4. CONCLUSION

From the above study it is concluded that the application of *Rhizobium*-20g/kg seed along with foliar application of iron 0.5% (T_8) produced higher yield and benefit cost ratio in Black gram.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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