Influence of Biofertilizers and Gibberellic acid on growth and yield of Blackgram (*Vigna mungo* L.)

Abstract

A field experiment was conducted during *Zaid* 2022 at CRF, (Crop Research Farm), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during Zaid season of 2023. The soil of experimental plot was sandy loam in texture, Basic in soil reaction (pH 7.19), low in organic carbon (0.54%), available N (286.93 kg/ha), available P (21.67 kg/ha), available K (157.12 kg/ha). The treatments included PSB seed inoculation at 10 and 20g/1kg seeds, Rhizobium seeds inoculation at 10 and 20g/1kg seeds and three levels of Gibberellic acid foliar application (50,100 and 150ppm) and control (20:40:20 NPK kg/ha) were used. The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. Maximum plant height (36.03 cm), plant dry weight (6.72 g/plant), Crop growth rate (7.08 $g/m^2/day$), Relative growth rate (0.056 g/g/day), Maximum Pod/plants (21.85), Seeds/pod (4.42),Seed yield (1.12 t/ha), Stover yield (2.03 t/ha) Test weight (34.89 g) and Harvest index (35.63 %) were recorded. Higher Gross returns (84179.17 Rs./ha), Net returns (57761.07 Rs./ha) and Benefit Cost Ratio (2.19) were obtained with application of (PSB 10 and 20g/1kg seeds,Rhizobium 10 and 20g/1kg seeds and Gibberellic acid at 50,100 and 150ppm).

Keywords: Black gram, Gibberellic acid, PSB, Rhizobium, Growth and Yield.

Comment [S1]: Enter the driving factors for conducting this research

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Introduction

Pulses are leguminous crops that constitute an essential part of Indian diet because nearly 43% of Indian vegetarian and pulses are important protein source. However, during last decades pulse production has remained stagnant around 13 to 15 million metric tonnes. Pulses are precursor of essential amino acids and contribute about 14% of total protein of an average Indian diet (ICMR 2009). The United Nations, declared 2016 as "International Year of Pulses" (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition. Pulses are an integrated part to many diets across the globe and they have great potential to improve human health, conserve our soil, protect the environment and contribute to global food security.

Black gram is the cheapest source of protein for the poor and is called the poor men's meat (Main, 1976). It contains approximately 25-28 per cent protein, 4.5-5.5 per cent ash, 0.5-1.5 per cent oil, 3.5-4.5 per cent fibre and 62-65 percent carbohydrate on dry weight basis (Kaul, 1982). Pulses are commonly grown in soilswith low fertility status or with application of low quantities of organic and inorganic sourcesof plant nutrients, which in turn resulted in deterioration of soil health and productivity (Kumpawat, 2010).

Due to high protein and carbohydrate content black gram is used in preparation of Dal makhni in Punjab or the Vada-Sambhar, idli, dosa, utthapa in South India. Apart from this, black gram forms excellent forage and it gives a profuse vegetative growth and covers the ground so well that it checks the soil erosion. It also forms a good silage and green manure crop. It has ability to fix about 22.10 kg of atmospheric nitrogen per hectare through its root nodules.

Besides, this green fodder of urdbean is very nutritive and is especially useful for mulch cattle. Urdbean being leguminous has the capacity to fix atmospheric nitrogen and thus helps in restoring the soil fertility. Blackgram is grown in several parts of Asia and Africa. It is grown in India, Bangladesh, Pakistan, Burma and Ceylon. It is grown all over the country, but the main area of production being Madhya Pradesh, Maharashtra, Karnataka, and west Bengal. It requires warm and humid conditions during growing season. It is generally cultivated as both summer and rainy season crop. Heavy and continuous rains at the time of germination and flowering are harmful for the crop and adversely affect the production.

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 supply imbalance use of nutrients. Proper fertilization is essential to improve the productivity of black gram.

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Pulse can fix atmospheric nitrogen through the symbiotic relationship between the host black gram roots and soil bacteria and thus improves soil fertility. In general, pulses do not require to be provided with external N application. But slow rate of dry matter accumulation during pre-flowering phase, leaf senescence during the period of pod development and low partitioning efficiency of assimilates to grain, which is identified as the main physiological constraints for increasing yield. But, these are also attributed in black gram for as key factors highly responsive to nitrogen. For the pulse crops, nitrogen is most useful because it is the main component of protein. The management of fertilizer greatly affects the growth, development and yield of this crop.

Biofertilizers like (PSB) create plant development ingredients in the soil by saturating insoluble soil phosphates like tri-calcium phosphate. Rhizobium is among the different bio-fertilizers of utmost significance. With the help of legumes, rhizobium fixes atmospheric nitrogen symbiosis. More phosphorus was readily accessible in the soil after PSB inoculation, which encouraged improved root development and produced a positive nodulation effect with higher PSB bacterial activity. The green gram must not suffer from insufficient mineral nutrients, notably nitrogen and phosphorus, in order to maximize the production.

Increased nitrogen fixation might increase output if a productive strain of Rhizobium is introduced to a nitrogen-deficient soil. As inoculants in the root zone of crop plants, phosphorus-solubilizing bacteria partially solubilize the insoluble phosphate and increase phosphorus usage productivity. In addition to helping crops reach their full potential, mineral nutrition is crucial for preserving the soil's viability as an agricultural resource.

Comment [S7]: enter the source of the theory

Gibberellic acid (GA3) is an important PGR that affects plant growth and development by inducing metabolic activities and regulating nitrogen utilization (Sure et al. 2012). It also plays a significant role in seed germination, endosperm mobilization, stem elongation, leaf expansion, reducing the maturation time and increasing flower and fruit set and their composition (Roy & Nasiruddin 2011). GA3 delays senescence, improves growth and development of chloroplasts, and intensifies photosynthetic efficiency which could lead to increased yield (Yuan & Xu 2001). The applications of gibberellins increase the seed germination percentage by attributing the fact that they increase the amino acid content in embryo and cause release of hydrolytic enzyme required for digestion of endospermic starch when seeds renew growth at germination.

Materials and methods

The experiment was conducted during the *Zaid* season 2023, at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.) which is located at 25.4089724 N latitude, 81.8535686 E longitude and 98 m altitude above the mean sea level (MSL). This area is situated on the right side of the Yamuna River of Prayagraj - Rewa road about 12 km from the city. The soil of experimental plot was sandy loam in texture, Basic in soil reaction (pH 7.19), low in organic carbon (0.54%), available N (283.93 kg/ha), available P (21.67 kg/ha), available K (157.12 kg/ha). The treatments included PSB seed inoculation at 10 and 20g/1kg seeds, Rhizobium seeds inoculation at 10 and 20g/1kg seeds and three levels of Gibberellic acid foliar application (50,100 and 150ppm) and control (20:40:20 NPK kg/ha) were used. The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The plots were set up with dimensions of 3 m x 3 m, and seeds of the Shekar-II variety were planted with 30 cm x 10 cm spacing. In determining growth characteristics, the following formulas were used: plant height (cm), dry weight per plant (g), crop growth rate (g/m2/day), and relative growth rate (g/g/day). The crop was completely harvested at the point of physiological maturity, and observations were made, including the number of pods per plant, the number of seeds per pod, the test weight in (g) of 1,000 seeds, the seed yield in tonnes per hectare (t/ha), and the stover yield in tonnes per hectare (t/ha).The growth parameters of the plants were recorded at frequent intervals from Sowing until 60 DAS and finally, the yield parameters were recorded after harvest.

Comment [S8]: complete with a map of the location of the research

Comment [S9]: climate data should be included

Treatment combinations

SI No.	Treatment combinations
1	PSB (20g/1kg seeds) + Gibberellic acid - (50ppm)
2	PSB (20g/1kg seeds) + Gibberellic acid - (100ppm)
3	PSB (20g/1kg seeds) + Gibberellic acid - (150ppm)
4	Rhizobium (20g/1kg seeds) + Gibberellic acid -(50ppm)
5	Rhizobium (20g/1kg seeds) + Gibberellic acid -(100ppm)
6	Rhizobium (20g/1kg seeds) + Gibberellic acid -(150ppm)
7	PSB (10g/1kg seeds) + Rhizobium (10g/1kg seeds) + Gibberellic acid - (50ppm)
8	PSB (10g/1kg seeds) + Rhizobium (10g/1kg seeds) + Gibberellic acid - (100ppm)
9	PSB (10g/1kg seeds) + Rhizobium (10g/1kg seeds) + Gibberellic acid - (150ppm)
10	Control -NPK-20:40:20 kg/ha

Result and Discussion

Growth Parameters

Plant Height (cm)

At 60 DAS, the highest plant height (36.03 cm) was recorded with treatment 9 (PSB 10g/1kg seeds + Rhizobium 10kg/1kg seeds + Gibberelic acid at 150ppm) which was statistically at par to treatment 5 (Rhizobium 20g/1kg seeds + Gibberellic acid at 100ppm) and treatment 6 (Rhizobium 20g/1kg seeds + Gibberellic acid at 150ppm) and treatment 8 (PSB at 10g/1kg seeds + 10g/1kg seeds Rhizobium and Gibberellic acid at 100ppm).

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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.***

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Foliar application of GA3 resulted in significantly higher plant height, number of leaves plant-1, branches plant-1, length of root, total dry matter plant-1, pod length, grains pod-1and test weight in mungbean.

Dry Weight (g/plant)

At 60 DAS, the highest plant dry weight (6.72 g) was recorded with treatment 9 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm). There are no statistically at par values in the treatment combination.

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The fact that the plant's dry weight rose after PSB treatment may be attributable to the strains' enhanced availability of P, which allowed the plant to absorb more P and improve its development characteristics. A comparable outcome was noted by **Kachave *et al*.**

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Plant growth regulators(GA3 and Salicylic acid) applied to black gram plants had significantly increased the plant height,days to maturity and dry weight per plant than control**.**

Crop growth rate (g/m^2/day) and Relative growth rate (g/g/day)

At 45-60 DAS, the highest Crop growth rate (7.08 g/m^2/day) was recorded with treatment 9 with PSB (10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm) which was statistically at par to treatment 6 (Rhizobium 20 g/1kg seeds + Gibberellic acid at

150ppm) and treatment 7 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 50ppm).

At 45-60 DAS, the highest relative growth rate (0.056 g/g/day) was recorded with treatment 7 (PSB 10g/1kg + Rhizobium 10g/1kg + Gibberellic acid at 50ppm) which was statistically at par to treatment 5 (Rhizobium 20g/1kg seeds + Gibberellic acid at 100ppm),treatment 8 (PSB 10g/1kg + Rhizobium 10g/1kg + Gibberellic acid at 100ppm) and treatment 9 (PSB 10g/1kg + Rhizobium 10g/1kg + Gibberellic acid at 150ppm).

The significant and higher crop growth rate noticed with the application of PSB may be attributable to better dry matter accumulation throughout the vegetative and reproductive phases of the plant. This improves physiological and metabolic activity and growth by assimilation of nutrients that are accessible at a greater extent of growth parameters and facilitating more photosynthesis, ultimately resulting in higher crop growth rate. A similar outcome was noted by might all be contributing factors. Similar results lined with by **Hussain *et al*.**

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Yield Parameters

Number of Pods/Plant

From the observations maximum number of pods per plant (21.85) was recorded with treatment 9 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm) which was statistically at par to treatment 6 (Rhizobium 20g/1kg seeds+ Gibberellic acid at 150ppm) and treatment 8 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 100ppm).

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The significant and higher number of pods/plant were observed with the application of rhizobium, this might be due to enhanced nitrogen fixation, thereby increasing the availability of plant efficient growth and development, particularly number of pods/plant. A similar result was concluded by **Kumar *et al*.,**

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The effect of seed treatment and foliar application of Gibberellic acid on mungbean crop. They reported that application of Gibberellic acid had greater number of pods, higher fresh and dry weight of pod**. Hoque and Haque.**

Number of Seeds/Pod

From the observations maximum number of seeds per pod (4.42) was recorded with treatment 9 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm) which was statistically at par to treatment 6 (Rhizobium 20g/1kg seeds + Gibberellic acid at 150ppm).

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The significant and higher number of seeds/pod were observed with application of rhizobium Due to increased nodulation, an extensive root system, and increased metabolite production and translocation to various sinks, particularly the fruiting structures (pods and seeds), the number of pods for each plant may have increased in furtherance to the plant's overall growth. **Ghansyam *et al*.**

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Test Weight (g)

From the observations maximum test weight (34.89 g) was recorded with treatment 9 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm) which was statistically at par to treatment 8 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 100ppm).

Because of PSB application, beneficial effects on the development of extensive root systems that can extract more water and nutrients from the soil and improve plant growth and yield attributes, significant and maximum test weight was seen with PSB application. Similar outcomes were seen by **Pramanik and Singh.**

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Seed or soil inoculation with bio-fertilizers (PSB, VAM and PSB + VAM) significantly enhanced the number of pods/plant, number of grains pod-1, test weight as well as grain and straw yield of urdbean over no inoculation and no significant effect on harvest index **Maya Yadav, Yadav SS, Sunil Kumar, Hansa Kumari Yadav and Pradip Tripura.**

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Seed Yield (t/ha)

From the observations maximum seed yield (1.12 t/ha) was recorded with treatment 9 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm) which was statistically at par to treatment 6 (Rhizobium 20g/1kg seeds + Gibberellic acid at 150ppm).

The bio-fertilizer Rhizobium has been linked to the supply of more plant hormones (auxin, cytokinin, gibberellin, etc.) by the microorganisms injected or by the root as a result of reaction to microbial population, which may be the cause of the increase in seed production with Rhizobium treatment. similar outcomes had been conformity to **Umamaheswari *et al***.

GA3 delays senescence, improves growth and development of chloroplasts, and intensifies photosynthetic efficiency which could lead to increased yield. **Yuan & Xu.**

Stover Yield (t/ha)

From the observations maximum stover yield (2.03 t/ha) was recorded with treatment 9 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm) which was statistically at par to treatment 6 (Rhizobium 20g/1kg seeds + Gibberellic acid at 150ppm).

Possibly as a result of the improved nutritional environment of the rhizosphere and plant system leading to better plant metabolism and photosynthetic activity, plants have grown and developed more in terms of height, branches, and dry matter. **Yadav *et al.***

The increased dry matter buildup and improved root growth brought about by the treatment of PSB and Rhizobium may have contributed to the higher stover output by allowing for maximal nutrient and moisture absorption. The same outcomes were reported by **Rajesh *et al.***

Harvest Index (%)

From the observations Harvest Index (35.63 %) was recorded with treatments 9 (PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm) which was statistically at par to treatment 6 (Rhizobium 20g/1kg seeds + Gibberellic acid at 150ppm).

The combined inoculation of IARI Rhizobium+ IARI PSB with proved one of the most efficient approaches to in increasing in harvest index, nutrient content and uptake (**Sharma *et al.*,**

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Table 1. Influence of Biofertilizers and Gibberellic acid on growth attributes of Blackgram

Treatments	60 DAS		45-60 DAS	
	Plant height (cm)	Dry weight (g/hill)	Crop growth rate ($g/m^2/day$)	Relative growth rate (g/g/day)
1. PSB-20g/1kg + GA3-50ppm	31.77	5.09	4.15	0.039
2. PSB-20g/1kg + GA3-100ppm	32.26	5.22	6.58	0.044
3. PSB-20g/1kg + GA3-150ppm	33.31	5.70	4.92	0.037
4. Rhizobium 20g/1kg + GA3-50ppm	32.88	5.39	5.59	0.035
5. Rhizobium 20g/1kg + GA3-100ppm	34.76	6.09	7.01	0.054
6. Rhizobium 20g/1kg + GA3-150ppm	35.21	6.24	6.77	0.041
7. PSB 10g/1kg + Rhizobium 10g/1kg + GA3-50ppm	34.29	5.76	6.69	0.056
8. PSB 10g/1kg + Rhizobium 10g/1kg + GA3-100ppm	35.73	6.44	5.77	0.049
9. PSB 10g/1kg + Rhizobium 10g/1kg + GA3-150ppm	36.03	6.72	7.08	0.044
10. 20:40:20 NPK kg/ha (Control)	31.25	4.72	5.03	0.039
F test	S	S	S	S
S. Em (±)	0.53	0.05	0.49	0.004
CD (P=0.05)	1.57	0.16	1.45	0.012

Table 2. Influence of Biofertilizers and Gibberellic acid on yield attributes of Blackgram

Treatments	No. of Pods/plant	No. of seeds/pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1. PSB-20g/1kg + GA3-50ppm	18.78	3.30	29.50	0.61	1.51	28.67
2. PSB-20g/1kg + GA3-100ppm	18.89	3.35	31.28	0.66	1.52	30.30
3. PSB-20g/1kg + GA3-150ppm	19.11	3.41	32.02	0.69	1.56	30.85
4. Rhizobium 20g/1kg + GA3-50ppm	20.45	3.52	30.66	0.73	1.78	29.23
5. Rhizobium 20g/1kg + GA3-100ppm	21.00	3.97	33.01	0.92	1.89	32.65
6. Rhizobium 20g/1kg + GA3-150ppm	21.78	4.30	32.70	1.02	1.95	34.35
7. PSB 10g/1kg + Rhizobium 10g/1kg + GA3-50ppm	20.67	3.75	33.01	0.85	1.75	32.66
8. PSB 10g/1kg + Rhizobium 10g/1kg + GA3-100ppm	21.33	3.86	33.96	0.93	1.85	33.47
9. PSB 10g/1kg + Rhizobium 10g/1kg + GA3-150ppm	21.85	4.42	34.89	1.12	2.03	35.63
10. 20:40:20 NPK kg/ha (Control)	18.59	3.20	28.98	0.57	1.45	28.35
F test	S	S	S	S	S	S
S. Em (±)	0.23	0.06	0.59	0.03	0.03	0.51
CD (P=0.05)	0.69	0.18	1.75	0.10	0.09	1.52

Conclusion

The results show that the treatment combination PSB 10g/1kg seeds + Rhizobium 10g/1kg seeds + Gibberellic acid at 150ppm were found more productive (1.12 t/ha) and significantly increased plant height, dry weight, pod number, seed yield, stover yield and harvest index.

Comment [S27]: better complete with data

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