MINI REVIEW

Response of Black Gram (*Vigna mungo* L. Hepper) to Rhizobium, Phosphorus and Nitrogen for Sustainable Agriculture: A Mini Review

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Abstract

Rhizobium microbial bacteria functioning that living a symbiosis relationship soil and leguminous plant root fixation of nitrogen to be utilized by plant superior performance during grain development stage. They can enter into symbiosis with leguminous plant, by infecting their root nodules. The legume crops are the bigger partner, often referred to as macro-symbiotic. Usually certain strains form nodule on the limited legume plants. Such a collection of strain is called cross inoculation group. Legume crops show a decrease in the nitrogenase activities observed in soil, the higher doses of nitrogen reduce nitrogen fixation on one hand and increase cost of production on the other. *Rhizobium* inoculation encourage both nutrient such as Mo and Fe nutrient increasing N-fixation capacity in soil with the effective agronomic practice directly plant root nodulation, nitrogen fixation, vegetative germination, maturity and yield of black gram. It is use of Rhizobium and phosphate solubilising bacteria (PSB) increases nitrogen and phosphorus uptake use efficiency from soil. Lesser efficiency of PSB has been showing through Co-inoculation with another profitable bacteria mycorrhiza. The main used of rhizobia, PSB and improvement of soil fertility and increased of yield of black gram and decrease the use of balance fertilizer.

Keywords: Black gram, *Rhizobium*, Nitrogen, Phosphorus, PSB, Yield.

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Introduction

The production of ravi crop in Punjab in near river of Indus reason and black gram cultivation has also been originate in Egyptain (Skerman *et al*., 1980). A pea seed from Swiss village is believed to reverse the pit era. Paleology confirmations recommend that pea cultivation in approximately 5000 years in Britain nation as the fast 11 century (Pryke 2018). It should be oil yield to soybeans around18%. The new time use and making soybean soil (Salter *et al.,* 2014). The Rhizobium leguminosarum is a bacterium which lives in a mutualistic symbiotic relationship leguminous crop with soil, and has the maximum capability to fix freely nitrogen occure from atmospheric air (Herridge, 2013). It is belongings the family Leguminaceae and used dried grain, seed and other. It is the pulse crop cultivation, mostly for human being used, animals, fodder, silage and as In situ-green manure to enhance fertility status of soil. Rhizobium microbial infected the plant nodule. Have a quantity of energy is consumed by the oxygen with the help of leghemoglobin through N_2 fixing requirement of nitrogenase enzymes is irreparable disable. There are some genera of archaea, and cyanobacteria (BGA) maximum nitrogen fixation. An emblematic quantity of nitrogen remaining behind the legume crops are harvested because at this stage totally consumed nitrogen content in root nodule. The main aim of legume crops there is no use of N_2 fertilizers (Veer *et al* 2021). As one of the most prevalent shortages in soils, nitrogen is one of the elements that plants need to survive. Concerns about few produce of N_2 in soil are raised on a host of environmental fronts. To carry out the process, particular species of rhizobia is needed construct root nodules activity. As a result, the crops produce more. Long-standing agricultural practise of leguminous inoculation has steadily increased soil fertility. *Rhizobium* is a bacterial species that coexists symbiotically together black gram plants root nodules fixation for N_2. As a result, Rhizobium requires a plant host for survive. In agriculture *Rhizobium* suppliers of nitrogen in soil and crop production. It turns nitrogen into hazardous ammonia by converting nitrogen. It is a crucial component of plant nutrition. N gas makes up 78.1% of the atmosphere, but black gram plants are does not utilize (Ferguson *et al*., 2010). The living nitrogen fixation is a loose provenance and deficient for farmers and increase black gram yields (Giller and Cadisch, 1995), Globally, the legume-rhizobia symbiosis provides 33-46 Tg of nitrogen each year and these are the made main significant microorganism procedures in existence (Herridge, 2008). They are twenty one plant bacterial species is recognized root nodule formation as micro-symbionts (Wang *et al*., 2019). Major bacterial genera are host to all of these micro-symbioses such as the alpha-proteobacteria such

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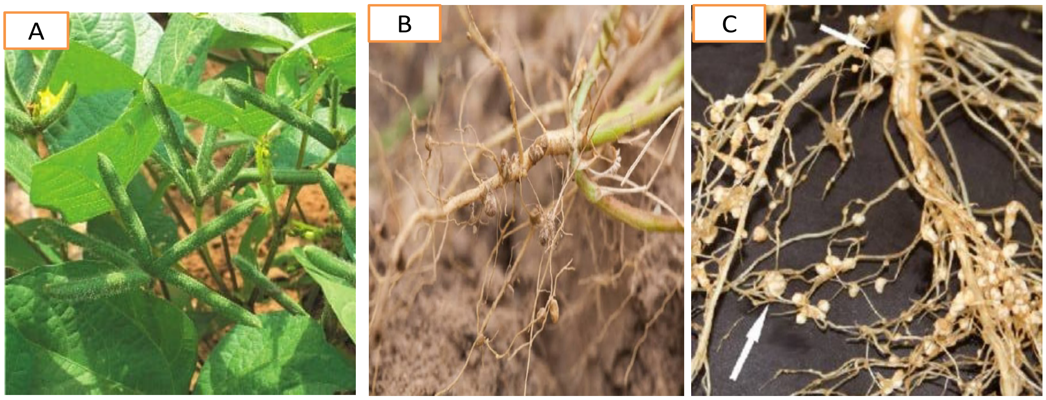

Fig. 1: Impact of Rhizobium on nodulation of Black gram
(A) Black gram crop (B) Black gram without Rhizobium (C) Black gram with Rhizobium (Veer *et al.,* 2021)

as Azorhizobium, Bradyrhizobium, Allorhizobium, *Rhizobium*, Mesorhizobium, Ensifer (Sinorhizobium), Neorhizobium, Pararhizobium and combined the "rhizobia". It can be producing mutualistic relationship together various pulses. Some important pulse crops formation of root nodules requires intricate molecular signalling linking the black gram plants in *Rhizobium* micro-symbiont. (Oldroyd *et al.*, 2011). These are the legumes plants some chemical compound found in rhizoid of flavonoid, seed overcoats and root discharges create the combination of few proteins and initiate the restating genes (Andrews *et al.,* 2017).

Role of *Rhizobium* in Agriculture

Due to rapid population growth and economic increases, agricultural production has approximately tripled. (Kumar et al., 2018). The application of bio-fertilizers not only improves soil physical condition but it also reduces pollution problems, which is necessary to increase production in sequence to connect the rising order. Synthetic fertilizers end up leaving the waste soil, poor soil pollute the nature in addition to being harmful to consumers. The growth and productivity of numerous agricultural crops can be increased by using microalgae as a key component in creating sustainable fertile soil. The root nodules and their future colonization by rhizobia necessary the production of rhizobial nod factors that permit for their identification of black gram crops (Via *et al.*, 2016). The development of upgrade consequence, rhizobia have been compromise in operate connect to induced systemic resistance (ISR) in healthy plants is rule by composite mechanisms; for example, inoculating common bean with Rhizobium to enhanced resistance to induced by Pseudomonas syringaepv phaseolicolavia the collection of conscious, maximum hard productive vitalize of defence related genes (Diaz-Valle and Alvarez-Venegas, 2019). Molecular interactions salicylic acid and jasmonates, and two essential for the activation of genes involved in plant defence, can occur during pathogen infection of the host plants. (Pieterse *et al.,* 2012). Occasion, when a plant occur attacked by insect, complex processes take place that result in the production of salicylic acid and jasmonates, activating genes involved in plant defence. (Hettenhausen *et*

Table.1: Effect of *Rhizobium*, Nitrogen and phosphorus levels on height, branches, no. and dry weight nodules of black gram, (Veer *et al.* 2021)

Treatments	*Plant height (cm)*		*Branches plant^{-1}*		*No. of nodulesplant^{-1}*		*Dry weight of nodules plant^{-1} (mg)*	
	40 DAS	60 DAS	40 DAS	40 DAS	60 DAS	60 DAS	40 DAS	60 DAS
Rhizobium levels								
Uninoculated	30.93	41.29	4.2	6.92	37.57	42.75	71.87	64.28
Inoculated	34.93	46.80	5.4	7.78	41.89	48.179	79.97	70.30
SEm±	0.40	0.43	0.14	0.01	0.33	0.74	0.46	0.85
CD (P=0.05)	1.18	1.28	0.43	0.37	0.99	2.23	1.39	2.54
Nitrogen levels (kg ha-1)								
00	30.34	42.21	4.72	6.82	37.33	44.4	71.07	64.27
15	33.12	44.24	4.86	7.18	40.38	45.45	77.60	68.49
30	34.25	45.67	5.00	8.05	41.48	46.54	79.09	69.14
SEm±	0.50	0.53	0.17	0.14	0.40	0.91	0.59	1.03
CD (P=0.05)	1.43	1.57	0.53	0.45	1.21	2.74	1.70	3.11
Phosphorus levels (kg ha-1)								
00	29.74	41.29	3.96	6.1	36.49	41.82	70.41	62.74
30	33.16	44.08	4.62	7.33	40.4	42.83	76.89	66.93
60	34.81	46.76	6.01	8.62	42.31	51.72	80.46	72.20
SEm±	0.50	0.53	0.17	0.14	0.40	0.91	0.59	1.03
CD (P=0.05)	1.43	1.57	0.53	0.45	1.21	2.74	1.70	3.11

Table 2: Effect of different *Rhizobium* isolates on nodulation and grain yield of black gram

Sr. No.	*Rhizobium isolates*	*No. of Nodules/plant*	*Nodule dry wt / plant(mg)*	*Plant dry wt./ plant(gm)*	*Grain yield (kg/ ha)*	*Reference*
1.	BMBS47	24.33	66.34	4.18	518	Geetanjali *et al.,* (2020)
2.	WUR-12^{-1}	25.80	74.09	4.28	533	Kallimath *et al.,* (2018)
3.	PUR-34	24.00	66.13	4.14	509	Abirami *et al.,* (2018).
4.	RDF + Rhizobium seed inoculation	35.4	39.41	-	1092	Tripathi *et al.,* (2021).
5.	P2+ S3: 40 kg ha^{-1} + 30 kg ha^{-1}	18.56	11.92	6.08	2760	Singh *et al.,* (2020)
6.	PSB + 55 kg P ha^{-1}	43.67	25.35	-	1840	Jayshree *et al.,* (2021)
7.	100 % RDF + LCBF Seed treatment	27.80	0.28	19.80	-	Shravani *et al.,* (2019)
8.	PSB + Rhizobium	28.74	-	11.66	733	Kant *et al.,* (2016)
9.	30 × 10 cm^2 + 40 kg/ha P_2O_5	21.40	5.37	-	854.0	Rashmitha *et al.,* (2021)

Table.3: Effect of Rhizobium isolates and phosphorus doses on Pod length (cm), Number ofPods/plant, Grains/pod, Test weight (g) of black gram

Sr. No.	*Treatments*	*Plants and at harvest*	*Pods/plant*	*Grain/pod*	*Test weight(g)*	*Reference*
1.	T6:20kg$P_2O_5ha^{-1}$+PSB	11.24	34.00	6.60	39.70	Singh *et al.,* (2018)
2.	T8:60kg$P_2O_5ha^{-1}$+PSB	11.69	38.60	8.20	41.20	Singh *et al.,* (2018)
3.	Bio-fertilizer + Black gram (NUL 7)	39.60	27.20	7.60	-	Choudhary *et al.,* (2017)
4.	PSB	33.69	24.01	7.18	37.29	Yadav *et al.,* (2017)
5.	60 Phosphorus levels (kg/ha)	33.27	28.80	8.20	39.85	Kumar *et al.,* (2014)
6.	Rhizobium	14.62	27.57	7.87	23.68	Hussain *et al.,* (2015)

al., 2015; Wang *et al.,* 2019). Furthermore, siderophores made by symbiotic rhizobia and further microorganisms and more than just improve the availability of Fe test plant develop and grain output on legumes. There are different types of role in agriculture and Rhizobium or without in black gram (Fig. 1B and 1C). Due the increased production of leguminous crops and the new discovery of symbiotic relationships between some plants, they are more effective in farming similar to Dhaincha (Sesbania aculeata) nodules, which improve soil fertility at the root and stem.

Use of *Rhizobium* on Growth, Yield and Quality of Black Gram

It reported that the important microbes is capability to change the insoluble phosphorous to an accessible form and maximum attributed characters such as growth and yield, germination, plant height, no. of branches, root nodules, dry matter, no. of pods, test wt. (g), grain yield, straw yield and biological yield of black gram by (Kant *et al.,* 2016). Some important plant characteristics for applied of PSB and Rhizobium as comparison to total other treatments plots (75 kg ha-1 P_2O_5 + PSB + Rhizobium) then both bio-fertilizers are used correct power to plant characters of black gram crops and pulses. (Kachave *et al.,* 2018) These are the results are found PSB and Phosphorus is more achieve for plant growth, yield and quality of legume crops, the applied of 100 percent N_2 +50 kg P_2O_5 ha^{-1} + PSB and application of 100% N + 60 kg ha-1 P_2O_5+ PSB was found to be superior for increase in grain and straw yield followed by 100% N + 50 kg ha^{-1} P_2O_5+ PSB of black gram and also improve the quality of black gram seed in terms of test weight, protein content and protein yield. (Shekhawat *et al.,* 2017) reported that 40 kg ha^{-1} P_2O_5 + 2.5 vermin-compost ha^{-1} + Rhizobium with Phosphorus solubilise bacteria reveal materials of yield higher yield, quality and symbiotic efficiency of black gram. (Tyagi and Singh,2019) reported that the integration of 75 percent RDF + 1 t vermicomposting closely followed by 100 percent RDF + Vermi-compost @ 1.0 t ha^{-1} in terms of plant height (52.1 cm), no. of primary branches $plant^{-1}$ (5.9), total dry biomass accumulation (20.5 g /$plant^{-1}$) at harvest, increase leaf area index (3.11) at 45 DAS, no. of pods $plant^{-1}$ (13.3), no. of seeds pod^{-1} (10.5), 1000 seed weight (37.9 g) When 4 t FYM ha^{-1}+ Rhizobium treatment was used, the minimum values for these parameters were noted. Additionally, application of 100% RDF + Vermi-compost @ 1.0 t ha^{-1} + Rhizobium resulted in greater N, P, and K uptakes by seed (40.9, 4.03, and 9.65 kg ha^{-1}, respectively) and (31.3, 4.29) as well as total uptakes (70.9, 8.32 and 19.9 kg ha^{-1}, respectively). (Choudhary, *et al.*, 2010) noticed that the control yield of mungbean drastically decreased when fertiliser applications of 50 and 100% and inoculations with Rhizobium, Rhizobium + PSB, and Rhizobium + VAM were made. Kumawat *et al.* (2010) were reported to have a favourable reaction to bio-fertilizers on green gram at various fertility levels. The no. of branches $plant^{-1}$ and root nodules $plant^{-1}$ were dramatically enhanced after Rhizobium + PSB inoculation and treatment of 15 kg N+20 kg ha^{-1} P_2O_5 (Elvakumar *et al.*, 2012). It is the release of bio-fertilization perform remarkable black gram plant growth and good quality, it increase seed growth percent of black gram, good dried wt., no. of plant/pods, no. of seed/plant, 100 seed wt. And no. of root nodules/plant was maximum together Rhizobium mostly phosphor-bacterial control then comparison of other treatments. (Sistani *et al.*, 2017) The observation of

Rhizobium symbiosis is good black gram plants unsusceptible sequence and increase the plant resistant opposite to territory. These are the many studies of explore is more profitable in *Rhizobium* spp. and black gram grain quality, plant diseases and root nodules in black gram Fig. 1A.

Effects of Nitrogen, Phosphorus, and *Rhizobium* on the Height of the Black Gram Plant

Data on account height of test crop are summarized in table 1. which shows that different treatments had significantly affected the plant height at 40 DAS and 60 DAS.

Rhizobium inoculation also brought significant impact on plant height^{-1} at stage. Significantly more nodules were recorded in plots where seeds were inoculated with *Rhizobium* than that of un-inoculated plots.

Nitrogen application increased plant height^{-1} per plant^{-1} as compared to control plots and maximum plant height^{-1}(34.25) at 40 DAS and (45.67) at 60 DAS were observed with 30 kg ha^{-1} nitrogen level. This was statistically equivalent to applying 15 kg of nitrogen per hectare. Minimum plant height^{-1} at stages was associated with control during 40 and 60 DAS.

When compared to control plots, phosphorus application raised plant height by one plant per plant, with a maximum increase in plant height^{-1} (34.81) at 40 DAS and (46.76) at 60 DAS were observed with 60 kg ha^{-1} phosphorus level. Over the rest treatment minimum number of plant height^{-1} at stages was associated with control during 40 and 60 DAS. It is the total help by (Dhyani *et al.,* 2011).

The effect of Rhizobium used in black gram crops enhancement production (var. Shekhar- II) with 9 treatments in the Zaid 2021 with many quantity of nitrogen (15 and 25 kg/ha), phosphorus (35 and 45 kg/ha) without and with Rhizobium inoculation (20g/kg of seed), Nitrogen (278.93 kg/ha), available P (14.1 kg/ha), obtainable K (213.4kg/ha). 9 treatments were used in the experiment, with three replications of each treatment using a randomised block design. 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 healthy weight (37.21g) was take down with applied of 25kg N/ha + 45kg P/ha + 20kg K/ha + Rhizobium (20g/kg of seed). (Philip *et al.*, 2021)

Impact of *Rhizobium*, Nitrogen, and Phosphorus on the Number of Branches in the Black Gram Plant

It is the healthy plant height data are reported in Table 1, which demonstrates that the number of branches plant^{-1} had at 40 days after sowing and 60 days after sowing had been considerably impacted by various treatments.

Significant effects on the number of branches in plant^{-1} at stage was also produced by Rhizobium inoculation. Significantly more branches were recorded in plots where seeds were inoculation with Rhizobium than that of un-inoculated plots.

As compared to control plots, nitrogen application maximum number of branches per plant, with the increase number of branches plant^{-1} being recorded at 40 DAS and (8.05) at 60 DAS with nitrogen levels of 30 kg ha^{-1}. Which mathematically is speaking, were equivalent to applying 15 kg N ha^{-1}. Between 40 and 60 days after sowing, the decrease no. of branches plant^{-1} at stages is linked to control.

Impact of Rhizobium, Nitrogen, and Phosphorus on the Number of Nodules of Black Gram Plant

Table 2 provides information on the test crop's nodule and plant related data. Which shows that different treatments had significantly affected the number of nodule plant^{-1} at 40 DAS and 60 DAS.

Rhizobium inoculation also brought significant impact on number of nodule plant^{-1} at stage. Significantly more nodules were recorded in plots where seeds were inoculation with Rhizobium than that of un-inoculated plots (Tripathi 2021).

Nitrogen application increased number of nodule plant^{-1} per plant as comparison to check treatments and increase the number of nodule plant^{-1} (41.48) at 40 DAS and (46.54) at 60 DAS were observed with 30 kg ha^{-1} nitrogen level.

Phosphorus application increased number of nodule plant^{-1} as compared to control plots and maximum number of nodule plant^{-1} (42.31) at 40 DAS and (51.72) at 60 DAS were observed with 60 kg ha^{-1} phosphorus level. Over the rest treatment minimum number of number of nodule plant-at stages were associated with control during 40 and 60 DAS (Rathour *et al.,* 2015.)

Data regarding fresh mass of nodules plant^{-1} at 40 and 60 days after sowing are summarized in an evaluation of the data clearly show that fresh weight of nodules enlarge the maturity of black gram around 40-45 days.

Impact of *Rhizobium*, Nitrogen, and Phosphorus on the Dry Biomass of the Nodules of Black Gram Plant.

The Table 3 summarises information on the dried mass of nodules plant^{-1} at 40 and 60 days after sowing. An exploration of the evidence demonstrates unequivocally that the dried weight of nodules plant^{-1} maximum as crop age advanced up to 40 days.

The dried mass of nodules on plant^{-1} at stage was significantly impacted by rhizobium inoculation as well. Rhizobium seed inoculation plots markedly enlarge the dry mass of nodules compared to uninoculated plots.

Nitrogen application increased dried clump of nodules plant^{-1} per plant as compared to control plots and maximum fresh weight of nodules plant^{-1}(79.09) at 40 DAS and (69.14) at 60 DAS were observed with 30 kg ha^{-1} nitrogen level. It is statistically at par with petition of 15 kg N ha^{-1}. Minimum dry weights of nodules plant^{-1} at stages were associated with control during 40 and 60 DAS.

Phosphorus application increased dried mass of nodules plant^{-1} in comparison to checked treatments and maximum dried weight of nodules plant^{-1} (80.46) at 40 DAS and (72.20) at 60 DAS were observed with 60 kg ha-1 phosphorus level. Over the rest treatment minimum number of dried mass of nodules plant^{-1} at stages were associated with control during 40 and 60 DAS (Tiwari *et al.,* 2015).

Conclusion

With the exception of red kidney bean and rajma, most legume crops fix nitrogen; however using Rhizobium in legumes increases production, soil quality, organic matter, and nitrogen fixation. It is the most significant some micro-organism methods on world, biological nitrogen fix and provides a normally supply of nitrogen and easily used for farmers to boost of black gram yield; globally, the legume-rhizobia symbiosis contributes 33–46 Tg of N^{-1}. The priming effect of Rhizobium symbiosis on the plant's immune system has been demonstrated to increase tolerance to environmental perturbations.

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