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Sonali Rathore
Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Himachal Pradesh, India

Anisha Mathur
Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Himachal Pradesh, India

Shivangi Sood
Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Himachal Pradesh, India

Rakesh Kumar
Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Himachal Pradesh, India

Bhamini
Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Himachal Pradesh, India

Corresponding Author:
Sonali Rathore
Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Himachal Pradesh, India

Impact of phosphorus levels and phosphorus solubilizing bacteria inoculation on growth of black gram (*Vigna mungo* L.)

Sonali Rathore, Anisha Mathur, Shivangi Sood, Rakesh Kumar and Bhamini

Abstract
The current study was set up at the Kakhli Research Farm of the Dr. KSG Akal College of Agriculture, Eternal University, Baru Sahib (HP), during the summer of 2022. The two elements that make up the experiment are phosphorus levels (0, 20, 40, and 60 kg P/ha) and PSB (with and without inoculation), which were combined to create eight treatment combinations that were put out in FRBD and reproduced three times. The phosphorus levels and PSB inoculation had a positive impact on the growth of the characters. According to the findings, growth parameters such as plant height, leaves per plant, branches per plant, dry weight per plant, as well as leaf area index, significantly improved with the application of 60 kg P/ha. These parameters were also increased when seeds were sown after PSB inoculation. It is possible to draw the conclusion that using 60 kg P/ha in conjunction with PSB resulted in statistically improved growth and yield features for black gram when compared to using lower levels and the control.

Keywords: Black gram, growth, inoculation, legume, phosphorus and phosphorous solubilizing bacteria

Introduction
Pulses are the main source of protein in India, where the bulk of the population is vegetarian. In India, significant legumes like the rued bean are grown everywhere. The main crop of legumes in India is the urad bean (*Vigna mungo* L.). The family "Leguminosae" and the genus "Vigna" are the home of Mash, who possesses chromosome number 22. The cultivar that is planted alongside the green gram is significant. India also uses the terms "mush," "purée," and "URD" to describe this culture. Costly self-pollinating legume with a high phosphoric acid content and 24% protein makes up this crop. Iron and calcium are both abundant in URD beans. A brief harvesting period is available for black gram. Black gram was largely developed in Central Asia and India. It may flourish in both thin and dense soil. It prefers nutrient-rich, moisture-retaining soils. It drains effectively in thick soils with a pH range of 5.0 to 7.5. Alkaline or salty surroundings are not suitable for it to survive. The plant can be used to produce high-quality dry or green food when the pods are harvested. A variety of cross-crop and multi-crop systems can use it. Pulses play a unique role in the farming system as a primary, medium, cover crop, green manure, and intermediate crop. The average production of Urdu beans is low because they are mismanaged and insufficiently resourced.
Black gram has a remarkable potential production that can be realized by employing careful management approaches. Non-financial factors such as the right type, planting time, and plant density are essential to achieving simultaneous maturation and high yield of URD bean. In essence, black gram is a crop that likes the heat. Grows up to 1800 mm tall at sea level and is found in areas with annual rainfall of 600-1000 mm. Both irrigated and rain-fed crops can be used to cultivate black gram throughout the year. It is mostly grown in wet conditions on bare ground in a monoculture mixed system without any fertilizers, which results in relatively small yield differences that may be managed by giving plants a full and balanced supply of nutrients (Rathore *et al.*, 2010) [9]. Low yields in farmer fields are mostly caused by the continued use of conventional cultivars with limited potential, low sowing rates, and poor agronomic practices. The biggest restriction on plant growth is the amount of personality, which also helps clear the way for the dispersal of the black gram seed.
In order for plants to develop and flourish at their best, phosphorus is the most important nutrient. Only 0.1% of the P that makes up a typical soil's 0.5% P content may be utilized by crops.

It is essential to the production of pulses because of its significant influence on root development and subsequent role in fixing atmospheric nitrogen (Nair, 1985) [5]. Phosphorus is essential for photosynthesis, cell division, the production of meristems in living tissues, seed quality, and the majority of physicochemical activities. It also promotes nodules, helps fix nitrogen, and aids in healthy root development. P promotes the fixation of nitrogen by symbiotic organisms. Bacterial cells must become mobile in order to travel to the roots of the node (Charel, 2006) [1], and this is what drives this process. By supplying more phosphorus and encouraging crop growth, the ratio of starch and sucrose in the original leaves and reproductive organs can be controlled. The favorable effects of phosphorus on plant fruiting and improved distribution of the essential metabolites to the harvesting regions of plants may be associated to increased grain yields. Some of the crops that can be treated with PSB (Phosphorus Solubilizing Bacteria) include rice, millet, oilseeds, legumes, and vegetables.

These beneficial microbes have the ability to convert insoluble phosphorus into soluble molecules. A new phosphate bio fertilizer called PSB has been introduced to agriculture. It is crucial for solubilizing soil phosphorus by the use of many organic acids so that plants can access it (Gaur, 1991) [2]. Additionally, the environmental damage caused by excessive fertilizer use is reduced by the use of PSB. Phosphorus application in PSB boosted plant productivity and phosphorus uptake. This exemplifies how PSB could degrade phosphorus and transfer it to crops. When PSB is mixed with rock phosphate, the need for crop phosphate fertilizers can be reduced by around 5%. By using PSB with phosphatase catalysis potential, phosphorus can be broken down.

Material and Method

The current research, titled "Growth and yield of black gram (*Vigna mungo* L.) as influenced by levels of phosphorus and phosphorus solubilizing bacteria inoculation," was carried out at the Dr. Khem Singh Gill Akal College of Agriculture's Experimental Research Farm in Kakhli throughout the summer. The following lists the specific material and method employed during the study process. Eight different treatment combinations were used in the experiment, and each treatment was repeated three times. The experiment consists of two variables: PSB (0, 20, 40, and 60 Kg P/ha) and PSB (with and without inoculation).

Result and Discussion

Effect of phosphorous levels on growth

The growth parameter of black gram was influenced significantly due to phosphorus levels. Black gram crop noted statically maximum growth characters i.e., plant height, leaves/plant, branch/plant, and weight of dry plant/plant, nodules/plant weight of dried nodules and LAI at 30and 60 days after sowing and at harvesting.

The various phosphorus levels prejudiced the plant/height at growth stages (30, 60 DAS and harvest). The plant height was noted highest in P_3 (60 kg of P/ha) than the other treatments and the minimum was noted with the control. The improvement in plant eight because of higher dose of phosphorus can be ascribed to better root proliferation which ultimately increases the plant height. These results were similar with Singh *et al.* (2020) [11], Parashar *et al.* (2020) [7], Singh *et al.* (2014) [14] and Mir *et al.* (2013) [4].

The different P levels on growth stages were significantly influenced. Treatment P_3 (60 kg P/ha) recorded higher leaves/plant, branches/plant as compare to other treatment and the lowest were notedwithP_0 (0 kg P/ha). It is because of the involvement of phosphorus in cell division cell development. The results were similar with Mir *et al.* (2013) [4] and Parashar *et al.* (2020) [7].

The leaves/plant, total branches/plant, dry weight/plant and LAI was statically influenced due to levels of phosphorus. The upper most values of these parameters were noted under P_3 (60 kg P/ha) and minimum values of these parameters was noted under P_0 (0 Kg P/ha). This is due to higher nutrient absorption may have increased photosynthesis and carbohydrate synthesis then translocate to various parts to promote meristem growth in potential apical shoots and meristems between the layers eventually give rise to roots and shoots growth according to all growth parameters. In addition to the solubilization of phosphates, these microorganisms can be mineralized Makes organic phosphorus soluble. Similar result was noted by Singh *et al.* (2008) [13], Mir *et al.* (2013) [4], Pathania, Sharma (2019) [10], Parashar *et al.* (2020) [7] and Singh *et al.* (2020) [11].

The combined result of P levels and inoculation of phosphorus solubilizing bacteria was noted significant and the result revealed that the treatment P_3B_1 (60kg P/ha+ with PSB inoculation) recorded maximum height at various intervals (30, 60, DAS and harvest) and the minimum plant height with the treatment P_0B_0 (0kg P/ha+ without PSB inoculation). Plant height increased due to well nutritional environment in root zone.

Effect of PSB on growth

Height of plants, leaves/plant, total branches/plant, total nodule/plant and weight of dry nodules/plant and LAI was statically influenced due to PSB inoculation. The maximum growth characters were recorded in the treatment B_1 (with PSB inoculation) and the minimum was recorded under the treatment B_0 (without PSB). It might be due to PSB produces fungal and growth promoting substances that affects plant growth. Phosphorus increases growth properties, which aids in early development of root, the creation of lateral fibers, healthy roots, with proliferation. P boosts metabolic activity as well as the amount of naturally produced phytohormones in the body. PSB strains produced more accessible P, allowing the plant to absorb more, leading in better growth characteristics. A similar result had been also noted by Mir, *et al.* (2013) [4], Kant, *et al.* (2016) [3] and Singh, *et al.* (2020) [11].

Table 1: Effect of P levels and PSB inoculation on plant height and Dry matter/plant

S. No.	Treatments	Plant Height(cm)			Dry Matter/Plant		
		30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
A	**Phosphorus Levels**						
	P_0- 0 Kg P/ha	15.36	34.28	45.67	3.50	11.17	13.47
	P_1- 20 Kg P/ha	15.67	34.90	46.11	3.62	11.33	14.01
	P_2- 40 Kg P/ha	16.81	35.95	46.69	3.89	11.95	14.43
	P_3- 60 Kg P/ha	18.17	37.65	48.32	4.46	12.98	15.42
	S.Em±	0.08	0.11	0.04	0.03	0.038	0.053
	$CD_{0.05}$	0.24	0.33	0.12	0.11	0.11	0.16
B	**PSB Inoculation**						
	B_0	16.24	35.28	46.54	3.80	11.70	14.15
	B_1	16.77	36.11	46.85	3.94	12.02	14.51
	S.Em±	0.05	0.08	0.02	0.02	0.02	0.03
	$CD_{0.05}$	0.16	0.24	0.08	0.07	0.08	0.11

Table 2: Effect of P levels and PSB on leaves/plant, branches/plant and LAI at harvest

S. No	Treatments	Leaves/Plant	Branches/Plant	Leaf Area Index
A	**Phosphorus levels**			
	P_0- 0 kg P/ha	10.45	4.44	0.81
	P_1- 20 kg P/ha	11.64	4.73	0.83
	P_2- 40 kg P/ha	11.87	5.12	0.86
	P_3- 60 kg P/ha	11.92	5.43	0.88
	S.Em±	0.07	0.05	0.003
	$CD_{0.05}$	0.20	0.15	0.008
B	**PSB inoculation**			
	B_0	11.39	4.84	0.84
	B_1	11.55	5.01	0.85
	S.Em±	0.05	0.035	0.002
	$CD_{0.05}$	0.15	0.10	0.006

Conclusion

It was inferred from this trial that application of 60 kg P/ha with PSB inoculation resulted in maximum growth along with highest net return and B/C ratio of black gram (Himachal mash 1).

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