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Effect of Phosphate Solubulizing Bacteria (PSB) and Levels of Phosphorus on Growth and Yield of Greengram (*Vigna radiata* L.)

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ABSTRACT: The present study aimed to evaluate the effect of phosphate solubulizing bacteria and phosphorus levels on growth and yield of greengram (var. "WGG-42") conducted during the *kharif* 2020 at Prakasam Krishi Vigyan Kendra (KVK), Jayaprakashnagar, Jammikunta, Karimnagar District-505122 Telangana. The experiment was laid out in Randomized Block Design with 9 treatments which included 3 levels of PSB (0%, 0.5% and 1%) and 3 levels of phosphorus (20kg, 40kg and 60kg) which replicated thrice. The treatment receiving PSB 1% and 20kg phosphorus produced significantly higher plant height (40.17cm), number of nodules/plant (21.73), number of branches/plant (5.93), plant dry weight (8.90g), crop growth Rate (4.51g/m^2/day), relative growth rate (0.017g/g/day), number of pods/plant (37.70), test weight (37.70g), seed yield (1440.00kg/ha), stover yield (2400.66kg/ha), harvest index (40.02), gross return (97,920.00 INR/ha) net return (69,964.60 INR/ha), and B:C ratio (2.50). This experiment shows treatment receiving PSB 1% and 20kg phosphorus was more productive and economic.

Keywords: Mungbean, PSB and phosphorus.

INTRODUCTION

Pulses stand a strategic position in the agriculture economy of our country, India is the largest producer (25% global production) consumers (27% of world consumption) and importer (14%) of pulses in the world, It is cultivated in both *kharif* and *zaid* by farmers, Mungbean contains about 24.3% protein and it is a good source of riboflavin and thiamine, It is a good green manure and erosion resisting cover crop, crop also improves soil fertility by symbiotic fixation of atmospheric nitrogen and the grains mainly used as dal or to make flour, But the present, the actual consumption however is much less at around 30-35 gram.

Pulses play an important role in Indian Agriculture as they restore soil fertility by fixing atmospheric nitrogen through their nodules. Pulses are less water requiring crop. Because of these good characters; pulses are called as "Marvel of Nature Pulses" can also be referred to as mini fertilizer factory, as they fix atmospheric nitrogen through symbiotic nitrogen fixation (Solaiman *et al*., 1997). Pulses are cheaper than meat; they are often referred to as "poor man's meat" in developing countries like India.

Indian soils are poor to medium in available phosphorus. Only about 30 per cent of the applied phosphorus is available for crops and remaining part converted into insoluble phosphorus. Phosphorus fertilization occupies an important place amongst the non-renewable inputs in modern agriculture. Crop recovery of added phosphorus seldom exceeds 20 per cent and it may be improve by the judicious management. As the concentration of available P in the soil solution is normally insufficient to support the plant growth, continual replacement of soluble P from inorganic and organic sources is necessary to meet the P requirements of crop.

Phosphorus plays pivotal structural and regulatory role at the nexus of photosynthesis, root development, energy conservation and transformation, carbon metabolism, enzyme activation and nucleic acid synthesis.

Phosphorus is important plant nutrient, the role of phosphorus is well documented that increases root proliferation and it plays a key role in root growth and dry matter production, nodulation and nitrogen fixation and also in metabolic activities especially in protein synthesis, it also helps in establishing seedling quickly and also hastens maturity and improves crop production.

Among different production practices, fertilizer management is one of the important agronomic practices for increasing crop yield and maintaining soil fertility. Growth and development of crops depend largely on the development of root system. Phosphorus (P) is one of the most important elements among the three macronutrients that plants must require for the better growth and development.

Phosphate Solubulizing Bacteria (PSB) plays an important role in solubulization of soil P through secretion of various organic acids and helps to available for plants by the use of PSB decreases the environmental pollution which is caused by the use of chemical fertilizers, by the combination of Phosphorus and PSB, the plants uptake more Phosphorus.

The PSB like *Pseudomonas* and *Bacillus* also enhances the availability of phosphorus to the plant by converting insoluble phosphorus from the soil in the soluble form, the inoculation with phosphate solubilizing bacteria (PSB) plays a vital role in solubilisation of various inorganic and organic phosphates added to the soil PSB may also release soluble phosphate in to the soil through the decomposition of phosphate from organic compounds since the culture of PSB is very cheap it would prove to be an effective low cost technology to farmer in cutting down the fertilizer expenses.

MATERIALS AND METHODS

The experiment was laid out during *kharif* at prakasam Krishi Vigyan Kendra (KVK), Jayaprakashnagar, Jammikunta, Karimnagar District-505122 Telangana State. Which was situated in the altitude of 243.4m above main sea level on 18°49′40"N latitude and 78°5′45"E longitude and soil having basic soil pH (6.83), organic carbon (0.62%), N (197.12 kg/ha), P (31.21 kg/ha) and K (198.71 kg/ha) is available. Treatment comprised of T_1- PSB-0% + Phosphorus-20kg/ha, T_2- PSB-0% + Phosphorus-40 kg/ha, T_3 -PSB-0% + Phosphorus-60 kg/ha, T_4-PSB-0.5% + Phosphorus-20 kg/ha, T_5- PSB-0.5% + Phosphorus-40 kg/ha, T_6 - PSB-0.5% + Phosphorus-60 kg/ha, T_7- PSB-1% + Phosphorus-20 kg/ha, T_8- PSB-1% + Phosphorus-40 kg/ha, T_9-PSB-1% + Phosphorus-60 kg/ha. These were replicated thrice on Randomized Block Design recommended dose of fertilizers was applied in the form of urea, SSP, MOP in the time of sowing. Seeds were placed in row-row spacing 30cm and plant to plant 10cm.

Note: Seeds of green gram were soaked in prepared PSB solution 8 – 12 hours before sowing.

RESULT AND DISCUSSION

A. Growth attributes

Plant height: The highest plant height was observed at 75 DAS with the application of PSB - 1% + Phosphorus-20 kg/ha (40.17cm) which is significantly superior over all the treatments except with the application of PSB - 0.5% + Phosphorus-40 kg/ha (39.65). The probable reason for increasing plant height for better root proliferation and increasing of Phosphorus increases nodulation. Which help in better utilization of nitrogen, which helps towards higher growth attributes. The results are reported with the Chovatia *et al*., (1993), Srinivas and Mohammad (2002).

Number of Branches/plant: At 75 DAS the highest number of Branches/plant was observed by the applying of PSB -1% + Phosphorus-20 kg/ha (5.93) which is significantly superior over all the treatments except by the application of PSB-0.5% + Phosphorus-40 kg/ha (5.80) and PSB-1% + Phosphorus-40 kg/ha (5.73). Phosphorus fertilization encouraged the new cells formation, promted plant vigour and hastened development of leaf, the utilization of nitrogen resulting in more number of branches and plant spread. These finding are revealed by Chaudhary *et al.* (2003). Microorganisms with Phosphate solubulizing potential increase the availability of soluble phosphate and improves plant growth by improving biological nitrogen fixation. Almost identical findings were revealed by Kucey *et al*., (1989); Ponmurugan and Gopi (2006); Devi *et al*., (2012).

Fig. 1. Recording of plant observations at research field.

No. of nodules/plant: At 75 DAS the highest No. of nodules/plant were recorded by the applying of PSB - 1% + Phosphorus-20 kg/ha (21.73) which is significantly superior over all the treatments except with the application of PSB - 0.5% + Phosphorus-40 kg/ha (21.50) and PSB – 1% + Phosphorus-40 kg/ha (21.50), PSB – 0.5% + Phosphorus-60 kg/ha (21.30), PSB –0.5% + Phosphorus-20 kg/ha (20.97), PSB – 1% + Phosphorus-60 kg/ha (20.97). The supply of P is limit, the availability of P and N affect the photosynthetic process as well as photosynthate supply of nodules. The effect of P could be related to the finding by that it stimulates root growth and activity and nodule formation Escalante *et al.*, (2014). Higher No. of nodules/plant at a higher P levels may be gives better growth, which helps for nodule formation. Similar observations were reported by Singh *et al*., (1994).

Dry weight: At 75 DAS the highest Dry weight was observed by application of PSB – 1% + Phosphorus-20 kg/ha (8.90 g/plant) which is significantly superior over all the treatments except with the application of PSB – 0.5% + Phosphorus-40 kg/ha (8.83 g/plant), PSB – 1% + Phosphorus-40 kg/ha (8.81 g/plant) and PSB – 0.5% + Phosphorus-60 kg/ha (8.67 g/plant). Component of the key molecules is P, plant grow better with the supply of this nutrients. Phosphorus is also involved in the enzyme reactions control (Theodorou and Plaxton 1993). Similar outcome was also revealed by Srinivas and Mohammad (2002); Yadav, (2004).

Crop growth rate: At 60-75 DAS the highest CGR was observed by application of PSB – 1% + Phosphorus-20 kg/ha (4.51 g/m^2/day) which is significantly superior over all the treatments except with the application of PSB – 0.5% + Phosphorus-40 kg/ha (4.47 g/m^2/day), PSB – 1% + Phosphorus-40 kg/ha (4.41 g/m^2/day), PSB – 0.5% + Phosphorus-60 kg/ha (4.41 g/m^2/day), PSB – 0.5% + Phosphorus-20 kg/ha (3.94 g/m^2/day), PSB – 1% + Phosphorus-60 kg/ha (3.94 g/m^2/day) and PSB – 0% + Phosphorus-60 kg/ha (4.28 g/m^2/day). Phosphorus helps in the new cells forming, promote plant vigour and go fast development of leaf, which uses the nitrogen better, which helps to higher growth attributes. The result is revealed by Chovatia *et al.*, (1993); Srinivas and Mohammad (2002). Microorganisms which are with phosphate solubulizing potential increase the soluble

phosphate availability and enhance the plant growth by improves biological nitrogen fixation. Similar findings were revealed by Kucey *et al.,* (1989), Ponmurugan and Gopi (2006); Devi *et al*. (2012).

Relative growth rate: At 60-75 DAS the highest relative growth rate was observed with the application of PSB – 1% + Phosphorus-20 kg/ha (0.017g/g/day), PSB – 1% + Phosphorus-40 kg/ha (0.017 g/g/day), PSB – 0.5% + Phosphorus-20 kg/ha (0.017 g/g/day) and PSB – 0.5% + Phosphorus-40 kg/ha (0.017 g/g/day) which is significantly superior over all the treatments except with the application of PSB – 0% + Phosphorus-60 kg/ha (0.016 g/g/day), PSB – 1% + Phosphorus-60 kg/ha (0.016 g/g/day) and lowest in PSB – 0% + Phosphorus-20 kg/ha (0.012 g/g/day), PSB – 0% + Phosphorus-40 kg/ha (0.012 g/g/day).

B. Yield Attributes and yield

Pods/plant: The highest number of pods/plant was recorded with the application of PSB - 1% + Phosphorus-20kg/ha (37.70) which is significantly superior over all the treatments except with the application of PSB-0.5% + Phoshorus-40 kg/ha (37.09) and PSB - 1% + Phosphorus-40 kg/ha (36.92).

Test weight: The highest test weight was recorded by the applying of PSB – 1% + Phoshporus-20 kg/ha (37.70g) which is superior over all the treatments except with the application of PSB – 0.5% + 40 kg-Phosphorus/ha (37.09g), PSB – 1% + Phosphorus-40 kg/ha (36.92g), PSB – 0.5% + Phosphorus-60 kg/ha (36.30g), PSB – 1% + Phosphorus-60 kg/ha (35.95g), PSB – 0.5% + Phosphorus-20 kg/ha (35.67g) and PSB – 0% + Phosphorus-60 kg/ha (35.36g) and lowest was observed in PSB – 0% + Phosphorus-20 kg/ha (34.83g).

Seed yield: The highest Seed yield was recorded by the application of PSB – 1% + Phosphorus-20 kg/ha (1440.00 kg) which is superior over all the treatments except with the application of PSB – 0.5% + Phosphorus-40 kg/ha (1373.33 kg), PSB – 1% + Phosphorus-40 kg/ha (1343.33 kg), PSB – 0.5% + Phosphorus-60 kg/ha (1246.66 kg) and lowest seed yield was observed in PSB – 0% + Phosphorus-20 kg/ha (1113.33 kg).

Stover yield: The highest stover yield was noted by the applying of PSB – 1% + 20 kg-Phosphorus/ha (2400.66 kg) which is superior over all the treatments except with the application of PSB – 0.5% + Phosphorus-40 kg/ha (2133.33 kg) and PSB – 1% + Phosphorus-40 kg/ha (2106.66 kg).

Harvest index: The highest harvest index was noted by the applying of PSB – 1% + 20 kg-Phosphorus/ha (40.02) which is superior over all the treatments except with the application of PSB – 0.5% + Phosphorus-40 kg/ha (39.43) and lowest was observed in PSB – 0% + Phosphorus-20 kg/ha (36.27).

The total number of pods/plant, test weight, Seed yield and stover yield might be due to increased availability of P which favored nodule formation, higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of other nutrients. Same results were revealed by Praveen *et al.,* (2002); Balachandran *et al.,* (2005); Prasad *et al.,* (2014) and Choudary *et al.,* (2014). The increase availability of P have increases the root growth and nodulation there by surged nitrogen fixation. The increased availability of N, P and their synergistic effect might have caused better dry matter accumulation and as a result increase in the value of above growth parameters was observed. Similar observation was also made by Mitra *et al.,* (1999); Perveen *et al.,* (2002). The favorable effect of phosphorus application on number of pods/plant, test weight characters were mainly due to its primary role in photosynthesis by way of rapid energy transfer and there by increases affects various biochemical process from the beginning of seedling growth through to the formation of grain and maturity. It also a component of RNA, the compound that reads the DNA genetic code to build proteins and other compounds essential for plant structure, seed yield and genetic transfer. These results are in the line with Chowdary *et al.,* (2003) ; Yadav (2004).

Table 1: Effect of Phosphate Solubulizing Bacteria (PSB) and Phosphorus levels on growth attributes of Mungbean.

Treatments	Plant height (cm)	Number of Branches/plant	Number of Nodules/plant	Dry weight (g)	Crop growth rate ($g/m^2/day$)	Relative growth rate (g/g/day)
T_1 - PSB-0% + Phosphorus-20kg/ha	36.23	5.20	19.17	7.85	2.90	0.012
T_2- PSB-0% + Phosphorus-40kg/ha	36.55	5.27	19.73	7.91	2.88	0.012
T_3 - PSB-0% + Phosphorus-60kg/ha	37.17	5.47	19.83	8.50	4.28	0.016
T_4 - PSB-0.5% + Phosphorus-20kg/ha	37.66	5.60	20.97	8.54	3.94	0.017
T_5 - PSB-0.5% + Phosphorus-40kg/ha	39.56	5.80	21.50	8.83	4.47	0.017
T_6 - PSB-0.5% + Phosphorus-60kg/ha	38.55	5.67	21.30	8.67	4.41	0.015
T_7 - PSB-1% + Phosphorus-20kg/ha	40.17	5.93	21.73	8.90	4.51	0.017
T_8 - PSB-1% + Phosphorus-40kg/ha	38.67	5.73	21.50	8.81	4.41	0.017
T_9 - PSB-1% + Phosphorus-60kg/ha	38.19	5.60	20.97	8.63	3.94	0.016
F test	S	S	S	S	S	S
SEm (±)	0.25	0.07	0.43	0.08	0.22	0.0009
CD (5%)	0.76	0.20	1.29	0.24	0.66	0.002

Table 2: Effect of Phosphate Solubulizing Bacteria (PSB) and levels of Phosphorus on yield attributes of Mungbean.

Treatments	Pods/plant	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index
T_1- PSB – 0% + Phosphorus-20 kg/ha	34.83	33.56	1113.33	1956.66	36.27
T_2- PSB – 0% + Phosphorus-40 kg/ha	35.36	34.83	1153.33	1940.00	36.63
T_3 - PSB - 0% + Phosphorus-60 kg/ha	35.67	35.36	1173.33	1973.33	36.77
T_4 – PSB – 0.5% + Phosphorus-20 kg/ha	35.67	35.67	1156.66	2000.66	37.28
T_5 – PSB – 0.5% + Phosphorus-40 kg/ha	37.09	37.09	1373.33	2133.33	39.46
T_6– PSB – 0.5% + Phosphorus-60 kg/ha	36.30	36.30	1246.66	2050.00	37.93
T_7 – PSB – 1% + Phosphorus-20 kg/ha	37.70	37.70	1440.00	2400.66	40.02
T_8– PSB – 1% + Phosphorus-40 kg/ha	36.92	36.92	1343.33	2106.66	38.63
T_9 – PSB – 1% + Phosphorus-60 kg/ha	35.95	35.95	1193.33	2040.00	37.29
F test	S	S	S	S	S
SEm (±)	0.86	0.84	79.45	104.49	0.34
CD (5%)	2.58	2.51	233.05	306.48	1.02

Table 3: Effect of Phosphate Solubulizing Bacteria (PSB) and Phosphorus levels on economics of Mungbean.

Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
T_1 - PSB – 0% + Phosphorus-20 kg/ha	25,755.40	75,684.00	49,928.60	1.93
T_2 – PSB – 0% + Phosphorus-40 kg/ha	25,995.40	78,404.00	52,408.60	2.01
T_3 – PSB – 0% + Phosphorus-60 kg/ha	26,235.40	79,764.00	53,528.60	2.04
T_4 – PSB – 0.5% + Phosphorus-20 kg/ha	26,855.40	78,604.00	51,748.60	1.92
T_5 – PSB – 0.5% + Phosphorus-40 kg/ha	27,095.40	93,500.00	66,404.60	2.45
T_6 – PSB – 0.5% + Phosphorus-60 kg/ha	27,335.40	84,728.00	57,392.60	2.09
T_7 – PSB – 1% + Phosphorus-20 kg/ha	27,955.40	97,920.00	69,964.60	2.50
T_8 - PSB – 1% + Phosphorus-40 kg/ha	28,195.40	91,324.00	63,128.60	2.23
T_9 – PSB – 1% + Phosphorus-60 kg/ha	28,435.40	81,124.00	52,688.60	1.85

Effect of PSB and Phosphorus levels on Economics of Mungbean: By the applying of PSB – 1% + Phosphorus-20 kg/ha was recorded the maximum Gross return (97,920 INR/ha), Net return (69,964.6 INR/ha) and B:C ratio (2.50) which is superior over all the treatments.

CONCLUSION

Based on the findings it may be concluded that for optimum Seed yield and economics, the performance of Mungbean at PSB – 1% + Phosphorus – 20kg/ha is the best. The conclusion drawn based on the one season data only which require further conformation for recommendation.

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Conflict of interest. Nil.

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