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Response of Phosphorus levels and Bio-fertilizers on the growth, yield and economics of green gram (*Vigna radiata* L. Wilczek)

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ABSTRACT

The field experiment was conducted during the *kharif* season of 2022 at the Crop Research Centre, School of Agriculture, ITM University, Gwalior, (M.P.) to investigate the effect of phosphorus levels and biofertilizers on growth and yield of green gram. The experiment consists of three levels of phosphorus (20, 40, 60 P_2O_5ha^{-1}) and three treatments of biofertilizers (PSB, *Rhizobium* and PSB + *Rhizobium*) and absolute control was laid out in Factorial randomized block design with three replications. The results revealed that application of 60 kg P_2O_5 ha^{-1} recorded significantly highest plant height, number of leaves plant^{-1}, number of primary and secondary branches plant^{-1}, number of nodules plant^{-1}, weight of nodules plant^{-1} and dry matter accumulation plant^{-1} and seed yield and it was found at par with 40 kg P_2O_5ha^{-1} and in biofertilizers when PSB + *Rhizobium*is combined used resulted in highest growth attributes and yield of green gram. Thus, for green gram cultivation, application of 60 kg ha^{-1} phosphorus and treatment of Phosphate solubilizing bacteria + *Rhizobium* (was found to be most promising treatment in enhancing the yield in green gram. Among all the treatment combinations, T_{10}- treatment recorded maximum value of gross return, net return and benefit cost ratio.

Key words: *Biofertilizers, Green gram, Phosphorus, Growth, Yield.*

Introduction

India is the world's largest producer and consumer of pulse crop. It contributes about a quarter to the world's total pulse production. While one-third of world's total acreage under pulses is in India, pulses play a vital role in Indian food chain particularly for vegetarians and contribute about 14 % of the total protein of average Indian diet. Production of pulses in the country is far below the requirement to meet even the minimum level per capita consumption.

Green gram (*Vigna radiata* L. Wilczek) is one of the major pulses grown during *kharif* (rainy season) and summer seasons, while in South India it is grown in *Rabi* season also. It is the richest source of 24 % protein, 60 % carbohydrate, and 1.3 % fat, phosphoric acid and vitamins. Green gram is self-pollinated crop, with epigeal germination type. It controls soil erosion and competes with weeds effectively due to its deep root system and foliage cover. It fixes atmospheric nitrogen into the soil and improved the soil fertility. But there exists a vast gap between potential productivity and actual productivity of black gram. So, to meet it, proper fertilization is essential. Although, the crop can meet its nitrogen requirements by symbiotic fixation of atmo-

spheric nitrogen. The nutrients which need attention is phosphorus (Thakur and Negi, 1985; Nandal, *et al*., 1987). Green gram being a leguminous crop, requires adequate amount of phosphorus and biofertilizers as well as apart from other nutrients these are directly involved in growth and development of plant.

Phosphorus is essential constituent of every living cell. It plays a key role in photosynthesis, metabolism of sugars, energy storage and transfer, cell division, cell enlargement, transfer of genetic information, root growth, nodulation and nitrogen fixation in plants. It promotes the development of roots, seed formation, and gives strength to straw, hastens maturity of crops, and increases ratio of grain to straw. It was reported that, 80 per cent of the Indian soils need P application (Motsara, 2002) at recommended rates, whereas, the application of some quantity of P fertilizers would be essential to arrest P mining from the soils so as to sustain high yield of crops

Biofertilizers are living cells of different types of microorganism (bacteria, algae, fungi), which have an abilityto mobilize nutritionally important elements from non-usable to usable form. They help to provide and keep the soil with all the minerals and microorganisms required for plant growth. They can be applied to seed, root or to soil and are cost effective, eco-friendly and renewable source of p lant nutrients to supplement chemical fertilizers in sustainable agricultural system in India. The nutritional requirement of pulses is similar tocereal but due to the unique feature of biological nitrogen fixation only 20 kgha^{-1} nitrogen is recommended. *Rhizobium* is the bacteria which are involve in symbiotic biological nitrogen fixation. The role of microorganisms in solubilizing inorganic phosphates in soil and making them available to plants is well known (Barroso *et al.,* 2006). These micro-organisms bring about solubilization by the production of organic acid and phosphate enzyme activity. As regards phosphate only about 15-20 percent of the applied phosphorous isutilized by first crop. The phosphate solubilizing Bacteria (PSB), dissolving interlocked pho sphates appear to have an important implication in Indian agriculture (Alikhani *et al.,* 2006). Therefore, inoculation of green gram seeds with biofertilizers increase the uptake of NPK from the soil which in turn increases the protein as well as nutrient content in the seeds thereby, enhancing the production of green gram. Similarly, inoculating of black gram seeds with Phosphate Solubilizing Bacteria (PSB) play a vital role in supplementing of phosphorus required by the crop. Thus, use of adequate phosphorus fertilizers along with correct strain of bio-fertilizers plays a pivotal role in achieving higher yield as well as higher economic return from green gram. Thus, keeping the above fact in view, an experiment was conducted to assess the effect of phosphorus levels and biofertilizers on growth and yield of green gram.

Materials and Method

The experiment was carried out during *kharif* season of 2022-23 at Crop Research Centre, School of Agriculture, ITM University Gwalior, (M.P.). The experimental site is located at 26^{0}14′ N latitude and 78^{0}14′ E longitude at an elevation of 206 meters above mean sea level. The climate of this place is typically sub-tropical in nature with high relative humidity, moderate temperature with medium to high rainfall. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction (pH 8.2), low in organic carbon (4.0), available nitrogen (183.50) and potassium (243.0) but medium in available phosphorus (14.4) with electrical conductivity (0.14) in the safer range.

The experiment consists of 10 treatment combination with three Phosphorus levels (20, 40, 60 kg P_2O_5 ha^{-1}) and biofertilizer (PSB, *Rhizobium* and PSB + *Rhizobium*) which was laid out in factorial block design with three replications. There are 10 treatments *viz*. T_1- Control, T_2- 20 kg P_2O_5ha^{-1} + PSB, T_3- 20 kg P_2O_5ha^{-1} + *Rhizobium*, T_4- 20 kg P_2O_5ha^{-1} + PSB + *Rhizobium*, T_5- 40 kg P_2O_5ha^{-1} + PSB, T_6- 40 kg P_2O_5ha^{-1} + *Rhizobium*, T_7- 40 kg P_2O_5 ha^{-1} + PSB + *Rhizobium*, T_8- 60 kg P_2O_5ha^{-1} + PSB, T_9- 60 kg P_2O_5ha^{-1} + *Rhizobium*, T_{10}- 60 kg P_2O_5ha^{-1} + PSB + *Rhizobium*)

The mungbean variety "IPM 410-3" was sown on July, 2nd 2022 using seed 25 kg ha^{-1} with a spacing of 30 x 10 cm. The crop was harvest on September, 25th 2022.As per the treatments seed were inoculated with PSB, *Rhizobium*, PSB + *Rhizobium* before sowing using a standard method and dried shade (Paul *et al.,*1971). Thining was carried out at 10-20 DAS. A uniform basal dose of 20 kg N ha^{-1} was applied through urea to the soil. However, in control plot no fertilizer was applied. The phosphorus was applied through SSP and potassium. Significant difference of sources of variation was tested at the probability level of 0.05. The standard error of the mean (SEm±)

and the Cd. value were indicated in the tables to compare the difference between the mean values.

Results and Discussion

Growth parameters

The data revealed that the maximum plant height (44.52) was recorded with the application of 60 kg P ha^{-1} and at par with of 40 kg P ha^{-1} at harvest stages. The growth parameters viz., number of leaves $plant^{-1}$(44.07), number of primary (6.55) and secondary branches (7.26), number of nodules $plant^{-1}$(42.16), weight of nodules (g) (41.24g), dry matter plant (g m^{-2}) (453.56). It might be due to account of stimulation of root growth of the crop as phosphorus plays an important role in various physiological processes including root development, nodulation and N-fixation. Similar findings were reported by Khaswa *et al*. (2014) and Anand *et al*. (2022).

Plant height was significantly affected due to application of biofertilizers at harvest stage of green gram crop. The maximum plant height (45.98) was recorded with the application of PSB + *Rhizobium* followed by application of *Rhizobium* and application of PSB but PSB and *Rhizobium* was at par with each other. The growth parameters viz., number of leaves $plant^{-1}$(44.14), number of primary (6.56) & secondary branches (7.27), number of nodules $plant^{-1}$(42.45), weight of nodules (41.06 g), dry matter plant (436.74g m^{-2}). These results corroborate with the findings of Hussain *et al*. (2011) where they observed that the maximum plant height was obtained with the seed treatment of *Rhizobium* and PSB.

Yield attributes and yield

The data on yield attribute and yield of green gram as influenced by varying levels of phosphorus and bio-fertilizers. The maximum grain yield (1122.09) was recorded with the application of 60 kg P ha^{-1}which was at par with 40 kg P ha^{-1}. The yield attribute and yield viz., pod length (5.29), number of pods $plant^{-1}$ (32.30), number of grains pod^{-1}(13.11), test weight (40.85), stalk yield (2631.31), biological yield (3753.40), and harvest index (29.93). This is due to fact that the increase in photosynthetic activities of plant and root system enabled the plants to extract more water and nutrients from the soil depth, resulted into better growth and development of plant, and ultimately led to higher yield.

In case of biofertilizers the maximum grain yield (1129.49) was recorded with the application of PSB + *Rhizobium* followed by application of *Rhizobium* and application of PSB but PSB and *Rhizobium* was at par with each other. The yield attribute and yield viz., pod length (5.80), number of pods $plant^{-1}$ (31.51), number of grains pod^{-1}(13.71), test weight (40.56), stalk yield (2656.94), biological yield (3786.44), and harvest index (29.81). This is due to fact that increase in yield of green gram with bio-fertilizers might be owing to increased supply of plant hormones by the micro-organisms or by roots as results of reaction to microbial colonization (Avivi and Feldman, 1982).

Table 1. Growth parameters of green gram at different stages as influenced by different levels of Phosphorus and Biofertilizers.

Treatment	At harvest						
	Plant height (cm)	No of leaves per plant	No. of primary branches	No. of secondary branches	No. of nodules	Weight of nodules (g)	Dry matter accumulation (g m^{-2})
Control	26.23	24.34	4.44	5.14	29.73	28.24	245.10
Phosphorus (kg ha^{-1})							
20	35.35	33.18	5.27	5.98	36.16	34.64	333.60
40	42.04	41.10	6.39	7.09	40.91	39.61	414.88
60	44.52	44.07	6.55	7.26	42.16	41.24	453.56
SE(m) ±	1.33	1.44	0.15	0.20	1.01	1.03	11.43
C.D (P=0.05)	3.95	4.28	0.43	0.60	2.99	3.06	33.95
Biofertilizer							
PSB	36.47	35.05	5.73	6.43	37.68	36.48	370.12
Rhizobium	39.46	39.17	5.93	6.63	39.11	37.94	395.19
PSB+Rhizobium	45.98	44.14	6.56	7.27	42.45	41.06	436.74
SE(m+)	1.33	1.44	0.15	0.20	1.01	1.03	11.43
C.D (P=0.05)	3.95	4.28	0.43	0.60	2.99	3.06	33.95

Table 2. Yield, Yield attributes and Economics of green gram at different stages as influenced by different levels of Phosphorus and Biofertilizers.

Treatment	At harvest										
	Pod length	No. of pods plant^{-1}	No of grains pod^{-1}	Test weight	Grain yield (Kg ha^{-1})	Stalk yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	Harvest index (%)	Gross return	Net return	B : C ratio
Control	2.83	20.73	6.73	26.71	488.56	1339.92	1777.78	26.71	40656	10512	0.35
Phosphorus (kg ha^{-1})											
20	3.87	27.18	11.34	39.00	922.59	2337.44	3260.03	28.14	76563	45213	1.44
40	5.08	30.06	12.57	39.58	1063.29	2537.24	3600.53	29.57	88066	55810	1.73
60	5.29	32.30	13.11	40.83	1122.09	2631.31	3753.40	29.93	92886	59723	1.80
SE(m) ±	0.19	0.78	0.29	1.35	28.15	60.12	72.75	—	2276.2	2276.2	0.07
C.D (P=0.05)	0.56	2.33	0.85	4.00	83.65	178.62	216.16	—	6762.9	6762.9	0.21
Biofertilizer											
PSB	4.02	28.69	11.34	38.68	951.55	2380.17	3331.72	28.45	78932	46826	1.45
Rhizobium	4.42	29.34	11.97	40.18	1026.93	2468.88	3495.81	29.39	85075	52969	1.64
PSB+Rhizobium	5.80	31.51	13.71	40.56	1129.49	2656.94	3786.44	29.81	93507	60951	1.87
SE(m+)	0.19	0.78	0.29	1.35	28.15	60.12	72.75	—	2276.2	2276.2	0.07
C.D (P=0.05)	0.56	2.33	0.85	4.00	83.65	178.62	216.16	—	6762.9	6762.9	0.21

Economics

Significantly higher Gross return (96190), Net return (62728.25) and B:C ratio (1.87)was noticed with higher levels of phosphorus and PSB + *Rhizobium*, while the lowest values were recorded with lower level of phosphorus and PSB and control.

Conclusion

It can be concluded that the among the phosphorus levels, application of 60 kg ha^{-1} phosphorus recorded significantly high growth characters, yield attribute, yield, and economics. Among the bio-fertilizers treatments, Phosphate solubilizing bacteria + *Rhizobium* resulted in high growth attributes and yield of green gram. Thus, for green gram cultivation, application of 60 kg ha^{-1} phosphorus and treatment of Phosphate solubilizing bacteria + *Rhizobium* was found to be most promising treatment in enhancing the yield in green gram.

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