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The study on response of bio-fertilizers (Rhizobium and phosphate solubilizing bacteria) along with inorganic fertilizers on yield attributes of green gram (*Vigna radiata*) crop in Chitrakoot region

Sujeet Gautam, Pawan Sirothia, Shikha Rao, Suryakant Gautam and Prashant Dwivedi

Abstract
Green gram (*Vigna radiata*) also known as moong is one of the main pulse crop of India. It is a rich source of protein along with fibre and iron. It can be cultivated as *kharif* as well as summer crop. In India It is grown in about 36 lakh hectares with the total production of about 17 lakh tonnes of grain with a productivity of about 500 kg/ha. Inorganic fertilizers at present are the major sources of providing nutrients and increasing yield of the green gram crop. But there are various issues such as environmental and health issues arising due to its hefty use. To overcome this problem and reduce the dependency on inorganic fertilizers the use of organic sources must be promoted. By keeping theses pointers in mind, a field experiment with the objective entitled "The study on response on bio-fertilizers along with inorganic fertilizers on yield attributes of green gram crop in Chitrakoot region" was performed. The experiment was conducted at Nanaji agriculture arm Rajaula, MGCGV, Chitrakoot Satna (M.P.). The experiment was conducted during the kharif season of the session 2021-22 with a total of three replications and thirteen treatments laid out in randomized block design (RBD) and the data collected thereafter was subjected to statistical analysis using analysis of variance (ANOVA). The variety of green gram that was used was "PDU-139". The treatment with 50% RDF + rhizobium showed the maximum grain yield per hectare that is 2019.33kg/ha. Other than yield per hectare other yield attributing parameters such as pod per plant, seed per pod, test weight and grain yield per plot were also taken under consideration. The results showed that treatment with 50% RDF + Rhizobium showed the best yield and other yield contributing attributes.

Keywords: Green gram, bio-fertilizers, rhizobium, PSB, yield

Introduction
Inorganic fertilizers directly or indirectly affect the physiology of the plant by altering its growth and development along with its metabolism hence increasing the yield. But as they become a part of the metabolism of the plant and plant based products are ultimately consumed by the humans, inorganic fertilizers ultimately become the part of human metabolism also which possess a great threat to human health. Other than that the residual effect of inorganic fertilizers on soil make the soil health even worse. To overcome this concern there is an urgent need to shift the approach from inorganic to organic sources. The symbiotic relationship between plant and microorganisms has been widely acknowledged as an effective method of enhancing agricultural productivity. Among these microorganisms, rhizobium and PSB have shown significant potential in improving the yield attributes of various crops, including green gram. Biological nitrogen fixation (BNF) involves the symbiotic relationship between bacteria of the genera Rhizobium and Bradyrhizobium and plants of the family Leguminosae. In this system, bacteria living in nodules on roots of legume plants convert nitrogen from the atmosphere into forms that can be utilized by the plants. Being a legume, the mungbean has the potential for fixing atmospheric nitrogen in root nodules through symbiosis with Rhizobium (Rai, 2002) [4]. Phosphorus is commonly "fixed" as iron or aluminum-phosphate compounds that have a low solubility, phosphorus deficiency then becomes a common limitation to plant growth. The limitation is particularly critical for legumes such as mungbean, that utilize symbiotically fixed nitrogen in their growth, due to the vital role played by phosphorus in reactions involving energy and ATP in nitrogenase activity.

The introduction of efficient phosphorus solubilisers' in the rhizosphere of crops and soil increases the availability of phosphorus from insoluble sources of phosphates and utilization efficiency of phosphorus fertilisation (Rai, 2002) [4]

Materials and Methods

A field experiment was performed at Nanaji agriculture research farm, faculty of agriculture, Rajaula, MGCGV Chitrakoot Satna (M.P.) which is located at 25.148º North latitude and 80.855º east longitude, to study the response of bio-fertilizers (rhizobium and PSB) on yield attributes of green gram crop in Chitrakoot region. There were a total of three replications along with thirteen treatments with various recommended doses of fertilizers namely 100%, 75% and 50% RDF given to the crop in combination with bio-fertilizers and also given purely in inorganic form. The details of treatment combination is given in Table-1. The variety of green gram crop that was used was "PDU-139" and bio-fertilizers were rhizobium *(R. leguminosarum)* and phosphate solubilizing bacteria *(Bacillus sp.)* was used. Rhizobium was used as seed treatment inoculation with half kg enough for 20 kg seeds and PSB was applied with farmyard manure as soil treatment. At the beginning of the experiment, various physical properties of the experimental soil was tested before sowing whose details and the methods employed are given in the table below

Various physical properties of the experimental soil was tested before sowing

S. No	Attributes	Values obtained	Method employed
	Textural classes	Sandy loam	Bouyoucos hydrometer method (1952)
1.	Sand (%)	51.3	
2.	Silt (%)	21.3	
3.	Clay (%)	25.1	
4.	Bulk Density (Mg/m^3)	1.24	Graduated measuring cylinder
5.	Particle density (Mg/m^3)	2.38	Graduated measuring cylinder

Other than physical properties, various chemical properties experimental soil were also were also subjected to chemical analysis. The chemical properties that were taken into consideration was soil pH, organic carbon percentage and available NPK. The soil pH was determined using pH meter method, organic carbon was determined using Walkley-Black method 1965, Available nitrogen was determined using modified Kjeldahl method 1956, available phosphorus was determined using Olsen's method 1954 and available potash was determined using flame photometric method. The data or yield attributes was taken at harvest stage and were subjected to statistical analysis by using analysis of variance (ANOVA).

Table 1: Treatment combination

S. No.	Symbol	Treatments
1.	T_0	0 kg fertilizer + no bio fertilizer
2.	T_1	20 kg N/ha + 40 kg P/ha + 20 kg K/ha + No bio fertilizer
3.	T_2	15 kg N/ha + 30 Kg P/ha + 15 kg K/ha + No bio fertilizer
4.	T_3	10 kg N/ha + 20 kg P/ha + 10 kg K/ha + No bio
5.	T_4	0 kg fertilizer + PSB (soil application)
6.	T_5	20 kg N/ha + 40 kg P/ha + 20 kg K/ha + PSB
7.	T_6	15 kg N/ha + 30 kg P/ha + 15 kg K/ha + PSB
8.	T_7	10 kg N/ha + 20 kg P/ha + 10 kg K/ha + PSB
9.	T_8	0 kg fertilizer + Rhizobium
10.	T_9	20 kg N/ha + 40 kg P/ha + 20 kg K/ha + Rhizobium
11.	T_{10}	15 kg N/ha + 30 kg P/ha + 15 kg K/ha + Rhizobium
12.	T_{11}	10 kg N/ha + 20 kg P/ha + 10 kg K/ha + Rhizobium
13.	T_{12}	20 kg N/ha + 40 kg P/ha + 20 kg K/ha + Rhizobium + PSB

Results and Discussion

There were majorly five yield attributes taken into account for the purpose of study viz. pods per plant, seed per pod, test weight, grain yield per plot and grain yield per hectare (Table 2).

Effect of rhizobium and PSB on pods per plant

The combined effect of rhizobium and PSB in combination with inorganic fertilizers has been extensively studied and research has reported that yield attributes such as pods per plant, number of seeds per pod and seed weight have shown substantial increments. The readings for pods per plant was taken at four days before harvest and data revealed that treatment with 50% RDF + Rhizobium showed maximum number of pods per plant that is 25.70. The result is supported by the findings of (Krishnan, 2016) (Singh, 2023) [3, 6].

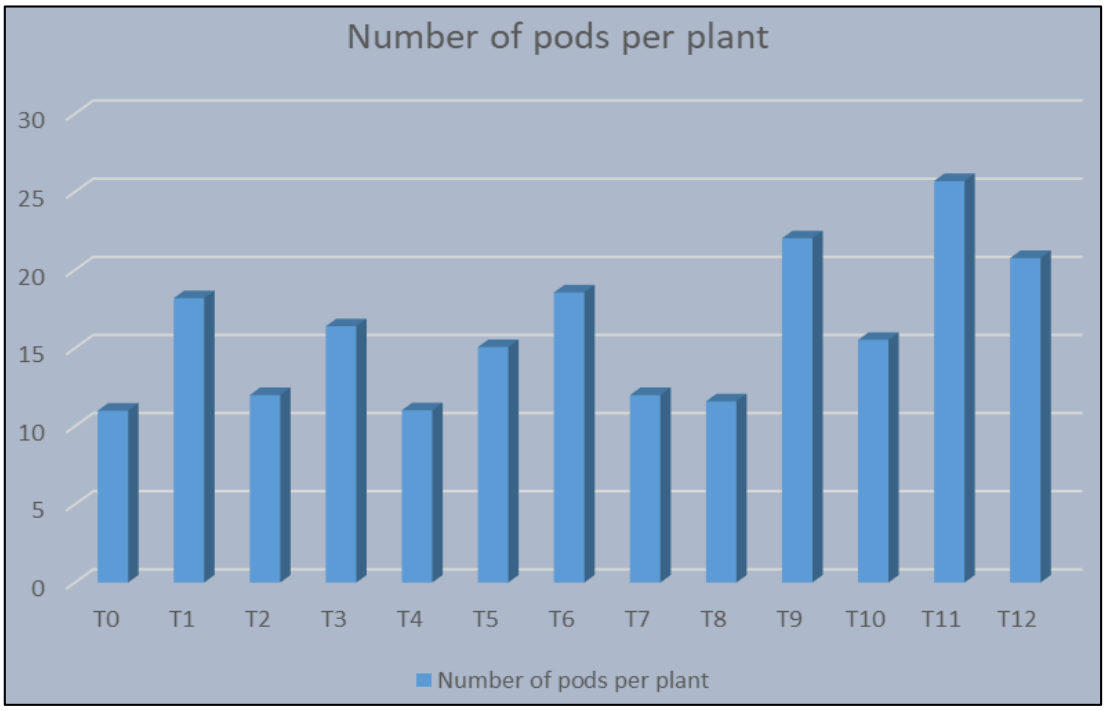

Fig 1: Number of pods per plant

Effect of rhizobium and PSB on seeds per pod

In this experiment, it was revealed by the data obtained that treatment with 50% RDF + rhizobium showed maximum seed count per pod that is 12.92 followed by 100+RDF+PSB which is 11.98. The similar results were obtained by (Shahi, 1996) [5]

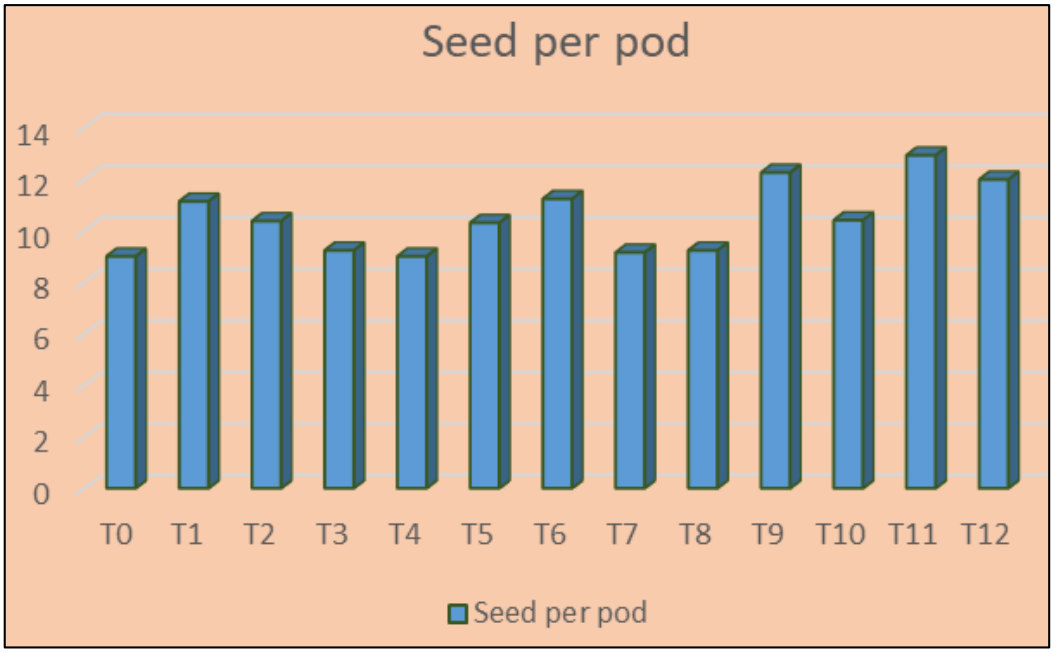

Fig 2: Seed per pod

Effect of rhizobium and PSB on Test weight

Test weight of 1000 seeds being a function of accumulation of major organic constituents like, carbohydrates, proteins and lipids along with minerals largely depends on better overall growth of plants. This in turn is governed by presence of available essential nutrients in balanced proportion, its efficient uptake, utilization and conversion in to storage organic forms. (Shahi, 1996) [5]. The results here showed the accuracy of the above mentioned statements as maximum seed test weight was observed in treatment with 50% RDF + Rhizobium that is 30.63gm followed by 100% RDF + Rhizobium + PSB that is 30.17 gm. The results was coincided with the findings of (Singh M., 2012) [7]

Fig 3: Test weight

Effect of Rhizobium and PSB on Grain yield per plot and Grain yield per hectare

Grain yield per plot and grain yield per hectare was significantly influenced by the application of rhizobium and PSB along with inorganic fertilizers. For both grain yield per plot and grain yield per hectare the maximum yield was obtained in treatment with 50% RDF + Rhizobium. Grain yield per plot was 3.02 kg and Grain yield per hectare was 2019.33 kg per hectare. The findings were supported by (Singh M., 2012) [7]

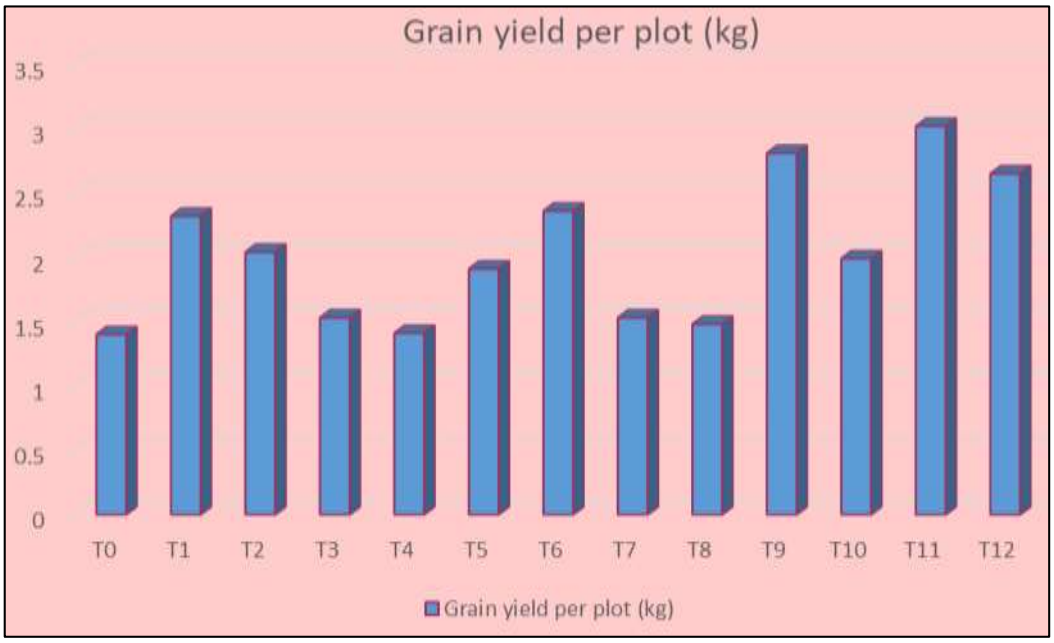

Fig 4: Grain yield per plot

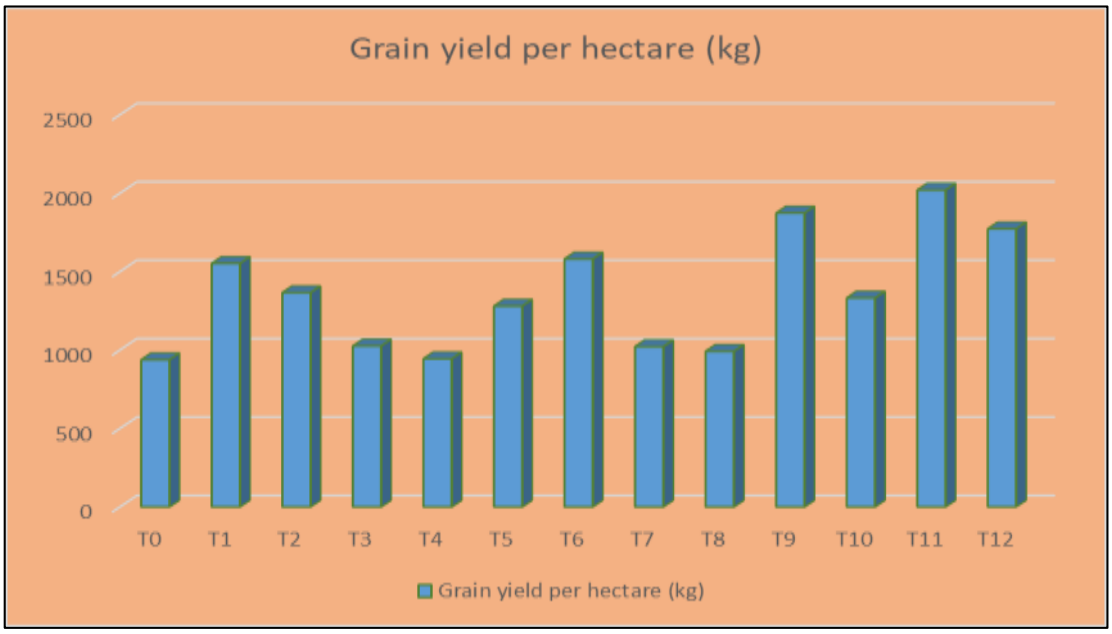

Fig 5: Grain yield per hectare

Table 2: Effect of rhizobium and PSB in combination with inorganic fertilizers on yield attributes of Green gram crop.

S. No.	Treatment	Pod per plant	Seed per pod	Test weight	Grain yield per plot (kg)	Grain yield per ha (kg)
1.	T_0	11.00	9.00	26.97	1.40	937.67
2.	T_1	18.20	11.13	29.10	2.32	1552.00
3.	T_2	12.00	10.37	28.83	2.04	1365.00
4.	T_3	16.40	9.23	28.50	1.53	1025.67
5.	T_4	11.03	9.00	28.10	1.41	943.67
6.	T_5	15.07	10.30	28.90	1.91	1280.00
7.	T_6	18.57	11.23	29.90	2.36	1580.00
8.	T_7	12.00	9.15	28.50	1.53	1021.33
9.	T_8	11.60	9.23	28.21	1.48	991.33
10.	T_9	22.03	12.25	30.17	2.81	1873.00
11.	T_{10}	15.53	10.40	29.30	1.99	1331.33
12.	T_{11}	25.70	12.92	30.63	3.02	2019.33
13.	T_{12}	20.77	11.98	30.17	2.65	1772.33

Conclusion

In the end, it can be concluded the addition of bio-fertilizers along with inorganic fertilizers found to be much more effective in increasing productivity of the green gram crop as compared to the sole application of inorganic fertilizers. The treatments incorporated with bio-fertilizers are much more effective, out of which treatment with 50% RDF + Rhizobium and 100% RDF + Rhizobium + PSB are the best treatments as far as yield attributes of green gram is concerned. At the end, the incorporation of rhizobium, PSB and inorganic fertilizers in the cultivation of green gram crop holds great promise for enhancing crop productivity. Furthermore, utilizing microbial inoculants can reduce the reliance on synthetic fertilizers, thereby minimizing there environmental impact.

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