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Effect of Bio-fertilizer and zinc levels on growth and yield of green gram (*Vigna radiata* L.)

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Abstract
The field experiment was conducted during *Zaid* season (2021) at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad (U.P). The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The treatments consisted Bio- fertilizers and Zinc levels *viz*., whose effect is observed on Green gram. The experiment was laid out in Randomized Block Design, with ten treatments which are replicated thrice. Results obtained that the maximum plant height (48.40cm), number of nodules (6.99), number of branches (6.44), plant dry weight (8.21 g/plant) pods per plant (40.10), seeds per pod (10.77), Test weight (35.60 g), grain yield (9.93 q/ha) and stover yield (41.34 q/ha) were significantly influenced with application of Azotobacter (10 g/kg) + PSB (10 g/kg) + Zn3 @ 30 kg/ha and Maximum crop growth rate (15.24 g/m^2 /day). Maximum net returns of 69230.67 INR/ha and B:C ratio 2.08 was recorded in treatment with application of Azotobacter (10 g/kg) + PSB (10 g/kg) + Zn3 @ 30 kg/ha. Therefore, it can be concluded that the application of Azotobacter (10 g/kg) + PSB (10 g/kg) + Zn3 @ 30 kg/ha was most productive and cost effective.

Keywords: Organic carbon, bio-fertilizers, zinc, green gram, randomized block design etc.

Introduction
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 and prevent soil erosion due to their deep root system and good ground coverage, because of these good characters pulses are called as “Marvel of Pulses” can also be referred to as mini fixation. Pulses are cheaper than meat; they are often referred to as “poor man’s meat” in developing countries like India. The pulses form an integral part of cropping system of the farmers all over the country because they fit well in crop rotation and crop mixture as well. Pulses are the most important component of the balanced diet in vegetarian country like India The pulses form an integral part of cropping system of the farmers all over the country because they fit well in crop rotation and crop mixture as well. Green gram contains about 25% protein, this being about two third of the protein content of soybean, twice that of wheat and rice Bio- fertilizer like Rhizobium and phosphate solubilise bacteria plays an important role in increasing availability of nitrogen and phosphorus through increase in biological fixation of atmospheric nitrogen and enhanced phosphorus availability to the crop. respectively. Introduction of efficient strain of Rhizobium in the soil poor in nitrogen may be helpful in boosting up production through more nitrogen fixation. Inoculation of seeds with Rhizobium culture is a very low-cost method. Azotobacter is a free-living N fixing bacterium. Theme by which Azotobacter promote plant growth are not fully understood. But, several mechanisms have been suggested by which Azotobacter can promote plant growth, including phytohormone production, enhancing stress resistance, N2 fixation, stimulation of nutrient uptake and biocontrol of pathogenic microorganisms, increasing the supply or availability of primary nutrients to the host plant. The phosphorus solubilising bacteria as inoculants in root zone of crop plants partially solubilise the insoluble phosphate and improve the fertilizer use efficiency and the productivity. Several phosphate solubilizing microorganisms have shown stable and consistent capacity to solubilizing insoluble phosphorous such as calcium, iron and aluminium phosphate and low-graded rock phosphate. Micronutrients are also essential for plant growth. Zinc influences the formation of growth hormones and it plays a helpful role in reproduction of certain plants (Patel *et al.*, 2017). Zinc is necessary to activate many enzymes like Tryptophan synthetase, superoxide dismutase and dehydrogenases. Lack of zinc causes deficiency in formation of RNA and protein.

Zinc fertilizer application causes root and shoot growth during the growing season and therefore, lead to increased seed yield. The increasing levels of zinc significantly increased the growth parameters such as chlorophyll content, total number of nodules, effective number of nodules and root density as well as yield attributes number of pods per plant, number of seeds per pod and test weight of green gram. Biofertilizer like rhzobium and PSB takes an important role in enhancing availability of N and P through increase in biological fixation of atmoshperic N and increasing the phosporous availability to plants (Gajara *et al*., 2014) [1]. The dry weight of root nodules per plant did not reach to the level of significance due to different rates of zinc appplication but the number of root nodules per plant was significantly affected due to zinc levels (M.S.Solanki *et al*., 2017) [8]. carried out an experiment to study the effect of inoculation with Rhizobium sp. and phosphate solubilizing bacteria (PSB) on the nodulation and seed yield of mung bean cv.B-1 at West Bengal, India and reported that plantsinoculated with Rhizobium strains and PSB showed increased rate of nodulation, N content and seed yield over control Chatterjee and Bhattacharjee (2002). Narayan *et al.* (2008) [9] revealed that the application of $ZnSO_4$, at 1% as foliar spray at 25 DAS had recorded significantly higher grain yield (1146 kg/ha) as compared to recommended dose of fertilizer and other methods of zinc application. Similar trend was also noticed with respect to growth and yield attributes of green gram.

Materials and Methods

The experiment was conducted during Zaid season of 2021. The experiment was conducted in Randomized Block Design consisting of ten treatment combinations with three replications and was laid out with the different treatments allocated randomly in each replication. The soil of the experimental field was sandy loam in texture, slightly alkaline reaction (pH 7.1) with low level of organic carbon (0.28%), available N (225 Kg/ha), P (19.50 kg/ha) and higher level of K (92.00 kg/ha). The treatment combinations are T1 - Azotobacter 20 g/kg + 20 kg/ha zinc, T2 - Azotobacter 20 g/kg + 25 kg/ha zinc, T3 - Azotobacter 20 g/kg + 30 kg/ha zinc, T4 - PSB 20 g/kg + 20 kg/ha zinc, T5 - PSB 20 g/kg +25 kg/ha zinc, T6 - PSB 20 g/kg + 30 kg/ha zinc, T7 - Azotobacter (10 g\kg) + PSB (10 g\kg) + 20 kg/ha zinc, T8 - Azotobacter(10 g/kg) + PSB (10 g/kg) + 25 kg/ha zinc, T9 - Azotobacter (10 g/kg) + PSB (10 g/kg)+ 30 kg/ha zinc and T10-control. The observations were recorded on different growth parameters at harvest *viz*. plant height (cm), number of nodules per plant, plant dry weight, Number of pods per plant, number of seeds per pod, test weight, grain yield and stover yield.

Result and Discussion

Growth Attributes

At harvest, significantly maximum plant height (48.40 cm) was recorded with application of Azotobacter + PSB + Zn 30 kg/ha. However, treatment with application of Azotobacter + PSB + Zn 25 kg/ha (47.66 cm) and Azotobacter + PSB + Zn 20 kg/ha (47.40) was statistically at par with application of Azotobacter + PSB + Zn 30 kg/ha compared to other treatments. At harvest recorded that significantly maximum number of nodules (6.99) recorded with application Azotobacter + PSB + Zn 20 kg/ha which was significantly superior over rest of the treatments. However, treatment with application of Azotobacter + PSB + Zn 20 kg/ha (6.44) were statistically at par with Azotobacter + PSB + Zn 20 kg/ha compared to other treatments. At harvest recorded that significantly maximum number of branches (6.44) was observed with application of Azotobacter + PSB + Zn 30 kg/ha. However, treatment with application of Azotobacter + PSB + Zn 25 kg/ha (6.14) were statistically at par with Azotobacter + PSB + Zn 30 kg/ha compared to other treatments. At harvest recorded that significantly maximum plant dry weight (8.21) was observed with application of Azotobacter + PSB + Zn 30 kg/ha. However, treatment with application of Azotobacter + PSB + Zn 25 kg/ha (7.60) were statistically at par with Azotobacter + PSB + Zn 30 kg/ha compared to other treatments.

Yield Attributes

Number of pods/plant recorded maximum was obtained with application of Azotobacter + PSB + Zn 30 kg/ha (40.10). however, treatment with application of Azotobacter + PSB + Zn 25 kg/ha (38.88) were statistically at par with application of Azotobacter + PSB + Zn 30 kg/ha compared to other treatments. Number of seeds/pod recorded maximum with application of Azotobacter + PSB + Zn 30 kg/ha (10.77) significantly superior over rest of the treatments. However, treatment with application of Azotobacter + PSB + Zn 25 kg/ha (10.44) and Azotobacter + PSB + Zn 20 kg/ha (10.33) were statistically at par with Azotobacter + PSB + Zn 30 kg/ha compared to other treatments. Test weight recorded maximum with application of Azotobacter + PSB + Zn 30 kg/ha (35.60) significantly superior over rest of the treatments. However, treatment with application of Azotobacter + PSB + Zn 25 kg/ha (34.93) and Azotobacter + PSB + Zn 20 kg/ha (34.36) were statistically at par with Azotobacter + PSB + Zn 30 kg/ha compared to other treatments.

Yield

Grain yield, recorded maximum with application of Azotobacter + PSB + Zn 30 kg/ha (9.93 q/ha) significantly superior over rest of the treatments. However, treatment with application of Azotobacter + PSB + Zn 25 kg/ha (9.20 q/ha) were statistically at par with application of Azotobacter + PSB + Zn 30 kg/ha compared to other treatments. Stover yield, recorded maximum with application of Azotobacter + PSB + Zn 30 kg/ha (41.34 q/ha) significantly superior over rest of the treatments. However, treatments with application of Azotobacter + PSB + Zn 25 kg/ha (36.56 q/ha) and PSB + Zn 30 kg/ha (35.92 q/ha) were statistically at par with Azotobacter + PSB + Zn 30 kg/ha compared to other treatment combination. Harvest index, recorded maximum with application of Azotobacter + Zn 20 kg/ha (23.11%) and minimum recorded with application of Azotobacter + Zn 25 kg/ha (19.61%). There is no significant difference in treatment.

Table 1: Effect of Bio-fertilizer and Zinc Levels on growth attributes of green gram.

Treatments	Plant height (cm) At Harvest	Number of nodules per plant At Harvest	Number of branches per plant At Harvest	Plant dry weight (g/hill) At Harvest
Azotobacter + Zn 20 kg/ha	44.16	5.22	4.44	5.55
Azotobacter + Zn 25 kg/ha	46.33	5.33	5.00	6.11
Azotobacter + Zn 30 kg/ha	46.86	5.55	5.22	6.72
PSB + Zn 20 kg/ha	44.73	5.33	4.55	5.88
PSB + Zn 25 kg/ha	46.53	5.44	5.11	6.22
PSB + Zn 30 kg/ha	47.16	5.99	5.66	7.00
Azotobacter + PSB + Zn 20 kg/ha	47.40	6.11	5.66	7.36
Azotobacter + PSB +Zn 25 kg/ha	47.66	6.44	6.14	7.60
Azotobacter + PSB + Zn 30 kg/ha	48.40	6.99	6.44	8.21
Control	41.86	4.88	4.33	4.77
S.Em(±)	0.38	0.14	0.12	0.18
CD (p=0.05)	1.13	0.44	0.42	0.53

Table 2: Effect of Bio-fertilizer and Zinc Levels on yield attributes and yield of green gram

Treatments	Number of pods Per plant	Number of seeds per pods	Test weight	Grain yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
Azotobacter + Zn 20 kg/ha	33.60	9.10	32.60	7.20	24.17	23.11
Azotobacter + Zn 25 kg/ha	36.33	9.44	33.76	8.63	35.52	19.61
Azotobacter + Zn 30 kg/ha	36.66	9.88	33.76	8.79	32.0	21.98
PSB + Zn 20 kg/ha	34.22	9.22	33.36	7.678	29.7	20.57
PSB + Zn 25 kg/ha	35.66	9.66	33.66	8.08	31.3	20.53
PSB + Zn 30 kg/ha	37.22	10.22	33.90	8.95	35.9	19.93
Azotobacter + PSB + Zn 20 kg/ha	36.66	10.33	34.36	9.04	31.84	22.46
Azotobacter + PSB +Zn 25 kg/ha	38.88	10.44	34.93	9.20	36.56	19.78
Azotobacter + PSB + Zn 30 kg/ha	40.10	10.77	35.60	9.93	41.34	20.72
Control	32.66	8.77	32.80	6.96	25.90	21.18
S.Em (±)	0.65	0.14	0.75	0.28	2.35	1.29
CD (5%)	1.94	0.44	2.24	0.84	6.99	----

Conclusion

On the basis of season experimentation application Azotobacter + PSB + Zn 30 kg/ha was found more productive (9.93 q/h.

The conclusions drawn are based on one season data only which requires further confirmation for recommendation.

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