Effect Of Different Strains Of Rhizobacteria On The Growth Performance Of Chickpea (*Cicer Arietinum L.*) And Nutrient Uptake

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Abstract
This research was carried out to evaluate the effects of combined inoculation with plant growth-promoting rhizobacteria from two genera including *Azotobacter* and *Rhizobacteria* on nutrient uptake, growth and yield of chickpea plants under field conditions. Nodulation and nutrient concentration in shoots were significantly affected by the treatments at the beginning of flowering stage. The maximum of root nodules, plant height, was recorded by applying the combined seed inoculation with *Azotobacter* and *Rhizobium*. All inoculants were statistically superior over inoculated control with respect to nitrogen concentration of shoots. The treatments containing *Azotobacter* +Iron and Boron significantly improved phosphorus concentration in shoots. Grain yield, biomass dry weight and nitrogen & phosphorus uptake of grains were statistically improved by applying every inoculation treatment in comparison with control plants. Group comparisons between treatments showed that the occurance of (T6RDF100%+Azotobacter+Iron0.25%+Boron0.5%) inoculants in the treatment composition caused an expressive improvement in grain yield and plant biomass. In conclusion, application of every inoculation treatment studied here, especially treatments which contained *Azotobacter* may stimulate growth and yield of chickpea as compared with uninoculated plants.

Keywords: *Azotobacter*; *Cicer arietinum* L.; Plant growth-promoting rhizobacteria; *Pseudomonas*.

Abbreviations: CFU- colony forming units; DAS- days after sowing; PGPR- plant growth promoting rhizobacteria.

Introduction

Plant growth promoting rhizobacteria (PGPR) represent a wide variety of soil bacteria which, when grown in association with a host plant, result in stimulation of growth of their host plant (Vessey, 2003). Several mechanisms have been suggested by which PGPR can promote plant growth, including phytohormone production, N2 fixation, and stimulation of nutrient uptake and bio control of pathogenic microorganisms (Kloepper et,al., 1981; Rodriguez and Fraga, 1999; Sindhu et, al., 1999; Benizri et,al., 2001; Persello- Cartieaux et al., 2003; Somers et al., 2004). Seed inoculation with a combination of beneficial microorganisms including rhizobia, PGPR and PSB (Phosphate Solubilizing Bacteria) have been shown to increase crop growth and productivity (Dashti et, al., 1998; Rodelas et,al., 1999; Chebotar et al., 2001; Sindhu et al., 2002; Zaidi et, al., 2003; Rudresh et al., 2005).Foliar application of B plays a significant influence in chickpea seed yield, it controls plant hormone level, photosynthetic activity and generative growth in all plant all of which boost chickpea output. However little is known about the response of chickpea to combined inoculation with rhizobium and plant growth promoting rhizobacteria under field conditions. Chickpea (*Cicer arietinum* L.) is one of the major pulse crops in the world and provides high quality protein for the people in South, West and East Asia and North Africa. It is also used as feed for livestock and has a significant role in farming systems (Singh, 1997). In Iran chickpea is the most important grain legume and improving it's productivity is a necessity. Hence the present study was conducted to evaluate the effects of different strain of rhizobacteria on the growth performance of chickpea (*Cicer arietinum L.)*and nutrient uptake under field conditions.

Materials and methods

The experiment was conducted during the Rabi season 2022, at the Crop Research Center, Department of Agronomy, School of Agriculture, and Uttaranchal University, Dehradun (Uttarakhand) which is located at 30.3384503 N latitude, 77.9474063 E longitude and 640 m a,ltitude above the mean sea level (MSL).Soil was tested before sowing , available N (302.4)P (12.5) and K(235.7)

Plot Experiment:

21 plot of experiment involved (Control) was conducted at the the Crop Research Center, Department of Agronomy, School of Agriculture and Uttaranchal University, Dehradun (Uttarakhand)

Seed Inoculation:

Seed was inoculated with rhizobacteria and azotobacter for 24 hours before sowing.

Experimental treatments:

RDF100% + Control, RDF100%+Azotobacter +Iron0.5%, RDF100%+Azotobacter +Boron 0.5%, RDF100%+Rhizobium + Iron 0.75%, RDF100%+Rhizobium + Boron 0.75%, RDF100%+Azotobacter+ Iron0.25% + Boron 0.25%, Rhizobium + Iron0.5% + Boron 0.5%

Statistic Analysis:

The data was analyzed from Randomized Block Design(RBD). In this analysis, three replication with seven treatment were conducted on the field experiment

Agronomic Practices of Chickpea:

Plant Heights:

Plant height was measured at crop maturity with the aid of a scale, height is determined from the ground to a plant's height point

Number of branches:

The numbers of branches from each of the five observational plants were counted every 15 days from the 304th day after sowing till harvest. Branches were counted at intervals of 30, 60, and 4 days. Then it was determined how many branches on average each plant had

Nodules count:

Count the numbers of nodules from each of the five observational plants was counted. Use a shovel to gently dig out each root system

Dry matter accumulation per plant:

The weight of dry matter is a listing of productive capacity of the plant hence, for calculating dry matter, five plants from each gross plot was randomly uprooted at each observation at 30, 60, 90 DAS until the time of harvest. Roots were separated for dry matter studies. The separated plant was sun dried at first instance and then oven dried at 65.2 ^{0}C temperature till constant weight was obtained

Number of pods per plant:

The pods from the randomly selected five plants were picked and total no.of pods were counted

Result and Discussion:

Plant height:

The experimental results indicated that in comparison of PGPRtreatments with the control, the treatments demonstrated a significant response of inoculated seeds. In terms of chickpea plant height, the (T_6 Azotobacter with micronutrient boron and iron)(45.431) gave highest plant height while lowest plant height was observed in the (T_1control) (32.585) . **(Anushal singh *et, al.,* 2021)**. found that PGPR are beneficial rhizobacteria for chickpea growth.

Nodule count:

The result indicated that T_6 was was noted as having the most nodules per plant at all growth phases.T_6 (34.930) gave more no. of nodules while lowest no. were observed in T_1 control (22.750) According to the findings, the Azotobacter treatment had the greatest number of nodules per plant. Azotobacter is an effective non-symbiotic and symbiotic nitrogen fixer. **Brown & Walker (1970); Jones and Greaves (1943); Mishustun (1963).** Additional supporting documentation may be obtained in papers by **Bandoupadhya (2002) and Tagoor *et, al.,* (2014),** who revealed increased leg-hemoglobin concentration in the Azotobacter inoculation therapy.

Number of branches per plant:
The result of number of branches revealed that the inoculants had a substantialimpact on number of branches of chickpea T6 recorded the highest number of branches per plant, whereas T1 (control) recorded the lowest number of branches per plant under all growth stages Combining chemical and biological fertilizers increases the amount of essential nutrients that affect vegetative development. Since there is greater vegetative growth as a result of the increased nutritional availability, there are more branches. Bio fertilizer is a crucial component of plant cells and aids in enhancing certain growth characteristics. Therefore, the treatment of various levels of Boron , Iron and other macronutrients (NPK) coupled with bio fertilizer(Azotobacter) greatly increases the number of branches per plant. As a result, it was discovered that the plant had its maximum number of branches during the beginning of its vegetative growth cycle. Findings were reported as supporting by (Patel and Thanki, 2020).

Dry matter accumulation ;
The data on dry matter determination/plant as influenced by the inoculation of bio fertilizer (Azotobacter) and basal application of macronutrients (NPK) and application of different levels of boron and iron.Dry matter /plant (gm) was maximum during the treatment with T6 (RDF100%+Azotobacter+Iron 0.25% + Boron 0.25%) is (15.020) with inoculation of bio fertilizer (Azotobacter) and basal application of macronutrients (NPK) and application of different levels of B and Fe. The minimum dry matter/plant was recorded with the treatment T1 (Control RDF) is (12.227). And the results are significantly at par with the treatments T4 is T4 (RDF100%+Rhizobium + Iron 0.75%) is (14.270) T5 (RDF100%+Rhizobium + Boron 0.75%) is (14.850) respectively. The treatment T6 (RDF100%+Azotobacter+Iron 0.25% + Boron 0.25%), which was recommended by many authors, was applied after the basal application of macronutrients (NPK) and all the bio fertilizers (Azotobacter), which resulted in the highest dry matter/plant.

Number of pods per plant:
The result of number of branches revealed that the inoculants had a substantial impact on the no. of pods per plant (29.809) was recorded with T6 (RDF100%+Azotobacter+Iron 0.25% + Boron 0.25%). According to their investigations, using bio fertilizers like Azotobacter and PSB as soil inoculants aids in the plant's absorption of nitrogen. The Rhizobium and Azotobacter influence the quantity of pods produced by each plant. When the plant receives sufficient amounts of nitrogen, phosphorus, and all other essential nutrients, its growth boundary is increased, increasing the number of pods produced per plant. These results are in agreement with **Swaminathan *et, al.,* (2007) and Prabhu *et, al.,* (2010).**

Table.1 Effect of seed inoculation of different strains of rhizobacteria and foliar spray of iron and boron on growth parameter and yield of chickpea

Treatments	Plant height (cm)	Nodule count (90 DAS)	Number of branches per plant(90 DAS)	Dry matter accumulation	Number of pods per plant
T_1 RDF100% + Control	32.585	22.750	4.154	12.219	20.721
T_2 RDF100%+Azotobacter +Iron0.5%	34.041	23.741	5.819	12.386	24.001
T_3 RDF100%+Azotobacter +Boron 0.5%	35.193	27.734	5.470	13.259	26.174
T_4 RDF100%+Rhizobium + Iron 0.75%	35.807	27.917	5.467	14.252	27.626
T_5 RDF100%+Rhizobium + Boron 0.75%	36.602	28.494	5.221	14.782	27.267
T_6RDF100%+Azotobacter+Iron 0.25% +Boron 0.25%	45.431	34.930	6.394	15.012	29.809
T_7 Rhizobium + Iron0.5% + Boron 0.5%	22.211	29.956	5.321	14.442	29.022
S Em±	0.25	0.112	0.112	0.0365	0.0774
CD at 5%	0.516	5.112	2.250	0.7302	1.5491

CONCLUSION:
Different treatments were administered to the experimental field in combination with sources of inorganic and organic fertilizer bio fertilizer and other organic fertilizers, as well as inorganic fertilizers including urea, DAP, and MOP, were applied to the field in the proper quantities. A considerable result was seen in each treatment as a result of the combination of various nutrient sources. The treatments with the highest gross and net returns overall were RDF100%+Azotobacter+Iron 0.25% + Boron 0.25% while other treatments were also praised for their effectiveness. Growth and yield metrics also shown superiority over alternative treatments.

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