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Effect of Rhizobium and PSB inoculation and foliar spray of micronutrient on growth and yield of Kabuli chickpea (*Cicer kabulium* L.)

Shubham Singh, Dr. AK Srivastava, Abhishek Singh and Prajjwal Agnihotri

Abstract
A field experiment was conducted during Rabi season of 2020-2021 at the Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur U.P. India, to study the "Effect of Rhizobium and PSB inoculation and foliar spray of micronutrient on growth and yield of Kabuli chickpea (*Cicer Kabulium* L.)". the study was conducted in Randomized block design with three replications. The treatments comprised of with 8 different treatment combination. T_1 – control, T_2 – soil application of Rhizobium @ 1.5 kg ha^{-1}, T_3 – soil application of PSB @ 1.5 kg ha^{-1}, T_4 – seed treatment with Rhizobium @ 200 g/10 kg seeds, T_5 - seed treatment with PSB @ 200 g/10 kg, T_6 – Foliar application of micronutrients mixture before flowering @ 0.5 g/litre, T_7 – Foliar application of micronutrients mixture after 50% flowering @ 0.5 g/litre, T_8 – Foliar application of micronutrients mixture after 50% podding @ 0.5 g/litre. The soil of experimental field was slightly alkaline with 8.09 pH and 0.22 EC. The soil is low in organic carbon and low in available nitrogen (260 kg/ha), medium in potash (175 kg/ha). The chickpea crop (Shubhra) was sown at 30 x 10 cm spacing. It was observed that the highest seed yield (17.33 q ha^{-1}), biological yield (41.43 q ha^{-1}) and harvest index (41.74%) were found when (seed Inoculated with Rhizobium @ 200 g/10 kg seed (T_4), followed by the T_6 i.e. seed yield 17.03 q ha^{-1}, biological yield 40.90 q ha^{-1}, harvest index 41.64%. whereas minimum value was in control, (seed yield 13.33 q ha^{-1}, biological yield 31.43 q ha^{-1}).

Keywords: Chickpea, rhizobium, PSB (Phosphorus Solubilizing Bacteria), micronutrients, seed yield

Introduction

Chickpea (*Cicer arietinum* L.) is a legume crop of family Fabaceae, subfamily Faboideae. It originated in southeastern Turkey (Ladizinsky 1988) [1]. The name Cicer is of Latin origin, derived from the Greek word 'kikus' meaning force or strength. Nutritionally, it contains 24% protein, 59.6% carbohydrates and 3.2% mineral. It has the ability to fix atmospheric nitrogen and can also tolerate high temperatures during and after. It is one of the earliest cultivated legumes: 7,500-year-old remains have been found in the Middle East. Grown usually as a rainfed cool-season crop or as a dry climate crop in semi-arid regions. Optimum conditions include 18-26 °C day and 21-29 °C night temperatures and annual rainfall of 600^{-1}000 mm (Duke, 1981; Muehlbauer *et al*., 1982; Smithson *et al*., 1985) [2, 3, 4]. In India, chickpea cultivation was done on 10.56 million ha with the production of 11.23 mt during 2017- 2018. During 2018^{-1}9, chickpea production reached to record 11.08 million tonnes. During 2020-21 the production estimated is about 11.62 million tonnes.

Chickpea is considered to sustain cropping system productivity due to its ability to fix atmospheric nitrogen. This crop possesses nodules on its roots where bacteria of the genus Rhizobium live with a specific function of converting the atmospheric nitrogen into plant available form called biological nitrogen fixation (BNF). In this way an appreciable amount of free of cost nitrogen is deposited in the soil which can be used by the same crop and the subsequent one. The efficiency of such crop in fixing maximum nitrogen depends upon the cultivar, efficient strain and management practices.

Artificial seed inoculation of chickpea in those soils lacking native effective rhizobia is a very useful practice for improving root nodulation and yield of the crop (Hernandez and Hill, 1984; Shamim and Ali, 1987; Shah *et al*., 1994; Tagore *et al*., 2013) [12, 5, 6, 7]. Chickpea also responded positively to artificial rhizobial inoculation when grown in soils that contain its native rhizobia (Sharma *et al*., 1983) [8].

Microbial inoculants are cost effective, ecofriendly, and renewable sources of plant nutrients (Khan *et al*., 2007) [10]. Rhizobium and phosphate solubilizing bacteria (PSB) assume a great importance on account of their vital role in N2-fixation and Psolubilisation. Use of Rhizobium and PSB had shown advantage in enhancing chickpea productivity (Jain *et al*., 1999: Rudresh *et al*. 2005) [11, 9]. Micronutrients are as important as major nutrients and can cause the same level of damage as major nutrients when they are deficient in soil and plant systems.

Over the last few years there has been a steady trend to the use of mineral fertilizers, especially soil applied nutrients such as – N, P and K and their use decreased seven times. These facts create preconditions to increase the importance of foliar nutrients application as an alternative to meet plant nutrients demands during the growing season. Interest on nutrients application, such as rapid and effective response to plant needs, regardless of soil conditions. Moreover, foliar application during the growth and development of crops can improve their nutrient balance, which may in turn lead to an increase in yield, quality or both (Kolota and Osinska, 2001) [13]. Foliar applications may sometimes facilitate the rapid absorption of mineral elements, avoiding the occurrence of soil interactions that may limit root uptake due to nutrient immobilization in the soil. Additionally, foliar fertilization may also stimulate the capability of the root system to absorb nutrients from soil solution (Taiz and Zeiger 1998, Kuepper 2003) [15, 14] indicated the great potential of foliar application as a means of reducing soil and ground water pollution.

Therefore, the present investigation was conducted during rabi season 2020-2021 at Chandrasekhar Azad University of Agriculture and Technology at SIF farm, Kanpur to study “Effect of Rhizobium and PSB inoculation and foliar spray of micronutrient on growth and yield of Kabuli chickpea (*Cicer kabulium* L.)”

Material and Method

The present was conducted at the Students Instructional Farm during rabi seasons of 2020- 2021. The field experiment was laid out in the field No. 03 at Students Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) India during Rabi season 2020-21. The farm is located in the main campus of university. The University is situated in Indo-Gangetic alluvial tract of Central Plain Zone of U.P. that is come in agro-climatic zone-V. The climate of Kanpur is sub-tropical, semi-arid with hot dry summer and severe cold in winter. Maximum temperature during summer reaches up to 46 °C, while during winter it fall up to 4 °C. The mean annual precipitation of the district is about 815.6 mm which is mostly received in the month of July to mid-September with occasional few showers of cyclonic rains during December and January. The total rainfall received 5.60 mm during crop growth period. The weather parameters collected for crop period from meteorological observatory of the university. In all, there are 8 treatments with chickpea crop.

1. T_1 Control
2. T_2 Soil application of Rhizobium @ 1.5 kg ha^{-1}
3. T_3 Soil application of PSB @ 1.5 kg ha^{-1}
4. T_4 Seed treatment with Rhizobium @ 200 gm/ 10 kg seeds
5. T_5 Seed treatment with PSB @ 200 gm/ 10 kg seeds
6. T_6 Foliar spray of micronutrients mixture before flowering @ 0.5gm/litre
7. T_7 Foliar spray of micronutrients mixture after 50% flowering @ 0.5gm/litre
8. T_8 Foliar spray of micronutrients mixture after 50% podding @ 0.5gm/litre

The experiment was conducted in Randomized Block Design with three replications. A plot size of 5*4m^2 was maintained with a spacing of 30cm * 10cm. The required quantity of seeds of chickpea variety (Shubhra) for experimental area was worked out using the recommended dose i.e., @100^{-1}20 kg/ha. Soil application of Rhizobium and PSB was done by mixing 1.5 kg inoculant thoroughly with 50 kg finely powdered FYM and broadcasting this mixture at the time of last ploughing. In case of PSB, best results are obtained when applied with well decomposed organic manure. Seed treatment with Rhizobium and PSB is done by Seed coating with 10% Maida gruel or jaggery @ 200-300ml/ kg of seeds and coating with Rhizobium and PSB @ 200-300 g per kg of seed improve the field emergence of crop. Growth attributes like plant height, primary and secondary branches and dry weight/plant are taken at 30, 60 DAS and at harvesting. Yield attributing traits like total number of pods /plants, number of grains per pod and test weight (100-seed weight (g) are also recorded. Seed yield/plant, Grain yield (kg/ha), Straw yields (kg/ha) are recorded. Harvest index is the ratio of economic yield to biological yield which is expressed in percentage. It was calculated as per formula given below as suggested by Donald 1969

Harvest Index (%) = (Economic Yield/Biological Yield) * 100.

The data recorded on various growth and yield attributes was subjected to statistical analysis by Fisher method of analysis of variance. Significance of various treatments was judged by comparing calculated, F value with Fisher’s F value at 5 percent level.

Result and Discussion

Growth attributes

Plant height (cm) Plant height is an important character of the vegetative phase and indirectly influences the yield components. The plant height was periodically recorded at 30 days interval starting from 30 days, up to maturity stage. The analyzed data are presented in Table 1. The data recorded to average plant height of chickpea at different stages of crop 30, 60 DAS and at harvest stage. The higher plant height recoded at 30 DAS (13.77 cm) 60 DAS (26.33 cm) and at harvest (40.10 cm). It is clear from the table 1 that in treatment, that highest plant height was observed at all the three stages and significantly superior over control (12.10 cm 30 DAS,25 cm 60 DAS ,34 cm at harvest respectively), and at par with T_5. The maximum plant height recorded in T_4 treatment which was significantly superior over all the treatments except and T_2. Number of root nodules Plant^{-1}: The variation in number of root nodules due to different seed inoculation was recorded significant effect at all the stages of crop growth and influenced by the seed inoculation with Rhizobium and PSB culture. Effect of different treatments on nodule formation recorded at 30,60 and 75 DAS presented in Table 3. It is clear from the table that all the stages of crop i.e 30, 60 and 75 DAS, the highest number of nodulations 15.16 plant^{-1}, 26.00

plant^{-1} and 23.66 plant^{-1} were recorded in T_4 followed by T_5 at 30 and 60 days - 13.33, 24.50 nodules plant^{-1}, respectively and T_2 in 75 days. It is also clear from the table that the significantly lowest number of nodules plant^{-1} was recorded in T_1 treatment but it is at par with T_6, T_7 and T_8, it is also clear from the table that maximum nodulation formation was found at 60 DAS and at 75 DAS reducing pattern was found.

Table 1: Effect of Rhizobium, PSB inoculation on plant height and number of nodules plant^{-1}

Treatments	Plant height (cm)			Number of nodules plant^{-1}		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	75 DAS
T_1	12.100	25.000	34.400	7.500	14.660	14.000
T_2	12.220	26.060	36.030	12.330	24.000	22.500
T_3	12.660	25.800	35.500	11.000	22.000	20.000
T_4	13.770	26.330	40.100	15.160	26.000	23.660
T_5	13.330	26.100	38.400	13.330	24.500	22.330
T_6	12.100	24.960	34.760	8.000	15.500	14.330
T_7	12.550	24.960	34.730	7.660	15.330	14.160
T_8	12.330	25.000	34.800	8.000	15.330	14.330
S. Em. ±	0.4531	0.3033	0.8933	0.4722	0.8128	0.8798
CD @ 5%	0.6407	0.9196	2.7095	1.4319	2.4653	2.6685

The observation on average number of Primary branches per plant was recorded at 30 DAS, 60 DAS, and at harvest stage and present in Table 2. It is clear that significantly highest number of primary branches i.e., 2.80 recorded in T_4 which were at par with T_5 (2.77), T_2 (2.66), T_3 (2.66) and significantly lowest number of primary branches in T_6 treatment (2.22). It is clear from the Table that significantly highest number of primary branches was found in T_4 which are at par with T_2 4.88, T_6 treatment 4.70 and significantly lowest number of primary branches recorded in T_1 treatment at 60 DAS At harvest stage, significantly highest number of primary Branches per plant recoded in treatment T_4 over all the treatments. The lowest number of primary branches recorded in T_1 treatments. The observation on average number of secondary branches per plant was recorded at 60 DAS and at harvest stage are depicted in Table 2. It is clear from the table that the significantly highest secondary branches per plant was found in T_4, but it is at par with T_5 at both the stages i.e 60 DAS and at harvest stage of crop.

Table 2: Influence of treatments on number of primary branches and secondary branches plant^{-1}

Treatments	Primary branches			Secondary branches	
	30 DAS	60 DAS	At harvest	60 DAS	At harvest
T_1: Control i.e. RDF	2.330	3.220	13.33	9.500	13.330
T_2: Soil application of Rhizobium @ 1.5 kg ha^{-1}	2.660	4.800	15.00	12.160	15.500
T: Soil application of PSB @ 1.5 kg ha^{-1}	2.660	4.300	15.50	10.100	15.000
T_4: Seed treatment with Rhizobium @ 200 gm/10 kg seed	2.980	5.440	18.50	14.000	18.500
T_5: Seed treatment with PSB @ 200 gm/10 kg seed	2.770	4.600	17.00	13.160	17.000
T_6: Foliar spray of micronutrients mixture before flowering @ 0.5 gm L^{-1}	2.220	4.700	17.33	11.500	17.330
T_7: Foliar spray of micronutrients mixture after 50% flowering @ 0.5 gm L^{-1}	2.440	4.220	15.00	9.830	15.000
T_8: Foliar spray of micronutrients mixture after 50% podding @ 0.5 gm L^{-1}	2.320	4.100	14.66	10.100	14.660
S. Em. ±	0.0683	0.2422	0.4899	0.4247	0.4899
CD @ 5%	0.2048	0.7356	1.4859	1.2885	1.4859

Total Fresh weight (g plant^{-1}) and Dry weight (g plant^{-1}): The total fresh weight and dry weight of chickpea recoded at different stages of crop growth recorded and presented in Table 3. It is clear from the table that significantly highest fresh weight recorded in T_4 i.e 7.66 g plant^{-1}, 32.06 g plant^{-1} and (27.43 g plant^{-1}) at all the stages of crop growth i.e 30 DAS, 60 DAS and at harvest stage and at par with T_5 and significantly lowest fresh weight recorded in T_8 at 30 DAS 6.03 g plant^{-1}, 60 DAS. Numerically lowest fresh weight 29.70 g plant^{-1} recorded in T_6 at 60 DAS. At harvest stage highest fresh weight recorded in T_4 27.43 g plant^{-1}, which is significantly highest over all other treatments and lowest was recorded in T_1 treatment. It is clear from the Table 3 that the highest dry matter found in T_4 in all stages of crop growth i.e 30 DAS, 60 DAS, and at harvest stage which is at par with T_5 at 30 and 60 DAS, and T_6 at harvest stage, and lowest were recorded in T_1 treatment at all the stages of crop growth.

Yield and yield attributing parameters

The yield and yield attributes like number of pods per plant, number of seed per pod, Test weight, seed yield and stover yield were significantly influenced by soil application of Rhizobium and PSB, seed inoculation of Rhizobium and PSB and foliar spray of different micronutrients.

The observations on average number of pods per plant influenced by various treatments are presented in Table 4. The number of pods per plant varied from 26.33 to 32.33 pods T_4. The seed treatment with Rhizobium and PSB and Foliar application of micronutrients before flowering @ 0.5 gm/liter along with RDF increase the number of pods per plant. The significant superior number of pods per plant was recorded in T_4 (32.33 pods plant^{-1}) which was at par with T_6 (31.66 pods plant^{-1}) and T_5 (30.44 pods plant^{-1}). However, it was statistically significant over control or T_1 treatment (26.33 pods plant^{-1}).

The observations on average number of seed pod^{-1} influenced by various treatments are presented in Table 4. The number of seed pod^{-1} varied from 2 seed pod^{-1} T_1 to 3.4 seed pod^{-1} T_4. The seed treatment with Rhizobium and PSB and Foliar application of micronutrients before flowering @ 0.5 gm/liter along with RDF increase the number of seed pod^{-1} per plant over control. The highest number of seed pod^{-1} was recorded in T_4 3.4 seed pods^{-1} which was at par with T_6 3.2 seed pod^{-1}, and significantly superior over control or T_1 treatment (2 seed pod plant^{-1}).

The data on test weight (Table 4) as influenced by various treatments was recorded and varied from 160.50 g (T_1) to 168.33 g (T_4). T_4 recorded highest value for test weight of (168.33 g) when compared to other treatments. However, it was at par with T_6 166.66 g (160.860 g), and lowest being was observed in control (160.500 g).

The data on biological yield pertaining to various treatments was recorded and presented in Table 4. The data on biological yield as influenced by various treatments revealed that higher biological yield was recorded in T_4 i.e. 41.43 q ha^{-1}, respectively and it was at par with T_6 40.90 q ha^{-1} respectively, T_5 38.90 q ha^{-1}, respectively and is significantly superior over control or T_1 treatment 31.430 q ha^{-1} . The extent of increase in biological yield in T_4 to the tune of 31.81% over control, 1.29% over T_6.

Seed yield of chickpea as influenced by soil application of Rhizobium and PSB, seed treatment with Rhizobium and PSB and Foliar application of micronutrients before flowering, after 50% flowering, and after 50% Podding are presented in Table 4. Among the different treatments, T_4 recorded significantly higher seed yield of 17.30 q ha^{-1} and it was at par with the T_6 17.03 q ha^{-1}, T_5 16.20 q ha^{-1}, and significantly superior over control or T_1 treatment – (13.30 q ha^{-1}). The extent of increase in seed yield in T_4 to the tune of 30.07% over control, 1.58% over T_6.

The data on straw yield pertaining to various treatments was recorded and presented in Table 4. The data on straw yield as influenced by various treatments revealed that higher straw yield was recorded in T_4 i.e. 24.13 q ha^{-1}, respectively and it was at par with T_6 23.86 q ha^{-1} respectively, T_5 22.70 q ha^{-1}, respectively and is significantly superior over control or T_1 treatment - 18.13 q ha^{-1}. The extent of increase in Straw yield in T_4 to the tune of 33.09% over control, 1.16% over T_6.

The data with respect to harvest index of chickpea showed significant to soil application of Rhizobium and PSB, seed treatment with Rhizobium and PSB and Foliar application of micronutrients before flowering, after 50% flowering and after 50% Podding observations are presented in Table 4. The harvest index of chickpea crop varied from 41.64 percent to 42.93 percent.

Table 3: Effect of treatments on fresh weight and dry weight (g plant^{-1})

Treatments	Fresh weight (g plant^{-1})			Dry weight (g plant^{-1})		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1: Control i.e. RDF	6.660	29.993	21.300	1.240	7.700	18.560
T_2: Soil application of Rhizobium @ 1.5 kg ha^{-1}	6.760	31.300	26.400	1.310	8.260	24.300
T_3: Soil application of PSB @ 1.5 kg ha^{-1}	6.560	30.930	24.830	1.290	8.230	22.130
T_4: Seed treatment with Rhizobium @ 200 gm/10 kg seed	7.660	32.060	27.430	1.590	8.700	25.100
T_5: Seed treatment with PSB @ 200 gm/10 kg seed	7.560	31.400	25.030	1.460	8.500	22.400
T_6: Foliar spray of micronutrients mixture before flowering @ 0.5 gm L^{-1}	6.030	29.700	25.300	1.270	7.860	24.760
T_7: Foliar spray of micronutrients mixture after 50% flowering @ 0.5 gm L^{-1}	6.130	30.030	25.100	1.250	7.900	22.460
T_8: Foliar spray of micronutrients mixture after 50% podding @ 0.5 gm L^{-1}	6.030	30.130	24.360	1.260	7.900	22.360
S. Em. ±	0.1354	0.3688	0.2652	0.0548	0.1065	0.5193
CD @ 5%	0.4098	1.1180	0.8040	0.1640	0.3217	1.5753

Table 4: Yield and harvest index of chickpea as influenced by different treatments

Treatments	Number of pods plant^{-1}	Number of seed Pod^{-1}	Test Weight (g)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1	26.330	2.000	160.500	13.300	18.130	31.430	42.300
T_2	28.880	2.800	161.700	15.300	20.330	35.630	42.930
T_3	28.330	2.300	161.060	14.360	19.500	33.860	42.400
T_4	32.330	3.400	168.330	17.300	24.130	41.430	41.740
T_5	30.440	2.800	160.860	16.200	22.700	38.900	41.640
T_6	31.660	3.200	166.660	17.030	23.860	40.900	41.640
T_7	30.330	2.800	160.760	13.400	18.230	31.630	42.350
T_8	29.330	2.660	160.630	13.500	18.330	31.830	42.400
S. Em. ±	0.6738	0.0816	1.2883	0.4817	0.5468	1.0159	0.2633
CD @ 5%	2.0438	0.2466	3.9077	1.4612	1.6586	3.0812	0.7982

Discussion and Conclusion

The seed inoculants with Rhizobium, PSB @ 200 g/10 kg seed, soil application of Rhizobium and PSB @ 1.5 kg ha^{-1} and Foliar spray of micronutrients @ 0.5 g/ liter influenced the growth attributing parameter *viz*. plant height and number of branches at all crop growth stages except at 30 DAS. At maturity, maximum plant height was observed with T_4 (40.10 cm), while minimum value was in T_1 (34.40 cm). Plant fresh weight and dry weight was influenced significantly at all the stages of observation. Seed Inoculation of Rhizobium (T_4) was recorded significantly superior fresh matter and dry matter per plant at 60 DAS and at maturity stage than all the other inoculants and lowest in T_1 - (21.30 g plant^{-1}). Number root nodule per plant was significant due to inoculants. nodules number were higher in Seed Inoculation of Rhizobium (T_4) was significantly superior over all the inoculants and lowest in T_1. The plant growth parameters like plant height, number of branches per plant and dry matter production were significantly influenced by foliar application of micronutrient before flowering @ 0.5 g/litre. Plant growth is dependent on the rate of accumulation of dry matter. The dry matter accumulation may reflect on the economic yield in view of the fact that vegetative parts of the plant serve as a source whereas seeds are the sink. Dry matter production per plant differed significantly due to soil application of Rhizobium and PSB, seed inoculation of Rhizobium and PSB and foliar spray of micronutrients at different rates of nutrient supply. In the present investigation, the plant growth parameters *viz*., plant population plant height, number of branches per plant, total fresh weight production, total dry matter production, number of nodules, were significantly influenced by soil application of Rhizobium and PSB, seed inoculation of Rhizobium and PSB and foliar application of micronutrients at different concentration at 30 DAS,60 DAS and at harvest. Increase in plant height might be due to biological nitrogen fixation and other biological process with the addition of these micronutrients as reported by Mahantesh (2013) [17] and also, he mentioned that availability of zinc stimulates the metabolic activity and enzymatic activity there by increasing the plant growth parameters. Similar findings were also reported by Meena *et al.* (2006) [18] and found that chickpea plant height was significantly increased with micronutrient application might be due to the effective absorption of nutrients (N + micronutrients mixture) through foliar spray. Similarly, increase in growth parameters with supplementation of micronutrients mixture might be attributed to the balanced nutrition of the black gram crop (Divyashree *et al*. 2018) [21]. Gowthami and Rao (2014) [20] in soybean, Kannan *et al*. (2014) [19] in blackgram and many others reported similar findings.

Seed inoculants were found significant effect on yield attributes such as pods per plant, seeds per pod and Test weight. The superior yield components were found when seed Inoculated with Rhizobium (T_4). The highest seed yield (17.33 q ha^{-1}), biological yield (41.43 q ha^{-1}) and harvest index (41.74%) was recorded by T_4 followed by the T_6 (17.03 q ha^{-1}), biological yield (40.90 q ha^{-1}), harvest index (41.64%). whereas minimum value was in control, seed yield (13.33 q ha^{-1}), biological yield (31.43 q ha^{-1}). The yield and yield attributes of chickpea were significantly influenced by foliar application of micronutrient mixture before flowering @ 0.5 g/liter T_6 - seed yield (17.03 q ha^{-1}), biological yield (40.90 q ha^{-1}), harvest index 68 (41.64%) which is superior over the other foliar application treatments. The growth and development of a plant is the net result of the interaction of diverse metabolic activities taking place in the different parts of a plant in accordance with the supply of light, water, temperature and nutrients from the environment. Among abiotic stress soil fertility is one of the most important factors that influence the crop productivity. The seed yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as the extent of translocation into sink (seeds) and also on plant growth and development during early stages of crop growth. The production and translocation of synthesized photosynthates in harmony with mineral nutrition supplied either through soil or foliar application. Foliar nutrition increases the utilization of plant nutrients too. The nutrients absorbed by the leaves stimulate the metabolic processes in the plant; positively influencing the nutrient uptake via the roots. Among the different agronomic manipulation to increase the yield, the applications of micronutrients play a vital role. Crop yields can be maximized only when soil has the capacity to supply nutrients in sufficient quantity and in balanced proportion. The application of chemical fertilizers to the soil at recommended dose and also supplementing the plant with micronutrients can address the nutritional balance of crops. Usually, micronutrients which are required by crops are in trace concentrations. Micronutrients on the other hand are as important as major nutrients and can cause the same level of damage as major nutrients when they are deficient in soil and plant systems. In addition to the above, the adverse soil environmental factors also come in the way of plant uptake and utilization of soil applied nutrients. On the other hand, foliar application of these micro nutrients could eliminate the impact of these factors and result in rapid absorption. It is acknowledged that foliar fertilizer use efficiency is about 20 times more effective in comparison to soil applied micronutrients. Therefore, the foliar application of micronutrients ensures the entry of nutrients into the foliage and distribution to all parts of the plant within a short period of time to get necessary effect. In the present study, results revealed that seed yield of chickpea significantly differ among the treatments with the soil application of Rhizobium and PSB, seed treatment with Rhizobium and PSB culture and foliar application of micronutrients varied. From Table 4 it revealed that the higher seed yield (17.30 q ha^{-1}) was recorded in T_4, which was higher over T_6, T_5, T_2, T_3, T_8, T_7 and significantly superior with absolute control treatments. Significantly higher seed yield of chickpea was mainly attributed to higher yield components *viz*., number of pods per plant (32.33 pods), average test weight of seeds (168.33 g) and harvest index (41.74 %) (Table 4). The increased yield and yield attributing characters might be due to increased biological nitrogen fixation and other physiological process with the addition of these micronutrients which favored the rapid growth of crop and produced a greater number of pods and there by seed yield under these treatments compared to other treatments. Similarly, significantly higher stover yield of chickpea was also recorded with seed treatment with Rhizobium @ 200 gm / 10 kg seed (24.13 q ha^{-1}).

On the basis of experimental result conducted during rabi season (2020-2021) at Students instructional farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur it can be concluded that the seed inoculation with Rhizobium @ 200 g/10 kg seeds was found best among other treatments with respect to productivity and profitability in chickpea. The plant growth parameters like plant height, number of branches per plant and dry matter production were significantly influenced by foliar application of micronutrient before flowering @ 0.5 g/liter. The yield and yield attributes of chickpea were significantly influenced by foliar application of micronutrient mixture before flowering @ 0.5 g/liter T_6 - seed yield (17.03 q ha^{-1}), biological yield (40.90 q ha^{-1}), harvest index (41.64%) which is superior over the other foliar application treatments.

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