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Effect of Rhizobium and PSB inoculation and foliar spray of micronutrient on yield, quality attributes and production economics of Kabuli chickpea (*Cicer kabulium* L.)

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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 yield, quality attributes and production economics 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 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}). The highest net return and B:C ratio was found in T_4 treatment (Seed Inoculation of Rhizobium @ 200 g/10 kg seed) i.e., Rs 48,831 and 1.99 respectively, followed by T_6 Treatment– (Foliar application of micronutrients mixture before flowering @ 0.5 g/liter) Rs 46,783 and 1.94 respectively. The lowest Net returns i.e., Rs 25,297 and B:C ratio i.e., 1.51 was found in T_1 Treatment or control.

Keywords: Chickpea, rhizobium, PSB (Phosphorus solubilizing bacteria), micronutrients, seed yield

Introduction
Chickpea is the third most important crop in the world after dry bean and pea. It accounts for 20% of the world pulses production. Major producers of chickpea include India, Pakistan and Mexico. Global production, as per the latest available estimates of Food and Agricultural Organization (FAO), is about 14.25 million metric tons in 2019. India is the largest producer, with about 11.62 million tons (Ministry of agriculture and farmers welfare)2021, accounting of about 70% of total world production. Six countries including India, Australia, Turkey, Myanmar, Pakistan and Ethiopia account for about 90% of world chickpea production India is the largest producer of chickpea in the world sharing 71.01 and 71.96 per cent of the total area (9.93mha) and production (9.88 mt), respectively with productivity of 995 kg ha^{-1} (FAOSTAT, 2016) [1]. During 2020-21 the production estimated is about 11.62 million tonnes (Ministry of agriculture and farmers welfare).

Microbial inoculants are cost effective, ecofriendly, and renewable sources of plant nutrients (Khan *et al*., 2007) [4]. Rhizobium and phosphate solubilizing bacteria (PSB) assume a great importance on account of their vital role in N2-fixation and P solubilisation. Use of Rhizobium and PSB had shown advantage in enhancing chickpea productivity (Jain *et al*., 1999: Rudresh *et al*. 2005) [3, 4]. 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.

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. In recent past, there are many reports which highlighted the deficiencies of micro nutrients in most of the soils; the reason may be attributed to prioritized use of fertilizers containing only major nutrients coupled with

minimum and less use of organic manures. The micronutrients deficiency, particularly zinc deficiency leads to reduction of stem elongation, auxin activities, protein synthesis, flowering and fruit development and also growth period is prolonged resulting in delayed maturity and reduced yield (Tandon, 2009) [6]. Next to zinc, iron deficiency is becoming a serious impediment in crop production. Iron is necessary for maintenance of chlorophyll in plants and also constituent of several enzyme *viz*., ferredoxin, hemoglobin and catalase, etc. (Kumari *et al*., 1993) [7]. Manganese serves as an activator for enzymes in growth processes. It assists iron in chlorophyll formation and it is also constituent of enzymes like Superoxide dismutase. It is part of the system where water is split and oxygen gas is liberated. High manganese concentration may induce iron deficiency in plants (Epstein and Bloom, 2005) [8].

In addition to the above, the adverse soil environmental factors also come in the way of plant uptake and utilization of soil applied nutrients. So, to cope with the above constraint, the nutrient requirements of the crop at important growth stages, the foliar fertilization seems to be the efficient way and much acceptable practice. Foliar application of micro nutrients could eliminate the impact of edaphic 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. Moreover, numerous studies have also confirmed positive response of many crops for foliar spray.

Therefore, the present investigation was conducted during rabi season 2020-2021 at Chandrasekhar Azad University of Agriculture and Technology at Student Instructional Farm, Kanpur to study "Effect of Rhizobium and PSB inoculation and foliar spray of micronutrient on yield, quality attributes and production economics 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 @ 0.5 gm/litre
7. T_7 Foliar spray of micronutrients mixture after 50% flowering @ 0.5 gm/litre
8. T_8 Foliar spray of micronutrients mixture after 50% podding @ 0.5 gm/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. 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.

Nutritional quality parameters Nitrogen content (%), Protein content (%), Methionine (%), Tryptophan (%), Lysine (%) are calculated. Production economics of the crop is analysed by calculating Cost of cultivation (Rs. ha^{-1}), Gross returns (Rs. ha^{-1}), Net returns (Rs. ha^{-1}), and Benefit cost ratio calculated using formula

Benefit - Cost ratio = Gross return (Rs/ha)/Cost of cultivation (Rs/ha).

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.

Results and Discussion

Nitrogen content, Protein content and different Amino acids (Methionine, Tryptophan, Lysine) in grain

The data for N and Protein content (%) in grain is presented in Table 1. It is clear from the table highest nitrogen (%) and highest protein content (%) is found in T_2 treatment (soil application of Rhizobium @1.5 kg ha^{-1}) and lowest protein and nitrogen content is found in T_1 treatment (Control). It is also clear from the table 1. that highest Methionine amino acid is found in T_4 treatment – (Seed treatment with Rhizobium @ 200 g/10 kg seeds) and lowest Methionine amino acid is found in T_1 treatment (Control) and Tryptophan amino acid T_4 treatment – (Seed treatment with Rhizobium @ 200 g/10 kg seeds) and lowest Methionine amino acid is found in T_1 treatment (Control) and Lysine amino acid is highest in T_4 treatment – (Seed treatment with Rhizobium @ 200 g/10 kg seeds) and lowest Lysine amino acid is found in T_1 treatment (Control).

Table 1: Influence of different treatments on quality of chickpea.

Treatments	Nitrogen content (%)	Protein content (%)	Methionine (%)	Tryptophan (%)	Lysine (%)
T_1	3.85	24.12	0.06	0.89	2.76
T_2	3.91	24.45	0.29	1.00	2.80
T_3	3.9	24.40	0.10	1.01	2.86
T_4	3.89	24.27	0.38	1.03	2.87
T_5	3.88	24.34	0.16	0.95	2.83
T_6	3.87	24.37	0.13	0.98	2.80
T_7	3.88	24.31	0.23	0.96	2.81
T_8	3.85	24.21	0.29	0.97	2.82

Yield

The data on biological yield pertaining to various treatments was recorded and presented in Table 2. 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 2. 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 2. 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 2. The harvest index of chickpea crop varied from 41.64 per cent to 42.93 per cent.

Table 2: Yield and harvest index of chickpea as influenced by different treatments.

Treatments	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1	13.300	18.130	31.430	42.300
T_2	15.300	20.330	35.630	42.930
T_3	14.360	19.500	33.860	42.400
T_4	17.300	24.130	41.430	41.740
T_5	16.200	22.700	38.900	41.640
T_6	17.030	23.860	40.900	41.640
T_7	13.400	18.230	31.630	42.350
T_8	13.500	18.330	31.830	42.400
S. Em. ±	0.4817	0.5468	1.0159	0.2633
CD @ 5%	1.4612	1.6586	3.0812	0.7982

Economics

Economics is the final criteria to evaluate the best treatment which is economically sound and can be accepted as viable one. The effect of 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 were nonsignificant with respect to gross returns, net returns and B: C ratio over control (Table 3)

(I) Cost of cultivation: Treatment wise costs of cultivation were calculated and recorded in Table 3. It is clear from the Table that the cost of cultivation is highest in T_6 – Foliar application of micronutrients before flowering @ 0.5 g/liter (Rs. 49,614) followed by other treatments. The lowest cost of cultivation recorded in T_1 - Control (Rs. 48,801)

(ii) Gross income: The data computed regarding gross income showed that the highest gross income was found in T_4 - seed treatment with Rhizobium @ 200 gm / 10 kg of seed (Rs. 97,882) followed by other treatment and the lowest gross income found in T_1- Control (Rs. 74,098).

(iii) Net income: The data pertaining to net income rupees per hectare received under different treatments were summarized in Table 6. It is clear from table that among all the treatment, highest net income was obtained in T_4 – seed treatment with Rhizobium @ 200 gm / 10 kg of seed (Rs. 48,831) followed by other treatments and lowest income obtained in T_1 – absolute control (Rs. 25,297).

(iv) Benefit: Cost ratio (B:C ratio): The data pertaining to Benefit: Cost ratio of different of treatments was summarized in Table 3. The highest B:C ratio was found maximum in T_4 – seed treatment with Rhizobium @ 200 gm / 10 kg of seed (1.99) followed by other treatments and lowest B:C ratio was found in T_1 – absolute control (1.51).

The cost economic analysis of various treatments in the present study has showed that highest cost of cultivation (Rs 49,614) observed in T_6 – Foliar application of micronutrients before flowering @ 0.5 g/liter and highest gross returns (Rs 97,882) was obtained by treatment that includes T_4 – Seed treatment with Rhizobium @ 200 g/10 kg seeds. The treatments which received foliar spray of micronutrients before flowering @ 0.5 g/liter recorded comparatively higher returns and B: C ratio over other treatments and absolute control. However, the higher net returns and B: C ratio was recorded by treatment which received seed treatment with Rhizobium @ 200 g/10 kg seeds (T_4).

Table 3: Influence of different treatments economics of chickpea cultivation

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
T_1	48801.00	74098	25297.0	1.51
T_2	48988.50	86162	37173.5	1.75
T_3	48988.50	81036	32047.5	1.65
T_4	49051.00	97882	48831.0	1.99
T_5	49051.00	91700	42649.0	1.86
T_6	49614.00	96397	46783.0	1.94
T_7	49614.00	75632	26018.0	1.52
T_8	49614.00	76182	26568.0	1.53
S. Em. ±	404.5706	608.0125	101.4335	0.0447
CD @ 5%	1227.1448	1844.2257	307.6685	0.1303

Discussion and Conclusion

High nitrogen, phosphorus and potassium content in leaf, stem and grain samples was recorded in treatment receiving foliar spray of micronutrients along with recommended dose of fertilizers. The concentration and uptake of micronutrients in grains and straw increased with increase in the concentration of foliar spray of micronutrients before flowering. The protein content of chickpea was improved by foliar application of micronutrients.

The result of analysis of variance revealed that yield attributing character except biological yield and straw yield of chickpea was significantly affected by the seed inoculation, soil application of Rhizobium and PSB and Foliar application of micronutrients. 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 - seed treatment with Rhizobium @ 200 g/ 10 kg seeds followed by the T_6 – Foliar application of micronutrients before flowering @ 0.5 g/liter (seed yield 17.03 q ha^{-1}, biological yield 40.90 q ha^{-1}, harvest index 41.64%). The observed seed yield and biological yield improvements when inoculation with T_4 - seed treatment with Rhizobium @ 200 g/ 10 kg seeds might be due to the increased N from atmospheric nitrogen fixation from effective nodule formation in the vicinity of root zone and P availability by seed inoculants with PSB as result of improvements observed for the yield traits discussed above. These results are in line with Dubey and Gangwar (2012).

Cost of cultivation gross returns, net returns and B: C ratio of chickpea was significantly influenced by foliar application of micronutrients. T_6– (Foliar application of micronutrients mixture before flowering @ 0.5 g/liter, cost of cultivation (Rs 49614), gross return (Rs 96397), net return (Rs 46783). B:C ratio (1.94) is superior over other treatments foliar application and is economically feasible. The cost of cultivation was found highest in T_6 – Foliar application of micronutrients mixture before flowering @ 0.5 g/liter (Rs 49,614) and lowest in T_1 – Control (Rs 48,801). The highest gross return was recorded in inoculants seed treatment with Rhizobium @ 200 g/10 kg seeds T_4 - (Rs 97,882 ha^{-1}) with net profit (Rs 48,831) and highest B:C ratio (1:99). The highest net return was found in Seed Inoculation of Rhizobium (T_4) @ 200 g/10 kg seed (Rs 48,831) and lowest in T_1 – absolute control (Rs 25,297). The highest B:C ratio was found in Seed Inoculation of Rhizobium (T_4) @ 200 g/10 kg seed (1.99) and lowest B:C ratio was observed in T_1 – absolute control (1.51).

On the basis of experimental result conducted during rabi season (2020-2021) 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 highest B:C ratio was found in T_4 treatment- (Seed Inoculation with Rhizobium @ 200 g/10 kg seed) (1.99) followed by T_6 (1.94), T_5 (1.86), T_2 (1.75), T_3 (1.65), T_8 (1.53), T_7 (1.51) and lowest B:C ratio was observed in T_1 – absolute control (1.51). The yield of chickpea was 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. From economic point of view the highest net return in T_4 - The highest net return was found in Seed Inoculation of Rhizobium (T_4) @ 200 g/10 kg seed (Rs 49,614), followed by T_6 - Foliar application of micronutrients mixture before flowering @ 0.5 g/liter (Rs 46783) and lowest in T_1 – absolute control (Rs 25,297). Thus it can be recommended that if the farmers can grow Kabuli chickpea with T_4 – (Seed Inoculation with Rhizobium @ 200 g/10 kg seed) treatment received maximum income. The cost of cultivation was found highest in T_6 – Foliar application of micronutrients mixture before flowering @ 0.5 g/liter (Rs 49,614) and lowest in T_1 – Control (Rs 48,801). The highest gross return was recorded in inoculants seed treatment with Rhizobium @ 200 g/10 kg seeds T_4 - (Rs 97,882 ha^{-1}) with net profit (Rs 48,831) and highest B:C ratio (1:99). The highest net return was found in Seed Inoculation of Rhizobium (T_4) @ 200 g/10 kg seed (Rs 48,831) and lowest in T_1 – absolute control (Rs 25,297). The highest B:C ratio was found in Seed Inoculation of Rhizobium (T_4) @ 200 g/10 kg seed (1.99) and lowest B:C ratio was observed in T_1 – absolute control (1.51).

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