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Effect of Rhizobium Inoculation with Different Levels of Inorganic Fertilizers on Yield, Nutrient Content & Uptake of Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted during Rabi season of 2021-22, to study the effect of combination of biofertilizer and different level of inorganic fertilizers on yield, quality, nutrient content & uptake of chickpea (*Cicer arietinum* L.) at pot culture farm of Department of Soil Science & Agricultural Chemistry of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.). The experiment comprises of eight treatments T_1 (Control), T_2 (RDF 75%), T_3 (RDF 100%), T_4 (RDF 125%), T_5 (Rhizobium), T_6 (RDF 75% + Rhizobium), T_7 (RDF 100% + Rhizobium), T_8 (RDF 125% + Rhizobium) in randomized block design with four replications. The chickpea variety RVG-202 is grown by adopting various agronomic practices. The result revealed that among all the treatments, RDF 125% + Rhizobium (T_8) treatment recorded maximum yield, highest nutrient content in terms of % N(3.58 %), % P (1.34 %) and % K (0.69 %) in grain % N(2.38 %), % P (1.35 %) and % K (0.86 %) in stover. Highest nutrient uptake viz. N (65.69 kg ha^{-1}), P (24.58 kg ha^{-1}) and (12.66 kg ha^{-1}) in grain and N (61.14 kg ha^{-1}), P (8.99 kg ha^{-1}) and (47.78 kg ha^{-1}) stover is also associated with the treatment T_8 [RDF 125% + Rhizobium]. It is clearly identified that seed inoculated with rhizobium can increase yield, nutrient content and uptake values of chickpea crop.

Keywords: Chickpea; nitrogen; phosphorus; potassium; rhizobium and yield.

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1. INTRODUCTION

India is the largest producer and consumer of pulses in the world. Major pulses grown in India include chickpea, pigeonpea, lentil, urd bean, mung bean, pea, lablab bean, moth bean, horse bean. Among the pulses, chickpea is the most important grown in every part of India. It is largest produced food legume in South Asia. Chickpea (*Cicer arietinum* L.) is a major legume crop cultivated for its edible seeds legume of the genus *Cicer*, Tribe *Cicereae*, family *Fabaceae* (*leguminaceae*), and subfamily *Papilionaceae*. It provide protein rich diet to the vegetarian of the Indian and complement the stable cereals in the diets with proteins, essential amino acids, vitamins and minerals [1]. They contain 22-24 % protein, which is almost twice the protein in wheat & thrice that of rice [2] and carbohydrate (61.51%), fat (4.5%) and relatively free from anti nutritional factors (Saxena, 1990). Chickpea is rich in protein content (20.47g/100g), carbohydrate (62.95g/100g), fibre (12.2g/100g), phosphorous (252mg/l00g), high amount of minerals such as calcium (57mg/100g), magnesium (79mg/100g), iron (4.31mg/l00g) and zinc (15mg/100g), low in fat content and most of it is polyunsaturated [3].

India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. India ranks first in the world in terms of pulse production (25% of total worlds production) (FAOSTAT 2017). In India chickpea occupies 10.17 million ha area, with a production of 11.35 million tonnes registering the productivity of 1116 kg/ha. In Uttar Pradesh, chickpea crop occupied 0.62 million hectares area, 0.85 million tonnes production and 1371 kg/ha productivity [4].

Nitrogen plays an imperative role in synthesis of chlorophyll, protoplasm, nucleic acid, protein, amino acids and other organic compounds which add to the building units of proteins in the plant system. Phosphorus is one of the most important major nutrients of plant and chickpea varieties also respond significantly to its application. Phosphate fertilization of chickpea promotes growth and nodulation which enhances yield. Phosphorus important for hardiness to shoot, improves grain quality, regulate the photosynthesis, govern physico-biochemical processes and thereby increase nitrogen fixation [5]. Phosphorus enhances the activity of rhizobia and increases the formation of root nodules thereby helps in fixing more of atmospheric nitrogen in root nodules. Phosphorus is also an important fertilizer in chickpea production; it is a very important chemical fertilizer that can raise the water holding capacity of soil [6].

Potassium is an essential macro nutrient for plant that enhances root growth and makes plant vigor, helps prevent lodging and enhances crop resistance to pests and diseases. Potassium is very effective in the nodulation of pulse crops thus increases the seed yield through better fixation of nitrogen [7]. Rhizobium inoculation helps to improve nodulation, plant growth and grain yield. Rhizobium inoculated pulse crop produces a 10–15% higher grain yield than a crop that has not been inoculated [8].

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was conducted at pot culture farm of Department of Soil Science & Agricultural Chemistry of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P) during *Rabi* season of 2021-22, under central plain zone.

2.2 Geographical Situation

Geographically, district “Kanpur Nagar” lies between the parallels of 25.26^0 and 26.58^0 N latitude, and 79.31^0 and 80.34^0 E longitude. It is situated on elevation of 124 meters above the sea level in the alluvial belt of Gangatic plains of central Uttar Pradesh.

2.3 Climate

The climate of Kanpur is sub-tropical with hot dry summer and severs cold winter. The annual precipitation is about 800 mm mostly received during rainy season, with occasional showers in winter from early November to the end of March. The maximum temperature during the experiment ranged from 15 to 40˚C while minimum temperature ranged from 4.5 to 18˚C. Mean relative humidity ranged from 50 to 85%.

2.4 Experimental Detail

The experiment comprises of eight treatments T_1 (Control), T_2 (RDF 75%), T_3 (RDF 100%), T_4 (RDF 125%), T_5 (Rhizobium), T_6 (RDF 75% + Rhizobium), T_7 (RDF 100% + Rhizobium), T_8 (RDF 125% + Rhizobium) in randomized block design with four replications. The recommended

dose of fertilizer to chickpea is 20-30 kg N ha^{-1}, 40-60 kg P_2O_5 ha^{-1} & 17-25 kg K_2O ha^{-1} (if soil low in K) were applied as per treatments through DAP and urea and MOP. The chickpea variety RVG-202 was sown with seed rate of 80- 100 kg ha^{-1} at spacing of 30 cm x 10 cm. The seed was treated with rhizobium before sowing at the rate of 20-25 gm of rhizobium per kg of seed. As per procedure seed was dry under shade for 6-8 hrs. The production of each plot collected separately and packed in bags carefully avoiding contamination. The grains & straw of each bag were then weighed and recorded in kg per net plot and there after computed as q ha^{-1}. The biological yield is the sum of grain and straw yield. The harvest index is computed by following formula –

$$H.I = \frac{\text{Grain yield}}{\text{biological yield}} \times 100$$

The chemical analysis of plants for the nutrient content was done when grain and straw samples were collected from each plot at harvest to analyze nitrogen, phosphorous and potassium concentration (%) and their uptake (kg ha^{-1}). The plant material was oven dried (70± 50C for 72 hours) and ground separately and then subjected for analysis. Plant analysis for the determination of nutrient content in grain and stover were done with the standard procedures viz., Nitrogen concentration in plant (both grain and straw) was determined by Kjeldahl's method [9], Phosphorus by colorimetric method [9], Potassium by flame photometer [9]. The uptake of nitrogen, phosphorus, potassium and were done by the following formula-

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{\% N or P or K content x yield (kg ha}^{-1}\text{)}}{100}$$

The data reported was analyzed statistically with standard procedure of ANOVA technique. The standard errors of mean were calculated in each item of investigation and critical differences (CD) at 5% level were worked out for comparing the treatment mean wherever 'F' test was found significant Gomez and Gomez [10].

3. RESULTS AND DISCUSSION

3.1 Grain and Stover Yield

Application of combination of rhizobium and different levels of inorganic fertilizers significantly influenced the grain and stover yield of chickpea. It is evident from the data given in Table 1 that the maximum grain and stover yield was observed with application of RDF 125% along with seed inoculation by rhizobium (T_8) gave the highest grain yield (18.35 q ha^{-1}) & stover yield (25.69 q ha^{-1}), which were superior to rest of the treatments, while minimum grain yield (12.25 q ha^{-1}) and stover yield (19.96 q ha^{-1}) was recorded in control (T_1). Seed inoculation with rhizobium increases the grain and stover yield as compared to un-inoculated. The increase in grain and stover yield due to adequate supply of available nutrients to crop resulting in better growth and development eventually reflected into better grain and stover yield. The increase in yields with bio-fertilizers was mainly due to the increase in almost all growth and yield contributing characters, which eventually lead to a significant increase in grain and stover yields. The consequences of the current investigation are additionally in concurrence with the investigation of Singh A. et al. [11], Sharma [12], Patel et al. [13], Patel H.A. et al., [14], Kantar et al. [15], Prasad et al., [16], Gupta [17], Kumar et al.[18].

3.2 Biological Yield

Biological yield is influenced by application of combination of biofertilizer and different level of inorganic fertilizers. It is evident from the data given in Table 1 that maximum biological yield (44.04 q ha^{-1}) was recorded with application of RDF 125% along with seed inoculation by rhizobium (T_8) and minimum biological yield (32.21 q ha^{-1})was observed in control (T_1). Similar result was also reported by Patel H.A. et al. [14].

3.3 Nitrogen Content and Uptake

The higher value of nitrogen content in grain (3.58%) and stover (2.38 %) (Table 2) was noticed with the application of 125% recommended dose of fertilizer (RDF) along with seed inoculation by rhizobium (T_8) followed by RDF 100% + rhizobium (T_7), RDF125% (T_4), RDF75% + rhizobium(T_6). The lowest values of nitrogen content in grain (3.05 %) and stover (1.88 %) were observed in control (T_1) where no fertilizer was given to chickpea. Similar finding was also reported by Singh A. et al. [11], Jain et al. [19] and Kumar et al. [18].

The nitrogen uptake in grain (65.69 kg ha^{-1}) and stover (61.14 kg ha^{-1}) of chickpea (Table 3) was significantly influenced by different levels of fertilizers over control by application of

combination of rhizobium and different level of inorganic fertilizer. Application of RDF125% + rhizobium (T_8) showed the highest uptake of N in grain and stover, followed by RDF 100% + rhizobium (T_7), RDF 125% (T_4), RDF75% + rhizobium (T_6). However, minimum N uptake in grain (37.36 kg ha^{-1}) and stover (37.52 kg ha^{-1}) was observed in control (T_1). This is due to higher nitrogen fixing capacity of plant roots. The consequences of the current investigation are additionally in concurrence with the investigation of Singh A. et al. [11], Kharche et al. [20] and Kumar et al. [18].

3.4 Phosphorus Content and Uptake

The data related to phosphorus content in grain and stover of chickpea presented in Table 2. The phosphorus content in grain and stover was influenced by application of combination of rhizobium and different level of inorganic fertilizers. Maximum P content in grain (1.34%) and stover (0.35 %) was recorded with T_8 (RDF125% + *Rhizobium*) followed by RDF100% + rhizobium (T_7), RDF 125% (T_4), RDF75% + rhizobium (T_6) and the lowest values of phosphorus content in grain (1.15%) and stover (0.21 %) were observed with control (T_1). The results of the present investigation are also in agreement with the findings of Singh A. et al. [11], Jain and Singh [19], Dadgale et al. [21] and Kumar et al. [18].

The significantly higher phosphorus uptake (Table 3) by grain (24.58 kg ha^{-1}) and stover (8.99 kg ha^{-1})of chickpea was noticed with the application of T_8 (RDF125% + *Rhizobium*) followed by RDF100% + rhizobium (T_7), RDF125% (T_4) and minimum phosphorus uptake in grain (14.08 kg ha^{-1}) and stover (4.19 kg ha^{-1})was reported at control (T_1). Comparative findings were detailed by Singh A. et al. [11], Kalipada and Singh [22], Thenua et al. [23] and Kumar et al. [18].

3.5 Potassium Content and Uptake

The data related to potassium content in grain and stover of chickpea presented in Table 2. The potassium content in grain and stover was influenced by application of combination of rhizobium and different level of inorganic fertilizers. Maximum K content in grain (0.69 %) and stover (1.86 %) was noted with T_8 (RDF125% + *Rhizobium*) followed by T_7 (100% RDF + *Rhizobium*) and minimum potassium content in grain (0.51 %) and stover (1.63 %) at control (T_1). Comparative findings were detailed by Singh A. et al. [11], Singh and Prasad [24], Murari et al. [25] and Kumar et al. [18].

The uptake of potassium in grain and stover (Table 3) of chickpea was also influenced with application of rhizobium and different level of inorganic fertilizer. The highest uptake of K in grain (12.66 kg ha^{-1}) and stover (47.78 kg ha^{-1})of chickpea was recorded with treatment T_8 (RDF 125% + *Rhizobium*) followed T_7 (RDF 100% + *Rhizobium*) and minimum potassium uptake in grain (6.24 kg ha^{-1}) and stover (32.53 kg ha^{-1}) at control (T_1). The consequences of the current investigation are additionally in concurrence with the investigation of Singh A. et al. [11], Sahu et al. [26], Meena and Sharma [27], and Jangir et al. [28] and Kumar et al. [18].

Table 1. Effect of treatment combinations on productivity parameters of chickpea

Treatments	Treatment Combinations	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})
T_1	control	12.25	19.96	32.21
T_2	RDF 75%	14.10	21.99	36.09
T_3	RDF 100%	14.85	22.72	37.57
T_4	RDF 125%	16.24	23.71	39.95
T_5	Rhizobium	13.42	21.47	34.89
T_6	RDF75% + Rhizobium	15.62	23.43	39.05
T_7	RDF100% + Rhizobium	17.44	24.93	42.37
T_8	RDF125% + Rhizobium	18.35	25.69	44.04
	S. Em ±	0.38	0.51	0.84
C.D. at 5%		1.14	1.51	2.49

Table 2. Effect of treatment combinations on nutrient content in grain & Stover of chickpea

Treatments	Treatment Combinations	Nutrient content in grain & Stover (%)					
		Grain			Stover		
		N	P	K	N	P	K
T_1	control	3.05	1.15	0.51	1.88	0.21	1.63
T_2	RDF 75%	3.16	1.21	0.54	1.97	0.24	1.68
T_3	RDF 100%	3.22	1.23	0.57	2.02	0.26	1.70
T_4	RDF 125%	3.44	1.26	0.63	2.20	0.30	1.77
T_5	Rhizobium	3.10	1.18	0.53	1.92	0.23	1.66
T_6	RDF75% + Rhizobium	3.32	1.25	0.60	2.11	0.28	1.73
T_7	RDF100% + Rhizobium	3.50	1.30	0.65	2.29	0.33	1.81
T_8	RDF125% + Rhizobium	3.58	1.34	0.69	2.38	0.35	1.86
	S. Em ±	0.077	0.027	0.012	0.071	0.012	0.045
C.D. at 5%		0.227	0.079	0.035	0.211	0.035	0.133

Table 3. Effect of treatments on nutrient uptake on grain & Stover of chickpea

Treatments	Treatment Combinations	Nutrient uptake in grain & Stover (kg ha^{-1})					
		Grain			Stover		
		N	P	K	N	P	K
T_1	control	37.36	14.08	6.24	37.52	4.19	32.53
T_2	RDF 75%	44.55	17.06	7.61	43.32	5.27	36.94
T_3	RDF 100%	47.81	18.26	8.46	45.89	5.90	38.62
T_4	RDF 125%	55.86	20.46	10.23	52.16	7.11	41.96
T_5	Rhizobium	41.60	15.83	7.11	41.22	4.93	35.64
T_6	RDF75% + Rhizobium	51.85	19.52	9.37	49.43	6.56	40.53
T_7	RDF100% + Rhizobium	61.04	22.67	11.33	57.08	8.22	45.12
T_8	RDF125% + Rhizobium	65.69	24.58	12.66	61.14	8.99	47.78
	S. Em ±	1.012	0.60	0.373	0.917	0.139	0.969
C.D. at 5%		2.99	1.78	1.103	2.7	0.411	2.869

4. CONCLUSION

From the result obtained with the following experiment it may concluded that application of different combination of rhizobium and inorganic fertilizers showed positive influence on yield, nutrient content & uptake of chickpea. Since the application of 125% RDF along with seed inoculation by rhizobium showed significantly higher results than rest of treatments so it is advisable to use rhizobium along with inorganic fertilizers to reduce the excessive use of inorganic fertilizers and to achieve higher yield as well as higher nutrient content and uptake of chickpea.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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