

## Original Research Article

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## Impact of Fertility Levels and Biofertilizers on Root Architecture, Yield and Nutrient Uptake of Chickpea (*Cicer arietinum* L.) Crop

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### ABSTRACT

A field experiment was conducted during *rabi* season of 2016-2017 at the Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh to assess the “impact of fertility levels and biofertilizers on root architecture, yield and nutrient uptake by crop”. The experiment was comprised of 12 treatment combination in split plot design with three replications. The results showed that, application of 100% RDF significantly enhanced root parameters, yield and nutrient uptake over control plot. Among the different biofertilizers treatments, application of *Rhizobium* + PSB + PGPR had significant effect on root parameters and enhanced yield and nutrient uptake as compared to *Rhizobium* + PGPR. The combined application of 100% RDF with *Rhizobium* + PSB + PGPR resulted significantly higher yield of chickpea during *rabi* season.

#### Keywords

Biofertilizers,  
Chickpea, Root  
architectures, Soil  
fertility, Yield

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### Introduction

Chickpea is the world's third most important winter food legume crop. In our country, it covered 9.18 mha area, with 8.22 mt production and 900 kg/ha productivity (Anonymous, 2017). Among the leguminous

crops, it has important position due to its nutritious value (17-23% protein) which is deficient in the diet of majority of peoples. It is not only supply the protein but also enhances the soil fertility and maintain the soil health. Bio-fertilizers contains living micro-organisms, when it is applied to seeds,

plant surfaces, or soil, colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to host plant (Dinesh *et al.*, 2014). It augments the biochemical processes in soil i.e., nitrogen fixation, phosphorus solubilization and mobilization, zinc solubilization, decomposition of organic wastes, nutrient cycling, production of plant growth promoting substances and pathogen control. Biofertilizers provide an economically, attractive and ecologically sound means of fertilization and are important for making agriculture more sustainable in the era of climate change (Giagnoni *et al.*, 2016). To meet the rising demand, a quantum jump in chickpea production is required. But, majority of farmers usually grow pulses in marginal land with indiscriminate use of chemical fertilizers without biofertilizers and other faulty management practices that resulted in reduction of organic matter content and creates multi-nutrient deficiency in soil (Das *et al.*, 2016). Productivity of chick pea is less compared to national average productivity. Therefore, there is a need of present hour to find out eco-friendly, feasible and cheaper options to meet the nutrient need of crop grown in different cropping systems for maintaining soil fertility and crop productivity.

## Materials and Methods

Field experiment was conducted during *rabi* season of 2016-2017 at the Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh is situated at 25°18'N latitude, 83°03'E longitude and altitude of about 80.71 m above mean sea level. The soil of experimental field was sandy clay loam in texture, bulk density (1.52 Mg/m<sup>3</sup>), pH 7.6, EC (0.11 dS/m), low is organic carbon (0.30%) and available N (188 kg/ha), medium in available P (13.4 kg/ha) and available K

(173.3 kg/ha). The experiment was comprised of 12 treatment combinations, which comprised of 4 treatments [F<sub>1</sub> (control), F<sub>2</sub> (RDF 100%), F<sub>3</sub> (75% RDF), F<sub>4</sub> (50% RDF)] in main plot and 3 treatments [B<sub>1</sub> (*Rhizobium* + PSB), B<sub>2</sub> (*Rhizobium* + PGPR), B<sub>3</sub> (*Rhizobium* + PSB + PGPR)] in sub plots, laid out in split plot design with three replications. The fertilizer nutrients were supplied through urea, diammonium phosphate (DAP) and muriate of potash (MOP). Starter dose of nitrogen and full dose of phosphorus and potassium as per treatment were applied as basal. Before sowing, seeds were treated with biofertilizers (20 g/kg of seeds) as per standard procedure after drying of six hours under shade. Chickpea cultivar Udai (KPG 59) was sown at 40 x 10 cm crop geometry with a seed rate of 75 kg/ha apart during the first week of December. Follow the standard procedures and observations were recorded on root parameters, yield and nutrient uptake.

Nutrient concentration and uptake by crop was calculated by using the following expression:

Nutrient uptake (kg ha<sup>-1</sup>) in grain/stover = [% nutrient concentration in grain/stover × grain/stover yield (kg ha<sup>-1</sup>)].

Total nutrient uptake (kg ha<sup>-1</sup>) = Nutrient uptake by grain + Nutrient uptake by stover.

The data collected of different parameters were subjected to appropriate statistical analysis under Split Plot Design by following the procedure of ANOVA analysis of variance (SAS Software packages, SAS EG 4.3). Significance of difference between means was tested through 'F' test and the least significant difference (LSD) was worked out where variance ratio was found significant for treatment effect. The treatment effects were tested at 5% probability level for their significance.

## Results and Discussion

### Root architectures (Root dry weight, number of nodules per plant, nodules dry weight)

Results showed that the different fertility levels and biofertilizers had significant effect on root parameters, yield and nutrient uptake but did not influenced nutrient concentration. However, significantly maximum root dry weight and nodule dry weight was registered by application of *Rhizobium* + PGPR than compared to *Rhizobium* + PSB and *Rhizobium* + PSB + PGPR. Whenever, highest number of nodules were recorded with the application of *Rhizobium* + PGPR which was statistically at par with *Rhizobium* + PSB + PGPR but significantly higher than *Rhizobium* + PSB and *Rhizobium* + PSB. This might be due to nutrient levels had favourable effect on plant growth over control treatment that results better nutrient availability and increased number of metabolic processes taking place in the plant body, which results more root dry weight, number of nodules and nodule dry weight (Egamberdieva *et al.*, 2015).

Higher root dry weight was noticed under *Rhizobium* + PSB + PGPR which was statically at par with *Rhizobium* + PSB but significantly higher than *Rhizobium*+ PGPR. However, maximum number of nodules and nodule dry weight was recorded under *Rhizobium* + PSB + PGPR which was significantly higher than *Rhizobium* + PSB and *Rhizobium* + PGPR. The probable reasons for such results could be the growth promoting substances secreted by the microbial inoculants, which in turn might have led to better root development, better transpiration of water and enhanced uptake of nutrients that results more root dry weight, number of nodules and nodule dry weight (Singh *et al.*, 2015).

### Yield (t/ha)

Seed and stover yield of chickpea was significantly influenced due to different fertility levels and biofertilizers. However, application of 100% RDF along with *Rhizobium* + PSB + PGPR resulted higher seed yield (20 q/ha) which was statistically at par with 75% RDF along with application *Rhizobium* + PSB + PGPR but significantly higher than other fertility levels.

Higher stover yield was registered with 100% RDF which was statistically at par with 75% RDF and significantly higher than other treatments. The increase in seed and stover yield due to adequate nutrients supply which helps in better translocation of photosynthates from source to sink that results more growth and yield attributes which ultimately more yield (Singh *et al.*, 2016).

Application of *Rhizobium* + PSB + PGPR was noticed significantly higher seed and stover yield compared to other treatments respectively. It might be due to proper establishment of *Rhizobium* strain which supply nitrogen and secreted certain growth promoting substances that results better root development and enhances the uptake and deposition of nutrients (Gupta *et al.*, 2018).

### Nutrient concentration %

None of the fertility levels and biofertilizers showed significant difference in nutrient content *i.e.* nitrogen, phosphorus potassium and sulphur in the seed and stover because decrease of nutrient concentration with advancement of crop age under all the fertility levels and biofertilizers was observed. This might be due to increased dry matter in later stage and thus affecting dilution in nutrient (N, P, K and S) concentration (Tomasi *et al.*, 2008).

**Table.1** Effect of different fertility levels and biofertilizers on root parameters and nutrient concentration of chickpea crop

Treatment	Root dry weight (gram/plant)	Number of nodules/plant	Nodule dry weight (mg/plant)	N concentration %		P concentration %		K concentration %		S concentration %	
	At harvest	60 DAS	60 DAS	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
<b>Fertility levels</b>											
<b>F1</b>	0.48	15.8	52.4	3.27	0.81	0.31	0.26	0.46	0.36	0.23	0.26
<b>F2</b>	0.71	19.0	62.4	2.81	0.98	0.48	0.43	0.63	0.51	0.34	0.39
<b>F3</b>	0.64	17.9	56.5	2.95	0.88	0.38	0.33	0.53	0.42	0.29	0.34
<b>F4</b>	0.52	18.1	54.8	3.10	0.83	0.33	0.28	0.48	0.37	0.25	0.28
<b>SEm ±</b>	0.02	0.48	1.48	0.14	0.04	0.04	0.03	0.04	0.03	0.03	0.03
<b>CD (P=0.05)</b>	0.06	1.67	5.14	NS	NS	NS	NS	NS	NS	NS	NS
<b>Bio fertilizers</b>											
<b>B1</b>	0.59	17.6	56.7	3.03	0.89	0.39	0.34	0.54	0.43	0.28	0.32
<b>B2</b>	0.55	15.7	51.5	2.99	0.83	0.33	0.28	0.48	0.37	0.25	0.29
<b>B3</b>	0.62	19.8	61.3	3.08	0.90	0.40	0.35	0.55	0.45	0.30	0.35
<b>SEm ±</b>	0.01	0.37	1.01	0.09	0.03	0.02	0.03	0.03	0.03	0.02	0.02
<b>CD (P=0.05)</b>	0.04	1.12	3.04	NS	NS	NS	NS	NS	NS	NS	NS

Where, F1- Control, F2- RDF 100%, F3- RDF 75%, F4- RDF 50%, B1- Rhizobium + PSB, B2- Rhizobium+ PGPR, B3- Rhizobium + PSB + PGPR

**Table.2** Effect of fertility levels and bio fertilizers on nutrient uptake of chickpea

Treatments	Seed yield (q/ha)	Stover yield (q/ha)	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)			S uptake (kg/ha)		
			Seed	Stover	Total									
<b>Fertility levels</b>														
<b>F1</b>	12.1	23.3	39.7	18.8	58.6	3.64	6.09	10.0	5.68	8.26	13.8	2.83	6.16	8.99
<b>F2</b>	18.0	31.9	50.6	31.4	82.0	8.56	13.84	22.5	11.50	16.50	27.9	6.27	12.41	18.5
<b>F3</b>	16.3	29.8	48.4	26.3	74.5	6.26	9.92	16.2	8.69	12.80	21.5	4.84	10.28	15.1
<b>F4</b>	15.6	29.5	48.5	24.6	73.0	5.25	8.36	13.5	7.55	11.11	18.5	3.97	8.28	12.2
<b>SEm ±</b>	0.34	0.9	1.36	0.74	2.17	0.22	0.29	0.48	0.21	0.29	0.66	0.14	0.32	0.45
<b>CD (P=0.05)</b>	1.11	2.78	4.69	2.55	7.52	0.75	1.01	1.67	0.71	1.01	2.30	0.49	1.10	1.54
<b>Bio fertilizers</b>														
<b>B1</b>	15.7	29.1	47.5	26.0	73.54	6.25	10.08	16.4	8.70	12.70	21.3	4.58	9.51	14.0
<b>B2</b>	13.1	24.6	39.0	20.6	59.5	4.36	7.11	11.4	6.40	9.15	15.5	3.38	7.11	10.3
<b>B3</b>	17.7	32.1	53.9	29.2	83.1	7.17	11.46	18.8	9.97	14.67	24.4	5.47	11.23	16.7
<b>SEm ±</b>	0.28	0.74	1.07	0.62	1.75	0.22	0.30	0.35	0.28	0.35	0.55	0.12	0.24	0.37
<b>CD (P=0.05)</b>	0.85	2.01	3.20	1.86	5.26	0.66	0.91	1.04	0.84	1.06	1.65	0.36	0.72	1.11

Where, F1- Control, F2- RDF 100%, F3- RDF 75%, F4- RDF 50%, B1- Rhizobium + PSB, B2- Rhizobium+ PGPR, B3- Rhizobium + PSB + PGPR

### Nutrient uptake (kg/ha)

Different fertility levels and biofertilizers had significant effect on nutrient. The maximum nitrogen uptake by the seed was recorded with the application of 100% RDF which was statistically on par with 75% RDF and 50% RDF but significantly higher than control treatment. Maximum nitrogen uptake by the stover was recorded with the application of 100% RDF which was significantly higher than other treatment. But maximum total nitrogen uptake by the crop was noticed with the application of 100% RDF which was statistically on par with 75% RDF but significantly higher than 50% RDF and control treatment. This might be due to more total N uptake at higher fertility levels were revealed to better N nutrition and its accumulation in seed and stover (Singh *et al.*, 2018). However, highest nutrients (total nitrogen, phosphorus, potassium and sulphur) uptake by the crop was recorded with the application of *Rhizobium* + PSB + PGPR which was significantly higher than other treatments. This may be due to the fact that microorganisms helps in nitrogen fixation, solubilization, mobilization of plant nutrients and reduce the need for chemical fertilizers and enhances the nutrients availability and uptake to plants Patel *et al.*, 2013). Moreover, the increase in nitrogen concentration may be due to inoculation of PGPR strains which show nitrate reductase activities and facilitate the uptake of ammonia and amino acids produced by plants Das *et al.*, (2016). However, maximum total phosphorus, potassium and sulphur uptake by the crop was recorded with the application of 100% RDF which was significantly higher than other treatments. The more total nutrients uptake at higher fertility levels revealed better nutrition and its accumulation in seed and stover Singh and Prasad (2008). However, maximum total phosphorus, potassium and sulphur uptake by the crop was recorded with the application of

*Rhizobium* + PSB + PGPR which was significantly higher than other treatments. This may be due to biofertilizers were released several organic acids which improves the physicochemical and biological properties of soil and increasing availability of macro and micro- nutrients to crop for better growth and development (Jaipaul *et al.*, 2011). It have the diversity of microorganisms like *Actinomycetes*, *Azotobacter*, *Rhizobium*, *Nitrobacter* and phosphate solubilising bacteria (PSB) and supplying the available nutrients, valuable growth promoting substances, and enzymes which resulting in increased content and uptake of nutrients by crop (Khaitov *et al.*, 2016).

Based on the finding of the present study, it can be inferred that application of 100% RDF along with *Rhizobium* + PSB + PGPR was found better in achieving the root architecture, yield and nutrient uptake by crop during *rabi* season in central zone of Uttar Pradesh.

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