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Effect of fertility levels and biofertilizers on agrophysiological performance, productivity and quality of chickpea (*Cicer arietinum*)

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ABSTRACT

A field experiment was conducted during winter (*rabi)* of 2016–17 at the Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh to evaluate the effect of different fertility levels and biofertilizers on agrophysiological performance, productivity and quality of late sown chickpea (*Cicer arietinum* L.). The experiment comprised of 12 treatment combinations in split plot design which comprised 4 treatments [F_1 (control), F_2 (RDF 100%), F_3 (75% RDF), F_4 (50% RDF)] in main plot and 3 treatments [B_1 (*Rhizobium* + PSB), B_2 (*Rhizobium* + PGPR) and B_3 (*Rhizobium* + PSB + PGPR)] in sub plots with three replications. Results showed that among the different fertility levels, application of 100% RDF significantly enhanced agrophysiological performance, yield attributes, yield, and protein yield over the control. Among the different biofertilizers treatments application of *Rhizobium* + PSB + PGPR had significantly improved agrophysiological performance, yield attributes, seed yield and protein yield as compared to *Rhizobium* + PGPR. The combined application of 100% RDF with *Rhizobium* + PSB + PGPR resulted in significantly higher seed yield of late sown chickpea during winter (*rabi*).

Key words: Agrophysiological performance, Chickpea, Fertility levels, Productivity, Quality

The Green Revolution in agriculture has been one of the most successful achievements of this century. This revolution resulted in global food security and played an important role in transforming developing countries, such as India, from being food deficient to having a food surplus. Chickpea (*Cicer arietinum* L.) is the world's third most important winter (*rabi*) food legume with 96% cultivation in the developing countries and in India, it occupies 9.18 million ha area, with a production of 8.22 million tonnes registering the productivity of 900 kg/ha (Anonymous, 2017). In Uttar Pradesh, chickpea crop occupied 12.6 lakh hectares area, 9.80 lakh tonnes production and 778 kg/ha productivity (Anonymous, 2017). Amongst the leguminous crops, chickpea occupies an important position due to its nutritinal value (17-23% protein) which is deficient in the diet of Indians. Chickpeas not only supply the protein but also enrich the soil fertility through symbiotic nitrogen fixation. 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 result in reduction of organic matter and multinutrient deficiency (Das *et al.* 2016).

Biofertilizers contains living micro-organisms which, when applied to seed, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of primary nutrients to host plant (Dinesh *et al.* 2014). It augments the biochemical processes in soil, viz. nitrogen fixation, phosphorus solubilization and mobilization, zinc solubilization, production of plant growth promoting substances and pathogen control. Biofertilizers provide an economically judicious, attractive and ecologically sound means of fertilization and are important for making agriculture more sustainable. These are important in catalyzing several vital reactions necessary for decomposition of organic wastes, organic matter formation and nutrient cycling in agriculture (Giagnoni *et al*. 2016). Therefore, this study was undertaken to find out ecofriendly, feasible and cheaper options to meet the nutrient needs of the chickpea crop grown in cropping systems for maintaining soil fertility and crop

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productivity, which is need of the hour. It is imperative to sustain productivity of chickpea through alternative and efficient technologies.

MATERIALS AND METHODS

Field experiment was conducted during winter (*rabi)* of 2016–17 at the Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh (25°18'N latitude, 83°03'E longitude and at an altitude of about 80.71 m amsl). The soil of experimental field was sandy clay loam in texture, bulk density (1.52 Mg/m^3), *p*H 7.6, EC (0.11 dS/m), low in organic carbon (0.30%), available N (188 kg/ha), medium in available P (13.4 kg/ha) and available K (173.3 kg/ha). Experiment comprised of 12 treatment combinations in split plot design which comprised 4 treatments [F_1 (control), F_2 (RDF 100%), F_3 (75% RDF) and F_4 (50% RDF)] in main plot and 3 treatments [B_1 (*Rhizobium* + PSB), B_2 (*Rhizobium* + PGPR) and B_3 (*Rhizobium* + PSB + PGPR)] in sub plots and replicated thrice. 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, seed was treated with biofertilizers (20 g/kg seed) as per standard procedure after drying of 6 h under shade. Chickpea cultivar Udai (KPG 59) was sown at row to row spacing 40 cm and plant to plant spacing of 10 cm apart during first week of December with a seed rate of 75 kg/ha. The observations were recorded on agrophysiological performance such as Leaf area index, crop growth rate, relative growth rate, yield attributes such as branches/plant, pods/plants, seeds/pod, 100 seed weight and yield. Protein content in grain was obtained by multiplying the nitrogen content in grain with factor 6.25 (AOAC, 1995). The protein yield (kg/ha) was obtained by the following formula:

$$\text{Protein yield} = \frac{\text{Protein content (\%)} \times \text{Yield}}{100} 100$$

The data were analysed statistically using ANOVA and treatment comparison were made at 5% level of significance.

RESULTS AND DISCUSSION

The data revealed that maximum leaf area index at 70 DAS was found with the application of 100% RDF which was statistically at par with 75% RDF and 50% RDF but significantly higher than control treatment (Table 1). Higher leaf area index under 100% RDF treatment might be ascribed to better growth of chickpea plant due to more supply of nitrogen.It might be due to application of balanced amount of fertilizers, availability of nutrients in adequate that resulted in better formation of photosynthates which promote the metabolic activities, accelerated cell division and formation of meristemtic tissues, number of functional leaves per plant increased, ultimately enhanced leaf area index (Patel *et al.* 2013). Among the different biofertilizer treatments, higher leaf area index at 70 DAS was found with B3 which was statistically similar with B1 but significantly higher than B2. This may be due to more nutrient availability and better uptake by the plants that results in more photosynthates formation which increased plant height and more number of functional leaves per plant ultimately enhanced leaf area index (Jaipaul *et al.* 2011). However, at 70 DAS, maximum crop growth rate was found with the application of 100% RDF which was significantly higher than other treatments. Maximum crop growth rate at harvest stage was found with the application of 100% RDF which was statistically

Table 1 Effect of different fertility levels and biofertilizers on agrophysiological performance of late sown chickpea

Treatments	Leaf area index		Crop growth rate (g/m_2/day)			Relative growth rate (mg/g/day)	
	35 DAS	70 DAS	35 DAS	70 DAS	Harvest	35 DAS	70 DAS
Fertility levels (F)							
F1	1.43	3.12	3.22	14.02	6.41	23.13	47.44
F2	1.53	3.53	3.96	19.12	10.33	28.43	50.67
F3	1.50	3.48	3.58	17.15	9.54	25.57	49.02
F4	1.47	3.47	3.27	14.84	8.43	23.17	49.01
SEm ±	0.03	0.06	0.23	0.54	0.25	1.80	2.30
CD (P=0.05)	NS	0.22	NS	1.86	0.86	NS	NS
Biofertilizers (B)							
B1	1.48	3.39	3.54	16.32	8.46	25.35	49.34
B2	1.42	3.32	3.19	13.14	7.42	22.21	46.59
B3	1.54	3.48	3.80	19.39	10.15	27.66	51.18
SEm ±	0.03	0.04	0.21	0.35	0.25	1.66	1.69
CD (P=0.05)	NS	0.12	NS	1.05	0.74	NS	NS
F×B	NS	NS	NS	NS	NS	NS	NS

F1-control, F2-RDF 100%, F3-75% RDF, F4-50% RDF, B1-Rhizobium + PSB, B2-Rhizobium + PGPR and B3-Rhizobium + PSB + PGPR 100% RDF: 20-60-20 kg N-P_2O_5-K_2O/ ha respectively at par with 75% RDF but significantly higher than 50% RDF and control. In general, crop growth rate decreased with advancement of crop age resulting from senescence of leaves. Increase in crop growth rate might be due to adequate availability of nutrients (NPK) attributed to better nutritional environment for plant growth at active vegetative stages as a result of enhancement in cell multiplications, cell elongation and cell expression in plant body which ultimately increased the CGR (Tomasi *et al.* 2008). At 70 DAS and at harvest stage higher crop growth rate was observed with the application of B3 which was significantly superior over all other treatments. Application of biofertilizers increases the crop growth rate due to adequate availability of nutrients by solubilisation and mineralization process that attributed to more plant growth and dry matter accumulation at active vegetative stages which ultimately increased the crop growth rate (Egamberdieva *et al.* 2015).

Yield attributes which determine yield, is resultant effect of the vegetative development of crop. Yield attributes, viz. number of branches/ plant, number of pods/ plant and number of seeds/ pod in significantly affected by different fertility levels except 100-seed weight. However, at harvest stage maximum number of branches/ plant were found with 100% RDF which was statistically at par with 75% RDF but significantly higher than 50% RDF and control. Number of pods/plant and number of seeds/pod was found maximum with 100% RDF which was significantly higher than other treatments. The increased number of branches/ plant was probably due to more activities of meristematic tissues of plants at higher fertility levels as NPK plays a role in cell differentiation, more meristematic division and more translocation of food materials in plants, thereby resulting in higher production of branches at different growth stages (Fatima *et al.* 2008). This increase in number of seeds/pod due to application of higher dose of fertilizers might have resulted from optimum fertilization of flowers and increased pollen grain viability and there by increased number of seeds/ pod (Singh *et al.* 2006).Biofertilizer treatments havesignificantly influenced the yield attributes, viz. number of branches/plant, number of pods/plant and numbers of seeds/pod except 100-seed weight (Table 2). Maximum number of branches/plant at harvest stage was found with B3 which was significantly higher than other treatments, respectively. Number of pods/ plant was found with B3 treatment which was statistically at par with B1 treatment but significantly higher than B2 treatment. But, maximum number of seed/ plant was found with the application of B3 treatment which was significantly higher than other treatments, respectively. It might be due to the fact that biofertilizers fix atmospheric nitrogen, mineralize and solubilise the nutrients rapidly and provide them to the plants in optimum manner thereby stimulating plant growth that results in more number of branches/plant, number of pods/plant and numbers of seeds/pod (Singh *et al.* 2018).

Seed, stover and biological yield was influenced significantly by different fertility levels except harvest index (Table 3). The interaction effect of different fertility levels and biofertilizers on seed yield was found significant. However, *Rhizobium*+ PSB+PGPR along with 100 % RDF gave the highest seed yield (20 q/ha) which was statistically at par with *Rhizobium*+ PSB along with 100 % RDF but significantly higher than *Rhizobium*+ PGPR along 100 % RDF. Application of 100% RDF along with *Rhizobium*+ PSB+PGPR resulted in higher seed yield (20 q/ha) which was statistically at par with 75% RDF along with application *Rhizobium*+ PSB+PGPR but significantly higher than

Table 2 Effect of different fertility levels and biofertilizers on yield attributes, yield and quality parameters of late sown chickpea

Treatments	No. of branches/ plant	No. of pods/plant	No. of seeds/ pod	100 seed weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index	Protein content (%)	Protein yield (q/ha)
Fertility level (F)										
F1	4.50	38.49	1.78	19.04	12.1	23.3	35.3	34.2	20.4	2.37
F2	6.20	46.41	2.52	22.06	18.0	31.9	50.0	36.1	17.5	3.17
F3	6.05	39.40	2.09	20.40	16.2	29.7	46.0	35.3	18.4	3.03
F4	5.53	39.33	1.81	20.30	15.6	29.5	45.1	34.5	19.3	3.03
SEm ±	0.17	0.92	0.06	0.89	0.3	0.89	1.4	0.70	0.85	0.08
CD (P=0.05)	0.59	3.17	0.22	NS	1.2	3.0	4.8	NS	NS	0.27
Bio fertilizer (B)										
B1	5.50	41.16	2.01	20.64	15.7	29.1	44.8	35.1	18.9	2.95
B2	4.99	38.59	1.72	18.23	13.1	24.6	37.7	34.7	18.6	2.38
B3	6.22	42.98	2.43	22.48	17.6	32.1	49.7	35.3	19.2	3.38
SEm ±	0.13	0.68	0.05	1.12	0.28	0.74	1.04	0.56	0.57	0.07
CD (P=0.05)	0.39	2.03	0.14	NS	0.85	2.22	3.13	NS	NS	0.20
F × B	NS	NS	NS	NS	S	NS	NS	NS	NS	NS

F1- control, F2- RDF 100%, F3- 75% RDF, F4-50% RDF,B1- Rhizobium + PSB, B2-Rhizobium + PGPR and B3 -Rhizobium + PSB + PGPR 100% RDF: 20-60-20 kg N-P_2O_5-K_2O/ ha, respectively

Table 3 Interaction effect of different fertility levels and biofertilizers on seed yield of late sown chickpea

Seed yield (q/ha)					
Treatment	F1	F2	F3	F4	Mean
B1	12	19	16	16	16
B2	11	15	13	13	13
B3	13	20	19	18	18
Mean	12	18	16	16	16
		SEm ±		CD (P=0.05)	
F at same level/ different B		0.57		1.84	
B at same level/ different F		0.59		1.81	

F1- control, F2- RDF 100%, F3- 75% RDF, F4-50% RDF,B1-Rhizobium + PSB, B2-Rhizobium + PGPR and B3 -Rhizobium + PSB + PGPR 100% RDF: 20-60-20 kg N-P_2O_5-K_2O/ ha, respectively.

other fertility levels along with application of *Rhizobium*+ PSB+PGPR. Higher stover yield was found with 100% RDF which was statistically at par with 75% RDF and significantly higher than other treatments. But, maximum biological yield was recorded with 100% RDF which was significantly higher than other treatments. The increase in seed and stover yield was due to adequate nutrients supply which helps in better translocation of photosynthates from source to sink that resulted in more yield attributes such as more branches/ plant, number of pods/ plant, more number of seeds/ pod and higher 100-seed weight and ultimately more seed yield (Singh *et al.* 2016). The increase in biological yield could be attributed to increased seed and stover yields under these treatments and also the pattern of dry matter accumulation at different stages (Gupta *et al.* 2018). Higher seed, stover and biological yield were found with the application of B3 which was significantly higher than other treatments. Increase in seed, stover and biological yield may be due to proper establishment of *Rhizobium* strain which resulted in supply of nitrogen in larger quantity to plants (Chain *et al.* 2006). Application of biofertilizer increased seed, stover and biological yield this was due to marked improvement in dry matter accumulation, yield attributes and greater nutrient content and their uptake by chickpea. The probable reasons for such results could be because of certain growth promoting substances secreted by the microbial inoculants, which is turn might have led to better root development, better transpiration of water, uptake and deposition of nutrients (Singh *et al.* 2006).

Maximum protein content was observed with the application of control treatment and lowest protein content was found with the application of 100% RDF. The increase in N fertility under 100% fertilized plot which ultimately results in low protein content in seeds (Singh *et al.* 2015). However, maximum protein content in seed was recorded with the application of B3 treatment and lowest protein content was found under B2 treatment. Application of biofertilisers increase the protein content in seeds because biofertilizers enhance the nutrient uptake and plant use nutrients rapidly and efficiently that results in more protein content in seeds as per Singh and Prasad (2008). Maximum protein yield was recorded with 100% RDF which was statistically at par with 75% RDF and 50% RDF but significantly higher than control treatment. It is a function of protein content in seeds multiplied by seed yield ha. Increase in the seed yield increased the protein yield. These results are in tune with Khaitov *et al.* (2016). Maximum protein yield was recorded with the application of B3 treatment which was significantly higher than other treatments. Protein yield is the function of seed yield/ha multiplied by protein content. Increasing the seed yield increased the protein yield (Tolanu 2008).

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 yields and quality of late sown chickpea crop during *rabi* season in central zone of Uttar Pradesh.

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