Original Research Article

Effect of fertility levels and biofertilizers on growth parameters, root architecture and quality of chickpea (*Cicer arietinum* L.)

Abstract:

The present field experiment was conducted during Rabi season of 2017–18 at the Student's 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 growth parameters, root architecture 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 growth parameters, root architecture and protein yield over the control. Among the different biofertilizers treatments application of *Rhizobium* + PSB + PGPR had significantly improved growth parameters, root architecture and protein yield as compared to *Rhizobium* + PGPR. The combined application of 100% RDF with *Rhizobium* + PSB + PGPR resulted in significantly higher growth parameters, root architecture and protein yield of late sown chickpea during winter (*Rabi*).

Key Words:- Biofertilizers, Chickpea, Fertility Levels, Protein, Root Architecture and Yield

Introduction

"Pulses play a pivotal role and occupy a unique position in Indian agriculture by virtue of their inherent capacity to grow on marginal lands. It is an easily available source of protein in the rural heart of India. Pulses provide significant nutritional and health benefits and are known to reduce several non- communicable diseases such as colon cancer and cardio-vascular diseases" **(Jukanti *et al.*, 2012).** 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" **(Pingoliya *et al.,* 2013).** "Pulses play an equally important role in rainfed and irrigated agriculture by improving physical, chemical and biological properties of soil and are considered excellent crop for natural resource management, environmental security, crop diversification and consequently for viable agriculture" **(Ali and Kumar, 2006).**Globally, India is recognized as, a major player in pulses contributing 25% global production, (4-6 mt.) and consumer (26-27mt). Import duty on chickpea has been fixed at 60%. The year 2017-2018 had, witnessed record production in pulses (25.23mt).In India, Madhya Pradesh is the largest pulse producing state, which accounts for 23% of total pulse production. It covers 32.97% area of chickpea in country. Chickpea is the King of pulses consist of more than 1/3 of area and 40% total pulse production. In Asian region chickpea is the premier pulse crop of Indian sub-continent. India is the largest producer as well as consumer of chickpea in the world. It is grown in area of 6.3million hectare with production of 5.1 mt. The average yield of chickpea is 806kg/hec. **(FAOSTAT 2017-18). "**It is an important source of energy, protein, soluble and insoluble fibre. Mature chickpea grains contain 60-65% Carbohydrates, 6% Fat and 12-25% Protein higher than any other pulse crop. Through symbiotic Nitrogen fixation, the crop meet up to 80% of soil nitrogen needs, so farmers have to apply less N fertilizers". **(Das *et al*., 2012).** Legumes are heavy feeder of phosphorus and less responsive to nitrogen because of their capacity to meet their own nitrogen requirement through symbiotic fixation **(Kumar *et al.,* 2016).** "Phosphorus is connected with some particular plant growth factors that are root development, vigorous stem, enhanced flower formation and seed production, earlier and more uniform crop maturity, increase nitrogen fixing capacity of legumes, improvement in crop quality and resistance to plant diseases" **(Rehan *et al.,* 2018).** "It is required for higher and sustainable production of grain legumes. Generally, legumes have higher P requisites due to more consumption of energy in the process of symbiotic nitrogen fixation" **(Islam *et al.,* 2012).** "Biofertilizers promote plant growth and development also reduce the cost of production as they tend to decrease the doses of chemical fertilizers used. These can be used for fodder, food, vegetables and leguminous crops. Commonly used microorganisms as biofertilizers are Rhizobia, Phosphate Solubilizing Bacteria (PSB) and Plant Growth Promoting Rhizobacteria (PGPR). Seed inoculation with Rhizobium increases the nodulation through better root development and improves nutrient availability which is beneficial in improving the grain yield" **(Ali *et al*., 2004)**. Inoculation of chickpea with *Rhizobium* significantly increased the nodulation and its dry weight, plant height, pods plant^{-1}, 1000-grain weight, root length, root dry weight and grain yield **(Akhtar *et al*., 2009).** "Rhizobium and phosphate solubilizing bacteria (PSB) assume a great importance on account of their vital role in N2 fixation and P solubilizations. Use of Rhizobium and PSB had shown advantage in enhancing chickpea productivity" **(Rudresh *et al.* 2005).**

Materials and Methods

Experimental site and Climate

The experiment was laid out in at the SIF Farm of CSAUA&T, Kanpur, Uttar Pradesh. It is located on **25^{o}18′ N** latitude, **83^{0}03′ E** longitude and at an altitude of **80.71 meters** above mean sea level. Experimental site area, Kanpur is situated in the central part of U.P. and have sub-tropical climate, characterized by hot summer and cool winters. Total rainfall received during the crop growing period was 15.90 mm.

Soil analysis

The experimental field is sandy clay loam in texture, neutral in reaction (pH 7.6), EC (0.11 dSm^{-1}), low in organic carbon (0.30%), available N (188 kgha^{-1}), medium in available P (13.4 kg ha^{-1}) and available K (173.3 kgha^{-1}).

Table 1: Mechanical and chemical of soil analyses of the experimental field

Particular	Values	Method employed
Mechanical Analysis		
Soil separates (%)		
i) Coarse sand	8.48	Hydrometer method (Bouyoucos, 1927)
ii) Fine sand	53.44	
iii) Silt	19.46	
iv) Clay	17.85	
Textural class	Sandy clay loam	
Chemical Analyses		
i) Soil reaction (pH) (1: 2.5 soil and water suspension)	7.6	Glass electrode pH meter (Jackson, 1973)
ii) Electrical conductivity (dSm^{-1} at 25°C)	0.11	Sytronics electrical conductivity meter (Jackson, 1973)
iii) Organic carbon (%)	0.30	Walkley and Black's Method, 1947
iv) Available N (kg ha^{-1})	188	Alakaline permanganate (Subbiah and Asija, 1956)
v) Available P (kg ha^{-1})	13.42	0.5 N $NaHCO_3$ extractable (Olsen *et al*, 1954)
vi) Available K (kg ha^{-1})	173.30	Ammonium acetate extractable flame photometer (Toth and Price, 1949)

Treatments of Investigation

The experiment was consists of 12 treatment combinations and laid out in split plot design assigning four treatments in main plot *viz.* F1- Control, F2- RDF 100%, F3- RDF 75%, F4- RDF 50% and three treatments in sub plot *viz*. B1- Rhizobium+PSB, B2- Rhizobium+ PGPR, B3- Rhizobium+PSB+PGPR with three replications. Each treatment was randomly allocated with in them.

Application of Fertilizers

The crop was fertilized with a recommended dose of @ 20-60-20-20 kg nitrogen, phosphorus potassium and sulphur/ha, respectively. Urea DAP, MOP and gandhak powder were used as the source of nitrogen, phosphorus, potassium and Sulphur respectively.

Seed Treatment

Culture of biofertilizers i.e. Rhizobium, PGPR and PSB, each packet has 200g weight and used for seed treatment at the rate of 20g/kg seed. Seeds were treated with *biofertilizers* (20 g per kg of seed) as per standard procedure and were sown after drying for six hours under shade.

Sowing of Seed

Chickpea seeds were sown at 75 kg ha^{-1} in the furrows opened by the kudal by manual labours at 40 cm row to row spacing and 10 cm plant to plant spacing.

Protein Analysis

The average nitrogen (N) content of proteins was found to be about 16 percent, which led to use of the calculation N x 6.25 (1/0.16 = 6.25) to convert nitrogen content into protein content. (**Mariotti *et al.*, 2008)**

$$\textbf{Protein (\%) = N (\%) x factor 6.25}$$

The protein yield (kg ha^{-1}) was obtained by the following formula:

$$\textbf{Protein yield (kg ha}^{-1}\textbf{) = Protein content (\%) x Yield (kg ha}^{-1}\textbf{) / 100}$$

Statistical analysis

The data recorded during the course of investigation was subjected to statistical analysis by "Analysis of variance technique". The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level **(Chandel, 1998).**

Result and Discussion

Growth Parameters

"The data revealed that maximum plant height at 60 DAS was found with the application of 100% RDF which was statistically at par with 75% RDF and significantly higher than 50% RDF and control treatment. The results of present investigation are also in agreement with the findings of" (**Fatima *et al.*, 2008**). "At 60 DAS and at 90 DAS found maximum plant dry matter accumulation with the application of 100% RDF which was significantly higher than 50% RDF and control treatment". **(Jat and Ahalawat, 2004)**

Table 2. Effect of fertility levels and Biofertilizers on plant population, plant height and dry matter accumulation

Treatments	Plant population (running meter)		Plant height(cm)			Dry matter accumulation (gram/plant)		
	Initial	Harvest	30DAS	60 DAS	Harvest	30 DAS	60DAS	90 DAS
Fertility levels								
F1	16.26	16.01	8.50	47.91	50.92	2.40	14.04	20.22
F2	16.76	16.55	10.49	58.36	61.99	3.01	17.57	25.31
F3	16.63	16.48	9.95	55.94	58.92	2.86	16.68	24.02
F4	16.58	16.41	9.41	52.83	55.93	2.70	15.76	22.71
SEm±	0.28	0.29	0.19	0.69	1.09	0.07	0.27	0.38
CD (P= 0.05)	NS	NS	0.68	2.39	3.77	0.25	0.96	1.31
Biofertilizers								
B1	16.57	16.45	9.59	53.87	56.99	2.75	16.08	23.16
B2	16.38	16.13	9.10	50.84	53.96	2.58	15.07	21.71
B3	16.72	16.51	10.07	56.56	59.86	2.89	16.88	24.32
SEm±	0.27	0.26	0.18	0.89	0.95	0.07	0.25	0.32
CD (P= 0.05)	NS	NS	0.53	2.69	2.85	0.25	0.75	0.96
FXB	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

Root Parameters

All the root parameters i.e. root dry weight/plant, number of nodules per plant and nodule dry weight/plant influenced significantly due to different Fertility levels at all the stages of crop growth except root dry weight/plant at 30 DAS. However, higher values of root parameters i.e. root dry weight/plant, number of nodules per plant and nodule dry weight/plant with the application of 100% RDF which was statistically at par with 75 % and 50% RDF and significantly higher than control treatment. "Favourable effect on plant growth with different nutrient levels over control treatment may be attributed to better nutrient availability and number of metabolic processes taking place in the plant body, which in turn are affected by a variety of inherent and environmental factors to which plant is exposed that results more root dry weight, number of nodules per plant and nodule dry weight/plant" **(Gray and Bahar, 2013; Egamberdieva *et al.*, 2015)**.Biofertilizers found significant effect on all the root parameters at all the stages of crop growth except root dry weight/plant at 30 DAS. Biofertilizers treatments resulted higher values of root parameters in chickpea with the application of Rhizobium + PSB + PGPR (B_3) followed by 75% RDF (F_3) treatment. "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/plant, number of nodules per plant and nodule dry weight/plant. These results were in accordance with works of" **(Triphati *et al.*, 2015; Singh and Prasd, 2008 and Gupta, 2004)**.

Table 3. Effect of fertility levels and biofertilizers on Root parameters of chickpea

Treatments	**Root dry weight (gram/plant)**			**Number of nodules /plant**			**Nodules dry weight (mg/plant)**		
	30DAS	**60 DAS**	**Harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60DAS**	**90 DAS**
Fertility levels									
F1	0.17	0.56	0.63	12.26	15.43	17.50	15.71	38.86	40.73
F2	0.21	0.70	0.78	15.16	19.08	21.65	19.07	47.19	49.46
F3	0.20	0.65	0.73	14.13	17.77	20.16	17.77	43.95	46.07
F4	0.19	0.62	0.69	13.42	16.89	19.16	16.88	41.76	43.77
SEm±	0.01	0.01	0.02	0.30	0.39	0.39	0.36	0.75	0.91

CD (P= 0.05)	NS	0.05	0.06	1.06	1.35	1.36	1.24	2.60	3.16
Biofertilizers									
B1	0.19	0.63	0.71	13.79	17.35	19.69	17.35	42.92	44.99
B2	0.18	0.59	0.66	12.95	16.26	18.45	16.46	40.72	42.69
B3	0.20	0.67	0.75	14.52	18.27	20.18	18.26	45.18	47.35
SEm±	0.008	0.02	0.02	0.25	0.34	0.33	0.32	0.64	0.84
CD (P= 0.05)	NS	0.05	0.06	0.77	1.02	1.02	0.94	1.94	2.51
FXB	0.19	0.63	0.71	13.79	17.35	19.69	17.35	42.92	44.99

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

Quality Traits

However, 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 fertility levels that results higher nitrogen content in 100% fertilized plot which ultimately results low protein content in seeds **(Singh *et al.*, 2004).**Maximum protein content in seed was recorded with the application of B3 treatment and lowest protein content was found B2 treatment. Application of biofertilizers increase the protein content in seeds because biofertilizers enhance the nutrient uptake and plant use nutrients rapidly and efficiently that results more protein content in seeds **(Singh and Prasad 2008)**.Protein yield influenced significantly by different fertility levels. Maximum protein yield was recorded with the application of 100% RDF which was statistically at par with 75% RDF and 50% RDF but significantly higher than control treatment. Increasing the seed yield increased the protein yield. These results are in tune with (**Meena *et al.*, 2005)**.Protein yield influenced significantly by different biofertilizers treatments. However, maximum protein yield was recorded with the application of B3 treatment which was significantly higher than other treatments. Increasing the seed yield increased the protein yield.

Table 4. Effect of fertility levels and biofertilizers on quality of chickpea

Quality parameter		
Treatment	**Protein Content (%)**	**Protein yield (q/ha)**
Fertility levels		
F_1	21.22	427.63

F2	23.11	572.31
F_3	22.10	523.34
F4	21.87	485.17
SEm ±	0.051	11.71
CD (P = 0.05)	0.17	40.42
Biofertilizers		
B1	21.81	500.68
B2	21.67	462.74
B3	22.70	542.91
SE± m	0.039	8.98
CD (P = 0.05)	0.117	26.94
FXB	NS	NS

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

Conclusion

Based on the finding of the present study, it can be inferred that application of 100% RDF (F_2) with Rhizobium + PSB + PGPR (B_3) resulted maximum growth and root parameters which results ultimate more protein yield of late sown chickpea crop during rabi season in central zone of Uttar Pradesh.

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