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Studies on effect of different biofertilizers on nutrients availability and uptake of nutrients under chickpea crop

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Abstract
A field experiment was conducted at Instructional Farm of the ANDUAT, Kumarganj, Ayodhya (U.P.), during Rabi of 2017-18 to evaluate the Effect of different combination of biofertilizers on nutrient uptake and soil fertility under chickpea. The results revealed that the combined application of RDF 100%, Rhizobium, PSB and azotobacter (T_8) significantly improved the N, P, K uptake by chickpea crop and improve soil properties like increase in availability of N (152 to 265.90 kg/ha), P (16.5 to 18.29 kg/ha), K (225.36 to 258.20 kg/ha), S (13.19 to 14.63 kg/ha) and Zn (0.49 to 0.59 ppm), organic carbon (3.5 to 3.9 g kg^{-1}) as well as maximum decline in soil pH (8.62 to 8.30) and EC (0.36 to 0.28 dSm^{-1}) which is closely followed by treatment (*Rhizobium* + PSB) T_5.

Keywords: *Rhizobium*, azotobacter, soil property, nutrients availability

Introduction
Chickpea (*Cicer arietinum*) belong to family leguminaceae. It is widely cultivated in India, Australia, Pakistan, Turkey, Myanmar and Ethiopia. It is an important cool season pulse crop and is also called Bengal gram. It is mostly consumed in the form of processed whole seed (boiled, roasted, fried, steamed, etc.), dal and as dal flour. It is used in preparing snacks, sweets and condiments. Fresh green seeds are also consumed as a green vegetable. It is an excellent source of protein (18-22%), carbohydrates (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron etc.) and vitamins. It is an excellent animal feed and its straw has good forage value (Prasad 2012) [9]. In the current scenario, sustainability of agriculture has become a major issue of global concern as the intensive use of chemical inputs show adverse impact on the environment and the soil fertility (Laranjo *et al.* 2014, Verma *et al.* 2014) [6, 14]. Leguminous crops have a unique property of maintaining and restoring soil fertility as well as conserving and improving physical properties of soil by virtue of their deep root system which enables them to efficiently utilize applied as well as residual soil nutrients. Biofertilizer are recognized as an important component of sustainable agriculture. Rhizobium culture and phosphorus solubilizing bacteria (PSB) can be used to inoculate pulse crops for enhancing the crop productivity and profitability (Bajracharya and Rai, 2009) [2]. Nitrogen is an essential component of several amino acids, enzymes nucleic acids etc. is required in comparatively less amount due to biological fixation by pulses. *Rhizobia* are agriculturally important soil bacteria capable of forming root nodules and in some cases, stem nodules on leguminous plant, where they can fix atmospheric nitrogen. Hence, the present investigation was conducted to study the Effect of different combination of biofertilizers on nutrient uptake and soil fertility under chickpea.

Materials and Methods
A field experiment was conducted at Instructional Farm of the ANDUAT, Kumarganj, Ayodhya (U.P.), during Rabi of 2017-18 to evaluate the effect of different combination of biofertilizers on nutrient uptake and soil fertility under chickpea. The chickpea cultivated variety Radhey that is 150 days duration variety was sown at 30cm x 10cm spacing with 4m x 3m plot size under subtropical region of Indo Gangetic plains with an average annual rainfall of 1250 mm. The soil of experimental field was clay in texture, alkaline in reaction (pH 8.2 to 8.5). Low in available N (185.00 kg ha^{-1}), Zn (0.49 ppm) medium in P_2O_5 (18.20 kg ha^{-1}) high in K_2O (225.36 kg ha^{-1}) S (13.19 kg ha^{-1}) and low in organic carbon (3.5 g kg^{-1}) respectively.

All treatments were randomly allocated and replicated three times in a randomized block design was adopted for the experimentation. The experiment was comprised with eight treatments (T_1) Control + RDF 100%, (T_2) *Azotobacter*, (T_3) *Rhizobium*, (T_4) Phosphorus solubilizing bacteria (PSB), (T_5) *Rhizobium* + PSB, (T_6) *Rhizobium* + *Azotobacter*, (T_7) *Azotobacter* + PSB, (T_8) *Rhizobium* + PSB + *Azotobacter*. The seed treatment was done by PSB @ 25 g kg-1 seeds. The treated seeds were kept in shade approximately for two h to get dry; thereafter the seeds were sown in plots as per treatment. To assess the various treatment effects, soil sample were collected after harvest of the crop from each plots. Soil pH and EC were determined by following Chopra and Kanwar (1991). Soil organic carbon was determined by Walkley and Black (1934) [15] rapid titration procedure. Soil available N was determined following Subbiah and Asija (1956) [11]. Available P was determined by Olsen *et al.* (1954) method. Available K was determined by following Jackson (1973) [5]. For nutrient uptake of plant material, nitrogen content was determined by Kjeltec-II auto analyzer. Phosphorus and potassium were estimated by taking 1g dry sample in a digestion flask with 10 ml tri-acid mixture (9:3:1 HNO_3: $HClO_4$: H_2SO_4) and digestion was carried out on a hot plate at 180 - 200°C until dense white fumes of H_2SO_4 and $HClO_4$ were evolved. The digested material was used for estimation of phosphorus as given by Jackson (1973) [5]. The determination of potassium was done using flame photometer. From the chemical analytical data, uptake of the each nutrient was calculated as shown below:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{dry weight in per kg ha}}{100}$$

Result and Discussion

Uptake of nutrients

Combined application of different biofertilizer significantly increased the uptake of N, P, K by grain and stover of chickpea over control (Table 1). Application of rhizobium along with azotobacter and PSB recorded maximum value of N, P, K in seed and straw followed by combined application rhizobium and PSB (T_5). Similar Trend for uptake of N, P, and K was followed in Stover of Chickpea. It is apparent from the data on nitrogen content in grain and straw that different combination of biofertilizer increases the nitrogen content in grain and Stover. This might be attributed due to inoculation of Rhizobium PSB enhances the nitrogen availability and this available nitrogen concentration in seed and straw. The application of different biofertilizers enhances the nitrogen availability. Similar results are also reported by Tanwar *et al.*, (2003) [12]. The maximum phosphorus concentration with the treatment (RDF 100%, Rhizobium, PSB and azotobacter) might be due to the availability of phosphorus in soil which ultimately increased the phosphorus concentration in plants. This might be due to the dilution effect of nutrient in biomass and thus consistent increases in dry biomass. Similar results were found by Dhakal *et al*. 2016 [4], Thenua and Sharma (2011) [13]. It is apparent from the data on the potassium content in grain and straw with treatment T_8 (RDF 100%, Rhizobium, PSB and azotobacter) had significant effect on availability of potassium in seed and straw. Similar findings also reported by Thenua and Sharma (2011) [13].

Soil properties

Soil pH, EC and organic carbon

The maximum reduction pH and Electrical conductivity (dSm^{-1}) was observed with the application of RDF 100% along with biofertilizer T_8 (*Rhizobium*, PSB and *Azotobacter*) followed by T_5 T_3 and T_6 respectively (Table-2). Where minimum reduction was observed with T_1 control 100% RDF. The PSB, Rhizobium and azotobacter help in atmospheric nitrogen and fixes the nitrogen from the atmosphere which helps in nutrients availability and all other major nutrient. The Rhizobium and PSB also helps in all availability of nutrient. PSB (phosphorus solubilizing bacteria) helps in conversion of the insoluble form into soluble and secrete organic acid and this organic acid lowers the soil pH. When we treated the seed with the biofertilizer inoculation the pH and EC lowers respectively. The soil pH decreases with respect of Rhizobium and PSB because PSB sparingly convert the insoluble form into soluble form and hence the pH decreases in all the treatment. Similar results are also reported by Kumar *et al.* (1995). The Organic carbon increased with the application of RDF 100% along with bio-fertilizers (*Rhizobium*, PSB and *Azotobacter*).

The maximum Organic carbon was recorded in treatment T_8 (*Rhizobium* + PSB + *Azotobacter*) followed by T_5 (*Rhizobium* + PSB) which was statistically at par with the treatments T_3 (*Rhizobium*), T_6 (*Rhizobium* + *Azotobacter*) and T_4 (Phosphorus solubilizing bacteria). A significant increase in the organic carbon when we apply the different biofertilizer the organic carbon increases respectively with the combination of Rhizobium and PSB azotobacter. The inoculations of biofertilizer are very helpful in increasing the organic matter and hence organic carbon also increases This could be attributed to direct addition of organic substances in soil and due to better root growth, more plant residues after crop harvest and their indirect influence on physic-chemical characteristics of the soil The inoculation of biofertilizers is very helpful in increasing the organic matter and hence there is organic carbon also increases. Similar results were reported by Meena *et al*. (2018) [7].

Availability of nutrients

The available nitrogen phosphorus potassium sulphur and Zinc in soil increase with the application of RDF 100% along with bio-fertilizers (*Rhizobium*, PSB and *Azotobacter*). The maximum build up in available nitrogen in soil was recorded (Table-3) with treatment T_8 (*Rhizobium* + PSB + *Azotobacter*) followed by T_5 (*Rhizobium* + PSB) which was statistically at par with the treatments T_3, T_6 and T_4. The application of different biofertilizer inoculation improved the nutrient N, P, K, Zn and sulphur content in the soil after harvest. Available nitrogen showed positive response after harvesting of the crop (chickpea). The treatment T_8 (RDF 100%, Rhizobium, PSB and azotobacter) had significant effect on the available N, P, K, Zn and sulphur. This might be due to the application of different biofertilizer which enhanced and established better root system. The PSB, Rhizobium and azotobacter help in atmospheric nitrogen and fixes the nitrogen from the atmosphere which helps in nutrients availability and all other major nutrient. The Rhizobium and PSB also helps in all availability of nutrient. PSB (phosphorus solubilizing bacteria. Similar results are also reported by Badar *et al*. 2015 [1].

Conclusion

From the present investigation it may be concluded that, application of different biofertilizer *viz.* Rhizobium + PSB + Azotobacter in combination with 100% RDF i.e. T_8 significantly increase the nutrient content with maximum build of available soil nutrients *viz.* N, P, K, S, Zn and improve organic carbon content as well as helps in maintaining soil pH and EC. Hence, this combination of treatment can be recommended for sustainable agriculture.

Table 1: Effect of different biofertilizers on nutrient uptake by chick pea

Treatments	Nitrogen content (%)			Phosphorus content (%)			Potassium content (%)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
T_1 Control (RDF100%)	2.72	1.32	3.43	0.258	0.141	0.399	1.31	1.98	3.29
T_2 *Azotobacter*	2.74	1.38	3.43	0.266	0.146	0.416	1.35	2.04	3.39
T_3 *Rhizobium*	2.82	1.42	3.53	0.273	0.150	0.423	1.39	2.10	3.49
T_4 Phosphorus solubilizing bacteria	2.78	1.40	3.48	0.270	0.149	0.419	1.37	2.07	3.44
T_5 *Rhizobium* + PSB	2.90	1.45	3.63	0.281	0.155	0.436	1.43	2.16	3.59
T_6 *Rhizobium* + *Azotobacter*	2.86	1.43	3.58	0.277	0.152	0.429	1.41	2.13	3.54
T_7 *Azotobacter* + PSB	2.79	1.41	3.50	0.270	0.149	0.419	1.37	2.07	3.44
T_8 *Rhizobium* + PSB + *Azotobacter*	2.96	1.47	3.70	0.287	0.158	0.445	1.46	2.20	3.66
SEm±	0.08	0.05	0.46	0.007	0.004	0.06	0.03	0.04	0.46
CD at 5%	0.24	0.16	1.38	0.02	0.01	0.18	0.09	0.14	1.40

Table 2: Effects of bio-fertilizer on pH, EC and organic carbon at after harvest the crop

Treatments	pH (1:2.5)	EC (dSm^{-1})	Organic carbon (g kg^{-1})
T_1 Control (RDF100%)	8.65	0.30	3.2
T_2 *Azotobacter*	8.55	0.29	3.4
T_3 *Rhizobium*	8.42	0.29	3.6
T_4 Phosphorus solubilizing bacteria	8.50	0.29	3.5
T_5 *Rhizobium* + PSB	8.35	0.28	3.8
T_6 *Rhizobium* + *Azotobacter*	8.40	0.29	3.7
T_7 *Azotobacter* + PSB	8.45	0.29	3.6
T_8 *Rhizobium* + PSB + *Azotobacter*	8.30	0.28	3.9
SEm±	0.22	0.00	0.14
CD at 5%	NS	NS	0.43

Table 3: Effects of bio-fertilizer on available N, P, K, S and Zn content after harvest crop in soil

Treatments	Available nutrients				
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Zn (ppm)
T_1 Control (RDF100%)	216.00	15.20	220.90	12.15	0.52
T_2 *Azotobacter*	225.10	16.15	231.85	12.92	0.53
T_3 *Rhizobium*	236.20	17.10	246.70	13.68	0.55
T_4 Phosphorus solubilizing bacteria	230.70	16.60	238.50	13.28	0.54
T_5 *Rhizobium* + PSB	255.50	17.94	256.60	14.35	0.58
T_6 *Rhizobium* + *Azotobacter*	246.80	17.56	248.50	14.05	0.57
T_7 *Azotobacter* + PSB	243.20	17.10	251.90	13.68	0.56
T_8 *Rhizobium* + PSB + *Azotobacter*	265.90	18.29	258.20	14.63	0.59
SEm±	8.89	0.39	9.01	0.67	0.03
CD at 5%	26.95	1.20	27.34	2.05	NS

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