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Effects of Phosphorus with Biofertilizers on Yield and Nutrient Content of Chickpea (*Cicer arietinum* L.) under Central Uttar Pradesh Condition

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A B S T R A C T

The present study which was conducted on the research farms of CSAUA&T, Kanpur (U.P.) during *Rabi* season of 2016. In the treatments a general combination of phosphatic fertilizer at its various levels (0, 30, 60, and 90 kg ha^{-1}) with *Rhizobium* and phosphate solubilizing bacteria (PSB) was done. The statistical analysis was done using Factorial RBD. The variety of chickpea used was 'Awarodhi' which was considered as good responsive crop under central UP region. It was observed that the highest yield was there in T_7 (P_{30}+Rh+PSB) 26.2 q ha^{-1} and minimum was there in control. The nitrogen content observed was 3.70% and protein content 23.18% in the grain, which surged through significantly than control. The phosphorus content 0.66% of the chickpea grains was also higher than the initial values. Overall response was best under the treatment having combined application of both the biofertilizers (Rhizobium and PSM) and phosphorus @ 30 kg ha^{-1}.

Introduction

Chickpea (*Cicer arietinum* L.) is one the major cultivated crop of Rabi season in India and the third most important crop in the world. It is cultivated over 11.5 million ha. area worldwide (Bidyarani *et al.*, 2015) while covering 7.89 million ha. in India and under Uttar Pradesh region covering 9.93 million ha. The production of this crop under Uttar Pradesh is 9.53 million tonnes (2013-14) and productivity is 960 kg ha^{-1} (2013-14) (Anonymus, 2013). Uttar Pradesh is at the fifth place among other states of India under chickpea production (Anonymus, 2013). The farmers here uses traditional method and production practices with lack of balanced use of fertilizers that leads to deficiency of nutrient to crops, this acts as a major reason for lacking behind for production compared to other Indian states. Chickpea is the rich source of better quality protein in human diet more than any other pulse crop, it also consist of various nutrients like carbohydrates, proteins, iron, zinc, calcium and magnesium (Jukanti *et al.*, 2012). Protein content in this

pulse crop varies from 17% to 23% (Ali and Kumar, 2006; Kumar *et al.*, 2014). In soils these plants are the higher consumer of phosphorus (P) because this nutrient is one of the major supporters of biological nitrogen fixation which is done by all leguminous crops. The addition of phosphorus in these crops also provides shoot hardiness, photosynthesis regulation, enhances nodulation, improved grain quality and plant growth, ultimately superior yields (Kumar *et al.*, 2016).

Balanced fertilization is the key to soil as well as plant health and it refers to the use of inorganic and organic fertilizers in coordination and equal proportions so that plant will get more and more benefit out of it. Hence, the inoculation of biofertilizers with inorganic fertilizer acts as a boon to crop growth. The inoculation of *Rhizobium* can increase grain yield in pulse crop from 10 to 15% (Ali and Chandra, 1985) while phosphate solubilizing bacteria (PSB) increase the availability of insoluble phosphorus into the soils by mineralizing organic phosphorus compounds (Parveen *et al.*, 2002). The objective of this study states the effect of phosphorus for its various levels of fertilization together with two different biofertilizers i.e. *Rhizobium* and phosphate solubilizing bacteria (PSB). For the above objective, Awarodhi variety of chickpea was considered because it is most popular under central Uttar Pradesh region due to its higher yield and wilt resistance (Yadav, 2009).

Materials and Methods

The study was conducted at Nawabganj Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.). Geographically, Kanpur is situated in the central part of Uttar Pradesh under sub-tropical tract of northern India between latitude ranging from 25^{O} 26′ and 28^{O} 58′ North and longitude 79^{O} 31′ to 80^{O} 34′ East. It is located on an elevation of about 125.9 meter above mean sea level (MSL) near the Gangetic plain of Central Uttar Pradesh. The mean annual rainfall is about 816 mm received mostly from second fortnight of June or first fortnight of July till mid October with a few showers during winter season.

The chickpea variety taken for experiment was 'Awarodhi'. The treatments detail included 16 combinations having 4 levels of Phosphorus fertilizers including control (0, 30, 60 and 90 kg ha^{-1}) which was applied as single super phosphate (SSP) together with the inoculation two biofertilizers *Rhizobium* and Phosphate Solubilizing Bacteria (PSB). The application of biofertilizers was done with the seed coating. The treatment combinations are described in Table 1.

The estimation of nitrogen (N) content was done using Kjeldahl Method. In this the grains was first dried, crushed and sieved for digestion in Kjeldahl tubes over digestion unit till yellow color of fumes completely disappears. The digestion is done by using 20g digestion accelerator mixture with 35ml. conc. sulphuric acid. Distillation of the digested samples was done in nitrogen analyzer using Subbhaiya and Asija, 1956 method, then green color of the distillate thus obtained. Finally, titration with 0.02N sulphuric acid was done that converted green distillate into pink color which represents the end point. Further, calculation was done so as to obtain content of N (%) in grains of chickpea. Later, to calculate protein content (%) in chickpea grains with the help of formula:

Protein content (%) = Nitrogen (%) × 6.25

The determination of phosphorus was also done by digestion of chickpea grains using diacid mixture (HNO_3: $HClO_4$). The digested

content was collected and taken for analysis using vanadomolybdate reagent from which yellow color of the solution was developed. The estimation of absorbancy (Abs) of the prepared solution was done using spectrophotometer. Afterwards calculation was done to estimate content of P (%).

The grain yield (q ha^{-1}) was estimated form per plot yield and converted to total yield by multiplying the yield recorded with the number of plots.

The statistical analysis of data was done based on factorial randomized block design (RBD) which was used to analyze significant difference between the phosphorus levels and biofertilizer treatments, and their interaction effects at $P < 0.05$ probability.

Experimental findings

Effect on grain yield (q ha^{-1})

The data pertaining to the effect of different inoculants have been given in Table 2 and Fig. 1.0. It is clear from the data that different inoculants differ statistically in respect to their effects on grain yield and an increase in grain yield was observed significantly in comparison to uninoculated plots. On an average, the grain yield recorded in treatment P_2O_5 @ 30 kg ha^{-1} with Phosphate Solubilizing Bacteria (PSB) and *Rhizobium* was highest i.e. 26.2 q ha^{-1}. The lowest grain yield was there under uninoculated plot which was 12 q ha^{-1}.

Effect on nitrogen (N) content (%) and protein content (%)

The data given in Table 3 and Fig. 1.1 indicates that the effect of different inoculants together with increase in the dose of phosphatic fertilizer have increased the nitrogen content significantly in grain as compared to control plots. It is clear from the data that different inoculants differ statistically in respect to their effect on nitrogen content in grain. On an average, the highest nitrogen content which was 3.70% in grains, recorded at the interaction between *Rhizobium* with PSB at 30 kg phosphorus application.

Table.1 Treatment detail of experiment

Symbol	Treatment Combinations	Description of treatments
T_0	P_0	No phosphorus
T_1	P_0+Rh	Only *Rhizobium*
T_2	P_0+PSB	Only Phosphate Solubilizing Bacteria
T_3	P_0+Rh+PSB	*Rhizobium* with PSB
T_4	P_{30}	Phosphorus (P_2O_5) as Single super phosphates @ 30 kg ha^{-1}
T_5	P_{30}+Rh	P_2O_5 @ 30 kg ha^{-1} with *Rhizobium*
T_6	P_{30}+PSB	P_2O_5 @ 30 kg ha^{-1} with Phosphate Solubilizing Bacteria
T_7	P_{30}+Rh+PSB	P_2O_5 @ 30 kg ha^{-1} with Phosphate Solubilizing Bacteria and *Rhizobium*
T_8	P_{60}	P_2O_5 as Single super phosphates @ 60 kg ha^{-1}
T_9	P_{60}+Rh	P_2O_5 @ 60 kg ha^{-1} with *Rhizobium*
T_{10}	P_{60}+PSB	P_2O_5 @ 60 kg ha^{-1} with Phosphate Solubilizing Bacteria
T_{11}	P_{60}+Rh+PSB	P_2O_5 @ 60 kg ha^{-1} with Phosphate Solubilizing Bacteria and *Rhizobium*
T_{12}	P_{90}	P_2O_5 as Single super phosphates @ 90 kg ha^{-1}
T_{13}	P_{90}+Rh	P_2O_5 @ 90 kg ha^{-1} with *Rhizobium*
T_{14}	P_{90}+PSB	P_2O_5 @ 90 kg ha^{-1} with Phosphate Solubilizing Bacteria
T_{15}	P_{90}+Rh+PSB	P_2O_5 @ 90 kg ha^{-1} with Phosphate Solubilizing Bacteria and *Rhizobium*

Table.2 Interaction effect of P fertilizer levels and biofertilizers on chickpea yield (q ha^{-1})

Sr. No.	Treatments	Levels of Phosphorus (kg ha^{-1})			
		P_0	P_{30}	P_{60}	P_{90}
1.	Without Inoculation	12.0	18.0	12.9	13.05
2.	Inoculation with *Rhizobium* (Rh)	13.9	21.4	14.5	15.4
3.	Inoculation with PSB	13.7	21.1	14.4	15.20
4.	Inoculation with Rh and PSB	17.9	26.2	15.2	20.6
	Mean	**14.4**	**21.7**	**14.3**	**16.06**
	P levels			**Interaction effect**	
SEm ±	0.238			0.531	
C.D. (5%)	0.438			N.S.	

Table.3 Interaction effect of P fertilizer levels and biofertilizers on Nitrogen content (%) on chickpea grains

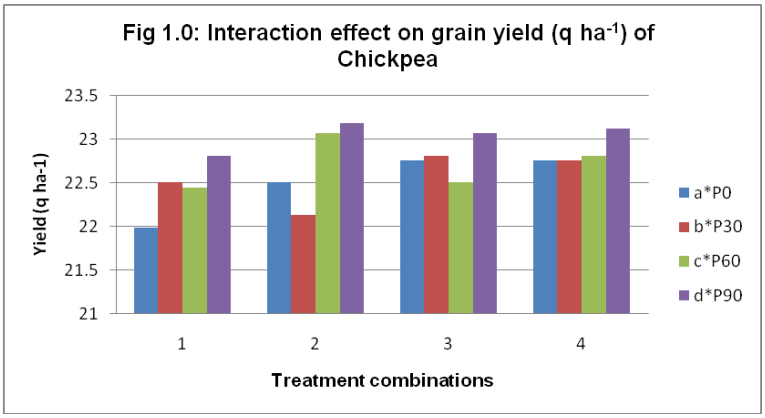
Sr. No.	Treatments	Levels of Phosphorus (kg ha^{-1})			
		P_0	**P_{30}**	**P_{60}**	**P_{90}**
1.	Without Inoculation	3.51	3.60	3.64	3.65
2.	Inoculation with *Rhizobium* (Rh)	3.60	3.70	3.65	3.64
3.	Inoculation with PSB	3.59	3.69	3.60	3.65
4.	Inoculation with Rh and PSB	3.65	3.70	3.69	3.70
	Mean	**3.59**	**3.67**	**3.64**	**3.66**
	P levels			**Interaction effect**	
SEm ±	0.0016			0.0036	
C.D. (5%)	0.0032			0.0073	

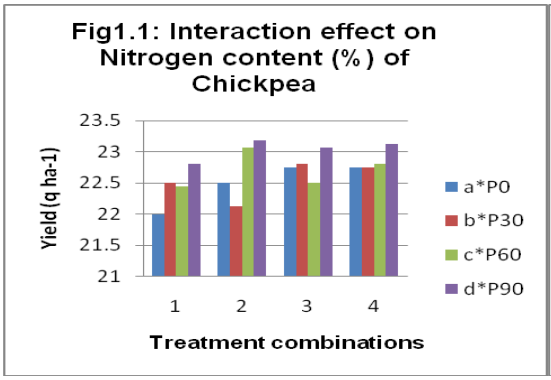
Table.4 Interaction effect of P fertilizer levels and biofertilizers on Protein content (%) on chickpea grains

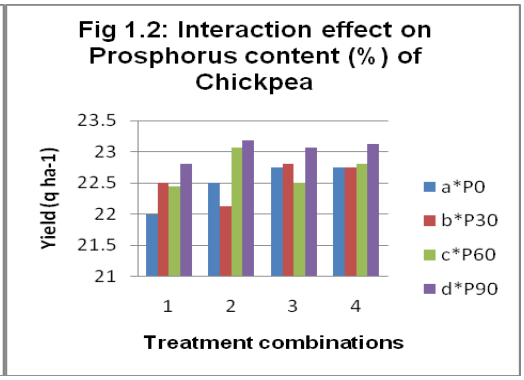
Sr. No.	Treatments	Levels of Phosphorus (kg ha^{-1})			
		P_0	**P_{30}**	**P_{60}**	**P_{90}**
1.	Without Inoculation	21.99	22.50	22.75	22.75
2.	Inoculation with *Rhizobium* (Rh)	22.50	22.13	22.81	22.75
3.	Inoculation with PSB	22.44	23.06	22.50	22.81
4.	Inoculation with Rh and PSB	22.81	23.18	23.06	23.12
	Mean	**22.42**	**22.70**	**22.78**	**22.86**
	P levels			**Interaction effect**	
SEm ±	0.0030			0.0810	
C.D. (5%)	0.0061			0.1644	

Table.5 Interaction effect of P fertilizer levels and biofertilizers on Phosphorus content (%) on chickpea grains

Sr. No.	Treatments	Levels of Phosphorus (kg ha $^{-1}$)			
		P_0	P_{30}	P_{60}	P_{90}
1.	Without Inoculation	0.60	0.62	0.61	0.62
2.	Inoculation with *Rhizobium* (Rh)	0.61	0.64	0.62	0.63
3.	Inoculation with PSB	0.60	0.63	0.60	0.62
4.	Inoculation with Rh and PSB	0.63	0.66	0.65	0.65
	Mean	**0.61**	**0.64**	**0.62**	**0.63**
		P levels		**Interaction effect**	
SEm ±		0.0023		0.0052	
C.D. (5%)		0.0047		0.0106	







[In the graphs above Inoculants are denoted as (a= Without Inoculation, b= *Rhizobium* (Rh), c = PSB, d= *Rhizobium* with PSB and * denotes interaction between different P levels)]

Different levels of phosphorus fertilizers application also significantly affected the protein content of grains. Initial lower level of nitrogen in the plots positively supported the growth and multiplication of *Rhizobium* (Erman *et al.*, 2011). As the value of nitrogen content had been increases the valve of protein content also gets increases in that similar ratio. The higher value of protein was recorded at P_{30} level that is (23.18%) and lowest under control plots (21.99%) which is presented in the Table 4.

Effect on phosphorus content (%)

As seen in Table 5 and Fig 1.2 the treatment combination interaction between P_{30} and *Rhizobium* with PSB shows good interaction result in terms of phosphorus availability in chickpea grains i.e. 0.66 %. As suggested by Erman *et al.,* 2011 the interaction between organic and inorganic fertilizers shows positive effect on plant development.

In conclusion the effect of all the above treatments when recorded shows a similar trend all over proves that the combination of *Rhizobium* together with the phosphate solubilizing bacteria (PSB) and with the phosphorus in the form of single super phosphate (SSP) proves very useful for chickpea crop under central UP conditions. This combination enhances yield and nutrient uptake of nitrogen and phosphorus in chickpea grains as according to their function. The quality protein, content was also improved for this pulse crop. Various other parameters also got positively affected by this treatment and enhanced than control. The similar resultant effect was mentioned in the work of Moinuddin *et al.*, 2014 his results had reflected an increase in yield and protein content with inoculation of *Rhizobium* and *Pseudomonas* together with inorganic P fertilization @ 30 kg ha^{-1}. Dutta and Purohit, 2009 supported that combined application of phosphate fertilizers together with N and P biofertilizers increases seed yield as well as yield component of chickpea.

In support to our result there were so many research findings present. Gan *et al.,* 2010 and Wani *et al.,* 2007 stated that the adaptability of this pulse crop probably enhanced by inoculation of effective N-fixing microbes like *Rhizobium* in proportion with improved cultural cropping practices or through the use of improved cultivars. Ansari *et al.,* 2015 had applied many liquid biofertilizers on chickpea plants and found 21–50% improvement in yield, over control treatments. Aparna *et al.,* 2014 observation with plant growth promoting rhizobacteria in chickpea results enhance in the number of associative nitrogen-fixers which leads to its better growth.

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