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Effect of different levels of phosphorus, sulphur and biofertilizers inoculation on nutrient uptake and quality of chickpea (*Cicer arietinum* L.)

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Abstract

A field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture & Technology, Faizabad (U.P.) during rabi season of two consecutive years to assess the effect of phosphorus, sulphur and biofertilizers on nutrient uptake and quality of chickpea (Cicer *arietinum* L.) The experiment was layout in SPD having twenty-four treatment combinations consisted of three phosphorus levels (0, 30, 60 kg P_2 O_5 ha^{-1}), two sulphur levels (0, 20 kg ha^{-1}) and four seed inoculation with biofertilizers (un-inoculated, PSB, Rhizobium and PSB + Rhizobium). The application of phosphorus at 60 kg ha^{-1} , sulphur at 20 kg ha^{-1} and seed inoculation with PSB + Rhizobium significantly increased the nutrient uptake and quality of chickpea over the control /un-inoculated. So, inoculation of biofertilizers with optimum level of fertilizers could able to improve the performance of chickpea (Cicer *arietinum* L.).

Keywords: phosphorous, sulphur, biofertilizers- PSB & *Rhizobium*, nutrient, uptake, quality and chickpea

Introduction

Chickpea (*Cicer arietimum* L.) originated in south eastern turkey, belongs to family *fabaceae* and derived from the greek word '*kikus'* meaning force or strength. In world chickpea is known by various names like- *garbanzo* (Spanish), *pois chiche* (French), *kichar* or *chicher* (German), *chana* (Hindi) and gram or bengal gram (English) and in some countries of world (Turkey, Romania, Bulgaria, Afghanistan) it is also called '*nakhut'* or '*nohut'*. Gram is mostly consumed in the form of processed whole seed and *dal* but also used for preparing a variety of snacks, sweets and condiments, which are very useful for health point of view like- stomach ailments and blood purification. In India, Madhya Pradesh (39%), Maharashtra (14%), Rajasthan (14%), Uttar Pradesh (7%), Karnataka (6%), and Gujarat (5%) are the major chickpea growing states which together account for more than 85 percent of the production. Chickpea contains 18-22 percent protein, 52-70 percent carbohydrate, 4-10 percent fat and sufficient quantity of minerals, calcium, phosphorus, iron and vitamins. Pulse crop have capacity to enrich the soil fertility through the symbiotic nitrogen fixation and supply more protein for vegetarian peoples, along with above pulses and their crop residues are major source of high quality livestock feed. Ali and Kumar (1988) [1] very well define it in symbolic to its nomenclature, PULSE (P= People, U= Umbrella, L= Livestock, S= Soil, and E= Energy) is needed a superb energy umbrella for people as dietary proteins, for livestock as green nutritious fodder and feed, for soil as a mini nitrogen plant and green manure.

Growth and development of crops depend largely on the development of root system. Phosphorus (P) is one of the three macronutrients that plants must obtain from the soil. It is a major component of compounds whose functions relate to growth, root development, flowering, and ripening. Better root development becomes helpful for better nodulation by *Rhizobium* bacteria in pulse crops. Sufficient supply of phosphorus to plant, hastens the maturity and increases the rate of nodulation and pod development. It is also an important constituent of vital substances like phospholipids and phosphor-protein. Since legume is heavy feeder of phosphorus, therefore, application of phosphatic fertilizer to chickpea promotes the growth, nodulation and yield. Phosphorus also imparts hardiness to shoot, improves the quality and regulates the photosynthesis and covers other physico- biochemical process. Most of the phosphorus present in the soil is unavailable to plants which are made available through the activities of efficient micro- organism like bacteria, fungi and even cyanobacteria with production of organic acid and increasing phosphatase enzyme activity. To increase the phosphorus use efficiency, it is required to find out the optimum level of phosphorus for chickpea.

Sulphur is increasingly being recognized as a fourth major plant nutrient, but the importance of sulphur (S) application has not been fully recognized in fertilizer recommendations. It is a key element of higher pulse production, its major role in plants is formation of proteins, vitamins and enzymes. Besides, it is involved in biological nitrogen fixation.

Deficiencies of sulphur in Indian soil is widespread due to extensive use of sulphur free fertilizer coupled with extensive cultivation of high sulphur demanding crop, Moreover, sulphur requirement of crop plants is quite high, with high yielding varieties and increased cropping intensity large amounts of nutrients are removed from the soil gradually.

Year after year sulphur deficiency is becoming more critical, which severely restrict the crop yield, produce quality, nutrient use efficiency and economic returns on millions farms. Like any essential nutrient, sulphur also has certain specific function to perform in the plant. Thus, sulphur deficiencies can only be corrected by the application of proper dose of sulphur fertilizer (Tandon & Messick, 2007) [11].

Biofertilizers are living microorganisms which colonizes the rhizosphere and promotes growth by increasing the availability and supply of nutrients and/or growth stimulus to crop Singh *et al.*, (2016) [7]. Through the nitrogen fixation and phosphate solubilization microorganisms play an important role in augmenting the supply of nitrogen & phosphorus to the plant and also increase the nutrient use efficiency (Singh *et al.*, 2018) [9] which help in sustainable use of fertilizers (Tambekar *et al.*, 2009) [10]. Generally, Indian soils are lacking in effective and specific strains of Rhizobium which are responsible for symbiotic nitrogen fixation. Some important strains are mentioned as plant growth promoting rhizobacteria (PGPR) and that can be used as biofertilizers (Kennedy *et al.*, 2004) i.e. *Rhizobium, Pseudomonas, Azospirillum, Azotobacter, Bacillus, Burkholdaria, Erwinia, Mycobacterium, Flavobacterium*, etc. Singh *et al.*, (2017) [8] was told that the biofertilizers are cheap and eco-friendly source for nutrient supply that can substitute a part of chemical fertilizers resulting reduce the soil, water and air pollution.

Materials and Methods

A field experiment was conducted at the Agronomy Research Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) situated at subtropical climate zone of indo-gangetic plains and 26.470N latitude and 82.120E longitude at an altitude of 113 metres from mean sea level receiving 1200 mm annual rainfall, during *rabi* season of two consecutive years to assess the effects of phosphorus, sulphur and biofertilizers on nutrient uptake and quality of chickpea. The soil of the experimental field was silty loam in texture with low organic carbon (0.31%) and nitrogen (175.40 kg ha-1) and medium in phosphorus (16.30 kg ha-1) and potassium (238 kg ha-1). In this experiment there was twenty-four treatment combinations involved in which, three phosphorus levels (0, 30 & 60 kg P_2O_5 ha^{-1}), two Sulphur levels (0 & 20 kg ha^{-1}) and four seed inoculation with biofertilizers (un-inoculated, PSB, Rhizobium and PSB + Rhizobium), The chickpea variety ‘Avrodhi’ was treated with biofertilizers and sown at the rate of 80 kg seed ha^{-1} in split plot design with three replications. To evaluate the effects of different treatments observation were taken in stipulated time.

Results and Discussion

Nitrogen uptake

Results showed that uptake of nitrogen by seed and straw as affected by phosphorus levels, sulphur and bio-fertilizers have been presented in Table 1. Application of phosphorus significantly affected the nitrogen uptake by seed and straw of chickpea. The maximum uptake of nitrogen by seed (66.47 and 68.64 kg ha^{-1}) and straw (15.34 and 15.76 kg ha^{-1}) was recorded with the application of 60 kg P_2O_5 ha^{-1}, which was significantly higher than other levels of phosphorus during both the years. Sulphur significantly affected the nitrogen uptake by seed and straw. The maximum nitrogen uptake by seed (66.26 and 68.29 kg ha^{-1}) and straw (15.26 and 15.71 kg ha^{-1}) was recorded with the application of 20 kg sulphur ha^{-1} and which was significantly higher over control. Use of bio fertilizers significantly affected the uptake by seed and straw. The maximum nitrogen uptake by seed (65.84 and 68.09 kg ha^{-1}) and straw (15.22 and 15.65 kg ha^{-1}) was recorded where seed was inoculated with PSB + *Rhizobium*, which was significantly higher over un-inoculation, PSB and *Rhizobium* alone. Interaction effect of phosphorus levels, sulphur and bio-fertilizers was found to be non-significant on the nitrogen uptake by seed and straw of chickpea.

Table 1: Effect of phosphorus, sulphur and bio-fertilizers on nitrogen uptake by seed, straw and total nitrogen uptake by crop of chickpea crop (kg ha^{-1}).

Treatment	Nitrogen uptake by seed		Nitrogen uptake by straw		Total		Protein content in seed (%)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Phosphorus levels (kg ha^{-1})								
0	54.14	55.97	12.51	12.85	66.28	68.82	18.55	18.60
30	59.75	62.16	13.90	14.17	68.19	76.33	19.22	19.27
60	66.47	68.64	15.34	15.76	75.16	84.41	19.60	19.65
SEm±	5.96	1.17	0.25	14.26	1.12	1.12	0.10	0.08
CD at 5%	3.32	3.68	0.80	0.81	3.52	3.55	0.33	0.27
Sulphur levels (kg ha^{-1})								
0	53.96	56.22	12.57	12.81	66.70	69.03	18.51	18.56
20	66.26	68.29	15.26	15.71	81.67	84.00	19.74	19.79
SEm±	0.86	0.95	0.20	16.26	0.91	0.92	0.08	0.08
CD at 5%	2.71	3.01	0.65	0.66	2.88	2.90	0.27	0.27
Bio-fertilizers								
Un-inoculation	54.34	56.62	12.66	12.93	67.23	69.55	18.46	18.50
PSB	57.96	60.50	13.53	13.80	71.78	74.30	19.09	19.14

Rhizobium	61.77	63.81	14.26	14.67	76.32	78.48	19.32	19.37
PSB+ *Rhizobium*	65.84	68.09	15.22	15.65	81.40	83.74	19.64	19.69
SEm±	60.27	1.18	0.22	14.26	1.24	1.23	0.11	0.11
CD at 5%	3.32	3.40	0.64	0.65	3.56	3.54	0.31	0.31
Interaction P×S	NS	NS	NS	NS	NS	NS	NS	NS

Phosphorus uptake

The data pertaining to phosphorus by seed and straw as affected by phosphorus levels, sulphur and bio-fertilizers have been presented in Table 2. Application of phosphorus significantly affected the phosphorus uptake by seed and straw of chickpea. The maximum uptake of phosphorus by seed (8.71 and 9.17 kg ha^{-1}) and straw (3.04 and 3.30 kg ha^{-1}) was recorded with the application of 60 kg P_2O_5 ha^{-1}, which was significantly higher than other levels of phosphorus during both the years. Sulphur significantly affected the phosphorus uptake by seed and straw. The maximum phosphorus uptake by seed (8.68 and 9.13 kg ha^{-1}) and straw (3.03 and 3.29 kg ha^{-1}) was recorded with the application of 20 kg sulphur ha^{-1} and which was significantly higher over control. Use of bio fertilizers significantly affected the phosphorus uptake by seed and straw. The maximum phosphorus uptake by seed (8.65 and 9.10 kg ha^{-1}) and straw (3.02 and 3.27 kg ha^{-1}) was recorded where seed was inoculated with PSB + *Rhizobium*, which was significantly higher over un-inoculation, PSB and *Rhizobium* alone. Interaction effect of phosphorus levels, sulphur and bio-fertilizers was found to be non-significant on the phosphorus uptake by seed and straw of chickpea. Sharma *et al.* (2008) [6] reported interaction effects of P and S on yield, nutrient and protein content in green gram using four rates of P_2O_5 (0, 30, 60 and 90 kg ha^{-1}) and three rates of S (0, 30 and 60 kg ha^{-1}), Application of 60 kg P_2O_5 ha^{-1} and 60 kg sulphur ha^{-1} individually as well as in combination significantly increased the grain, straw and dry matter yield of green gram over control. The concentration and uptake of S increased with application of S and P up to 60 kg ha$^{-1.}$ The interaction between P and S was found to be significant P concentration and uptake of S. The concentration and uptake of P in green gram increased significantly up to 90 kg P ha^{-1}. However, application of S had no significant effect on P concentration. Meena *et al.* (2005) [3] reported that increasing P levels increased the P content and uptake in chickpea.

Table 2: Effect of phosphorus, sulphur and bio-fertilizers on phosphorus uptake by seed, straw and total phosphorus uptake by crop of chickpea (kg ha^{-1}).

Treatment	Phosphorus uptake by seed (kg ha^{-1})		Phosphorus uptake by straw (kg ha^{-1})		Total Phosphorus uptake by crop (kg ha^{-1})	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Phosphorus levels (kgha^{-1})						
0	7.10	7.48	2.48	2.69	9.58	10.17
30	7.83	8.31	2.76	2.96	10.58	11.27
60	8.71	9.17	3.04	3.30	11.75	12.47
SEm±	0.13	0.15	0.05	0.05	0.15	0.15
CD at 5%	0.43	0.49	0.16	0.17	0.48	0.47
Sulphur levels (kgha^{-1})						
0	7.07	7.51	2.49	2.68	9.56	10.19
20	8.68	9.13	3.03	3.29	11.71	12.41
SEm±	0.11	0.12	0.04	0.04	0.12	0.12
CD at 5%	0.35	0.40	0.13	0.13	0.39	0.38
Bio-fertilizers						
Un-inoculation	7.13	7.57	2.51	2.70	9.65	10.27
PSB	7.62	8.09	2.68	2.89	10.30	10.97
Rhizobium	8.11	8.53	2.83	3.07	10.94	11.60
PSB+ *Rhizobium*	8.65	9.10	3.02	3.27	11.67	12.37
SEm±	0.15	0.15	0.04	0.04	0.17	0.17
CD at 5%	0.43	0.45	0.12	0.13	0.48	0.49
Interaction P×S	NS	NS	NS	NS	NS	NS

Sulphur Uptake

Results showed that uptake of sulphur by seed and straw as affected by phosphorus levels, sulphur and bio-fertilizers have been presented in Table 3. Application of phosphorus significantly affected the sulphur uptake by seed and straw of chickpea. The maximum uptake of sulphur by seed (7.10 and 7.45 kg ha^{-1}) and straw (5.20 and 5.54 kg ha^{-1}) was recorded with the application of 60 kg P_2O_5 ha^{-1}, which was significantly higher than other levels of phosphorus during both the years. Sulphur significantly affected the sulphur uptake by seed and straw. The maximum sulphur uptake by seed (7.08 and 7.41 kg ha^{-1}) and straw (5.17 and 5.52 kg ha^{-1}) was recorded with the application of 20 kg sulphur ha^{-1} and which was significantly higher over control. Use of bio fertilizers significantly affected the sulphur uptake by seed and straw. The maximum sulphur uptake by seed (7.05 and 7.39 kg ha^{-1}) and straw (5.16 and 5.50 kg ha^{-1}) was recorded where seed was inoculated with PSB + *Rhizobium*, which was significantly higher over un-inoculation, PSB and *Rhizobium* alone. Interaction effect of phosphorus levels, sulphur and bio-fertilizers was found to be non-significant on the phosphorus uptake by seed and straw of chickpea. Naagar and Meena (2004**)** [5] reported the seed inoculation of chickpea with PSB significantly increased the total uptake of N, P and S which crop over un-inoculated control. Bharathi and Poongothai (2008) [2] reported the residual effect of sulphur application or nutrient uptake, yield and sulphur use efficiency of subsequent greengram. The application was treated with 4 levels of sulphur (0, 15, 30 and 45 kg SSP ha^{-1}) while the residual crop greengram received no sulphur. The sulphur uptake was maximum at 30 kg sulphur ha^{-1} while a phenomenal increase in nitrogen, phosphorus and potassium uptake was recorded. Application of 30 kg sulphur ha^{-1} was found to be the optimum dose for maize and the residual effect on greengram.

Table 3: Effect of phosphorus, sulphur and bio-fertilizers on sulphur uptake by seed, straw and total uptake sulphur by crop of chickpea (kg ha^{-1}).

Treatment	Sulphur uptake by seed		Sulphur uptake by straw		Total Sulphur	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Phosphorus levels (kg ha^{-1})						
0	5.78	6.07	4.24	4.51	10.02	10.59
30	6.38	6.75	4.71	4.98	11.09	11.73
60	7.10	7.45	5.20	5.54	12.30	12.99
SEm±	0.11	0.12	0.08	0.09	0.15	0.13
CD at 5%	0.35	0.40	0.27	0.28	0.47	0.42
Sulphur levels (kg ha^{-1})						
0	5.77	6.10	4.26	4.50	10.03	10.60
20	7.08	7.41	5.17	5.52	12.25	12.93
SEm±	0.09	0.10	0.07	0.07	0.12	0.11
CD at 5%	0.28	0.32	0.22	0.23	0.38	0.34
Bio-fertilizers						
Un-inoculation	5.81	6.15	4.29	4.54	10.11	10.69
PSB	6.21	6.57	4.58	4.85	10.79	11.41
Rhizobium	6.61	6.93	4.83	5.15	11.44	12.08
PSB+ *Rhizobium*	7.05	7.39	5.16	5.50	12.21	12.89
SEm±	0.12	0.12	0.07	0.08	0.16	0.16
CD at 5%	0.35	0.36	0.22	0.23	0.46	0.45
Interaction P×S	NS	NS	NS	NS	NS	NS

Protein content in seed (%)

The data pertaining to protein content in seed have been presented in Table1. Protein content in seed increased with increasing levels of phosphorus up to 60 kg P_2O_5 ha^{-1}. The maximum protein content (19.60 and 19.65 %) in seed was found with 60 kg P_2O_5 ha^{-1}, which was significantly higher than 30 kg P_2O_5 ha^{-1} and control treatment. Maximum protein content in seed (19.74 and 19.79 %) was recorded with application of 20 kg S ha^{-1}, which was significantly higher than control. The maximum protein content (19.64 and 19.69 %) in seed was recorded when seed was inoculated with PSB + *Rhizobium*, and it was significantly higher over rest of the treatments. The interaction effect of phosphorus levels, sulphur and bio-fertilizer on protein content in seed of chickpea was found to be non-significant. Meena *et al.* (2006) [4] reported that application of 60 kg P_2O_5 ha^{-1} significantly increased the protein content in seed of chickpea.

Conclusion

Based on the result obtained during both years of experimentation, it may be concluded that the performance of the application of adequate and balance fertilizers along with suitable biofertilizers can enhance the nutrient uptake and quality of crop.

Recommended

Crop on the basis of results, it is recommended that chickpea crop higher yield and profit the quality grown with application 60 kg P_2O_5, 20 kg S ha^{-1} and seed inoculation PSB+*Rhizobium* for getting higher yield and profit.

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