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Effect of phosphorus, potassium and bio-fertilizer on growth and yield of chick pea (*Cicer arietinum* L.)

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Abstract
A field experiment was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out on Randomized Block Design with nine treatments each replicated thrice on the basis of one year experimentation. The treatments which are T_1: 30kg P_2O_5 /ha + *PSB*, T_2: 30kg P_2O_5 /ha + *Rhizobium*, T_3: 60kg P_2O_5 /ha + *PSB*, T_4: 60kg P_2O_5 /ha + *Rhizobium*, T_5: 30kg K_2O/ha + *PSB*, T_6: 30kg K_2O/ha + *Rhizobium*, T_7: 40kg K_2O/ha + *PSB*, T_8: 40kg K_2O/ha + *Rhizobium*, T_9: Control with RDF 20:40:20 (NPK kg/ha) are used. The results showed that application of 60kg P_2O_5 /ha + *PSB* was recorded significantly higher Plant height (43.53 cm), Plant dry weight (8.51 g/plant), whereas significantly highest Crop growth rate (3.33 g/m^2/day) was recorded with the treatment 40kg K_2O/ha + *PSB*. However, Pods/plant (30.37), Test weight (224.30 g), Seed yield (3.18 t/ha), Harvest index (37.27%), Higher gross returns (Rs. 155,753.7/ha), net returns (Rs. 1,19,459/ha) and benefit cost ratio (3.29) was obtained in the treatment60kg P_2O_5 /ha + *PSB*.

Keywords: Phosphorus, potassium, bio-fertilizer, *Rhizobium*, *PSB*, Growth, yield

Introduction
Chickpea (*Cicer arietinum* L.) is the major pulse crop of India. At global level, it ranks third in terms of area and production under legumes. It is grown with less care and less manurial requirement. The earliest record of chickpea in India is from Atranji Khera in Uttar Pradesh and this dates backs to 2000 BC. With an estimated global production of 13.1 million tons in 2013, chickpea is grown in about 50 countries around the world covering an area of 14 million ha with an average global productivity of 968 kg ha-1 (Karwasra *et al.*, 2007).

Chickpea is mostly consumed in the form of processed whole seed (boiled, roasted, parched, fried, steamed, sprouted etc.) or dal or as dal flour (besan). It is used in preparing a variety of snacks, sweets and condiments. It is mixed with wheat flour for "chapati" making. Fresh green seeds are consumed as green vegetable. Green leaves are used as vegetable. Grains are also used as vegetable (chole). Husk and bits of dal are used as nutritious feed for animals. Chickpea can also be used as green fodder for animals. It is mainly grown in more than 50 countries including India, Pakistan, Turkey, Iran, Myanmar, Australia, Ethopia, Canada, Mexico and Iraq (Gaur *et al.*, 2010). Chickpea is the third most important pulse crop in the world after beans and field peas. In India, it is the premier pulse crop occupying 10.2 million hectares area and contributing 9.9 million tonnes to the national pulse basket with the productivity of 967 kg ha-1 (Anonymous, 2014-15).

Potassium influences the water economy and crop growth through its effects on water uptake, root growth, maintenance of turgor, transpiration and stomatal regulation. Although potassium unlike N and P, does not enter into the composition of any product, yet literature on K reveals that it has an important role either direct or indirect, under different environments, in major plant processes such as photosynthesis, respiration, protein synthesis, enzyme activation, water uptake, osmoregulation, growth and yield of plant

Biofertilizers may colonizes the rhizosphere and promotes growth by increasing the availability and supply of nutrients and/or growth stimulus to crop. Nitrogen fixer and phosphate solubilizing microorganisms play an important role in supplementing nitrogen and phosphorus to the plant, allowing a sustainable use of nitrogen and phosphate fertilizers. 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

Materials and Methods

The present examination was carried out during *Kharif* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28ºN latitude, 81.54ºE longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consisting of nine treatments with T_1: 30kg P_2O_5 /ha + *PSB*, T_2: 30kg P_2O_5 /ha + *Rhizobium*, T_3: 60kg P_2O_5 /ha + *PSB*, T_4: 60kg P_2O_5 /ha + *Rhizobium*, T_5: 30kg K_2O/ha + *PSB*, T_6: 30kg K_2O/ha + *Rhizobium*, T_7: 40kg K_2O/ha + *PSB*, T_8: 40kg K_2O/ha + *Rhizobium*, T_9: Control with RDF 20:40:20 (NPK kg/ha) are used.. The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium available N (225 kg ha^{-1}), higher available P (19.50 kg ha^{-1}) and medium available K (213.7 kg ha^{-1}). In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters, plant height, no. of nodules/plant and plant dry weight are recorded. The yield parameters like No. of pods/plant, No. of seeds/pod, Test weight (g), seed yield, stover yield and harvest index were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results and Discussion

Growth attributes

Plant height

Significantly higher plant height (43.53 cm) was recorded with the treatment 60Kg P2O5 ha+ PSB. However, the treatments 40kg K2O ha + PSB (43.20 cm) and 60Kg P_2O_5 ha + *Rhizobium* (43.02 cm) was found to be statistically at par with 60Kg P2O5 ha+ PSB as compared to all the treatments.

Memon *et al.,* (2016) [5] reported that the different P levels with K application significantly increased plant height (102.4cm), average yield (1058 kg /ha), shoot P (0.49%), P uptake (5.18 kg ha-1) and protein content (17.4%) over control plot at the rate of 75 P2 05 kg ha-1 at Chickpea (Benazir) cultivar

Rehan *et al.,* (2018) [11] indicated that plots treated with 90 kg P /ha provided higher nodules per plant (74.00), plant height (82.60 cm), pods per plant (50.00), and biological yield (5.18 t /ha), which were statistically alike with 60 kg P/ha (5.17 t /ha). Significantly higher grains per pod (1.70), 100-grain weight (24.86 g), and grain yield (1.45 t /ha) were recorded in plots treated with 60 kg P /ha.

Number of Branches/plant

Significantly higher nodules/plant (6.34) was recorded with the treatment 60Kg P2O5 ha+ PSB. However, the treatments 40kg K2O ha + PSB (6.24) was found to be statistically at par with 60Kg P2O5 ha+ PSB as compared to all other treatments.

M. Erman *et al.,* (2011) Inoculation with rhizobium increased plant height (3.32%), first pod height (7.25%), branches per plant (4.08%), pods per plant (6.90%), grains per plant (6.40), and grain yield (6.30%) over the control [10]. It has been reported that increased nodulation due to rhizobium inoculation resulted in higher N2-fixation and ultimately resulted in higher pod number per plant, which offered higher grain yields as a whole.

Plant dry weight (g/plant)

Significantly higher dry weight/plant (8.51g/plant) was recorded with the treatment 60Kg P2O5 /ha+ PSB. However, the treatments 40kg K2O ha + PSB (8.40 g/plant) was found to be statistically at par with 60Kg P2O5/ ha+ PSB as compared to all other treatments.

R. Singh *et al.,* (2018) [6] demonstrated that the use of 60 kg P /ha, 20 kg S /ha and seed inoculation with PSB + rhizobium considerably increased growth, dry weight, nodules per plant, and grain and straw yields of chickpea over the uninoculated ones.

T. Meleta *et al.,* (2019) [10] observed that all nodulation parameters excluding the nodule color of chickpea were significantly affected by P rate, and the maximum values were recorded at 45 and 60 kg P2O5 /ha. Nodule rating and dry weight per plant increased at 60 (47.50 and 6.44%) and 45 (52.30 and 6.60%) kg P2O5/ ha, respectively, relative to the control treatment.

Yield attrubutes and Yield

Number of Pods/plant

Significantly Maximum Number of Pods/plant (30.37) was recorded with the treatment of application of 60Kg P_2O_5/ha+ *PSB* over all the treatments. However, the treatment 40kg K_2O/ha + *PSB* (29.44) which were found to be statistically at par with 60Kg P_2O_5/ha+ *PSB*.

S. Hussen *et al.,* (2015) [7] A field trial signified that P levels significantly affected plant height, branches, and pods per plant, and highest plant height (39.25 cm), branches per plant (9.37), and pods per plant (49.00) were recorded in 60 kg P2O5 / ha, whereas the lowest plant height (32.50 cm), branches plant−1 (6.75), and pods /plant (30.75) were obtained from the control

Test weight (g)

Significantly Maximum seed index (201.33) was recorded with the treatment of application of 60Kg P_2O_5/ha+ *PSB* over all the treatments. However, the treatment 40kg K_2O/ha + *PSB* (200.28) which were found to be statistically at par with 60Kg P_2O_5/ha+ *PSB***.**

S. K. Das *et al.,* (2016) [8] found that application of P 60 kg /ha resulted in significantly higher grain yield (2.74 t /ha) mainly due to the significantly higher primary branches plant−1 (8.10), pods per plant (33.60), and 100-grain weight (13.10 g). It improved the grain yield by 6.80% over P at 30 kg /ha and 53.90% over the control.

Samiullah and Khan (2003) The increased branches/plant-1, pods/plant-1, grain weight/plant- 1 and 100-seed weight due to potassium application eventually contributed to higher seed yield.

Seed yield (t/ha)

Significantly highest Seed yield (1.89 t/ha) was recorded with the treatment of application of 60Kg P_2O_5/ha+ *PSB* over all the treatments. However, the treatment 40kg K_2O/ha + *PSB* (1.79 t/ha) which were found to be statistically at par with 60Kg P_2O_5/ha+ *PSB***.**

M. Aslam *et al.,* (2000) [3] reported that the trial signified that total biomass and grain yields of chickpea were significantly influenced by P levels, and the average maximum total biomass (4.05 t/ ha) and grain (2.11 t /ha) yields were observed at 60 kg P2O5 ha−1, whereas the average lowest total biomass (2.54 t /ha) and grain (1.34 t /ha) yields were

recorded in the control.

M. Aslam Avais *et al.*, (2017) [2] A similar study showed a significant increase in nodulation (17.50%), plant height (4.00%), pods/ plant (9.33%), and grain yield (7.50%) due to bacterial inoculation) advanced line D-06052 had the highest grain yield (2.89 t /ha) due to bacterial inoculation over the other advanced lines and the local cultivar.

Harvest Index (%)

Significantly highest Harvest index (37.27%) was recorded with the treatment of application of 60Kg P_2O_5/ha+ *PSB* over all the treatments. However, the treatment 40kg K_2O/ha + *PSB* (36.84%), 40kg K_2O/ha + *Rhizobium* (36.36%), 60Kg P_2O_5 /ha+*Rhizobium* (36.34%), 30kg K_2O/ha + *PSB* (36.20%) and Control with RDF 20:40:20 (NPK kg/ha) (36.06%) which were found to be statistically at par with 60Kg P_2O_5/ha+ *PSB*. Khan *et al*., (2007) [1] and Singh *et al*., (2018) [6] reported significant increase in yield attributes with bio-fertilizer.

Biological yield

Significantly highest Biological yield (5.07) was recorded with the treatment of application of 60Kg P2O5/ha+ PSB over all the treatments. However, the treatment 40kg K2O/ha + PSB (4.85) which were found to be statistically at par with 60Kg P2O5/ha+ PSB.

W. Rehan *et al.*, (2018) A research result indicated that the seeds treated with rhizobium produced maximum nodules per plant (75.00), grains per pod (3.00), pods/ plant (49.00), 100-grains weight (24.74 g), and biological (5.17 t /ha) and grain (1.44 t /ha) yields compared to uninoculated seeds.

Table 1: Effect of Phosphorus, Potassium and Bio-fertilizer on Growth attributes of Chickpea.

	Treatments	Plant height (cm)	No. of Branches	Dry weight (g/plant)
1.	30kg P_2O_5 /ha + *PSB*	42.69	5.68	7.76
2.	30kg P_2O_5 /ha + *Rhizobium*	41.75	5.58	7.47
3.	60kg P_2O_5 /ha + *PSB*	43.53	6.34	8.51
4.	60kg P_2O_5 /ha + *Rhizobium*	43.02	6.09	8.21
5.	30kg K_2O/ha + *PSB*	42.16	5.84	7.95
6.	30kg K_2O/ha + *Rhizobium*	42.21	5.62	7.58
7.	40kg K_2O/ha + *PSB*	43.20	6.24	8.40
8.	40kg K_2O/ha + *Rhizobium*	42.63	5.97	8.08
9.	Control with RDF 20:40:20 (NPK kg/ha)	41.38	5.43	7.33
F test		S	S	S
S.Em±		0.09	0.04	0.03
CD (P=0.05)		0.28	0.11	0.10

Table 2: Effect of Phosphorus, Potassium and Bio-fertilizer on Yield attributes of Chickpea.

	Treatments	Pods/plant	Seed index(g)	Seed yield (t/ha)	Halum yield (t/ha)	Harvest index (%)
1.	30kg P_2O_5 /ha + *PSB*	26.90	193.35	1.45	2.68	35.15
2.	30kg P_2O_5 /ha + *Rhizobium*	25.91	189.96	1.29	2.36	35.29
3.	60kg P_2O_5 /ha + *PSB*	30.37	201.33	1.89	3.18	37.27
4.	60kg P_2O_5 /ha + *Rhizobium*	28.65	197.52	1.69	2.96	36.34
5.	30kg K_2O/ha + *PSB*	27.29	195.02	1.56	2.75	36.20
6.	30kg K_2O/ha + *Rhizobium*	26.24	191.29	1.37	2.51	35.39
7.	40kg K_2O/ha + *PSB*	29.44	200.28	1.79	3.06	36.84
8.	40kg K_2O/ha + *Rhizobium*	27.70	196.66	1.62	2.83	36.36
9.	Control with RDF 20:40:20 (NPK kg/ha)	25.14	188.20	1.21	2.15	36.06
F test		S	S	S	**S**	**S**
S. EM (±)		0.09	0.37	0.04	0.04	0.80
CD (P = 0.05)		0.28	1.09	0.11	0.12	2.36

Conclusion

As per my research trial in Rabi season, treatment 3, with combination of 60kg P2O5 /ha+ PSB was found to be more productive also economically feasible as compared to other treatments.

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