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GROWTH AND YIELD OF CHICKPEA (*CICER ARIETINUM* L.) AS INFLUENCED BY GRADED LEVELS OF FERTILIZERS AND BIO-FERTILIZERS

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ABSTRACT
An experiment with three levels of fertilizers (100, 75 and 50% of RDF) and 4 levels of bio-fertilizers (B_1: Control B_2: *Rhizobium* as seed treatment + PSB as soil application, B_3: *Rhizobium* as seed treatment + VAM as soil application, B_4: *Rhizobium* and PSB both as seed treatment) was conducted to study the response of chickpea (*Cicer arietinum* L.). 100% RDF recorded significantly highest plant height (42.33 cm), no. of branches plant^{-1} (12.68), no. of nodules plant^{-1} (31.10), dry matter accumulation plant^{-1}(18.05 g), no. of pods plant^{-1}(44.19), seed yield (1854 kg ha^{-1}) and stover yield (2722 kg ha^{-1}) over 75 and 50% RDF. Among bio-fertilizers, treatment B_4 recorded significantly higher plant height (42.11 cm), no. of nodules plant^{-1} (30.16), no. of pods plant^{-1} (44.01), seed yield (1824 kg ha^{-1}) and stover yield (2709 kg ha^{-1}) over control but found at par with B_3 and B_2. With respect to interaction effect it is interesting to note that the yield recorded with 75% RDF + B_4 found as good as the yield obtained with 100% RDF + B_4 indicates 25% saving of fertilizers. The use of bio-fertilizers with reduced quantity of chemical fertilizers is therefore recommended for better yield of chickpea.

INTRODUCTION

Among the grain legumes, chickpea (*Cicer arietinum* L.) commonly known as Bengal gram and locally Chana is an important and unique food legume because the variety of food products like snacks, sweets etc. Condiments and vegetables are prepared from it world-wide. It also consumed in the form of processed whole seed (boiled, roasted, parched, fried, steamed sprouted etc.) or as dal flour (besan). Gram is a good source of protein (18-22 per cent), carbohydrate (52-70 per cent), fat (4-10 per cent), minerals and vitamins. In India, it occupies about 9.18 million hectare area with production of 8.22 million tonnes and an average productivity of 900 kg ha^{-1} (Anonymous, 2013). In spite of the importance of this crop in our daily diet and in agricultural production, productivity of this crop is very low in India. Hence, it is very much essential to take the stock of the situation and search for new innovations which can enhance the productivity without causing much damage to the environment.

Greater scope for further improvement in yields of food grains in India is the strength for Indian agricultural science. Research needs to concentrate more on climate resilient agriculture safeguarding the natural resource base in order to make our future generations thrive on this living planet (Shetty *et al.*, 2014).The low production of chickpea crop is due to improper use of fertilizers and least importance given to bio-fertilizers such as *Rhizobium*, PSB and VAM fungi.Fertilizers like nitrogen and phosphorus are the most important elements as well as expensive inputs in crop production. An adequate supply of chemical fertilizers is closely associated with growth and development of plant. In modern agriculture, chemical fertilizers are extensively used in order to increase yield.

Excessive use of these chemicals has adverse effect on the soil micro flora and fauna (Shetty *et al.*, 2013).*Rhizobium* inoculation can increase the grain yield of pulse crops to the tune of 10 to 15 per cent (Ali and Chandra, 1985). Phosphate solubilizing bacteria (PSB) have the consistent capacity to increase the availability of phosphates to plants by mineralizing organic phosphorus compounds (Parveen *et al.*, 2002).Additional inoculation with selected VAM strains, which are available as commercial products, often yields better growth promotion than indigenous VAM fungi populations (Salami *et al.*, 2005).

In India, because of existing intensive farming system, organic manures, which requires in bulk quantities, increased the transportation and labour charges and hence increased the cost of production. So, there is a need to find out alternative to bulky organic matter. Thus bio-fertilizers can serve as an alternative of bulky organic matter and NPK fertilizer upto certain extent. Therefore present study was conducted to investigate the effect of NPK and bio-fertilizers on growth and yield of chickpea (*Cicer arietinum* L.).

The paper deals with the effect of graded levels of fertilizers and bio-fertilizers and interaction effect of different treatments on growth, yield attributes and yield of chickpea.

MATERIALS AND METHODS

The present study was conducted throughout *rabi* season of 2013-14 at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, India to study the effect of graded levels of fertilizers and bio-fertilizers on growth and yield of chickpea (*Cicer arietinum* L.). Soil of the experimental field was clayey in texture and showed low, medium and high rating for available nitrogen (197kg ha^{-1}), phosphorus (30 kg ha^{-1}) and potassium (369 kg ha^{-1}), respectively. The soil was found slightly alkaline (pH 7.8) with normal electrical conductivity (0.36 dSm^{-1}).The experiment was conducted in factorial randomized block design with total 12 treatment combination consisting of 3 levels of fertilizers *viz.*,100% RDF (F_1), 75% RDF (F_2) and 50% RDF (F_3) and 4 levels of bio-fertilizers *viz.*,Control (no bio-fertilizer) (B_1), *Rhizobium* as seed treatment and PSB as soil application (B_2), *Rhizobium* as seed treatment and VAM as soil application (B_3), and *Rhizobium* and PSB both as seed treatment (B_4) with 3 replications.Seed treatments of Bio-fertilizers for treatments B_2, B_3 and B_4 were applied to seeds prior to sowing and were dried in shade as prescribed by Uddin *et al.* 2014. For the soil application of bio-fertilizers (for treatments B_2 and B_3) required quantity of PSB culture for the experimental area was throughly mixed with sand and uniformly applied in furrows as per treatments before sowing.The viability count and microbial load of microorganisms used in this experiment are shown in Table 1.

Observation on plant height, branches $plant^{-1}$, nodules $plant^{-1}$, dry matter accumulation $plant^{-1}$, pods $plant^{-1}$, seed index, seed yield and stover yield were recorded at different stages. The data pertaining to various growth stages and yield were subjected to analysis of variance prescribed for factorial randomized block design as described by Panse and Sukhatme (1967).

Table 1: Viability count and microbial load of microorganisms used in the study

Bio-fertilizers	Viability count
Rhizobium	1 x 10^8 CFU/mL
PSB	1 x 10^8 CFU/mL
VAM	1.8 x 10^4 IP/g

CFU/ml: Colony Forming Units per 1 ml of liquid, IP/g: Infective Propagules per gram

RESULTS AND DISCUSSION

Effect of fertilizer levels

The growth and yield attributes like plant height, no. of branches $plant^{-1}$, no. of nodules $plant^{-1}$, dry matter accumulation $plant^{-1}$, no. of pods $plant^{-1}$ and seed index were progressively enhanced due to graded levels of fertilizers. An application of 100% RDF recorded significantly highest plant height (42.33 cm), no. of branches $plant^{-1}$ (12.68), no. of nodules $plant^{-1}$ (31.10), dry matter accumulation $plant^{-1}$(18.05 g) (Table 2), no. of pods $plant^{-1}$(44.19) and seed index in g (22.56) (Table 3). This kind of behaviour could be explained on the basis of role of N and P in plant body. Nitrogen being an essential part of nucleic acids and proteins which are very important in promoting the growth. Similarly at initial stage phosphorus helped on promoting root growth and better establishment of crop. Further as soil of experimental plot was low in available nitrogen and medium in available phosphorus, the higher doses also elicit significant crop response in terms of higher vegetative growth.The higher number of root nodules per plant were recorded with 100% RDF. This might be due to beneficial effect of phosphorus on root growth which provided more root surface for bacterial infection and enhance the nodulation. These all combined effects resulted in conductive for plant growth and development.100% RDF recorded significantly highest seed yield (1854 kg ha^{-1}) and stover yield (2722 kg ha^{-1}) (Table3) over 75 and 50% RDF.The treatment 100% RDF (F_1) increased the seed yield of chickpea in terms of kg ha^{-1} to the tune of 6.80 and 25.87% over 75 and 50% RDF.This was largely be attributed to better growth of plants in terms of plant height, number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$ which resulted in adequate supply of photosynthates for development of sink under higher level of fertilizers.Positive response of crops in terms of growth, yield attributes and yield to levels of fertilizer has also been reported by Jat and Mali, (1992); Kasole *et al.* (1995); Dalal and Nandkar, (2010); Dalal and Nandkar, (2011) and Thenua and Sharma (2011).

Table 2: Effect of fertilizer levels and bio-fertilizers on growth of chickpea

Treatments	Plant height		Branches $plant^{-1}$		Nodules $plant^{-1}$		DMA (g $plant^{-1}$)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90DAS
Fertilizer levels								
F_1	34.53	42.33	8.15	12.68	25.93	31.10	8.08	18.05
F_2	30.91	39.25	7.26	11.56	24.90	28.94	7.24	16.71
F_3	29.31	37.91	6.88	10.99	19.77	23.69	7.00	15.09
SEm ±	0.80	1.00	0.28	0.36	0.55	0.66	0.17	0.45
CD at 5%	2.36	2.96	0.82	1.08	1.62	1.95	0.52	1.33
Bio-fertilizers								
B_1	29.22	37.11	6.60	10.62	18.55	22.47	6.87	15.31
B_2	31.86	40.11	7.22	11.68	24.22	28.91	7.46	17.11
B_3	31.38	40.00	7.86	12.02	25.04	30.08	7.42	16.44
B_4	33.88	42.11	8.04	12.65	26.32	30.16	8.01	17.61
SEm ±	0.93	1.16	0.32	0.42	0.63	0.77	0.20	0.52
CD at 5%	2.73	3.41	0.95	1.25	1.87	2.25	0.60	1.53

F_1: 100% RDF, F_2: 75% RDF, F_3: 50% RDF, B_1: Control (no bio-fertilizer), B_2: *Rhizobium* as seed treatment + PSB as soil application, B_3 : *Rhizobium* as seed treatment + VAM as soil application, B_4 : *Rhizobium* and PSB both as seed treatment. DMA : Dry matter accumulation

Table 3: Effect of fertilizer levels and bio-fertilizers on yield and economics of chickpea

Treatments	No. of pods plant^{-1}	Seed index (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Fertilizer levels				
F_1	44.19	22.56	1854	2722
F_2	41.16	20.79	1736	2520
F_3	36.50	19.84	1473	2299
SEm ±	1.01	0.57	39.30	66.58
CD at 5%	2.98	1. 69	115.28	195.29
Bio-fertilizers				
B_1	34.48	19.07	1422	2177
B_2	42.08	21.36	1749	2574
B_3	41.90	21.62	1754	2595
B_4	44.01	22.20	1824	2709
SEm +	1.17	0.66	45.38	76.88
CD at 5%	3.44	1.95	133.11	225.51

F_1: 100% RDF, F_2 : 75% RDF, F_3 : 50% RDF, B_1 : Control (no bio-fertilizer), B_2 : *Rhizobium* as seed treatment + PSB as soil application, B_3 : *Rhizobium* as seed treatment + VAM as soil application, B_4 : *Rhizobium* and PSB both as seed treatment.

Table 4: Number of root nodules plant^{-1}, number of pods plant^{-1} and seed yield (kg ha^{-1}) of chickpea as influenced by interaction effects of levels of fertilizers and bio-fertilizers

Fertilizer levels (F)	Bio-fertilizers (B)			
	B_1	B_2	B_3	B_4
No. of root nodules plant^{-1} 90 DAS				
F_1	28.60	31.40	31.53	32.86
F_2	24.56	29.93	30.93	30.33
F_3	14.26	25.40	27.80	27.30
SEm ±	1.33			
CD at 5%	3.91			
No. of pods plant^{-1} at harvest				
F_1	41.66	43.60	43.63	47.86
F_2	36.66	42.06	42.06	43.86
F_3	25.13	40.60	40.00	40.30
SEm ±	2.03			
CD at 5%	5.97			
Seed yield (kg ha^{-1})				
F_1	1687	1905	1899	1924
F_2	1573	1757	1703	1910
F_3	1007	1586	1660	1639
SEm ±	78.60			
CD at 5%	230.56			

F_1:100% RDF, F_2: 75% RDF, F_3: 50% RDF, B_1: Control (no bio-fertilizer), B_2: *Rhizobium* as seed treatment + PSB as soil application, B_3: *Rhizobium* as seed treatment + VAM as soil application, B_4: *Rhizobium* and PSB both as seed treatment.

Effect of bio-fertilizers

The application of bio-fertilizers had shown marked influence on growth parameters (Table 2), yield attributes and yield (Table 3). Crop sown with treatment B_4 : *Rhizobium* and PSB both as seed treatment recorded significantly higher plant height (42.11cm), no. of branches plant^{-1} (12.65), no. of nodules plant^{-1} (30.16), dry matter accumulation plant^{-1}(17.61g), no. of pods plant^{-1}(44.01), seed index in g (22.20), seed yield (1824kg ha^{-1}) and stover yield (2709kg ha^{-1}) over control but found at par with B_3: *Rhizobium* as seed treatment and VAM as soil application and B_2: *Rhizobium* as seed treatment and PSB as soil application. The magnitude of increase in seed yield kg ha^{-1} under B_4, B_3 and B_2were 28.27, 23.35 and 23.00%, respectively over B_1 (No bio-fertilizer).This might be due to the inoculation of bio-fertilizers benefited the plant by providing atmospheric nitrogen and rendering the insoluble phosphorus into available form. The enhanced availability of phosphorus favored nitrogen fixation and rate of photosynthesis and consequently led to better plant growth. Use of PSB and VAM increased surface area of roots which resulted in increased no. of root nodules. The increase in seed and stover yield was attributed to remarkable improvement in almost all the growth parameters and yield attributes under bio-fertilizer treatments. These results are in conformity with those reported by Mukherjee and Rai (2000); Shivakumar *et al.* (2004); Dalal and Nandkar (2010); Patel *et al.* (2013) and Tagore *et al.* (2013).

Interaction effect

Interaction effect between levels of fertilizers and bio-fertilizers were found to be significant in terms of number of root nodules plant^{-1}, number of pods plant^{-1} and seed yield of chickpea (Table 4). However, significantly higher values for almost all the above characters were observed with treatment combination of F_1B_4 but it was at par with F_2B_4, F_2B_3, F_2B_2, F_1B_2 and F_1B_3, indicating saving of 25 percent of fertilizer through combined use of bio-fertilizers like *Rhizobium*, PSB or VAM. Similar findings were recorded by Prasad *et al.* (2014).

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