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Optimizing Fertilizer and Biofertilizer Levels for Enhanced Chickpea (*Cicer arietinum* L.) Growth and Yield

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Abstract

The field experiment was conducted during *Rabi*, 2023-24 at Research farm, Vivekananda Global University, Jaipur. Experiment was laid out in Factorial Randomized Block Design with three replications and twelve treatment combinations, which includes Fertilizer levels [Control, 50% RDF (10:20:20), 75% RDF (15:30:30) and 100% RDF (20:40:40) NPK kg/ha] and biofertilizers as seed inoculation (*Rhizobium* @ 500 g/ha, NPK consortia @ 1000 ml/ha and *Rhizobium* @ 500 g/ha + NPK consortia @ 1000 ml/ha). Results revealed that application of Fertilizer level (100% RDF 20:40:40 NPK kg/ha) significantly improved the growth characters *viz.*, plant height at harvest (55.89 cm), dry matter accumulation (18.82 g plant^{-1}), number of pods/plant (42.17), number of seeds/pod (1.87), no. of braches per plant (11.68), test weight (140.16 g), seed yield (1848 kg/ha), stover yield (2866 kg/ha) and biological yield (4714 kg/ha) of chickpea over rest of treatments. Seed inoculated with *Rhizobium* @ 500 g/ha + NPK consortia @ 1000 ml/ha recorded significantly higher growth characters *viz.*, plant height (53.69 cm), dry matter accumulation (139.63 g plant^{-1}), number of pods/plant (41.52), number of seeds/pod (1.72), no. of branches per plant (9.58), test weight (139.63 g), seed yield (1704 kg/ha), stover yield (2670 kg/ha) and biological yield (4374 kg/ha) of chickpea than individual inoculation of *Rhizobium* @ 500 g/ha and NPK consortia @ 1000 ml/ha.

Keywords: Bio fertilizer, Growth, Fertilizer and Yield

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Introduction

Chickpea is the 3rd most valuable food legume crop belonging to family Leguminosae. In India, chickpea is the major *Rabi* pulse crop, with high acceptability and wider use which occupies maximum acreage, production and contributes about 70% of the total world's production. The productivity of chickpea in Rajasthan is deplorable low as compared to Madhya Pradesh. Chickpea being a high protein and energy crop and its productivity is often limited by the low availability of essential nutrients or imbalanced nutrition farming one of the important constraints to chickpea productivity in India. Hence, a balanced nutrients application is must to harness the productivity of the crops. The improvement in quality and quantity of chickpea can be achieved by balance nutrition along with nitrogen and adequate supply of phosphate and potash is highly important. The application of bio fertilizers enhances the nutrient levels of soil which support plant growth and productivity in agricultural field [1]. Liquid bio fertilizers formulation is the promising and one of the best modern tools for agriculture productivity and reduces the use of chemical fertilizers found to improve soil quality with physical, chemical and biological soil properties [2]. The combined application of inorganic fertilizers and bio fertilizers has a significant result on higher plant height, number of branches/plant, number of active and inactive root nodules/plant and dry weight of roots and root nodules. Therefore, use optimum dose of fertilizers and bio fertilizers assumes special attention for their economic, eco-friendly, environmentally safe and sustainability in nature, besides improving the physical, chemical and biological properties of soil and in turn crop yield per unit area [3].

Material and Methods

The field experiment was conducted on sandy loam soil during *Rabi*, 2023-24 at Research farm, Vivekananda Global University, Jaipur. Experiment was laid out in Factorial Randomized Block Design with three replications and twelve treatment combinations, which includes Fertilizer levels [Control, 50% RDF (10:20:20), 75% RDF (15:30:30) and

100% RDF (20:40:40) NPK kg/ha] and biofertilizers as seed inoculation (*Rhizobium* @ 500 g/ha, NPK consortia @ 1000 ml/ha and *Rhizobium* @ 500 g/ha + NPK consortia @ 1000 ml/ha).

Fertilizer application

The inorganic fertilizers 100% RDF (20:40:40 kg/ha), 75% RDF (15:30:30 kg/ha) and 50% RDF (10:20:20 kg/ha) were applied through urea, diammonium phosphate and murate of potash as basal dose as per treatments in the marked plots of the field experiment. Grain treatment with biofertilizer: Take 250 g jaggery and dilute in 500 ml hot water and cool the jaggery solution after that mix Rhizobium powder @ 500 g/ha and Grain inoculated by rhizobium solution and keep for some time. After that Grain was treated with NPK Consortia @ 1000 ml/ha (Ready-mix) before sowing, so that homogenous layer is evenly applied on all the Grain. After drying under shed for half an hour, sowing of the Grains was done as per treatments in the plots of the field experiment.

Statistical analysis

In order to test the significance of variation in experimental data obtained for various treatment effects, the data were statistically analyzed as described by [4]. The critical differences were calculated to assess the significance of treatment mean wherever the F' test was found significant at 5 per cent level of probability. To elucidate the nature and magnitude of treatment effects, summary tables along with SEm± and CD (P=0.05) were prepared and are given in the text of the chapter. Experimental results and their analyses of variance are given in Appendices at the end.

Results and Discussion

Effect of fertilizer levels on growth attributes

The chickpea crop responded favorably to increasing levels of fertilizers in terms of plant height, dry matter accumulation (**Table 1**) at all the stages of observation. Application of 100% RDF (20:40:40) significantly increased all the growth determining characters over preceding fertilizer levels. Application of 100% RDF (20:40:40) remained at par with 75% RDF (15:30:30) in all the growth parameters. The overall improvement in crop growth under the influence of increasing fertilizer levels application could be attributed to better environment for growth and development that might be due to increased availability of nitrogen to the growing plants. Further, addition of phosphatic fertilizers in the soil increases the concentration of readily available H_2PO_4- ions in the rhizosphere. The increased availability of phosphorus to plant might have enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth in terms of plant height, dry matter accumulation per plant of chickpea. It is known that exchangeable potassium easily comes in to the available supply pool of the soil as and when, it is required. Further, the application of potassium is easily available to plant. The combined application of NPK to the chickpea increased availability of major nutrients to plant as it might have enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth in terms of plant height and dry matter accumulation. Similar results were found that application of 15-20 kg N, 30-40 kg P_2O_5 and 20-40 kg K_2O /ha proved beneficial for the most of the pulses in India [5]. [6] have also observed similar results with the foliar spray of N, P_2O_5 and K_2O. The study was in close conformity with [7-9].

Effect of fertilizer levels on yield attributes and yield

Yield attributing characters of chickpea were also significantly improved due to application of different levels of fertility. (**Table 2**). Application of 100% RDF (20:40:40) recorded significantly number of pods per plant (42.17), number of Grains per pod (1.87), no. of branches per plant (11.68) and test weight (140.16 g) over control. Further, the maximum grain (1848 kg/ha), straw (2866 kg/ha) and biological (4714 kg/ha) yield were also recorded under the application of 100% RDF (20:40:40) over rest of the treatments. The increase in yield attributes and yield might be due to effective utilization of applied nutrients along with maintaining proper plant density. The positive and significant improvement in dry matter and nodulation at different stages, increase in yield attributes due to application of phosphorous which contributed to the effective metabolic activities coupled with increased rate of photosynthesis, leading to better translocation of nutrients and better growth in plant which resulted in enhanced Grain and Straw yield. These results are also in agreement with findings of [10]. Phosphorous also contributed in increase stalk during vegetative stage and stem strength, root growth and development also promotes respiration, photo synthesis, Nucleic acid synthesis and act as a catalyst lead to faster growth and a greater allocation of biomass to the harvestable parts [11]. P supplement in legumes has great potential for promoting growth and higher yield, increases nodule number, as

well as enhances symbiotic establishment for increased N-fixation. The increased in the availability of phosphorous to plant might have stimulated the metabolic and enzymatic activities thereby increasing the growth of the crop. Similar findings were also reported by [12].

Table 1 Effect of fertilizer levels and bio fertilizers on plant height (cm) and Dry matter of chickpea

Treatments	Plant height at 30 DAS	Plant height at 60 DAS	Plant height at 90 DAS	Plant height at harvest	At 30 DAS	At 60 DAS	At 90 DAS	At harvest
Fertilizer Levels (kg N:P:K ha^{-1})								
Control	17.70	25.92	37.74	49.36	0.32	1.25	5.17	14.80
50% RDF (10:20:20)	18.45	27.45	38.64	52.79	0.38	1.35	5.83	16.83
75% RDF (15:30:30)	19.23	28.34	40.68	54.35	0.40	1.38	6.32	18.59
100% RDF (20:40:40)	19.67	29.14	41.35	55.89	0.43	1.39	6.55	18.82
SEm+	0.51	0.66	0.74	0.65	0.02	0.01	0.13	0.23
CD (P=0.05)	NS	1.94	2.16	1.90	0.05	0.04	0.37	0.67
Biofertilizers								
Rhizobium@500g/ha	17.92	26.14	37.16	50.81	0.34	1.30	5.46	14.66
NPK Consortia@1000ml/ha	18.66	27.66	39.66	51.99	0.36	1.32	5.79	17.48
Rhizobium@500g/ha + NPK Consortia@1000ml/ha	18.80	27.91	40.25	53.69	0.41	1.36	6.07	18.07
SEm+	0.45	0.57	0.64	0.56	0.02	0.01	0.11	0.20
CD (P=0.05)	NS	1.68	1.87	1.64	0.05	0.03	0.32	0.58

Table 2 Effect of fertilizer levels and bio fertilizers on No. of branches and yield attributes and Yield of chickpea

Treatments	No. of Branches per plant	No. of pods per plant	No. of seeds per pod	Test weight (g)	Grain Yield (Kg/ha)	Straw Yield (Kg/ha)	Biological Yield (Kg/ha)	Harvest index (%)
Fertility Levels (Kg N:P:K/ha)								
Control	6.36	35.80	1.11	136.24	1325	2170	3495	37.93
50% RDF (10:20:20)	8.45	38.98	1.49	138.78	1577	2545	4122	38.21
75% RDF (15:30:30)	9.79	40.64	1.79	139.14	1745	2730	4475	38.86
100% RDF (20:40:40)	11.68	42.17	1.87	140.16	1848	2866	4714	39.13
SEm+	0.64	0.78	0.10	0.69	57	77	129	0.44
CD (P=0.05)	1.88	2.28	0.29	2.02	168	225	378	NS
Bio fertilizers								
Rhizobium@500g/ha	6.92	36.32	1.28	135.64	1409	2299	3708	37.91
NPK Consortia@ 1000ml/ha	8.10	37.58	1.39	138.89	1533	2477	4009	38.18
Rhizobium@500g/ha + NPK Consortia@ 1000ml/ha	9.58	41.52	1.72	139.63	1704	2670	4374	38.90
SEm+	0.55	0.67	0.26	0.60	50	66	112	0.38
CD (P=0.05)	1.62	1.97	1.28	1.75	146	194	328	NS

Effect of bio-fertilizers on growth attributes

Growth parameters of chickpea like plant height and dry matter accumulation were significantly improved due to application of Rhizobium@500g/ha + NPK Consortia@1000ml/ha. The highest values of above parameters were recorded when combined application of Rhizobium@500g/ha + NPK Consortia@1000ml/ha (Table 1). It can be ascribed mainly to the greater availability and uptake of nitrogen and phosphorus by plants as these inoculations play a very important role in improving availability of N and P in many ways. Inoculation of Grain with symbiotic nitrogen fixers might have increased the concentration of an efficient and healthy strain of rhizosphere, which in turn resulted in greater fixation of atmospheric nitrogen in soil for use by the plants and consequently resulting in to higher growth. It is obvious because of the fact that Rhizobium spp. stimulated chickpea nodulation and nitrogen fixation and supply more nitrogen to the crop [13]. Thus, rhizobium and NPK consortia increased the availability of phosphorus in root

zone which in turn resulted better growth and development of roots as well as shoots and also helped in better nodulation. Similar results were obtained by [14]. Phosphorus has a specific role in nodule initiation, growth and function in addition to its role in host plant growth. Microorganisms with phosphate solubilizing potentially increase the availability of soluble phosphate and enhance the plant growth by improving biological nitrogen fixation. Phosphorus deficiency has been shown to restrict the nodulation process severely in soybean [15]

Effect of bio-fertilizers on yield attributes and yield

Results revealed that biofertilizers (Rhizobium@500g/ha + NPK Consortia@1000ml/ha) significantly enhanced the no. of branches per plant, number of pods per plant, number of Grains per pod, test weight as well as Grain and Straw yield of chickpea over preceding levels of biofertilizer (Table 2). The highest values of these yield determining parameters as well as yield were recorded under Rhizobium@500g/ha + NPK Consortia@1000ml/ha. The beneficial effects of rhizobium and NPK consortia as explained earlier thus might have enhanced the availability of nitrogen and phosphorus along with other nutrients which in turn resulted into higher production of assimilates and their partitioning to different reproductive structures such as yield attributes and ultimately, grain yield. It is obvious that rhizobium and NPK consortia native and sparingly soluble nutrients in soil which that might have enhanced the availability of P reducing its fixation in the soil. Greater P availability also increased the nodulation and biological N fixation and root extension which might have helped in higher uptake of other nutrients especially micro and secondary nutrients and enhanced photosynthesis. Thus, greater assimilation of photosynthates and their subsequent partitioning between vegetative and reproductive structures might have helped in improving the yield attributes and finally, the Grain as well as Straw yield. Increase in Grain, Straw and biological yield may be due to proper establishment of Rhizobium strain which resulted in supply of nitrogen in larger quantity to plants [16]. Application of biofertilizer increased Grain, Straw and biological yield this was due to marked improvement in dry matter accumulation, yield attributes and greater nutrient content and their uptake by chickpea.

Conclusion

Based on the results of one year experimentation, it can be concluded that application of inorganic fertilizers 100% RDF (20:40:40 NPK kg/ha) along with Grain inoculation of *Rhizobium* @ 500 g/ha + NPK consortia @1000 ml/ha recorded significantly higher yield of chickpea over no application of fertilizer. Therefore, application of inorganic fertilizers 100% RDF (20:40:40 NPK kg/ha) and Grain inoculation by *Rhizobium* @ 500 g/ha + NPK consortia @1000 ml/ha may be proved productive, profitable and economically viable to the farmers.

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