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Biofertilizer and Inorganic Fertilizers Effect on Favorable Characters for Productivity of Chickpea in Bundelkhand of Madhya Pradesh

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ABSTRACT

Background: A field experiment was conducted at the Instructional Farm of Krishi Vigyan Kendra, Chhatarpur during two consecutive *rabi* seasons of 2017-18 and 2018-19 to evaluate the effect of biofertilizers with 75% recommended dose of fertilizers on growth, yield, nutrient uptake, nutrient use efficiency and B:C ratio of chickpea (*Cicer arietinum* L.).

Methods: In the two consecutive *rabi* seasons of 2017-18 and 2018-19, the experiment was laid out in randomized block design with improved wilt resistant variety of chickpea (JAKI 9218). Experiment consisted of five treatments including T_0 (control), T_1 (recommended dose of $N:P_2O_5:K_2O$ as 20:60:20 kg ha^{-1}), T_2 (recommended dose of NPK + seed inoculation by *Rhizobium* @ 10 g kg^{-1} seed), T_3 (recommended dose of NPK + seed inoculation by *Rhizobium* and PSB separately @ 10 g kg^{-1} seed) and T_4 (75% of recommended NPK+ seed inoculation by *Rhizobium* @ 10 g kg^{-1} seed + soil application of PSB and KSB each @ 5 kg ha^{-1})

Result: The result showed that among the biofertilizers seed treatment with *Rhizobium leguminosorum* @ 10 gkg^{-1} seed and soil application of PSB and KSB @ 5 as above along with application of 75% recommended dose of fertilizers have been significantly enhanced root nodule formation, fertilizer use efficiency, productivity and reduced wilt infestation under this treatment followed by recommended dose of NPK + seed inoculation by *Rhizobium* and PSB separately @ 10 g kg^{-1} seed as compared to control plot.

Key words: B:C, FUE, Growth root nodulation, Protein yield, Wilt incidence, Yield.

INTRODUCTION

Chickpea is a main crop of *rabi* season widely cultivated in rainfed areas of Bundelkhand region of Madhya Pradesh. Blackgram-chickpea and groundnut-wheat is the predominant cropping pattern in this region. Due to predominant cropping pattern enhance the infestation of wilt (*Fusarium oxysporum* f. sp. *ciceris*), dry root rot (*Rhizoctonia bataticola*) and collar rot (*Sclerotium rolfsii*) are the major seed and soil-borne diseases of chickpea (Gupta *et al.,* 2016). Besides these in modern days, intensive crop cultivation requires the use of higher quantity of chemical fertilizer, which helps in increasing environment pollution. There is a need to develop a suitable agricultural system that requires lower fertilizer input with higher fertilizer use efficiency. Therefore, the current trend needs to explore the possibility of supplementing chemical fertilizers with organic ones and more use of bio fertilizers of particularly microbial origin. The use of *Rhizobium leguminosorum*, *Phosphate solubilizing bacteria* (PSB) and *Potash solubilizing bacteria* (KSB) have opened new vistas of nitrogen, phosphorus and potash nutrition. This playing pivotal roles in symbiotic nitrogen-fixing bacteria called *rhizobia.* The *Rhizobia* convert nitrogen gas from the atmosphere into ammonia, which is then used in the formation of amino acids and nucleotides and solubilization of insoluble P and K by PSB and KSB through the process of organic acid production, chelation and ion exchange reactions and make them available to plants. Therefore, it may be significantly increased the root surface area, root and foliage dry weight of the chickpea yield by converting nutritionally important elements through biological process. As recognized the above facts, this study was framed to evaluate the Effect of integrated use of biofertilizers and inorganic fertilizers on performance of improved wilt resistant variety of Chickpea (JAKI 9218) in terms of growth, yield, nutrient uptake, nutrient use efficiency and B:C ratio under Bundelkhand region.

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MATERIALS AND METHODS

Field trial was conducted at the Instructional Farm of Krishi Vigyan Kendra, Chhatarpur (25.035307′N latitude and

79.505258′E longitude), Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh in the *Rabi* seasons of 2017-18 and 2018-19 with improved wilt resistant variety of chickpea (JAKI 9218). Experiment consisted of five treatments including T_0 (control), T_1 (recommended dose of $N:P_2O_5:K_2O$ as 20:60:20 kg ha^{-1}), T_2 (recommended dose of NPK + seed inoculation by *Rhizobium* @ 10 g kg^{-1} seed), T_3 (recommended dose of NPK + seed inoculation by *Rhizobium* and PSB separately @ 10 g kg^{-1} seed) and T_4 (75% of recommended NPK+ seed inoculation by *Rhizobium* @ 10 g kg^{-1} seed + soil application of PSB and KSB each @ 5 kg ha^{-1}), which were replicated thrice in randomized block design. All biofertilizers were procured a fresh from the Microbes Research and Production Centre and Department of Soil Science and Agriculture Chemistry, JNKVV, Jabalpur. The soil of the experimental field was sandy loam, *Typic Ustochrept* having pH 6.9, EC 0.13 dSm^{-1}, organic carbon 4.73 g kg^{-1} and available N, P and K as 205.1, 17.3 and 210 kg ha^{-1}, respectively. The seed of chickpea was treated by biofertilizers (*Rhizobium/PSB)* @ 10 g kg^{-1} seed separately and PSB and KSB @ 5 kg ha^{-1} were applied in soil at the time of sowing as per the treatments. Seed was sown at row and plant spacing of 45 cm × 22 cm. recommended dose of nutrients (N-20, P_2O_5-60 and K_2O-20 kg ha^{-1}) were applied in the soil at the time of field preparation through urea, single super phosphate and muriate of potash. Standard recommended agronomic practices other than those under treatments were followed to grow the chickpea crop. Three randomly selected plants per plot were carefully uprooted to study the nodulation characteristics at 25, 50 and 75 days after sowing (DAS). Plant roots were cleaned under tap water and nodules were carefully detached from the roots, collected in icebox and brought to the laboratory then nodules were kept over filter paper for soaking of excess adhered moisture. At the maturity three randomly selected plants from each plot were harvested separately to study the growth and yield attributing parameters. The crop was harvested, threshed and cleaned manually and seed and stover yield per plot have been recorded. Seed and stover samples were taken separately from each plot and dried at 75°C for 48 hours then grind in a mechanical grinder. Grind sample was passed through a 2.0 mm sieve and stored for biochemical analysis. In seed and stover samples nitrogen, phosphorus and potassium were estimated by modified Kjeldahl, Vanadomolybdo phosphoric acid yellow colour and flame photometric methods, respectively. Protein content was calculated by multiplying the nitrogen percentage by a factor 6.25 (Jackson, 1962) protein yield (kg ha^{-1}) was calculated by protein content multiplying grain yield. The uptake of nutrient (N, P and K) was calculated from concentration of nutrient in grain and straw multiplied by their yield. Nutrient use efficiency was calculated by the procedure suggested by Singh *et al.* (2007). Statistical analysis of data was carried out by “Analysis of Variance” method (Panse and Sukhatme, 1967), the data were analyzed statistically using ANOVA and treatment comparison was made at 5% level of significance.

RESULTS AND DISCUSSION

Growth attributes

The results showed that the significantly higher plant height, number of branches/plant and number of roots/plant was recorded in the treatment T_4 followed by T_3 as compared to control plot (Table 1). However, T_1 and T_2 were statistically at par in same characters. Similarly, it has been reported that inoculation of chickpea with *Rhizobium* and soil application of PSB and KSB enhances stem height, root length and number of roots/plant through integration with inorganic nutrients and biofertilizers, which promote growth by increase the translocation of photosynthates through fixation of atmospheric N and supply of nutrients from insoluble to soluble by the positive effect of biofertilizers on improved physical, chemical and biological condition in root zone. (Jaipaul *et al.,* 2011 and Verma *et al*., 2019).

Phonological changes

Days to 50% flowering and maturity

Chickpea plants attained early average flowering of 5 days in the plot where no application of inorganic and biofertilizers. Due to the reduced the supply of plant nutrients as per requirement of crop plants. It resulted in poor flowering and early maturity (13 days). While, prolonged the vegetative growth delayed days to flowering 5 days and maturity 13 days under the application of 75% recommended dose of NPK along with soil application of PSB and KSB @ 5 kg ha^{-1} and seed treatment with *Rhizobium leguminosorum* @ 10 g kg^{-1} seed (Table 1) followed by application of 75% recommended dose of NPK along with soil application of PSB and KSB @ 5 kg ha^{-1}. It could be due to the proper supply of plant nutrients as per demand of crop through solubilization of insoluble phosphorus and potash and provide favorable

Table 1: Effect of integrated use of biofertilizers and inorganic fertilizers on growth and development character of chickpea.

Treatments	Plant height (cm)	Branches plant^{-1}	Number of root plant^{-1}	Average flowering date (DAS)	Days to maturity
T_0	48.5	3.8	9.3	42.0	127.0
T_1	50.5	4.5	11.3	45.0	134.0
T_2	51.5	5.4	13.8	45.0	135.0
T_3	52.3	5.4	15.2	45.0	137.0
T_4	55.5	5.9	16.0	47.0	140.0
S.Em ±	0.89	0.03	0.35	0.87	0.77
C.D. (p=0.05)	2.9	0.10	1.2	2.8	2.5

environmental condition in root zone. The dealy flowering and fruiting its resulted maturity was noted delay in line with this result, Ghosh *et al*. (2010).

Nodule number, diameter and their fresh and dry weight

Under the current investigation, all the tested Treatments inorganic and biofertilizers application in chickpea depicted variable results in term of nodule number, nodule diameter and their fresh and dry weight. The data revealed that the significantly higher nodule number/plant, nodule diameter and their fresh and dry weight at 25 and 50 and75 DAS was recorded under the treatments T_4 followed by Treatments T_3 as compared to control. While, the lowest number of these characters were noted in control plot (Table 2). However, drastically reduced trend was observed in nodule number per plant, nodule diameter fresh and dry weight at 75 DAS all the treatments due to cessation of nodulation and started drying of nodules. It may be happened with the better supply of plant nutrients that created good physical, chemical and biological condition in root zone, which professed root development and improve mobility of *Rhizobia* in rhizosphere of root zone, It may be ultimately resulted in more nodulation due to the promotion of symbiotic process in legume crop roots with the bacteria responsible for increased the nitrogenase activity that can be related to the improved photosynthetic process which ultimately increase the nitrogen fixation and solubilization of insoluble phosphorus and potash in accordance with De and Singh (2010). While, the reduction in the nodulation could possibly due to decreasing the nitrogenase activity that can be correlated with the photosynthetic apparatus disturbance with the nodule alteration that resulted reduce the nodule number, nodule diameter, nodule fresh and dry weight at all three stages in control plot in accordance with Ayala and Rao (2002). The similar trend was recorded at 25 and 50 days stage and in case of 75 days stage, declined the number of nodules, nodule fresh and dry weight /plant due to cessation of nodulation and started drying of nodules. The results are in agreement with the findings of Nagy and Pinter (2015) .

Yield and protein yield

These attributes was directly influenced by the use of inorganic and biofertilizers through provide better environment and proper supply of nutrients to crop for their better quality particularly protein and yield attributes *i.e.* number of pods/plant, number of seeds/pod and their test weight (32, 2.0 and 181.7 g) under the treatments T_4 followed by T_3 (30.3, 2.0 and 179.3 g) as compared to control plot of (22, 1.5 and 165.3g) respectively. It resulted in better yields of protein, grain as well as biomass in treatment T_4 (2.84, 13.8 and 20.6 q/ha) followed by T_3 (2.71, 12.4 and19.4 q/ha) as compared to control plot of (1.63, 8.4 and 13.9 q/ha) respectively (Table 3, 4).

The development of more and healthy plants by improving the photosynthetic efficiency of the crop through enhance the utilization use efficiency of available nutrients *i.e*. nitrogen, phosphorus and potash, which resulted maximum protein, grain yield and their attributed was noticed under the application of inorganic and biofertilizers combination by their synergistic effect and multiply nature participants in nutrient cycling and induce the plant growth by several processes including biological N_2 fixation, increase of nutrient availability in the *Rhizosphere*, enlargement of root surface area, enhancement of beneficial symbioses for the

Table 2: Effect of integrated use of biofertilizers and inorganic fertilizers on nodulation characters of chickpea.

Treatments	Nodules plant^{-1} at different DAS			Nodule diameter (mm) at different DAS			Nodule weight (mg/plant) at different DAS					
							Fresh weight			Dry weight		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_0	15	17.3	11.3	3.5	4.0	2.3	70.3	90.3	50.3	14.2	19.8	12.3
T_1	18	20.0	14.3	4.8	5.3	2.8	90.7	114.0	60.5	18.9	27.1	13.8
T_2	19	22.3	13.7	5.2	5.6	2.9	97.0	124.7	60.7	19.4	27.2	14.5
T_3	20	27.0	15.3	5.4	6.4	3.0	104.7	130.7	62.2	20.4	28.6	17.5
T_4	23	29.3	17.3	5.6	6.8	3.3	115.3	163.7	73.5	24.6	36.0	21.5
S. Em±	1.1	0.89	0.5	0.24	0.08	0.06	1.6	1.7	0.11	0.44	0.23	0.52
C.D. at 5%	3.6	2.9	1.6	0.80	0.26	0.21	5.3	5.6	0.36	1.46	0.76	1.7

S_1- 25 Days after sowing, S_2- 50 Days after sowing and S_3- 75 Days after sowing.

Table 3: Effect of integrated use of biofertilizers and inorganic fertilizers on yield and yield characters of chickpea.

Treatments	Pods plant $^{-1}$	Seeds pod^{-1}	Seed test weight (g)	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Increased yield (%)
T_0	22.0	1.5	165.3	8.4	13.9	-
T_1	27.3	1.5	178.7	11.4	18.5	35.7
T_2	28.3	1.5	178.3	11.9	18.7	30.7
T_3	30.3	2.0	179.3	12.4	19.4	33.6
T_4	32.0	2.0	181.7	13.8	20.6	43.5
S. Em ±	0.55	0.15	1.5	0.29	0.11	
C.D. (p=0.05)	1.8	0.51	4.9	0.96	0.36	

host plant. This resulted better productivity of protein, grain and biomass particularly protein concentration in plants is highly dependent on nitrogen and other nutrients availability (Khaitov *et al.,* 2016, Verma *et al.,* 2019).

Economics

Maximum gross monetary and net return was recorded in treatment T_4 (` 55200/ ha, ` 35800 ha^{-1}) respectively followed by treatments T_3 (` 4960/ and ` 28600 ha^{-1}) as compared to control plot (` 33600 and ` 15100 ha^{-1}) respectively (Table 5). The treatment T_4 was found best than rest of all treatments in terms of benefit cost ratio (2.8) followed by treatments T_3 (2.6) as compared to control plot (1.8). These results are in the conformity with the work of Singh *et al.* (2018).

Nutrients uptake and nutrient use efficiency

Significantly enhanced nutrient uptake and fertilizers use efficiency of NPK by grain and straw under the application of 75% recommended dose of NPK along with soil application of PSB, KSB @ 5 kg ha^{-1} individual and seed treatment by *Rhizobium legiminosorum* followed by application of 75% recommended dose of NPK along with seed treatment with Rhizobium and PSB @ 10 g kg^{-1} seed (Table 5). Significantly higher uptake and nutrient use efficiency of nitrogen, phosphorus and potash in linear order by more availability of nitrogen, solubilization of insoluble phosphorus and potash, which promoting the nodulation through the excite nitrogenase enzyme activity thus improve more N-fixation then more uptake and efficiency of nitrogen in grain and straw increased through synergistic and linear correlation impact between host crop and biofertilizers. Phosphorus status of grain and straw increased chickpea rhizosphere by secretion of root exudates by reducing soil P^{H} leads to phosphorus and potash release and absorption of these by plant through anion exchange phenomena have increased the availability of phosphorus and potash due to more content, uptake and their use efficiency of both nutrients in grain and straw supporting these nutrients by Singh *et al.* (2018). Besides, organic sources of nutrient acts as slow release fertilizer as it synchronizes the nutrient demand set by plants both in time and space with supply of the nutrients from the labile soil and applied nutrient pools. So it enhanced the fertilizers use efficiency in accordance with Singh and Sharma (2011) and Verma *et al.* (2019).

Wilt incidence

Significantly reduced the wilt incidence (64.3%) under the use of seed dressing by *Rhizobium leguminosorum* @ 10 g kg^{-1} seed and soil application of PSB and KSB @ 5 kg ha^{-1} along with 75% recommonded dose of fertilizers followed by recommended dose of fertilizers along with seed treatments by *Rhizobium* and PSB @ 10 g kg^{-1} seed (52.4%) as compared to control plot (Table 6). *Rhizobium leguminosarum and PSB* reported to remarkably inhibit the growth of pathogenic fungi such as *Rhizoctonia solani* and *Fusarium* sp., in both legume and non legume plants in accordance with Cheema *et al.* (2009). Besides all of these, *Rhizobium* strains (rhizobia) ability to produce volatile compounds and solubilization of insoluble phosphate through secretion of acid by bacteria, which produce plant growth regulators such as auxins, cytokinins and gibberellins like substances that stimulate plant growth as reported by Gupta *et al.* (2016).

Table 4: Effect of integrated use of biofertilizers and inorganic fertilizers on nutrient uptake and protein yield of chickpea.

Treatments	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})		Protein content in seed (%)	Protein yield (kg ha^{-1})
	Grain	Straw	Grain	Straw	Grain	Straw		
T_0	26.0	16.6	4.4	3.2	5.7	16.4	19.4	162.8
T_1	36.5	25.9	7.5	5.4	8.3	24.6	20.0	228.0
T_2	40.5	28.1	8.7	6.4	9.5	26.5	20.6	252.9
T_3	43.4	30.9	9.4	6.6	10.2	27.9	21.3	271.3
T_4	45.5	32.9	9.9	8.3	10.5	28.3	21.9	284.6
S. Em ±	0.51	0.09	0.08	0.33	0.03	0.42	0.20	1.21
C.D. (p=0.05)	1.60	0.31	0.25	1.08	0.10	1.38	0.66	3.96

Table 5: Effect of integrated use of biofertilizers and inorganic fertilizers on fertilizer use efficiency and production economics of chickpea.

Treatments	Fertilizers use efficiency						Production economics				
	Agronomic (kg kg^{-1})			Chemical (%)			Economic (%)	Cost of Production (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C Ratio
	N	P	K	N	P	K					
	-	-	-	-	-	-	81.6	18500	33600	15100	1.8
T_1	20	6.7	20	70	7.0	17.4	140.0	19000	45600	26600	2.4
T_2	23.3	7.8	23.3	96	9.6	25.4	150.5	19000	47600	28600	2.5
T_3	26.7	8.9	26.7	116	9.6	29.7	161.1	19000	49600	30600	2.6
T_4	36	12.0	36	130	12.4	31.8	184.5	19400	55200	35800	2.8

Table 6: Effect of integrated use of biofertilizers and inorganic fertilizers on wilt incidence in chickpea.

Treatment	Actual plant population/m^2	Wilt affected plant/m^2 at maturity stage	Damage %
To	12.0	4.2	35
T_1	12.0	3.3	27.5
T_2	12.0	2.6	21.7
T_3	12.0	2	16.7
T_4	12.0	1.5	12.5
S. Em±	0.63	0.11	0.24
C.D. at 5%	2.06	0.37	0.80

CONCLUSION

Seed treatment with *Rhizobium leguminosorum* @ 10 g kg^{-1} seed and soil application of PSB and KSB @ 5 kg ha^{-1} along with application of 75% recommended dose of fertilizers have been significantly enhanced root nodule formation, fertilizer use efficiency, productivity and reduced wilt infestation in chickpea and observed high economic return. The application of biofertilizers with chemical fertilizers have potential to improve the net returns by curtail the cost of production in terms of inorganic fertilizers and maximizing the productivity and nutrient use efficiency.

Conflict of interest: None.

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