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Studies on Growth, Yield, Soil Nutrient Status and Economics of Chickpea as Influenced by INM in Chickpea-fodder Maize Cropping Sequence

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ABSTRACT

Background: Increasing agricultural productivity is a key challenge in realising higher output and farmers' income. In India, total food grain production 291.95 million/tonnes. The major sources of growth operating within agriculture sector may be improvement in productivity, resource use efficiency or saving in cost of production, increase in cropping intensity and diversification towards high value crops.

Method: Experiment was carried out during *rabi* and summer seasons of 2017-18 and 2018-19 at College Farm, Navsari Agricultural University, Navsari to study the Studies on growth, yield, nutrient status of soil of chickpea as influenced by integrated nutrient management in chickpea- fodder maize cropping sequence. The treatment consisted of five treatment of integrated nutrient management to chickpea in *rabi* season as replicated four times in randomized block design.

Result: Application of 100% RDF + *Rhizobium* + PSB (T_3) recorded significantly higher almost all the growth attributes, yield attributes and yield as well as available soil nutrient remained at par with 100% RDF and 75% RDF + *Rhizobium* + PSB. Moreover, economics was remarkably improved due to inorganic fertilizers as well as combination of inorganic fertilizers with *Rhizobium* + PSB.

Key words: Biofertilizers, Chickpea, Nutrient, Seed yield, Stover yield.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important pulse crop grown and consumed all over the world. In India, chickpea is grown in an area of 10.56 million hectares with total production of 11.23 million tonnes with productivity of 1063 kg/ha. While in Gujarat, chickpea is grown in an area of 0.29 million hectares producing 0.37 million tonnes with the productivity of 1253 kg/ha (Anonymous, 2018).

The most important reason for the emergence of agrarian distress in the country during 1990s is the low level of absolute income as well as large and deteriorating disparity between income of a farmer and non-agricultural worker, which turned even more serious in latest years. The Hon'ble Prime Minister, goal set to double farmers' income by 2022 can play crucial role to promote farmer's welfare, reduce agrarian distress and bring parity between income of farmers and those working in non-agricultural professions. Therefore, strong measures are actually needed to harness all possible sources of growth in farmers (Khanam *et al*. 2018).

A system consists of several components which are closely related to interacting among themselves. In agriculture, management practices are usually formulated for individual crops. However, farmers are cultivating different crops in different season based on their adaptability to a particular season, domestic needs and profitability, therefore production technology should be developed keeping in view all the crops grown in a year or more than one year if any sequence or rotation extends beyond one year. Such a package of management practices for all the crops leads to efficient use of costly inputs, besides reduction in production cost. Nitrogen, phosphorus and biofertilizers like *rhizobium* and *phosphate solubilizing bacteria* play a vital role in the nutrition of plants. In fact, these fertilizer nutrients are lacking mostly in the soils. Fertility analysis of Indian soils has indicated that the soils are deficient in micro-organisms and nutrients. Therefore, application of biofertilizers and inorganic fertilizers becomes essential to raise the crop yield. *Rhizobium* has an enormous potential to fix atmospheric nitrogen. PSB solubilize the unavailable bound phosphates of the soil and make them available to plants which increase overall plant growth resulting in 10 to 15% increase in yield.

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MATERIALS AND METHODS

The present investigation was carried out by laying out a field experiment on chickpea with levels of recommended dose of fertilizer in combination with biofertilizers (*Rhizobium*, PSB), general application of farm yard manure in *rabi* season during 2017-18 and 2018-19 period of two consecutive years on same site without changing the randomization at College Farm, Navsari Agricultural University, Navsari (Gujarat). The soil of experimental field was clay in texture and low in organic carbon (0.42%) and available nitrogen (196.80 kg/ha), medium in available phosphorus (38.30 kg/ha), high in available potassium (315.43 kg/ha) and slightly alkaline in reaction (pH 8.23). The different treatments consisted of integrated nutrient management *viz*., T_1 - 100% RDF (20 N +40 P_2O_5+00 K_2O kg/ha), T_2 - 75% RDF, T_3 - 100% RDF+ *Rhizobium*+PSB, T_4 - 75% RDF+*Rhizobium*+PSB, T_5 - control and general application of FYM 2.5 t/ha to chickpea in *rabi* season replicated four times in randomized block design. Chickpea variety GG-2 was used for sowing. Sowing was done manually in 3 cm depth previously opened small furrows at 30 cm apart using seed rate of 60 kg/ha on 14th November in 2017 and 19th November in 2018. The seeds were covered properly with soil and light irrigation was applied in each plot immediately after sowing. The chickpea crop was fertilized as per treatment. The nitrogen was applied through urea (46% N) whereas phosphorus was applied through single superphosphate (16% P_2O_5). The recommended dose of fertilizer was applied at the time of sowing. The required quantity of seeds was worked out for experimental area. Inoculation of biofertilizers (*Rhizobium* +PSB each of 10 ml/kg) to chickpea seeds according to treatment of plot in both the years before sowing. The inoculated seeds were dried under shade and were sown as per the treatments.

RESULTS AND DISCUSSION

Effect of integrated nutrient management in chickpea

Growth parameters

It is evident from the results presented that different INM treatments influenced crop growth from 30 DAS onward upto harvest of chickpea. The periodical plant height, number of branches per plant, dry matter accumulation per plant and volume of nodules per plant was significantly influenced by the integration of inorganic fertilizers with organic sources. Application of 100% RDF+*Rhizobium*+PSB (T_3) recorded significantly higher plant height (Table 1) at 30, 60 DAS and at harvest but it was at par with 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4) during first and second years and in pooled analysis. The increase in plant height with increase in different fertilizer levels and biofertilizer might be attributed to greater availability of nutrients with increase in application rate, which might have increased all the vital physiological processes, which in turn facilitated translocation of photosynthates to the growing meristematic tissues. It is well documented fact that application of phosphorus assists in absorption of metabolites, water and its further transformation for the growth of plant in terms of plant height. The plant height in chickpea tended to increase due to quick release of available nitrogen synthesized by root rhizobia to the plant at the time of vegetative growth. Similar results were reported by Patel *et al*. (2007), Goyal *et al*. (2010), Singh *et al*. (2012) and Singh *et al*. (2017).

Significantly higher number of branches per plant (Table 1) was observed in treatment 100% RDF+*Rhizobium*+PSB (T_3) at 30 DAS during both the years as well as in pooled and remained at par with treatment 100% RDF (T_1) during first year and in pooled analysis, whereas in second year it was found at par with treatments 100% RDF (T_1) and 75% RDF+ *Rhizobium*+PSB (T_4). Application of 100% RDF+*Rhizobium* + PSB (T_3) resulted in significantly maximum mean number of branches per plant at 60 DAS and at harvest during both the years and in pooled being at par with treatment 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4). The increase in number of branches per plant to increasing fertilizer level and biofertilizers might be due to improvement in nutrient availability that enhanced horizontal expansion of chickpea by encouraging cell division in the meristematic region. These findings corroborate with earlier findings of Patel *et al*. (2007), Singh *et al*. (2012), Tripathi *et al*. (2013) and Singh *et al*. (2017).

Table 1: Growth parameters of chickpea as influenced by different INM treatments.

Treatment	Plant height (cm) at harvest			Number of branches plant at harvest			Dry matteraccumulation plant (g) at harvest			Volume of nodules plant (ml) 50 DAS		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1	47.88	48.35	48.12	10.93	10.97	10.95	22.84	23.12	22.98	2.34	2.46	2.40
T_2	43.54	44.59	44.06	10.15	10.21	10.18	19.59	19.87	19.73	1.65	1.78	1.72
T_3	50.72	51.20	50.96	11.13	11.21	11.17	23.14	23.94	23.54	2.65	2.72	2.68
T_4	47.56	47.48	47.52	10.46	10.64	10.55	21.93	22.21	22.07	1.76	1.88	1.82
T_5	40.81	42.31	41.56	9.63	9.42	9.52	17.15	17.68	17.42	1.10	1.23	1.16
SEm±	1.63	1.70	1.18	0.30	0.31	0.22	0.71	0.72	0.50	0.07	0.06	0.05
CD (P=0.05)	5.01	5.24	3.46	0.92	0.96	0.64	2.18	2.21	1.48	0.21	0.19	0.13
CV (%)	7.05	7.27	7.16	5.73	5.94	5.84	6.75	6.72	6.73	7.18	5.97	6.57
General mean	46.10	46.79	46.45	10.46	10.49	10.47	20.93	21.37	21.15	1.90	2.01	1.96
Interaction (Y × T)												
SEm±		1.66			0.31			0.71			0.06	
CD (P=0.05)		NS			NS			NS			NS	

Application of 100% RDF+*Rhizobium*+PSB (T_3) reported significantly higher dry matter accumulation per plant (Table 1) at all crop growth stages during both years and pooled analysis and remained at par with treatment 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4) at 60 DAS and at harvest except at 30 DAS being at par with 100% RDF (T_1) only during first and second years and in pooled results. This might be attributed due to better growth of plant in terms of plant height and number of branches per plant recorded with this treatment. Moreover, nitrogen and phosphorus might have increased the photosynthetic efficiency and thus increased the production of photosynthates. This is in agreement with the findings reported earlier by Patel *et al*. (2007) and Singh *et al*. (2017).

Significantly higher volume of nodules per plant (Table 1) at 30 DAS was recorded with treatment 100% RDF+*Rhizobium* +PSB (T_3) and remained at par with 100% RDF (T_1) during first year. While, application of 100% RDF+*Rhizobium*+ PSB (T_3) resulted in significantly highest volume of nodules per plant during second year and in pooled analysis. At 50 DAS, application of 100% RDF+*Rhizobium*+PSB (T_3) produced significantly highest volume of nodules per plant during both the years as well as in pooled result. It was properly due to positive effect of biofertilizers and FYM by increasing the nodulation resulted higher fixation of atmospheric nitrogen and ultimately increased the growth characters.

Yield attributes and Yield

The treatment receiving 100% RDF+*Rhizobium*+PSB (T_3) recorded significantly higher number of pods per plant, seed index, seed yield per plant, seed yield and stover yield (Table 2) but it was found at par with treatment 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4) during both the years and in pooled analysis. This was largely attributes due to better growth of plant in terms of plant height, number of branches and dry matter accumulation per plant which resulted into adequate supply of photosynthates for development of sink. The complementary role was played by combining application inorganic fertilizer with biofertilizers in producing seed and stover yields of chickpea. These results are in close conformity with Patel *et al*. (2007), Ali *et al*. (2010), Poonia and Pithia (2014), Kumar *et al*. (2015) and Singh *et al*. (2017).

Table 2: Yield and yield attributes of chickpea as influenced by different INM treatments.

Treatment	Number of pods/plant			Seed index (g)			Seed yield (q/ha)			Stover yield (q/ha)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1	36.98	36.96	36.97	23.01	23.52	23.27	22.13	22.28	22.20	41.65	41.69	41.67
T_2	34.24	34.85	34.54	22.12	21.92	22.02	19.64	19.81	19.73	39.84	39.92	39.88
T_3	38.82	39.02	38.92	24.36	24.67	24.52	23.22	23.73	23.47	42.71	42.80	42.76
T_4	36.79	37.09	36.94	22.86	23.22	23.04	21.73	21.78	21.75	41.42	41.38	41.40
T_5	33.64	33.78	33.71	20.46	20.74	20.60	17.37	18.17	17.77	36.68	36.80	36.74
SEm±	0.96	0.96	0.68	0.72	0.74	0.52	1.15	1.09	0.79	0.65	0.66	0.46
CD (P=0.05)	2.95	2.96	1.99	2.22	2.28	1.52	3.54	3.36	2.33	2.00	2.04	1.36
CV (%)	5.30	5.28	5.29	6.39	6.48	6.44	11.03	10.30	10.66	3.21	3.27	3.24
General mean	36.09	36.34	36.22	22.56	22.81	22.69	20.82	21.15	20.99	40.46	40.52	40.49
Interaction (Y × T)												
SEm±		0.96			0.73			1.12			0.66	
CD (P=0.05)		NS			NS			NS			NS	

Table 3: Available nutrient status of soil as influenced by different treatment after harvest of chickpea.

Treatment	Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1	226.47	229.92	228.20	44.68	46.66	45.67	321.01	324.18	322.60
T_2	213.49	215.30	214.39	40.45	42.50	41.47	301.24	306.32	303.78
T_3	233.41	233.78	233.59	46.32	47.30	46.81	325.27	332.38	328.83
T_4	224.20	227.40	225.80	43.91	44.89	44.40	304.55	307.10	305.83
T_5	197.45	198.15	197.80	39.97	41.29	40.63	293.35	294.28	293.82
SEm±	3.75	3.79	2.67	1.20	1.14	0.83	11.53	12.66	8.56
CD (P=0.05)	11.55	11.68	7.84	3.69	3.52	2.43	NS	NS	NS
CV (%)	3.42	3.43	3.43	5.56	5.13	5.34	7.46	8.09	7.79
General mean	219.00	220.91	219.96	43.06	44.53	43.80	309.09	312.85	310.97
Interaction (Y × T)									
SEm±		3.77			1.17			12.11	
CD (P=0.05)		NS			NS			NS	

Table 4: Economics of chickpea as influenced by different treatments (Average 2017-18 and 2018-19).

Treatment	Yield (q/ha)		Cost (Rs./ha)		Cost of gross	monetary	Net monetary	B:C ratio
	Seed	Stover	Fixed	Variable	cultivation	returns	returns	
T_1	22.20	41.67	32435	7094	39529	147785	108256	2.74
T_2	19.73	39.88	32435	6570	39005	132338	93333	2.39
T_3	23.47	42.76	32435	7334	39769	155786	116017	2.92
T_4	21.75	41.40	32435	6810	39245	144990	105745	2.69
T_5	17.77	36.74	32435	5000	37435	119479	82044	2.19

Selling price of chickpea seed (60 ₹ /kg), chickpea stover (3.5 ₹ /kg).

Soil analysis

The soil available nitrogen and phosphorus (Table 3) recorded after harvest of chickpea was significantly higher due to application of 100% RDF+*Rhizobium*+PSB (T_3) but it was found at par with 100% RDF (T_1) and 75% RDF+ *Rhizobium*+PSB (T_4) during both the years of study and in pooled result. This could be attributed to the fact that addition of inorganic fertilizers with biofertilizers and FYM to chickpea crop residues such as roots, stubbles, leaves, nodules and bodies of *Rhizobia* rich in nitrogen and greater N fixation. Significantly higher available phosphorus might be due to the lower loss of nutrients due to slow available nutrients in soil. These results are in agreement with the findings of Meena and Ram (2013) and Dewangan *et al*. (2017). The available potassium content of soil after harvest of chickpea did not reach to the level of significance during both the years of study and in pooled analysis.

Economics

Maximum net monetary returns of and B:C ratio (Table 4) was recorded with application of 100% RDF+*Rhizobium*+ PSB (T_3) followed by treatments 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4). The increase in gross income, Net income and B:C ratio may be due to higher production because more availability of nutrient with combine application of nutrient sources. Similar results were also reported by Kumar *et al*. (2015), Singh *et al*. (2017) and Kumar *et al*. (2018).

CONCLUSION

It can be concluded that for getting higher yield, returns and maintenance of soil status, chickpea crop should be nourished with 75% RDF (15 N + 30 P_2O_5 + 00 K_2O kg/ha) + *Rhizobium* (10 ml/kg seed) + PSB (10 ml/kg seed) with 2.5 t/ha FYM in chickpea- fodder maize cropping sequence in south Gujarat condition.

Conflict of interest: None.

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