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Productivity, Profitability and Nutrient Status of Soil as Influenced by Integrated Nutrient Management in Chickpea-fodder Maize Cropping Sequence

H.A. Patel, J.D. Thanki

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ABSTRACT

Background: Cropping system approach has gained importance in agriculture and relative enterprises. In agriculture, management practices are usually formulated for individual crops. However, farmers are cultivating different crops in different seasons based on their adaptability to a particular season, domestic needs and profitability, therefore production technologies should be developed keeping in view of crops grown in a sequence in a year or more than one year depending on the crop duration. The current study aims in application of biofertilizers and inorganic fertilizers which are 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.

Methods: A field experiment was conducted during *rabi* and summer seasons of 2017-18 and 2018-19 at College Farm, Navsari Agricultural University, Navsari. The treatment consisted of five treatment of integrated nutrient management to chickpea in *rabi* season as main plot treatments replicated four times in randomized block design. During summer season each main plot treatment was split into four sub plot treatments with different levels of RDF to fodder maize resulting in twenty treatment combinations replicated four times in split plot design.

Result: Application of 100% RDF+*Rhizobium*+PSB (T_3) to chickpea recorded significantly higher almost all the growth attributes, yield attributes and yield, nutrient uptake, protein content and yield as well as available nutrient status in soil being remained at par with 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4). while economics was remarkably improved due to inorganic fertilizers as well as combination of inorganic fertilizers with *Rhizobium*+PSB to chickpea and 100% RDF (S_1) to summer fodder maize significantly highest all growth and yield attributes, available nutrient status of soil and economics.

Key words: Biofertilizers, Chickpea, Fodder maize, Fodder yield, Nutrient, Seed 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.

Maize (*Zea mays* L.) is an important cereal fodder crop. Maize ranks second in position after sorghum among the cereal fodder crops. It is the ideal fodder crop having quick growing habit, high yielding ability, palatability, nutritive value and acceptable to the cattle at any stage of growth. It can be grown within still wider limits and tolerate minimum temperature of about 10°C and maximum of 45°C.

In cropping system good management practices leads to efficient use of costly inputs, besides reduction in production cost. In legume cereal cropping system, residual effect of fertilizers applied and nitrogen fixed by the legumes can considerably bring down the production cost. In this context, cropping system approaches are gaining importance rather than sole crop.

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 *Rhizobium*, PSB, application of farm yard manure in *rabi* season and levels of recommended dose of fertilizer to fodder maize in summer season during 2017-18 and 2018-19 for two consecutive years on same site without changing the randomization. The soil of experimental field was clay in texture and low in nitrogen (196.80 kg/ha), medium in phosphorus (38.30 kg/ha), high in potassium (315.43 kg/ha) and slightly alkaline in reaction (pH 8.23). The treatment combinations for chickpea were T_1-100% RDF (20 N+40 P_2O_5+00 K_2O kg/ha),

Department of Agronomy, Navinchandra Mafatlal College of Agriculture, Navsari Agricultural University, Navsari-396 450, Gujarat, India.

Corresponding Author: H.A. Patel, Department of Agronomy, Navinchandra Mafatlal College of Agriculture, Navsari Agricultural University, Navsari-396 450, Gujarat, India.
Email: hardik.577.hp@gmail.com

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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. During summer season each main plot treatment was split into four sub plot treatments with four levels of RDF *viz.*, S_1- 100% RDF (80 N+40 P_2O_5+00 K_2O kg/ha), S_2- 75% RDF, S_3- 50% RDF and S_4- control to fodder maize resulting in twenty treatment combinations replicated four times in split plot design. Chickpea variety GG-2 was used for the study. 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 fodder maize variety, African tall was used for this experiment in summer season. Furrows were opened in each plot at 30 cm apart and seeds were placed in dry soil condition at 5 cm depth were sown manually with seed rate of 40 kg/ha on 16th March and 22nd March in 2018 and 2019, respectively.

RESULTS AND DISCUSSION

Effect of integrated nutrient management in chickpea

Growth parameters

Application of 100% RDF+*Rhizobium*+PSB (T_3) recorded significantly higher plant height, number of branches per plant and dry matter accumulation per plant (Table 1) at harvest but it was at par with 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4). 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. The increase in number of branches per plant with 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 earlier findings of Singh *et al.* (2017). At 50 DAS, application of 100% RDF+*Rhizobium* +PSB (T_3) produced significantly highest volume of nodules per plant (Table 1). It might be due to positive effect of

Table 1: Growth parameters and yield attributing of chickpea crop in relation to application of different levels of fertilizers and biofertilizers (Pooled data of 2 years).

Treatment	Plant height (cm) at harvest	Number of branches/plant at harvest	Dry matter accumulation/ plant (g) 50 DAS	Volume of nodules /plant(ml)	Number of pods/plant	Seed index (g)	Seed yield (q/ha)	Stover yield (q/ha)
T_1: 100% RDF	48.12	10.95	22.98	2.40	36.97	23.27	22.20	41.67
T_2: 75% RDF	44.06	10.18	19.73	1.72	34.54	22.02	19.73	39.88
T_3: 100% RDF+*Rhizobium*+PSB	50.96	11.17	23.54	2.68	38.92	24.52	23.47	42.76
T_4: 75% RDF+*Rhizobium*+PSB	47.52	10.55	22.07	1.82	36.94	23.04	21.75	41.40
T_5: Control	41.56	9.52	17.42	1.16	33.71	20.60	17.77	36.74
SEm±	1.18	0.22	0.50	0.05	0.68	0.52	0.79	0.46
CD (P=0.05)	3.46	0.64	1.48	0.13	1.99	1.52	2.33	1.36
CV (%)	7.16	5.84	6.73	6.57	5.29	6.44	10.66	3.24
General mean	46.45	10.47	21.15	1.96	36.22	22.69	20.99	40.49
Interaction (Y × T)								
SEm±	1.66	0.31	0.71	0.06	0.96	0.73	1.12	0.66
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Available soil nutrient as influenced by different treatment of chickpea (Pooled data of 2 year).

Treatment	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
T_1: 100% RDF	228.20	45.67	322.60
T_2: 75% RDF	214.39	41.47	303.78
T_3: 100% RDF+*Rhizobium*+PSB	233.59	46.81	328.83
T_4: 75% RDF+*Rhizobium*+PSB	225.80	44.40	305.83
T_5: Control	197.80	40.63	293.82
SEm±	2.67	0.83	8.56
CD (P=0.05)	7.84	2.43	NS
CV (%)	3.43	5.34	7.79
General mean	219.96	43.80	310.97
Interaction (Y × T)			
SEm±	3.77	1.17	12.11
CD (P=0.05)	NS	NS	NS

biofertilizers and FYM by increasing the nodulation resulted higher fixation of atmospheric nitrogen and ultimately increased the growth characters.

Yield parameters

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 1) but it was found at par with treatment 100% RDF (T_1) and 75% RDF+*Rhizobium*+PSB (T_4). This was largely attributed 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 combined application of inorganic fertilizer with biofertilizers in producing seed and stover yields of chickpea. These results are in close confirmity with Singh *et al.* (2017).

Soil analysis

The soil available nitrogen and phosphorus (Table 2) 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). This could be attributed to the fact

Table 3: Economics of chickpea as influenced by different treatments (Average 2017-18 and 2018-19).

Treatment	Yield (kg/ha)		Cost (Rs./ha)		Cost of cultivation (₹)	Gross monetary returns (₹)	Net monetary returns (₹)	B:C ratio
	Seed	Stover	Fixed	Variable				
T_1: 100% RDF	22.20	41.67	32435	7094	39529	147785	108256	2.74
T_2: 75% RDF	19.73	39.88	32435	6570	39005	132338	93333	2.39
T_3: 100% RDF+*Rhizobium*+PSB	23.47	42.76	32435	7334	39769	155786	116017	2.92
T_4: 75% RDF+*Rhizobium*+PSB	21.75	41.40	32435	6810	39245	144990	105745	2.69
T_5: Control	17.77	36.74	32435	5000	37435	119479	82044	2.19

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

Table 4: Growth and yield as well as yield attributing for fodder maize as influenced by different treatments (Pooled data of 2 years).

Treatment	Plant height (cm) at harvest	Number of leaves/plant at harvest	Green fodder yield (q/ha)	Dry fodder yield (q/ha)
I). Main plot treatments (*rabi* chickpea)				
T_1: 100% RDF	175.13	15.40	220.41	79.11
T_2: 75% RDF	170.37	14.84	211.92	76.06
T_3: 100% RDF + *Rhizobium* + PSB	179.28	15.93	242.74	87.12
T_4: 75% RDF + *Rhizobium* + PSB	171.58	14.95	217.79	78.17
T_5: Control	167.02	14.51	199.96	71.77
SEm±	1.84	0.20	5.08	1.86
CD (P=0.05)	5.38	0.59	14.83	5.43
CV (%)	6.04	7.60	13.15	13.42
II). Sub plot treatments (summer fodder maize)				
S_1: 100% RDF	182.15	16.64	256.62	92.11
S_2: 75% RDF	173.74	15.40	223.91	80.37
S_3: 50% RDF	169.26	14.59	208.62	74.88
S_4: Control	165.54	13.86	185.09	66.43
SEm±	1.46	0.15	3.85	1.49
CD (P=0.05)	4.50	0.47	11.87	4.59
CV (%)	5.35	6.41	11.15	12.00
General mean	172.67	15.12	218.56	78.45
Interaction (M × S)				
SEm±	3.27	0.34	8.61	3.33
CD (P=0.05)	NS	NS	NS	NS

Interaction (Pooled)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
M × Y	2.61	NS	0.29	NS	7.19	NS	2.63	NS
S × Y	2.07	NS	0.22	NS	5.45	NS	2.10	NS
M × S × Y	4.62	NS	0.48	NS	12.18	NS	4.70	NS

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 Dewangan *et al.* (2017).

Economics

Maximum net monetary returns and B:C ratio (Table 3) was recorded with application of 100% RDF+*Rhizobium*+PSB (T_3) followed by 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 which might be more availability of nutrients with combined application of nutrient sources. Similar results were also reported by Singh *et al.* (2017) and Kumar *et al.* (2018).

Residual effect of INM to preceding chickpea in *rabi* on succeeding summer fodder maize

Growth parameters

The treatment receiving 100% RDF+*Rhizobium*+PSB (T_3) produced significantly higher plant height, number of leaves per plant and leaf: stem ratio at harvest (Table 4) and was at par with 100% RDF (T_1). Similarly, the beneficial residual effect of addition of inorganic fertilizers along with biofertilizers and FYM under cropping sequence on growth attributes recorded by Samborlang *et al.* (2019).

Yield attributes and yield

An examination of data given in (Table 4) on fodder maize revealed that the green fodder yield, dry matter content and dry fodder yield was significantly influenced due to residual effect of integrated nutrient management applied in *rabi* chickpea crop. Application of 100% RDF+ *Rhizobium* +PSB (T_3) to preceding chickpea crop by producing significantly highest green fodder yield, dry matter content and dry fodder yield of fodder maize. The increased green and dry fodder yields of fodder maize due to INM application to preceding *rabi* chickpea reflected to good crop growth resulted into influenced positively on yield and growth parameters might have positive correlation with green and dry fodder yields of fodder maize. Similar results were also reported by Chaudhari (2019) and Dixit *et al.* (2015).

Soil analysis

Available nitrogen and phosphorus (Table 5) in soil after harvest of summer fodder maize crop was found significant due to residual effect of different treatments to *rabi* chickpea, however, did not influence available potassium in soil during both years of experimentation. Application of 100% RDF+

Table 5: Available soil nutrient as influenced by different treatments after harvest of fodder maize (Pooled data of 2 years).

Treatment	Available N (kg/ha)		Available P_2O_5 (kg/ha)		Available K_2O (kg/ha)	
I). Main plot treatments (*rabi* chickpea)						
T_1: 100% RDF	208.95		49.11		324.70	
T_2: 75% RDF	204.75		48.03		321.86	
T_3: 100% RDF+*Rhizobium*+PSB	211.80		51.22		327.08	
T_4: 75% RDF+*Rhizobium*+PSB	206.75		48.80		318.05	
T_5: Control	202.45		47.49		315.19	
SEm±	1.19		0.47		4.30	
CD (P=0.05)	3.48		1.36		NS	
CV (%)	3.26		5.40		7.56	
II). Sub plot treatments (summer fodder maize)						
S_1: 100% RDF	212.00		50.47		326.67	
S_2: 75% RDF	209.65		49.53		323.29	
S_3: 50% RDF	206.58		48.73		319.57	
S_4: Control	199.53		46.99		315.98	
SEm±	0.97		0.34		2.83	
CD (P=0.05)	2.97		1.06		NS	
CV (%)	2.95		4.43		5.56	
General mean	206.94		48.93		321.38	
Interaction (M × S)						
SEm±	2.16		0.77		6.32	
CD (P=0.05)	NS		NS		NS	
Interaction (Pooled)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
M × Y	1.69	NS	0.66	NS	6.07	NS
S × Y	1.37	NS	0.48	NS	4.00	NS
M × S × Y	3.05	NS	1.08	NS	8.94	NS

Table 6: Economics of fodder maize as influenced by different treatments (Average 2018 and 2019).

Treatment	Dry fodder yield (q/ha)	Cost (₹/ha)		Cost of cultivation (₹/ha)	Gross monetary returns (₹/ha)	Net monetary returns (₹/ha)	B:C ratio
		Fixed	Variable				
I). Main plot treatments (*rabi* chickpea)							
T_1: 100% RDF	79.11	24936	1665	26601	35600	8999	0.34
T_2: 75% RDF	76.06	24936	1665	26601	34227	7626	0.29
T_3: 100% RDF+*Rhizobium*+PSB	87.12	24936	1665	26601	39204	12603	0.47
T_4: 75% RDF+*Rhizobium*+PSB	78.17	24936	1665	26601	35177	8576	0.32
T_5: Control	71.77	24936	1665	26601	32297	5696	0.21
II). Sub plot treatments (summer fodder maize)							
S_1: 100% RDF	92.11	24936	2961	27897	41450	13553	0.49
S_2: 75% RDF	80.37	24936	2220	27156	36167	9011	0.33
S_3: 50% RDF	74.88	24936	1480	26416	33696	7280	0.28
S_4: Control	66.43	24936	0	24936	29894	4958	0.20

Selling price of fodder maize straw (4.5 ₹/kg).

Rhizobium+ PSB (T_3) recorded significantly higher available nitrogen which was at par with 100% RDF (T_1). Moreover, significantly highest available phosphorus in soil was recorded with application of 100% RDF+*Rhizobium*+PSB (T_3). This was probably due to increased N-fixation by *Rhizobium*+PSB inoculation. Biofertilizer also increased available P in soil due to the favourable effect on soil and increased solubilization of unavailable phosphorus by PSB. It could also be attributed to the synergistic effect of *Rhizobium* + PSB on the available P status of the soil. This resulted reported by Jat and Ahlawat (2006).

Economics

Among the different INM practices, application of 100% RDF +*Rhizobium*+PSB (T_3) to chickpea was noted the highest net returns of ₹ 12603/ha with B:C ratio of 0.47 followed by 100% RDF (T_1) with net returns of ₹ 8999/ha and B:C ratio of 0.34 and 75% RDF+*Rhizobium*+PSB (T_4) with net returns of ₹ 8576/ha and B:C ratio of 0.32 of fodder maize (Table 6). Similar benefits of residual effect of INM were reported by Samborlang *et al.* (2019).

Effect of direct application of recommended fertilizer levels on fodder maize

Growth attributes

Significantly highest plant height and number of leaves per plant (Table 4) was recorded under treatment of 100% RDF (S_1) over 75% RDF (S_2), 50% RDF (S_3) and control (S_4) at harvest of fodder maize. Adequate nitrogen fertilization of fodder maize influencing plant height, number of leaves per plant and photosynthetic efficiency. Appropriate phosphorus application might have helped in early root development and energy transfer in plant. Similar findings were reported by Kumar *et al.* (2016).

Yield attributes and yield

The effect of inorganic fertilizer on yield parameters like green fodder yield and dry fodder yield (Table 4) was found significant. Application of 100% RDF (S_1) produced significantly maximum green fodder yield, dry matter content and dry fodder yield over 75% RDF (S_2), 50% RDF (S_3) and control (S_4). The increase in green and dry fodder yield of fodder maize with increasing levels of fertilizers was due to remarkable improvement in yield. The results are reported by Kumar *et al.* (2016) and Kumar *et al.* (2017).

Soil analysis

Available N and P (Table 5) in soil after harvest of summer fodder maize crop was found significant due to different levels of RDF applied to fodder maize but different treatments did not influence available potassium in soil. Application of 100% RDF (S_1) was found significantly higher available nitrogen being at par with treatment 75% RDF (S_2). Treatment 100% RDF (S_1) registered significantly highest available phosphorus in soil after harvest of fodder maize crop. The improvement in available phosphorus could be ascribed to addition of phosphorus through fertilizers reported by Kumar *et al.* (2017).

Economics

Maximum net returns of ₹ 13553/ha and B:C ratio of 0.49 (Table 6) was obtained with application of 100% RDF (S_1), followed by 75% RDF (S_2) with net returns of ₹ 9011/ha and B:C ratio of 0.33.

CONCLUSION

It can be concluded that for getting higher yield, monetary 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 and summer fodder maize crop should be fertilized with 100% RDF (80 N + 40 P_2O_5+00 K_2O kg/ha) through inorganic fertilizer in chickpea- fodder maize cropping sequence in south Gujarat condition.

Conflict of interest: None.

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