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Growth, Yield and Nutrient Status in Soil of Summer Fodder Maize (*Zea mays* L.) as Influenced by Residual Effect of INM and Direct Application of Varying Fertility Levels

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ABSTRACT

Keywords

Fodder maize, Integrated nutrient management, Fertility levels, Residual effect

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A field experiment was conducted at the College Farm, Navsari Agricultural University, Navsari (Gujarat) during the *rabi* and summer seasons of 2018 and 2019to study the residual effect of integrated nutrient management treatments imposed in preceding chickpea on succeeding fodder maize crop. The treatments in *rabi* chickpea consisted of *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. These treatments were replicated four times in randomized block design. Insucceeding summer season, each main plotwas splitted into four sub-plots for fodder maize with treatments consisting of varying fertility levels *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. Treatments 100% RDF + *Rhizobium* + PSB (T_3), 100 % RDF(T_1) and 75% RDF + *Rhizobium* + PSB(T_4) showed significantly improvement in growth and yield attributes, yields and available nutrient status in soilin fodder maize. Among the four fertility levels directly applied in fodder maize, application of 100% RDF (S_1) significantly highest all growth and yield attributes, available nutrient status in soil.

Introduction

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. The maize is also most useful crop for making silage. It can be grown within still wider limits and tolerate minimum temperature of about 10 ^{0}C and maximum of 45 ^{0}C.In Gujarat state, animals are mainly fed by poor quality roughages, straws of pearl millet, paddy and wheat. Thus, the state is not only facing the shortage of quantity but good quality fodder. The productivity of livestock is primarily a function of fodder intake. Therefore, the need is of two types *i.e.*, to increase the production of fodder crops and to improve the quality of fodder.

In the recent past, cropping system approach has gained importance in agriculture and relative enterprises. 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. For instants, residual effect of fertilizers applied and nitrogen fix by legumes can considerably bring down the production cost, if all the crops are considered when individual crops. In this context, cropping system approaches gaining importance.

Materials and Methods

The present investigation was carried out at the College Farm, Navsari Agricultural University, Navsari (Gujarat) during the summer and *kharif* seasons of 2018 and 2019 to study the residual effect of integrated nutrient management treatments imposed in preceding chickpea on succeeding fodder maize crop.

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). A total of six treatments were imposed in *rabi* chickpea *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. These treatments were replicated four times in randomized block design. Then, in succeding summer season, each main plot treatment was splited into four sub plot treatments with four levels of recommended dose of fertilizers *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. The nitrogen was applied through urea (46% N) and phosphorus through single superphosphate (16% P_2O_5). The 50% dose of nitrogen and full dose of phosphorus were applied at the time of sowing, remaining 50% dose of nitrogen was top dressed at 30 DAS. All the successive biometric observations during the crop growth were recorded periodically from these plants. The mean values of all observations were utilized for statistical analysis by using statistical procedures as described by Panse and Sukhatme (1967). The treatment effects on all the characters under study were compared by employing 'F' - test and the data was analysed in split plot design.

Results and Discussion

Growth attributes

Residual effect of treatments consisting of 100% RDF + *Rhizobium* + PSB (T_3), 100 % RDF(T_1) and 75% RDF + *Rhizobium* + PSB(T_4) in chickpea proved to be significantly better than remaining treatments for almost all the growth attributes *viz.* plant height, number of leaves/plant and leaf: stem ratio at all the growth stages (Table 1). This might be due to the residual effect of the beneficial residual effect of addition of inorganic fertilizers along with biofertilizers and FYM under cropping sequence on growth attributes recorded by Malik (2003), Pankhaniya (2007), Samborlang *et al.,* (2019).

Treatments with varying fertility levels in fodder maize, significantly highest plant height (Table 1) and number of leaves per plant was recorded under treatment of 100% RDF (S_1) over 75% RDF (S_2), 50% RD (S_3) F and control (S_4) at 30, 50 DAS and at harvest of fodder maize during first and second years and in pooled analysis. Significantly higher leaf: stem ratio was noted under treatment 100% RDF (S_1) being at par with treatment 75% RDF (S_2) during individual years of study. While significantly highest leaf: stem ratio was recorded under the treatment 100% RDF (S_1) during pooled analysis. Since, nitrogen is an integral part of chlorophyll helped in more photosynthesis and resulted in better growth. 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, which favoured better growth in fertilized plots. Similar findings were reported by Kumar *et al.,* (2002), Kumar *et al.,* (2016) and Jadhav *et al.,* (2018).

Yield attributes and yield

Yield attributes (Table 2) of fodder maize crop *viz.,* 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 higher green fodder yield of fodder maize but remained at par with treatment 100% RDF (T_1) during first year only. While, significantly highest green fodder yield recorded under the treatment of 100% RDF + *Rhizobium* + PSB (T_3) during second year of investigation and in pooled results. In first year, significantly higher dry matter content was recorded with application of 100% RDF + *Rhizobium* + PSB (T_3) but it was at par with 100% RDF (T_1). However, highest dry matter content was obtained under the treatment 100% RDF + *Rhizobium* + PSB (T_3) during second year of study and in pooled analysis. Significantly higher dry fodder yield was noted under application of 100% RDF + *Rhizobium* + PSB (T_3) which was at par with 100% RDF (T_1) during first year. While, application of 100% RDF + *Rhizobium* + PSB (T_3) recorded highest dry fodder yield during second year of study and in pooled analysis. The increased green and dry fodder yields of fodder maize due to integration of inorganic, common application of organic source *i.e.* FYM, along with biofertilizers (*i.e. Rhizobium* + PSB) application to preceding *rabi* chickpea reflected to good crop growth (growth attributes) 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 Pankhaniya (2007), Prajapat *et al.,* (2014) and Dixit *et al.,* (2015).

The effect of inorganic fertilizer on yield parameters like green fodder yield, dry matter content and dry fodder yield (Table 2) was found significant during both the years of experimentation and pooled analysis. The beneficial effect of higher fertilization on vegetative growth was reflected into increasing the fodder yield. 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) treatments during 2018 and 2019 as well as in pooled analysis. Response of fertilizers depends on numerous variable factors such as environmental conditions, management systems and plant density.

Table.1 Plant height, number of leaves/plant and leaf: stem ratio of fodder maize as influenced periodically by different treatments

Treatment	**Plant height (cm)**			**Number of leaves/plant**			**Leaf : stem ratio**		
	At harvest			At harvest			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
I). Main plot treatments (*rabi* chickpea)									
T_1	173.67	176.59	175.13	15.39	15.41	15.40	0.29	0.31	0.30
T_2	169.78	170.96	170.37	14.96	14.71	14.84	0.27	0.28	0.28
T_3	178.69	179.86	179.28	16.12	15.74	15.93	0.31	0.33	0.32
T_4	170.94	172.22	171.58	15.04	14.86	14.95	0.28	0.29	0.29
T_5	165.88	168.15	167.02	14.59	14.44	14.51	0.28	0.29	0.29
SEm±	2.64	2.58	1.84	0.29	0.29	0.20	0.01	0.01	0.01
CD (P=0.05)	8.13	7.95	5.38	0.88	0.89	0.59	0.02	0.03	0.02
CV (%)	6.14	5.94	6.04	7.54	7.65	7.60	10.29	12.28	11.38
II). Sub plot treatments (summer fodder maize)									
S_1	181.25	183.04	182.15	16.73	16.55	16.64	0.32	0.33	0.33
S_2	173.79	173.70	173.74	15.50	15.31	15.40	0.30	0.32	0.31
S_3	168.22	170.30	169.26	14.59	14.59	14.59	0.28	0.30	0.29
S_4	163.90	167.19	165.54	14.05	13.68	13.86	0.24	0.25	0.25
SEm±	2.19	1.93	1.46	0.21	0.22	0.15	0.01	0.01	0.00
CD (P=0.05)	6.24	5.51	4.50	0.61	0.63	0.47	0.02	0.02	0.01
CV (%)	5.71	4.98	5.35	6.26	6.56	6.41	8.45	9.51	9.03
General mean	171.79	173.56	172.67	15.22	15.03	15.12	0.29	0.30	0.29
Interaction (M x S)									
SEm±	4.90	4.32	3.27	0.48	0.49	0.34	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (Pooled)	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
M x Y	2.61	NS		0.29	NS		0.01	NS	
S x Y	2.07	NS		0.22	NS		0.01	NS	
M x S x Y	4.62	NS		0.48	NS		0.01	NS	

T_1: 100% RDF, T_2: 75% RDF, T_3: 100% RDF + *Rhizobium* + PSB, T_4: 75% RDF + *Rhizobium* + PSB, T_5: Control, S_1:100% RDF, S_2:75% RDF, S_3:50% RDF and S_4:Control

Table.2 Green fodder yield, dry matter content and dry fodder yield of fodder maize as influenced by different treatments

Treatment	Green fodder yield (q/ha)			Dry matter content (%)			Dry fodder yield (q/ha)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
I). Main plot treatments (*rabi* chickpea)									
T_1	221.13	219.68	220.41	16.39	16.28	16.34	79.37	78.85	79.11
T_2	213.40	210.43	211.92	15.58	15.65	15.62	76.59	75.53	76.06
T_3	243.46	242.01	242.74	17.92	17.72	17.82	87.38	86.86	87.12
T_4	218.37	217.22	217.79	15.97	15.99	15.98	78.38	77.96	78.17
T_5	206.15	193.77	199.96	15.08	14.93	15.00	73.99	69.55	71.77
SEm±	7.34	7.02	5.08	0.50	0.43	0.33	2.74	2.52	1.86
CD (P=0.05)	22.63	21.64	14.83	1.54	1.34	0.97	8.44	7.77	5.43
CV (%)	13.32	12.97	13.15	12.35	10.76	11.58	13.85	12.97	13.42
II). Sub plot treatments (summer fodder maize)									
S_1	256.27	256.98	256.62	18.96	18.61	18.78	91.98	92.24	92.11
S_2	228.16	219.66	223.91	16.58	16.34	16.46	81.89	78.84	80.37
S_3	209.51	207.74	208.62	15.50	15.59	15.54	75.20	74.56	74.88
S_4	188.06	182.12	185.09	13.72	13.91	13.82	67.50	65.37	66.43
SEm±	4.76	6.06	3.85	0.42	0.37	0.28	2.10	2.11	1.49
CD (P=0.05)	13.57	17.25	11.87	1.19	1.05	0.86	5.97	6.02	4.59
CV (%)	9.66	12.50	11.15	11.57	10.19	10.91	11.84	12.16	12.00
General mean	220.50	216.62	218.56	16.19	16.11	16.15	79.14	77.75	78.45
Interaction (M x S)									
SEm±	10.65	13.54	8.61	0.94	0.82	0.62	4.69	4.73	3.33
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Interaction (Pooled)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
M x Y	7.19	NS	0.47	NS	2.63	NS
S x Y	5.45	NS	0.39	NS	2.10	NS
M x S x Y	12.18	NS	0.88	NS	4.70	NS

T_1: 100% RDF, T_2: 75% RDF, T_3: 100% RDF + *Rhizobium* + PSB, T_4: 75% RDF + *Rhizobium* + PSB, T_5: Control, S_1:100% RDF, S_2:75% RDF, S_3:50% RDF, S_4: Control.

Table.3 Available nutrient (N, P_2O_5 and K_2O) status of soil as influenced by different treatments after harvest of fodder maize

Treatment	Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
I). Main plot treatments (*rabi* chickpea)									
T_1	207.89	210.00	208.95	48.83	49.39	49.11	326.45	322.96	324.70
T_2	203.58	205.93	204.75	47.37	48.69	48.03	323.68	320.04	321.86
T_3	208.81	214.79	211.80	50.36	52.09	51.22	328.23	325.92	327.08
T_4	204.63	208.87	206.75	48.35	49.24	48.80	319.93	316.16	318.05
T_5	201.96	202.94	202.45	47.06	47.91	47.49	317.51	312.88	315.19
SEm±	1.60	1.77	1.19	0.62	0.70	0.47	6.22	5.92	4.30
CD (P=0.05)	4.94	5.45	3.48	1.90	2.16	1.36	NS	NS	NS
CV (%)	3.12	3.39	3.26	5.09	5.68	5.40	7.70	7.41	7.56
II). Sub plot treatments (summer fodder maize)									
S_1	211.79	212.21	212.00	49.45	51.48	50.47	328.43	324.90	326.67
S_2	208.75	210.56	209.65	49.52	49.54	49.53	325.39	321.19	323.29
S_3	203.70	209.45	206.58	47.99	49.48	48.73	321.09	318.05	319.57
S_4	197.25	201.81	199.53	46.63	47.35	46.99	317.74	314.22	315.98
SEm±	1.42	1.31	0.97	0.45	0.51	0.34	3.96	4.04	2.83
CD (P=0.05)	4.05	3.72	2.97	1.29	1.47	1.06	NS	NS	NS
CV (%)	3.09	2.80	2.95	4.17	4.66	4.43	5.48	5.65	5.56
General mean	205.37	208.51	206.94	48.40	49.46	48.93	323.16	319.59	321.38
Interaction (M x S)									
SEm±	3.18	2.92	2.16	1.01	1.15	0.77	8.85	9.03	6.32
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Interaction (Pooled)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
M x Y	1.69	NS	0.66	NS	6.07	NS
S x Y	1.37	NS	0.48	NS	4.00	NS
M x S x Y	3.05	NS	1.08	NS	8.94	NS

T_1: 100% RDF, T_2: 75% RDF, T_3: 100% RDF + *Rhizobium* + PSB, T_4: 75% RDF + *Rhizobium* + PSB, T_5: Control, S_1:100% RDF, S_2:75% RDF, S_3:50% RDF, S_4: Control.

The increase in green and dry fodder yield of fodder maize with increasing levels of fertilizers was due to remarkable improvement in yield attributes and yield like dry matter content, green and dry fodder yield as well as the residual effect of the INM treatments in preceding crop. The results are in conformity with those reported by Rathod *et al.,* (2002), Kumar *et al.,* (2004), Kumar *et al.,* (2016) and Kumar *et al.,* (2017).

Nutrient status in soil

Various INM treatments imposed in preceding crop had significant influence on available nitrogen, phosphorus and potassium in soil after harvest of summer fodder maize crop (Table 3) was found significant due to residual effect of different treatments applied to *rabi* chickpea but different treatments did not influence available potassium in soil during both years of experimentation. Application of 100% RDF + *Rhizobium* + PSB (T_3) recorded significantly higher available nitrogen which was at par with 100% RDF (T_1) and 75% RDF + *Rhizobium* + PSB (T_4) during first year. While during second year as well as in pooled analysis it was found at par with T_1 only. Significantly higher available phosphorus in soil was registered under treatment 100% RDF + *Rhizobium* + PSB (T_3) but it was found at par with treatment 100% RDF (T_1) during first year of study. Moreover, in second year and pooled data, significantly highest available phosphorus in soil was recorded with application of 100% RDF + *Rhizobium* + PSB (T_3). The total soil N content increased with the biofertilizer inoculation after the harvest of both chickpea and fodder maize crops. This was probably due to increased N-fixation by *Rhizobium* + PSB inoculation. Biofertilizer inoculation also increased available P in soil due to the favourable effect on soil and increased solubilization of unavailable phosphorus by PSB. However, dual inoculation with *Rhizobium* + PSB had more pronounced influence on population of bacteria in rhizosphere. This might be due to the release of higher quantities of root exudates as soluble carbohydrates and sugars into rhizosphere. This, in turn, might have resulted in enhanced proliferation of bacteria added through inoculation. The increase in available N and P status of soil has also been reported by Jat and Ahlawat (2006) and Umale (2016).

Available nitrogen, phosphorus and potassium (Table 3) 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 during both years and in pooled analysis. Application of 100% RDF (S_1) was found significantly higher available nitrogen being at par with treatment 75% RDF (S_2) during both years and in pooled analysis. Whereas in second year, it was remained at par with 50% RDF (S_3). Significantly higher available phosphorus in soil after harvest of fodder maize crop was recorded with treatment 100% RDF (S_1) which was at par with treatment 75% RDF (S_2) during first year of experimentation whereas in pooled data and during second year, 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. The present findings are in accordance with those reported by Kumar *et al.,* (2017) and Patel *et al.,* (2018).

Based on the above findings obtained from two years of experimentation, it can be concluded that for getting higher yield and maintenance of soil status, fodder maize was recorded due to residual effect of 100% RDF (20 N + 40 P_2O_5 + 00 K_2O kg/ha) +

Rhizobium + PSB (T_3), 100% RDF (T_1) 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.

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