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Effect of integrated nutrient management on productivity and profitability in chickpea: Fodder sorghum sequence

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Abstract
The basic concept of integrated nutrient management in cropping system is the supply of plant nutrients to an optimum level for sustaining the desired crop productivity. In this context, pulse-fodder based cropping system gain more importance. Field experiments were carried out during *rabi* and summer seasons of 2019-20 and 2020-21 at College Farm, Navsari Agricultural University, Navsari. The experiment consisted nine treatment of integrated nutrient management to chickpea in *rabi* season replicated three times in randomized block design. During summer season each main plot treatment was split into two sub plot treatments with different levels of RDF to fodder sorghum resulting in eighteen treatment combinations replicated three times. Application of In chickpea-fodder sorghum sequence significantly higher productivity and profitability obtained with 75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS to chickpea and along with 75% RDF to summer fodder sorghum.

Keywords: Biocompost, banana pseudostem enriched sap, chickpea, fodder sorghum, yield

Introduction
Pulses play a vital role in Indian agriculture. Pulses are an adequate source of protein, vitamins and minerals. Chickpea (*Cicer arietinum* L.) is the most extensively grown edible legume after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.) in South Asia and the world. Pulses are cultivated in 27.98 million hectares in India with a production of 23.03 million tonnes. Chickpea is grown in an area of 10.56 million hectares with total production of 11.23 million tonnes with productivity of 1063 kg/hain India. While in Gujarat, chickpea is raised in an area of 0.29 million hectares producing 0.37 million tonnes with the productivity of 1253 kg/ha (Annon, 2021).
India has 5.0 per cent of the total cropped area under cultivated forages. At present, the country faces net deficit of 11.24% green fodder (Bhagora, 2020) [3]. Fodder sorghum is a widely used fodder crop that is farmed extensively during the *kharif* and summer seasons. It is widely grown in different parts of the country because of its great growth habits, high yield potential.
Good management practices in cropping systems result in the efficient use of valuable inputs and a decrease in production costs. 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 conducted by laying out an experiment on chickpea with levels of recommended dose of fertilizer in combination with bicompost and banana pseudostem enriched sap (1% spray) in *rabi* season and levels of recommended dose of fertilizer to fodder sorghum in summer season during 2019-20 and 2020-21 for two consecutive years on same site same randomization. The trial consist of nine treatments *viz.* T_1 - (Control), T_2 - (Bio compost 2.5 t/ha), T_3 - Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS), T_4 - (50% RDF + Bio compost 2.5 t/ha), T_5 - (50% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS), T_6 - (75% RDF + Bio compost 2.5 t/ha), T_7 - (75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS), T_8 - (100% RDF (20-40-00,N-P_2O_5-K_2O

kg/ha), T_9 - (Fallow) to chickpea (variety GG-5) in *rabi* season replicated three times in randomized block design. During summer season each main plot treatment was split into two sub plot treatments with two levels of RDF *viz*. F_1 - 75% RDF and F_2 - 100% RDF (80 N + 40 P_2O_5 + 00 K_2O kg/ha) to fodder sorghum (variety CSV 21-F).The experimental field was ploughed then a fine seedbed was created by harrowing in both directions with a tractor-drawn harrow followed by planking and prepared the irrigation channels. According to the treatments fertilizers, biocompost, and banana psedostem enriched sap (1% spray) were applied. Before sowing in specific plots the appropriate amount of bio compost was calculated according to treatments and evenly scattered and blended. Chickpea seed was sown at 30 cm x 10 cm spacing using seed rate of 60 kg/ha on 24 November 2019 and 23 November 2020. After harvest of *rabi* chickpea, minimum soil was disturbed while preparing the land for summer fodder sorghum. Subsequently, each plot was leveled separately. Flat beds, irrigation channels and bunding of individual plots were prepared manually before sowing of fodder sorghum. Fodder sorghum seed was sown on 18 March 2020 and 19 March 2021 with seed rate of 60 kg/ha. Pre emergence application of pendimethalin 30 EC @ 1 kg/ha was done at next day of sowing and one hand weeding and one inter culturing was followed at 35-40 DAS during both the years of experimentation of *rabi* chickpea. Periodical observations of growth, yield attributes and yield were recorded for assessment of effect of treatments on growth and development of chickpea and fodder sorghum. The data on various variables were analyzed by using statistical procedures as described by Panse and Sukhatme (1985) [18]. The treatment effects on all the characters under study were compared by employing 'F test'. Barter's test was applied to examine the homogeneity of variance due to error.

Result and Discussion

Effect of integrated nutrient management in chickpea

Plant height of chickpea was recorded significantly higher with treatment T_7 (Application of 75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) 30 DAS and 45 DAS) during pooled analysis which remained at par with treatments T_6 and T_8 (Table 1). Number of branches per plant was found significantly superior with treatment T_7 which remained at par with treatment T_6. Dry matter accumulation and number of pods per plant were recorded significantly highest under treatment T_7 over other treatments. More number of seeds per pod was observed under T_7. Treatment T_7 resulted significantly the highest seed yield (Table 2). The percent increase in seed yield of chickpea with treatment T_7, T_6, T_8, T_5, T_4, T_3 and T_2 was (65.57, 45.23, 38.26, 28.71, 19.16, 10.73, 7.18) over control T_1. Stover yield was found significantly higher under T_7 which remained at par with T_6. The lowest plant height, number of branches per plant, dry matter accumulation, number of pods per plant, number of seeds per pod, seed yield and stover yield were recorded under control (T_1). The increased availability of nutrients due to combined application of organics and inorganics resulted in better absorption, translocation and assimilation of nutrients. Better partitioning of photosynthates between source and sink led to greater assimilation of dry matter in the reproductive or fruiting parts which resulted on improvement of yield attributing characters and ultimately yield. These results support to the earlier finding of Patil *et al.* (2012) [10] Singhal *et al.* (2015) [12], Kumar *et al.* (2015) Yadav *et al.* (2017), Singh *et al.* (2017) [11], Kumar *et al.* (2018) [6] and Sodavadiya (2020) [13] in chickpea.

Table 1: Effect of INM on growth and yield parameters of chickpea (Pooled of 2 years).

Treatment	Plant height (cm) at harvest	Number of branches per plant	Dry matter accumulation (g/plant)	Number of pods per plant	Number of seeds per pod	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1	39.96	8.07	24.93	41.50	1.07	1435	2799
T_2	42.33	9.60	26.47	49.67	1.10	1538	2924
T_3	43.96	10.37	28.50	51.57	1.20	1589	2948
T_4	43.60	10.23	29.65	53.43	1.23	1710	3141
T_5	44.63	11.20	31.18	56.13	1.27	1847	3350
T_6	48.67	12.57	33.95	59.87	1.32	2084	3692
T_7	50.31	13.63	36.93	67.33	1.33	2376	4170
T_8	48.29	12.27	31.87	56.12	1.30	1984	3577
S.Em±	1.22	0.45	0.96	1.85	0.04	79	187
CD(P=0.05)	3.54	1.32	2.79	5.35	NS	229	540
CV(%)	6.62	10.13	7.75	8.3	8.53	10.63	13.75
Interaction (Y×T)							
S.Em±	1.73	0.64	1.36	2.61	0.10	112	264
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS

Treatment detail: T_1 - (Control), T_2 - (Bio compost 2.5 t/ha), T_3 - Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS), T_4 - (50% RDF + Bio compost 2.5 t/ha),T_5 - (50% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS),T_6 - (75% RDF + Bio compost 2.5 t/ha),T_7 - (75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS), T_8 - (100% RDF (20-40-00,N-P_2O_5-K_2O kg/ha), T_9 - (Fallow)

Effect of residual INM on succeeding summer fodder sorghum: Significantly the highest plant height fodder sorghum recorded with treatment 75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS (T_7) showed that (180.41 cm) which was found at par with the application of 75% RDF + Bio compost 2.5 t/ha (T_6). In pooled analysis significantly maximum number of leaves per plant was observed under treatment T_7 which remained at par with treatment T_6 and T_8. Dry matter accumulation, stem thickness and leaf: stem ratio, green fodder yield (43.81 t/ha) and dry fodder yield (13.15 t/ha) were obtained under the treatment T_7 (75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS) which remained at par with

75% RDF + Bio compost 2.5 t/ha (T_6). It might be due to balanced application of nutrient through INM to chickpea crop gave residual positive impact on fodder sorghum dry matter production by improving its effective photosynthesis, luxuriant crop vegetative growth, healthy root development and improved nutrient absorption. Treatment T_9 (Fallow) resulted in significantly lower plant height, number of leaves per plant, dry matter accumulation, stem thickness and leaf: stem ratio, green fodder yield and dry fodder yield in pooled analysis.

The improvement in plant growth and yield attributes might have resulted in better interception and utilization of radiant energy leading towards higher photosynthesis. The application of INM to preceding *rabi* chickpea crop shows significant effect on sequence as presented in chickpea equivalent yield during pooled. Application of 75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS (T_7) recorded significantly the highest chickpea equivalent yield 4.55 t/ha as compared to rest of treatments in pooled. Lower chickpea equivalent yield 1.48 t/ha was observed under the treatment T_9 (fallow). These results are in agreement with the findings of Pankhaniya (2007) [7] in soybean-fodder sorghum, Thenua *et al.* (2010) [14] in chickpea-fodder sorghum, Patel and Thanki (2020) [9] in chickpea-fodder maize and Kalal (2021) [4] in green gram-finger millet crop sequence.

Effect of direct application of recommended fertilizer levels on fodder sorghum

At harvest, significantly the more plant height (169.69cm), number of leaves, stem thickness, leaf: stem ratio, green fodder yield, dry fodder yield and chickpea equivalent yield were observed with the treatment F_2 (100% RDF) (Table 3). The results are in conformity with the earlier finding of Bhagora (2020) [3]. It could be owing to the favorable effect of chemical fertilizers on plant vegetative development via active protein metabolism, photosynthate transportation and protein synthesis. As a result, during the vegetative stage, the plant's N nutrition affects its growth to a great extent. These findings are in agreement with the findings of Patel and Thanki (2020) [9] in chickpea-fodder sorghum.

Table 2: Growth and yield attributes and yield of fodder sorghum as influenced by different treatments (Pooled)

Treatments	Plant height (cm) at harvest	Number of leaves/plant	Dry matter accumulation (g/plant)	Stem thickness (cm) at harvest	Leaf: stem ratio at harvest	Green fodder yield (t/ha)	Dry fodder yield (t/ha)	CEY (t/ha)
Main plot (Applied to chickpea)								
T_1	152.83	7.77	28.92	1.02	0.256	32.29	9.67	3.09
T_2	162.71	7.90	30.19	1.09	0.260	33.79	10.11	3.26
T_3	164.61	7.83	31.55	1.09	0.266	34.14	10.22	3.33
T_4	165.45	7.80	30.57	1.10	0.268	34.93	10.45	3.49
T_5	168.03	7.77	32.22	1.12	0.267	35.53	10.64	3.66
T_6	179.24	8.13	37.63	1.17	0.288	43.54	12.99	4.25
T_7	180.41	8.37	38.55	1.19	0.293	43.81	13.15	4.55
T_8	168.44	8.08	30.78	1.06	0.258	37.40	11.19	3.84
T_9	151.96	7.48	26.96	1.00	0.244	29.89	8.95	1.48
S.Em±	2.42	0.16	0.87	0.01	0.004	1.07	0.32	0.05
CD(P=0.05)	6.96	0.46	2.52	0.04	0.011	3.08	0.92	0.15
CV(%)	5.04	6.96	9.49	4.55	5.104	10.26	10.22	5.39
Sub-plot (Applied to fodder sorghum)								
F_1	162.24	7.77	30.51	1.06	0.260	35.14	10.52	3.39
F_2	169.69	8.04	33.35	1.12	0.274	37.15	11.12	3.49
S.Em±	0.76	0.07	0.21	0.01	0.002	0.22	0.07	0.01
CD (P=0.05)	2.17	0.19	0.61	0.02	0.005	0.63	0.19	0.03
Interaction (T x F)								
S.Em±	2.27	0.20	0.64	0.02	0.005	0.65	0.20	0.03
CD (P=0.05)	6.50	NS	1.83	0.05	0.014	1.88	0.57	0.09
Sig. interactions with Y	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)	3.34	6.19	4.89	3.71	4.47	4.44	4.47	2.33

Interaction effect

Growth, yield attributes and yield

Table 3 to 6 Treatment combination T_7F_2 gave significantly higher dry matter accumulation at harvest of fodder sorghum, green fodder yield and dry fodder yield of fodder sorghum during pooled analysis. Treatment combination T_7F_2 was at par with treatment combinations T_7F_1, T_6F_1 and T_6F_2 in pooled result. Significantly the lowest values of dry matter accumulation at harvest, green fodder sorghum yield and dry fodder yield were observed in treatment combination T_9F_1 in pooled study. Significantly higher chickpea equivalent yield was observed under the treatment combination T_7F_2 during pooled study (4.57 t/ha) which was remained on par with treatment combination T_7F_1 during pooled analysis, while lower values in terms of chickpea equivalent yield 1.42 t/ha were observed under the treatment combination T_9F_1 during pooled study.

Table 3: Effect of Interaction on (T x F) dry matter accumulation at harvest of fodder sorghum during pooled study

Sub plot	Dry matter accumulation at harvest (g/plant)									
	Main plot									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean
F_1	27.36	28.89	29.38	27.22	31.35	37.58	37.78	28.83	26.17	30.51
F_2	30.49	31.48	33.71	33.91	33.09	37.67	39.32	32.72	27.75	33.35
Mean	28.92	30.19	31.55	30.57	32.22	37.63	38.55	30.78	26.96	
S.Em±	0.64					CD (P=0.05)		1.83		

Table 4: Effect of interaction (T x F) on green fodder yield of fodder sorghum during pooled analysis

Sub plot	Green fodder yield (t/ha)									
	Main plot									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean
F_1	30.34	32.60	33.98	33.94	35.59	43.31	43.59	34.29	28.62	35.14
F_2	34.25	34.98	34.30	35.91	35.48	43.76	44.03	40.51	31.16	37.15
Mean	32.29	33.79	34.14	34.93	35.53	43.54	43.81	37.40	29.89	
S.Em±	0.65					CD (P=0.05)		1.88		

Table 5: Effect of interaction (T x F) on dry fodder yield of fodder sorghum in pooled analysis

Sub plot	Dry fodder yield (t/ha)									
	Main plot									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean
F_1	9.08	9.75	10.17	10.16	10.65	12.93	13.09	10.25	8.57	10.52
F_2	10.25	10.47	10.27	10.73	10.62	13.06	13.21	12.13	9.32	11.12
Mean	9.67	10.11	10.22	10.45	10.64	12.99	13.15	11.19	8.95	
S.Em±	0.20					CD (P=0.05)		0.57		

Table 6: Interaction effect (T x F) on chickpea equivalent yield during in pooled analysis

Sub plot	Chickpea equivalent yield (t/ha)									
	Main plot									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean
F_1	2.99	3.21	3.33	3.44	3.66	4.24	4.54	3.69	1.42	3.39
F_2	3.19	3.32	3.34	3.54	3.66	4.26	4.57	4.00	1.55	3.49
Mean	3.09	3.26	3.33	3.49	3.66	4.25	4.55	3.84	1.48	
S.Em±	0.03					CD (P=0.05)		0.09		

Chickpea-fodder sorghum sequence

Economics of chickpea – fodder sorghum crop sequence data presented in Table 7 indicated that maximum net realization of ₹ 214212 per hectare with B:C ratio of 2.86 was secured under treatment combination of T_7F_2 (75% RDF + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS along with 100% RDF), closely followed by T_7F_1 (75% RDF +Bio compost 2.5 t/ha along with 75% RDF), (₹ 213625/ha) and B:C ratio of 2.88. However looking to the CEY, both the treatment combination T_7F_2 and T_7F_1 are at par. The lower net realization of ₹ 58473 per hectare was noted under T_9F_1.

This is mainly because of the higher yields and reasonable cost in INM treatments. Earlier research findings also suggest that conjunctive use of organic and inorganic nutrient sources secured higher net realization and BCR over the sole chemical fertilizers. These findings corroborate with the results of Pankhaniya (2007) [7], Thenua *et al.* (2010) [14], Chaudhary *et al.* (2018b), Sodavadiya (2020) [13] and Joshi (2020).

Table 7: Economics of chickpea - fodder sorghum sequence (Average of 2019-20 and 2020-21)

Treatment combination	Gross return (₹/ha)			Cost of cultivation (₹/ha)			Net return (₹/ha)	B: C ratio
	Chickpea	Fodder sorghum	Sequence	Chickpea	Fodder sorghum	Sequence		
T_1F_1	95897	91020	186917	41107	27387	68494	118423	1.73
T_1F_2	95897	102750	198647	41107	28119	69226	129421	1.87
T_2F_1	102514	97800	200314	43107	27387	70494	129820	1.84
T_2F_2	102514	104940	207454	43107	28119	71226	136228	1.91
T_3F_1	105658	101940	207598	45147	27387	72534	135064	1.86
T_3F_2	105658	102900	208558	45147	28119	73266	135292	1.85
T_4F_1	113594	101820	215414	44205	27387	71592	143822	2.01
T_4F_2	113594	107730	221324	44205	28119	72324	148999	2.06
T_5F_1	122545	106770	229315	46245	27387	73632	155683	2.11
T_5F_2	122545	106440	228985	46245	28119	74364	154621	2.08
T_6F_1	137962	129930	267892	44754	27387	72140	195752	2.71
T_6F_2	137962	131280	269242	44754	28119	72873	196369	2.69
T_7F_1	157035	130770	287805	46794	27387	74181	213625	2.88

T_7F_2	157035	132090	289125	46794	28119	74913	214212	2.86
T_8F_1	131560	102870	234430	43303	27387	70690	163740	2.32
T_8F_2	131560	121530	253090	43303	28119	71422	181668	2.54
T_9F_1	0	85860	85860	0	27387	27387	58473	2.13
T_9F_2	0	93480	93480	0	28119	28119	65361	2.32

Conclusion

On the basis of two years experimentation, It can be concluded that for getting higher yield and net returns in chickpea- fodder sorghum sequence, *rabi* chickpea crop should be fertilized with 75% RDF (15-30-00 N-P_2O_5-K_2O kg/ha) + Bio compost 2.5 t/ha + Banana pseudostem enriched sap (1% spray) at 30 DAS and 45 DAS and summer fodder sorghum should be fertilized with 75% RDF (60-30-00 N-P_2O_5-K_2O kg/ha).

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