Sustaining Productivity of Sorghum Chickpea Cropping System in Integrated Nutrient Management

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ABSTRACT

To identify an ideal combination of organic and inorganic nutrient sources for getting maximum yield of kharif sorghum and rabi chickpea sequence a field experiment on Integrated Nutrient Management in sorghum chickpea cropping system was conducted during 2012-2014 at the experimental farm, Annamalai university, Annamalai nagar. The experiment was planned in RBD with the treatments as Nutrient management treatments - 09 (Kharif-Sorghum) T_1-100% RDN through inorganic fertilizer, T_2-50% RDN through inorganic fertilizer+50% RDN through FYM, T_3-75% RDN through inorganic fertilizer+25% RDN through FYM, T_4-50% RDN through inorganic fertilizer+50% RDN through vermicompost, T_5:75% RDN through inorganic fertilizer+25% RDN through vermicompost, T_6-50% RDN through inorganic fertilizer+25% RDN through FYM+25% RDN through vermicompost, T_7-75% RDN through inorganic fertilizer+25% RDN through FYM+seed treatment with microbial fertilizers Phosphobacteria+*Azospirillum*, T_8-75% RDN through inorganic fertilizer+25% RDN through vermicompost+seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum*, T_9- 75% RDN through inorganic fertilizer+seed treatment with microbial fertilizers Phosphobacteria +*Azospirillum*. In rabi chickpea was gown on the same randomization without application of fertilizers. It can be concluded from the three years experiment that the integrated treatments are superior to inorganic treatment. Application of 75% RDN through inorganic fertilizer+25% RDN through FYM + seed treatment with Phosphobacteria + *Azospirillum* to kharif sorghum and growing rabi chickpea without recommended dose of fertilizer is the superior treatment for getting maximum growth and yield attributes and yield of individual crop as well as of the system.

Introduction

Improving and maintaining soil quality for enhancing and sustaining agricultural production is of utmost importance for India's food and nutritional security. INM has multifaceted potential for the

improvement of plant performance and resource efficiency while also enabling the protection of the environment and resource quality. A comprehensive literature search revealed that INM enhances crop yield by 8-150% compared with conventional practices, increases water-use efficiency, and the economic returns to farmers, while improving grain quality and soil health and sustainability (Wei Wua and Baoluo Ma, 2015). It is well known that the organic sources cannot meet the total nutrients need to modern agriculture, integrated use of nutrients seems to be more appropriate. Incorporation of organic sources and later on its decomposition determines the availability of the nutrients. Organic sources of nutrients applied to the preceding crop benefits the succeeding crop to a great extent (Hedge and Dwivedi, 1992). Therefore, the present study was undertaken with a view to find out the efficient combination of organic and inorganic fertilizers under sorghum- chickpea cropping sequence under rainfed conditions.

Materials and Methods

A field experiment was conducted at experimental farm, Annamalai university, Annamalai nagar during 2012-2014. Nine Nutrient application treatments (INM) were assessed during Kharif for Sorghum and in rabi chickpea was grown on same site same randomization without any RDF in three replication in RBD on clayey soil, having pH 7.34 and electrical conductivity 0.28 dS/m. It was medium in organic carbon (0.53 %), low in available nitrogen (232 kg/ha), low in available phosphorus (20.34 kg/ha) and high in available potassium (365 kg/ha). The experiment was laid out in randomized block design and nine nutrient application treatments (INM) were assessed during Kharif for Sorghum and in rabi chickpea was grown without any RDF in three replication (Table 1) Recommended doses of inorganic fertilizers consisting of 80 kg N and 40 kg each of P_2O_5 and K_2O/ha were applied to sorghum only and rabi Chickpea was grown on residual soil nutrients. For sorghum N was applied in 2 splits, half at sowing along with entire quantity of P_2O_5 and K_2O and remaining N was applied 30 days after sowing. Nitrogen, phosphorus and potassium were applied through urea, single superphosphate and muriate of potash, respectively. The FYM and vermicompost were applied based on the nitrogen equivalent basis and nutrient requirement of sorghum and biofertilizers used in the form of seed inoculation were *Azospirillum* and phosphate- solubilizing bacteria. Sorghum (CSH-14) and chickpea (JAKI-9218) were sown using seed rates of 7.5-10 kg ha^{-1} and 75-85 kg ha^{-1} with a spacing of 45 cm x 15 cm and 30 cm x 10 cm for sorghum and chickpea respectively. Sorghum was sown in second fortnight of July and harvested during 1st week of November. To study the residual effect of INMS treatments chickpea was sown

on same site without changing the randomization in 2nd week of November and harvested in 1st week of March during each year of experimentation. The crop sequence received total rainfall of 946.4 mm in 2012-13, 623.6 mm in 2013-14 and 796.5 mm in 2014-15 during the crop growth periods. The data on growth and yield attributes, grain and fodder yields of sorghum and chickpea were recorded. Representative soil samples were drawn before start of the experiment and also at each harvest of the sequence. Representative plant and grain samples were also drawn from each harvest of the sequence. The data was analyzed statistically as per Panse and Sukhatme (1967).

Results and Discussion

The residual effect of treatments with combination of organic and inorganic manures significantly influenced the plant height of sorghum. The plant height was significantly maximum with the application of 75% RDN through inorganic fertilizer+25% RDN through FYM+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* however it was at par with 75% RDN through inorganic fertilizer+25% RDN through vermicompost+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* during the years as well as in pooled mean. Better nutrient availability might have resulted in greater plant height. Yield attributing characters as Panicle length (cm), Grain wt per panicle (g) and number of grains panicle^{-1} of kharif sorghum was significantly maximum with the application of 75% RDN through inorganic fertilizer+25% RDN through FYM+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* however it was at par with 75% RDN through inorganic fertilizer+25% RDN through vermicompost+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* during the years as well as in pooled mean. Integrated nutrient management treatments had recorded better crop growth and yield attributing characters than only inorganic fertilizer application owing to better soil conditions and moisture storage in soil. The yield attributing characters were resulted in to higher yield of grain as well as fodder of sorghum and the application of 75% RDN through inorganic fertilizer+25% RDN through FYM+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* recorded significantly higher grain as well as fodder yield however it was at par with 75% RDN through inorganic fertilizer+25% RDN through vermicompost+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* during the years as well as in pooled mean. The lowest grain and fodder yield was recorded with the application of 75% RDN through inorganic fertilizer+seed

treatment with microbial fertilizers Phosphobacteria + *Azospirillum.* The response to FYM application may be attributed to the better nutrient availability and its favourable effect on soil physical and biological properties, resulting in increased growth and yield attributes and finally higher yield.

Chickpea grown after harvest of sorghum responded favorably to the residual effect of INM treatments applied to the preceding crop sorghum. Number of pods/plant, grain yield and dry fodder yield of chickpea was significantly maximum with the application of 75% RDN through inorganic fertilizer+25% RDN through FYM+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* however it was at par with 75% RDN through inorganic fertilizer+25% RDN through vermicompost+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum* during the years as well as in pooled mean. This indicated that the residual nutrients were adequate. Inclusion of legumes in cropping systems for green-manuring, fodder or grain purposes proved an as sured agro-technique to improve nutrient-use efficiency especially that of N (Yadav *et al.*, 1996).

Table.1 Treatment details (Kharif- Sorghum)

T_1	:	100% RDN through inorganic fertilizer
T_2	:	50% RDN through inorganic fertilizer+50% RDN through FYM
T_3	:	75% RDN through inorganic fertilizer+25% RDN through FYM
T_4	:	50% RDN through inorganic fertilizer+50% RDN through vermicompost
T_5	:	75% RDN through inorganic fertilizer+25% RDN through vermicompost
T_6	:	50% RDN through inorganic fertilizer+25% RDN through FYM+25% RDN through
T_7	:	75% RDN through inorganic fertilizer+25% RDN through FYM+ seed treatment with microbial fertilizers Phosphobacteria + *Azosnirillum*
T_8	:	75% RDN through inorganic fertilizer+25% RDN through vermicompost+ seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum*
T_9	:	75% RDN through inorganic fertilizer+seed treatment with microbial fertilizers Phosphobacteria + *Azospirillum*

(N application methods) were applied to Kharif Sorghum only and Rabi Chickpea was grown on residual soil nutrients.)

Table.2 Plant height (cm) and panicle length(cm), grain wt per panicle(g),grain no per panicle, grain yield and dry fodder yield (q/ ha) and sorghum equivalent yield (q/ha) of kharif sorghum as influenced by different treatments

Treatment details	Plant height (cm)				Panicle length (cm)			Grain wt per panicle			Grain No/panicle			Grain yield (q/ha)				Dry fodder yield (q/ ha)				Sorghum Equivalent Yield (q/ha)
	2012	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2012	2013	2014	Pooled	2012	2013	2014	Pooled	
N_1:100% RDN(IF)	219.60	195.67	203.00	206.09	25.16	25.30	25.23	31.60	35.14	33.37	1994	2249	2122	27.39	30.14	23.10	26.88	136.93	99.73	103.63	113.43	64.31
N_2:50% RDN(IF) +50% RDN FYM	197.61	206.00	213.33	205.65	26.77	26.90	26.84	39.58	43.12	41.35	2105	2360	2233	21.69	34.03	26.04	27.25	114.94	112.97	113.64	113.85	71.31
N_3:75% RDN (IF) +25% RDN FYM	189.78	218.33	225.67	211.26	28.14	28.28	28.21	41.21	44.75	42.98	2068	2323	2196	20.21	35.74	27.33	27.76	100.45	122.24	120.64	114.44	67.86
N_4:50% RDN (IF)+50% RDN VC	215.18	199.33	206.67	207.06	26.68	26.82	26.75	40.54	44.08	42.31	2093	2488	2291	31.66	31.64	24.23	29.18	163.11	105.94	108.33	125.79	67.24
N_5:75% RDN(IF) +25% RDN VC	211.44	182.33	189.67	194.48	27.14	27.28	27.21	41.34	44.87	43.105	2058	2313	2185	27.01	35.36	27.04	29.80	132.51	119.97	118.93	123.80	69.05
N_6:50% RDN(IF) +25% RDN FYM+25% RDN VC	193.42	208.67	216.00	206.03	27.01	27.15	27.08	40.40	43.93	42.165	2120	2375	2248	19.54	32.78	25.09	25.80	105.09	116.58	116.37	112.68	64.54
N_7:75%RDN(IF)+25%RDN FYM+ST(PSB+ Azspirillum)	210.75	225.67	233.00	223.14	28.69	29.16	28.93	45.04	48.58	46.81	2233	2387	2310	26.31	38.86	29.69	31.62	129.42	134.98	130.27	131.56	79.99
N_8:75% RDN(IF) +25% RDN ST (PSB+ *Azospirillum)*	180.95	225.33	232.67	212.98	28.59	28.72	28.66	43.39	46.93	45.16	2132	2348	2240	27.49	37.37	28.56	31.14	124.95	124.85	122.62	124.14	75.59
N_9:75% RDN(IF) + ST (PSB+ *Azospirillum*)	179.85	196.00	203.33	193.06	25.46	25.60	25.53	35.75	39.28	37.515	2142	2397	2270	19.08	31.04	23.77	24.63	97.18	103.92	106.80	102.63	55.73
SE(m) +	**15.72**	**11.46**	**8.88**	**2.46**	**0.15**	**0.09**	**0.02**	**0.90**	**0.78**	**0.48**	**32**	**35**	**35**	1.94	1.18	0.90	0.48	**12.27**	**5.05**	**8.38**	**1.02**	2.04
CD P=0.05	**NS**	**24.28**	**25.12**	**6.97**	**0.31**	**0.27**	**0.07**	**1.90**	**2.22**	**1.36**	**68**	**98**	**99**	5.82	2.50	2.56	1.37	**36.80**	**10.70**	**23.70**	**2.87**	5.78

Table.3 Number of pods /plant, grain yield and dry fodder yield (q/ ha) of rabi chickpea as influenced by different treatments

Treatment details	No. of Pods /plant				Grain yield (q/ha)				Dry fodder yield (q/ ha)			
	2012	**2013**	**2014**	**Pooled**	**2012**	**2013**	**2014**	**Pooled**	**2012**	**2013**	**2014**	**Pooled**
N_1:100% RDN(IF)	24.41	24.41	18.77	22.53	12.32	11.70	9.17	11.23	15.97	19.09	16.64	17.23
N_2:50% RDN(IF) +50% RDN FYM	37.07	25.30	23.59	28.65	15.78	12.51	10.86	13.22	22.02	16.98	17.25	18.75
N_3:75% RDN (IF) +25% RDN FYM	25.30	27.63	21.22	24.72	11.07	14.14	10.38	12.03	17.60	20.64	18.22	18.82
N_4:50% RDN (IF)+50% RDN VC	36.91	23.63	22.42	27.65	14.93	9.95	8.87	11.42	21.60	16.07	16.51	18.06
N_5:75% RDN(IF) +25% RDN VC	25.63	31.81	24.11	27.18	10.57	14.08	10.17	11.77	21.41	19.40	18.66	19.82
N_6:50% RDN(IF) +25% RDN FYM+25% RDN VC	31.81	24.63	21.39	25.94	14.76	10.45	9.15	11.62	21.26	16.07	16.39	17.91
N_7:75%RDN(IF)+25%RDNFYM+SD (PS B+ Azspirillum)	24.63	37.07	27.29	29.66	14.70	15.16	12.27	14.21	19.71	22.98	20.48	21.06
N_8:75% RDN(IF) +25% RDN SD (PSB+ *Azospirillum)*	27.63	36.91	28.18	30.91	13.13	14.31	11.18	13.04	18.43	20.79	18.60	19.27
N_9:75% RDN(IF) + SD (PSB+ *Azospirillum)*	23.63	24.41	18.51	22.18	10.42	9.8	7.27	9.33	16.69	16.03	14.84	15.85
SE(m) +	3.62	3.62	1.54	1.60	0.47	0.47	0.55	0.58	1.15	1.15	0.69	0.63
CD P=0.05	10.85	7.68	4.35	4.52	1.40	0.99	1.55	1.65	3.15	2.44	1.94	1.77

Significantly maximum sorghum equivalent yield(q/ha) was recorded with the application of 75% RDN through inorganic fertilizer+25% RDN through FYM+ seed treatment with microbial fertilizers PSB+ *Azospirillum* however it was at par with 75% RDN through inorganic fertilizer+25% RDN through vermicompost+ seed treatment with microbial fertilizers PSB+ *Azospirillum* during the years as well as in pooled mean. The lowest sorghum equivalent yield was recorded with the application of 75% RDN through inorganic fertilizer + seed treatment with microbial fertilizers PSB+ *Azospirillum*.

The sustained availability of nutrient may be attributed to the reason that FYM acts as nutrients reservoir and release major and minor nutrients slowly. The superiority of organic manure is also because of its beneficial effect on soil physical condition apart from acting as nutrient source (Laddha, 1993). Gawai and Pawar (2007) reported similar results of recording higher values for number of pods, grain weight and total dry matter per plant and 1000 seed weight. Results of long-tern fertilizer experiments further supported the beneficial role of farmyard manure in enhancing apparent use efficiency of fertilizer NPK, add maintaining yield stability in multiple cropping systems.

Also reported that organic manure application in conjunction with lower doses of N, P and K resulted in higher grain yield in important cropping systems. Singh *et al.,* (1981) opined that the organic manures like FYM increased the adsorptive power of soil for cations and anions particularly phosphates and nitrates and these were released slowly for the benefit of crops during entire crop growth period leading to higher yields The results clearly showed the combined application of manures, fertilizers and biofertilizers produced higher yield than when inorganic fertilizers applied alone.

Data in consideration with growth and yield, it is revealed that, the use of farm yard manure to compensate 25 % nitrogen dose and biofertilizers in combination with 75 per cent recommended dose for sorghum crop in sorghum- chickpea cropping sequence is the most appropriate source for optimum nutrient balance in said sequence. Thus, it can be concluded that, integration of inorganic fertilizers (75 per cent RDF) and organic manures (FYM) at 2.5 ton per ha and seed treatment with biofertilizers to sorghum crop followed by chickpea without application of recommended dose is the best proposition to achieve the high productivity of sorghum and chickpea sequence. Similar results were obtained by Gawai and Pawar (2006), Sarangmath *et al.,* (1994).

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