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Effect of Nitrogen Levels, Bio-Fertilizers and FYM on Content and Uptake of Nutrients by Rice-Fallow Sorghum

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ABSTRACT

A field experiment was conducted during 2012 at Agricultural College Farm, Bapatla to study the effect of inorganics, bio-fertilizers and FYM on nutrient content and uptake of nutrients by rice-fallow sorghum. The nitrogen content of sorghum plants at flowering and harvest was markedly influenced by the treatments with highest N recorded in treatment supplied with 150 kg N ha^{-1} + FYM + Bio-fertilizers. The effect of treatments on other nutrients in plants was non-significant. The uptake of macro and micronutrients at harvest was markedly influenced by the treatments with maximum values recorded by the treatment that received 150 kg N ha^{1} + FYM + Bio-fertilizers, which was at par with 150 kg N ha^{-1}+ FYM and 120 kg N ha^{1} + FYM + Bio-fertilizers.

Key words : Bio-fertilizers, Nutrient uptake, Nutrient content, Organic manure.

New opportunities and areas for sorghum cultivation are emerging mainly due to changes in cropping systems. In rice - fallows of Krishna zone, Andhra Pradesh, sorghum (*Sorghum bicolor L. Moench*) cultivation is gaining popularity among farmers due to its high average productivity of 5.7 t ha^{-1}. As cereal-cereal sequence is found to exhaust more nutrients an intervention in between may help in maintaining proper supply of nutrients. Application of organics to rice-fallow crops is not in practice considering the difficulties in their decomposability and availability of nutrients. Organics are recommended only to rice crop and several studies revealed that much of nutrients from organics are available to subsequent fallow crop. However several farmers due to peak demand and shortage of suffieient quantities of FYM are depending only on inorganics for rice cultivation. The application of phosphate solubilising cultures nitrogen fixers (*Azospirillum)* with organic manures increases the process of decomposition, releasing nutrients at a faster rate which, increases the nutrient uptake by plants.

Hence research efforts are required to find out the influence of combined use of farmyard manure, inorganics and bio-fertilizers in satisfyind the overall nutrient requirement of rice fallow sorghum crop.

MATERIAL AND METHODS

A field experiment was conducted at the Agricultural College Farm, Bapatla of Acharya N.G. Ranga Agricultural University in rice-fallow situation during 2012. The experiment was laid out in a randomized block design with three replications and thirteen treatments viz., T_1 - 90 kg N ha^{-1}; T_2 - 120 kg N ha^{-1}; T_3 - 150 kg N ha^{-1}; T_4 - 90 kg N ha^{-1} + Bio-fertilizers; T_5 - 120 kg N ha^{-1} + Bio-fertilizers; T_6 -150 kg N ha^{-1} + Bio-fertilizers; T_7 - 90 kg N ha^{-1} + FYM; T_8 - 120 kg N ha^{-1} + FYM; T_9 - 150 kg N ha^{-1} + FYM; T_{10} - 90 kg N ha^{-1} + FYM + Bio-fertilizers; T_{11} - 120 kg N ha^{-1} + FYM + Bio-fertilizer; T_{12} - 150 kg N ha^{-1} + FYM + Bio-fertilizers; T_{13} - No nitrogen. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (pH 7.4), medium in organic carbon (0.55 %), low in available nitrogen (122 kg ha^{-1}), medium in available phosphorus (27.9 kg ha^{-1}) and high in available potassium (729 kg ha^{-1}). Sorghum hybrid MLSH-151 was dibbled at 45 cm x 15 cm spacing on 2^{nd} February, 2012. Well decomposed FYM (C:N of 25:1) was applied 7 days before sowing. Bio-fertilizer consortium consisting of *Azospirillum*, phosphorus solubilising bacteria (PSB) and plant growth promoting rhizobacteria (PGPR) @ 5 kg ha^{-1} each was applied one day before sowing. Nitrogen was applied in 2 splits, while P_2O_5 and

K_2O (30 kg ha^{-1}) each were applied to all treatments as per recommendation. Plant samples collected at flowering and at harvest were analysed for nitrogen, phosphorus and potassium contents by microkjeldhl method (Piper,1966), Vanadomolybdate yellow colour method (Jackson,1973) and Flame photo meter method (Jackson,1973), respectively. Micronutrient contents were analysed by using DTPA extractant (Lindsay and Norvell, 1978). Nutrient uptake was calculated at harvesting stage.

RESULTS AND DISCUSSION

NUTRIENT CONTENT IN PLANTS:

Macronutrients:

The macro nutrient contents of sorghum plants collected at flowering, in grain and stover are presented in table 1. At flowering among inorganic treatments (T_1 to T_3) the nitrogen content significantly increased from 2.76 to 2.99 per cent with increasing nitrogen level from 90 to 150 kg N ha^{-1}. When bio-fertilizers and/or FYM were added, application of nitrogen upto 120 kg ha $^{-1}$ recorded significantly higher nitrogen contents. Among FYM treatments (T_7 to T_{12}) the nitrogen content was highest (3.10 %) in the treatment that received combined application of 150 kg N ha^{-1} + FYM + Bio-fertilizer consortium (T_{12}), which was found to be on par with treatments supplied with 120 kg N + FYM+ Bio-fertilizers (T_{11}), 150 kg N ha^{-1} + FYM (T_9) and 120 kg N ha^{-1} + FYM (T_8) and significantly superior over all other treatments. A significant increase in nitrogen contents was observed in both grain and stover with an increase in N dose up to 150 kg ha^{-1}. Bio-fertilizers when combined with different levels of fertilizer nitrogen, resulted in increased contents of nitrogen in both grain and stover. However, such increase was significant in stover only. Significant increase in nitrogen content at both stages of crop growth with added levels of nitrogen, this might be due to ready supply of nitrogen through inorganics, which might have increased the absorption (Khanda and Dixit, 1996).

The influence of treatments on phosphorus and potassium contents of plants at different stages were not significant. The highest phosphorus and potassium contents at flowering and in grain and stover at harvest were recorded in T_{12} , while the lowest contents were observed in T_{13}. The critical observation of the data revealed that there was a decrease in N, P and K concentrations with plant maturity, which might be due to the dilution effect caused by an increase in the plant biomass. Similar decrease in nutrient concentration with maturity was reported by Samarah *et al*. (2010). The integrated application of inorganics, FYM and bio-fertilizers resulted in higher nutrient contents in plants, this might be due to the fact that inorganic fertilizer component provided nutrients during the early vegetative growth, while the organic component provided nutrients over a long period as it takes some time for the mineralization.

Micronutrients:

Micronutrient contents in sorghum plants at flowering and in grain and stover at harvest (Table2) were not significantly influenced by the treatments. However, the treatments which received higher nitrogen through inorganics, bio-fertilizers and or FYM (T_{12}, T_9, T_{11} and T_8) recorded higher iron, zinc, manganese and copper contents of drymatter at flowering and in grain and stover at harvest and lower values were recorded in treatment T_{13} (no nitrogen). The results in the present study revealed that FYM treated plots recorded higher contents of micronutrients as it influenced the microbial activity (bacteria, fungi) that in turn enhanced the rate of decomposition of organic matter and solubility of nutrients. Wu *et al*. (2005) also documented increased nutrient content by combined use of organic and mineral fertilizers.

NUTRIENT UPTAKE

Macronutrients:

The data related to uptake of nitrogen, phosphorus and potassium by sorghum grain and stover are presented in table 3. The data indicated that, increase in dose of inorganic nitrogen with or without integrated treatments resulted in a significant increase in nitrogen uptake up to 120 kg N ha^{-1} both in grain and stover. Among integrated treatments the highest values of nitrogen uptake by grain (77.41 kg ha^{-1}) and stover (63.17 kg ha^{-1}) were recorded in treatment that received combined application of 150 kg N ha^{-1} + FYM + bio-fertilizer (T_{12}), which was on par with treatments supplied with 150 kg N ha^{-1} + FYM (T_9) and 120 kg N ha^{-1} + FYM + Bio-fertilizers (T_{11}) and T_8 (120 kg N ha^{-1} +

Table 1. Effect of nitrogen levels, bio-fertilizers and FYM on macronutrient content (%) of sorghum.

Treatments	Nitrogen			Phosphorus			Potassium		
	Flowering	Grain	Stover	Flowering	Grain	Stover	Flowering	Grain	Stover
T_1 - 90 kg N ha^{-1}	2.76	1.73	0.86	0.38	0.31	0.11	1.84	0.45	1.33
T_2 - 120 kg N ha^{-1}	2.86	1.83	0.93	0.49	0.37	0.15	1.99	0.49	1.45
T_3 - 150 kg N ha^{-1}	2.99	1.91	1.03	0.48	0.43	0.19	2.27	0.54	1.58
T_4 - 90 kg N ha^{-1} + Bio - fertilizers	2.78	1.75	0.87	0.32	0.32	0.12	1.89	0.46	1.35
T_5 - 120 kg N ha^{-1} + Bio- fertilizers	2.86	1.80	0.92	0.42	0.34	0.15	2.06	0.51	1.48
T_6 - 150 kg N ha^{-1} + Bio- fertilizers	2.95	1.85	1.00	0.46	0.41	0.19	2.16	0.56	1.56
T_7 - 90 kg N ha^{-1} + FYM	2.88	1.85	0.95	0.42	0.38	0.17	2.14	0.55	1.53
T_8 - 120 kg N ha^{-1} + FYM	3.04	1.93	1.05	0.53	0.44	0.21	2.32	0.64	1.63
T_9 - 150 kg N ha^{-1} + FYM	3.07	1.94	1.07	0.56	0.32	0.23	2.28	0.63	1.60
T_{10} - 90 kg N ha^{-1} + FYM + Bio - fertilizers	2.91	1.87	0.98	0.43	0.39	0.20	2.13	0.53	1.50
T_{11} - 120 kg N ha^{-1} + FYM + Bio - fertilizers	3.08	1.95	1.09	0.51	0.44	0.21	2.36	0.66	1.64
T_{12} - 150 kg N ha^{-1} + FYM + Bio - fertilizers	3.10	1.96	1.11	0.58	0.48	0.23	2.39	0.68	1.68
T_{13} - Control	2.65	1.62	0.81	0.31	0.29	0.09	1.73	0.44	1.24
SEm±	0.13	0.09	0.05	0.07	0.02	0.03	0.07	0.07	0.06
CD@0.05	0.07	0.06	0.04	NS	NS	NS	NS	NS	NS

FYM @ 10 t ha^{-1}; Bio-fertilizer consortium consists of *Azospirillum,* PSB and PGPR @ 5 kg ha^{-1} each.

Table 2. Effect of nitrogen levels, bio-fertilizers and FYM on micronutrient content (µg g^{-1}) of sorghum.

Treatments	Copper			Zinc			Manganese			Iron		
	Flowering	Grain	Stover	Flowering	Grain	Stover	Flowering	Grain	Stover	Flowering	Grain	Stover
T_1 - 90 kg N ha^{-1}	12.0	5.3	7.1	36.1	15.3	22.2	41.2	37.2	39.1	131	137	223
T_2 - 120 kg N ha^{-1}	12.4	6.1	7.7	36.7	17.8	25.0	41.9	38.2	41.3	140	145	240
T_3 - 150 kg N ha^{-1}	13.4	6.8	8.4	37.4	19.4	27.3	43.6	39.3	42.7	153	157	251
T_4 - 90 kg N ha^{-1} + Bio - fertilizers	12.2	5.1	7.1	36.0	15.1	22.4	41.6	37.2	39.7	136	135	225
T_5 - 120 kg N ha^{-1} + Bio- fertilizers	12.6	6.2	7.8	36.7	17.9	25.4	42.1	38.4	41.4	141	145	240
T_6 - 150 kg N ha^{-1} + Bio- fertilizers	13.2	6.3	7.9	37.2	18.3	26.9	43.5	39.0	42.1	149	153	247
T_7 - 90 kg N ha^{-1} + FYM	14.0	6.4	8.0	36.9	18.2	25.8	45.2	38.8	41.1	146	149	245
T_8 - 120 kg N ha^{-1} + FYM	13.0	7.0	8.7	37.7	20.4	28.0	44.3	39.7	42.9	157	161	257
T_9 - 150 kg N ha^{-1} + FYM	14.2	7.2	8.8	38.0	20.9	28.1	46.2	41.0	43.1	160	163	260
T_{10} - 90 kg N ha^{-1} + FYM + Bio - fertilizers	13.6	6.4	8.0	36.8	18.0	25.4	42.6	38.6	41.7	142	147	242
T_{11} - 120 kg N ha^{-1} + FYM + Bio - fertilizers	12.7	6.9	8.6	37.5	20.1	27.7	44.3	39.4	42.8	154	159	253
T_{12} - 150 kg N ha^{-1} + FYM + Bio - fertilizers	14.4	7.4	9.0	38.2	21.3	28.6	47.6	41.3	43.4	164	165	262
T_{13} - Control	11.6	5.0	6.8	35.9	13.7	20.1	39.8	37.1	39.0	125	135	228
SEm±	0.8	0.4	0.6	1.5	0.6	0.8	0.9	0.8	1.9	13	12	10
CD@0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

FYM @ 10 t ha^{-1}; Bio-fertilizer consortium consists of *Azospirillum,* PSB and PGPR @ 5 kg ha^{-1} each.

Table 3. Effect of nitrogen levels, bio-fertilizers and FYM on uptake of macronutrients (kg ha^{-1}) by sorghum at harvest.

Treatments	Nitrogen		Phosphorus		Potassium	
	Grain	Stover	Grain	Stover	Grain	Stover
T_1 - 90 kg N ha^{--1}	41.36	37.11	6.63	5.84	10.46	72.74
T_2 - 120 kg N ha^{-1}	54.24	44.31	9.88	8.87	13.09	85.70
T_3 - 150 kg N ha^{-1}	61.53	50.32	12.57	11.67	15.05	97.06
T_4 - 90 kg N ha^{-1} + Bio - fertilizers	43.91	36.17	7.20	6.47	10.36	72.89
T_5 - 120 kg N ha^{-1} + Bio- fertilizers	55.01	43.37	9.38	8.97	13.96	88.53
T_6 - 150 kg N ha^{-1} + Bio- fertilizers	62.11	50.42	12.18	11.95	16.64	101.18
T_7 - 90 kg N ha^{-1} + FYM	57.24	45.11	10.60	10.22	15.36	92.03
T_8 - 120 kg N ha^{-1} + FYM	71.06	56.46	12.34	13.94	21.39	108.26
T_9 - 150 kg N ha^{-1} + FYM	74.07	59.65	15.14	15.96	21.88	110.71
T_{10} - 90 kg N ha^{-1} + FYM + Bio - fertilizers	58.91	47.49	11.08	12.16	15.08	91.34
T_{11} - 120 kg N ha^{-1} + FYM + Bio - fertilizers	73.36	60.63	15.00	14.30	22.52	111.72
T_{12} - 150 kg N ha^{-1} + FYM + Bio - fertilizers	77.41	63.17	17.18	16.28	24.37	116.63
T_{13} - Control	32.33	29.72	4.31	4.21	7.60	59.45
SEm±	2.87	2.43	0.37	0.43	0.89	4.32
CD@0.05	8.52	7.14	1.72	1.57	2.61	12.52

FYM @ 10 t ha^{-1}; Bio-fertilizer consortium consists of *Azospirillum,* PSB and PGPR @ 5 kg ha $^{-1}$ each.

FYM) and significantly superior over other treatments. Higher biomass production might be the most pertinent reason for the increased uptake of nutrients in the treatments with graded levels of nitrogen. The inorganic nitrogen not only provides an immediate source of N for plant growth but also enhances the mineralization of applied as well as native organic matter by meeting the N requirement of the decomposers. The results of the present experiment strongly support the findings of Jain *et al*. (2003).

The data indicated that increase in nitrogen levels resulted in significant increase in phosphorus uptake in both grain and stover upto 150 kg N ha^{-1}. Similar significant increase in phosphorus uptake at high levels of nitrogen with bio fertilizers and FYM were observed. However, application of bio-fertilizers at a given dose of nitrogen did not significantly influence the phosphorus uptake. Among FYM treated plots the phosphorus uptake by grain (17.18 kg ha^{-1}) and stover (16.28 kg ha^{-1}) was highest when the treatment received combined application of 150 kg N ha^{-1} + FYM + Bio-fertilizers (T_{12}), which was significantly superior over all others except T_9 in stover. Lowest phosphorus uptakes in grain (4.31 kg ha^{-1}) and in stover (4.21 kg ha^{-1}) were observed in T_{13} treatment (no nitrogen). At a given dose of inorganic nitrogen phosphorus use efficiency was more when combined with both bio-fertilizers and FYM than their individual application, which could be due to increased biomass obtained as a result of more availability of nutrients released during decomposition of FYM and also solubilisation of native phosphorus by phosphate solubilizing microbes. The results are coinciding with those of Patidar and Mali (2004).

The potassium accumulated by grain and stover was significantly increased due to the application of inorganic nitrogen up to 120 kg nitrogen ha^{-1} and in combination with FYM, while the uptake was significant up to 150 kg N ha^{-1} with bio-fertilizers. The potassium uptake by grain (24.37 kg ha^{-1}) and stover (116.63 kg ha^{-1}) were highest when the treatment received combined application of 150 kg N ha^{-1} + FYM + Bio-fertilizers (T_{12}), which was on par with T_{11}, T_9 and T_8. The lowest uptake of potassium was observed in T_{13} treatment (no nitrogen). The increase in uptake of potassium in organic and bio-fertilizer treated plots might be due to release of K from organic manures during decomposition and solubilisation and release

Table 4. Effect of nitrogen levels, bio-fertilizers and FYM on uptake of micronutrients (g ha^{-1}) by sorghum at harvest.

Treatments	Copper		Zinc		Manganese		Iron	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1 - 90 kg N ha^{-1}	11.86	38.76	33.8	117.9	79	217	293	1286
T_2 - 120 kg N ha^{-1}	16.30	45.51	47.7	147.9	102	244	387	1418
T_3 - 150 kg N ha^{-1}	18.37	48.53	53.5	165.2	113	258	446	1517
T_4 - 90 kg N ha^{-1} + Bio - fertilizers	11.49	38.33	33.9	121.0	83	214	304	1214
T_5 - 120 kg N ha^{-1} + Bio- fertilizers	16.97	46.66	49.1	151.9	105	247	396	1435
T_6 - 150 kg N ha^{-1} + Bio- fertilizers	20.21	52.84	57.7	171.8	116	268	466	1578
T_7 - 90 kg N ha^{-1} + FYM	17.87	47.52	50.4	152.7	107	250	410	1455
T_8 - 120 kg N ha^{-1} + FYM	23.06	57.12	67.2	183.9	131	284	531	1680
T_9 - 150 kg N ha^{-1} + FYM	25.01	60.33	72.7	192.7	142	295	566	1782
T_{10} - 90 kg N ha^{-1} + FYM + Bio - fertilizers	18.21	48.71	51.7	157.2	110	256	424	1491
T_{11} - 120 kg N ha^{-1} + FYM + Bio - fertilizers	23.88	59.26	69.5	190.8	135	292	549	1750
T_{12} - 150 kg N ha^{-1} + FYM + Bio - fertilizers	26.52	62.48	76.3	198.5	148	301	591	1818
T_{13} - Control	7.65	32.30	23.7	96.5	64	186	223	1093
SEm±	1.18	2.09	3.37	7.12	5	6	23	63
CD@0.05	3.51	6.22	10.1	21.0	15	23	70	190

FYM @ 10 t ha^{-1}; Bio-fertilizer consortium consists of *Azospirillum*, PSB and PGPR @ 5 kg ha^{-1} each.

of native and fixed forms of potassium, charging the soil solution with K^+ ions. The increase in uptake may also be ascribed to the role of organics and bio-fertilizers in increasing the use efficiency of applied fertilizers. The results are coinciding with those of Mahavishnan *et al*. (2004).

Micronutrients(copper, zinc, manganese and iron):

The analytical results revealed a significant increase in uptake of all micronutrients both in grain and stover with increase in nitrogen levels from 90 to 120 kg N ha^{-1} except for iron in stover. The highest micronutrient uptakes in grain and stover were recorded in treatment T_{12} (150 kg N ha^{-1} + FYM + Bio-fertilizers), which was on par with T_9, T_{11} and T_8 in all except Mn in grain, where it was on par with T_9 and T_{11}. The lowest uptakes were observed in T_{13} treatment (no nitrogen). Higher uptake of micronutrients by combined addition of inorganics, organics and bio-fertilizers might be due to release of micronutrients on mineralization or production of organic acids during their decomposition, which aids in solubilization of insoluble micronutrient compounds in soil or due to supply of natural chelating agents, which renders them more available (Stevenson and Ardakani, 1972). The chelating action of released organic compounds prevent the micronutrient cations from fixation, precipitation, oxidation and leaching. This is in accordance with Gogoi *et al*. (2010).

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