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N Goutami
M.Sc. Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

P Prasuna Rani
Professor, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

Correspondence
N Goutami
M.Sc. Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

Yield, quality and enzyme activities in rice - Fallow sorghum as influenced by nutrient management

N Goutami and P Prasuna Rani

Abstract
A field experiment was conducted during *Rabi,* 2012 at Agricultural College Farm, Bapatla to study the effect of inorganics, bio-fertilizers and FYM on yield, quality and enzyme activities in rice fallow sorghum. Results indicated that significantly higher number of grains per ear, grain yield and stalk yield were recorded by the integrated treatment that received 150 kg N ha^{-1} + FYM + Bio-fertilizers followed by150 kg N ha^{-1} + FYM and 120 kg N ha^{-1} + FYM + Bio- fertilizers as compared to control. The treatment receiving 90 kg N ha^{-1} + FYM + Bio-fertilizers was at par with application of 150 kg N ha^{-1} in grain sorghum production. The protein content of the grain was significantly influenced by imposed treatments while no such effect was noticed with carbohydrates. Addition of inorganics in combination with organics and bio-fertilizers proved to be more efficient in improving the enzyme activities (urease and dehydrogenase) significantly.

Keywords: organic manure, inorganics, bio-fertilizers, grain sorghum

Introduction

Continuous adopting of rice - sorghum sequence is a point of concern as cultivation of two cereal crops in a year involves heavy removal of nutrients, which diminishes the soil health and in turn productivity. Continuous cultivation of cereal-cereal sequence for longer periods with low system productivity, and often with poor crop management practices, results in loss of soil fertility due to emergence of multiple nutrient deficiency (Dwivedi *et al.,* 2001) [1] and deterioration of soil physical properties (Tripathi, 1992) [9], and decline in factor productivity and crop yields in high productivity areas (Yadav, 1998) [10]. It is therefore necessary to judiciously manage the inflow of inorganic fertilizers and their integration with bio-fertilizers besides adopting general package of practice.

Modern agriculture relies heavily on the intensive cultivation of crops with the use of high analysis N, P and K fertilizers resulting in disparity in the availability and supply of the secondary and micronutrients. At this juncture conjunctive use of organics can increase the productivity of soils as they act as a source of nutrients and modify the soil physical behavior as well as increase the efficiency of applied nutrients (Sahadeva Reddy and Aruna, 2008) [8]. Hence, the present study was carried out to see the influence of inorganics,bio-fertilizers and FYM on yield and quality of rice-fallow sorghum.

Materials and Methods

A field experiment was conducted at the Agricultural College Farm, Bapatla of Acharya N.G. Ranga Agricultural University during *rabi* 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 with bulk density 1.56 Mg m^{-3}, pH 7.4, EC 0.49 dS m^{-1}, organic carbon 0.55 %, available nitrogen 122 kg ha^{-1}, phosphorus 27.9 kg ha^{-1}, potassium 729 kg ha^{-1}, zinc 0.49 ppm, copper 3.42 ppm, iron 6.93 ppm and manganese 6.72 ppm. A rainfall of 10.8 mm was received in 2 rainy days during crop growth period. Sorghum hybrid MLSH-151 was dibbled at 45 cm x 15 cm spacing on 2nd February,

2012. Crop was fertilized with recommended dose of 30:30 kg P_2O_5 and K_2O ha^{-1}, respectively to all the treatments. FYM was applied 7 days before sowing. bio-fertilizer consortium consisting of *Azospirillum*, PSB and PGPR @ 5 kg ha^{-1} each was applied one day before sowing. Nitrogen was applied in 2 splits. Data was collected on yield and quality parameters and enzyme activities in sorghum.

Results and Discussion

Sorghum grain yield and Stover yield (q ha^{-1})

The data pertaining to grain and stover yields presented in (Table 2) revealed a significant effect of levels of nitrogen and its integration with FYM and bio - fertilizers on grain and stover yields of sorghum.

Among inorganic treatments an increase in grain yield was observed with each increament in dose of nitrogen (T_1 to T_3). However a significant increase in grain yield was observed only up to 120 kg N ha^{-1}. Similar significant increase with increase in N dose was observed in the presence of bio fertilizer consortium. However, at a given dose, addition FYM alone and in combination with bio-fertilizer resulted in a significant increase in yield.

The highest grain yield (35.8 q ha $^{-1}$) was recorded by the treatment T_{12} (150 kg N ha^{-1} + FYM + Bio-fertilizers), which was on a par with treatment T_9, T_{11} and T_8. Treatments receiving FYM with 150 or 120 kg N ha^{-1} were on par with each other showing no significant effect of high dose of N or addition of bio fertilizers. Treatments supplied with higher doses of nitrogen viz. T_{12}, T_9 and T_{11} were significantly superior over all other treatments except treatment T_8 (120 kg N ha^{-1} + FYM). The lowest grain yield (17.2 q ha^{-1}) was recorded in no nitrogen treatment (T_{13}).

Stover yield followed the same pattern as grain yield. Treatment T_3 recorded maximum stover yield among inorganic treatments but a significant increase was observed with T_2 (120 kg N ha^{-1}) only. Application of bio-fertilizers along with inorganics also followed similar trend. Addition of bio-fertilizers and /or FYM along with inorganics followed similar trend.

The highest stover yield (69.4 q ha $^{-1}$) was recorded in treatment supplied with 150 kg N ha^{-1} +FYM + Bio-fertilizers (T_{12}), which was on par with treatments T_9 (150 kg N ha^{-1} + FYM ha^{-1}) and T_{11} (120 kg N ha^{-1} +FYM +Bio- fertilizers) and significantly superior over others. The treatment T_8 (120 kg N ha^{-1} + FYM) was on a par with the treatment T_6 (150 kg N ha^{-1} + Bio-fertilizers) and significantly superior over T_3 (150 kg N ha $^{-1}$). The lowest stover yield (47.9 q ha $^{-1}$) was found in the treatment T_{13} (no nitrogen).

Critical observation of the data revealed a positive influence of levels of nitrogen and application of FYM and/or bio fertilizers on yield. The favourable response to higher level of nitrogen on yield could be ascribed to overall improvement in crop growth that enabled the plant to absorb more nutrients and moisture which empowered the plant to manufacture more quantities of photosynthates and accumulate them in sink. Similar findings of response of sorghum to higher nitrogen levels were reported by Patil *et al.* (1998) [5].

The production of organic acids and growth promoting substances during decomposition of organic manures might have facilitated easy availability of macro as well as micronutrients. Adequate supply of nutrients to the crop helps in the synthesis of carbohydrates, and their subsequent translocation to sink. An increase in yield might also be on account of increased symbiotic activity of nitrogen fixating and solubilization of nutrients and production of growth regulators due to addition of bio- fertilizer consortium consists of *Azospirillum*, PSB and PGPR.

Quality parameters

The data presented in table 3 revealed that application of organic and inorganic source of nutrient combinations significantly influenced the protein content of sorghum grain. Among inorganic treatments increase in nitrogen level from 90 to 150 kg N ha^{-1} significantly increased the protein content in grain. While in combination with bio-fertilizers the effect was non-significant. At a given dose up to 120 kg N ha $^{-1}$, FYM treated plots reported a significant increase over other treatments. Maximum protein content was observed in T_{12} (150 kg N ha^{-1} + FYM + Bio-fertilizers) and the lowest protein content was recorded in T_{13} (no nitrogen).The increase in protein content at higher doses of nitrogen might be due to increased availability of nitrogen and its uptake and storage in grain. Nitrogen, an essential constituent making up to 16 per cent by weight of protein is found to influence the protein content, if it is available in abundance. These results are in accordance with the findings of Raja (2005) [7]. Similar reports were made by Mishra *et al.* (1994) [4] and Koteva *et al*. (1995) [3]. The perusal of data presented in (Table 1) indicated that carbohydrate content in grain was not significantly influenced by different treatments. Maximum carbohydrate content was observed in T_4 (90 kg N ha^{-1} + Bio- fertilizers) and the lowest was recorded in T_{13} (no nitrogen).

Enzyme Activity

Data presented in the table 4 indicated that urease activity of the soils at flowering and harvest of crop was significantly influenced by different treatments. There was a significant increase in urease activity with increase in nitrogen up to 150 kg N ha^{-1} both at flowering (14.1 to 19.8 µg NH_4^+ - N g^{-1} soil h^{-1}) and harvest (11.5 to 15.4 µg NH_4^+ - N g^{-1} soil h^{-1}). Bio-fertilizers when combined with different levels of nitrogen, resulted in significant increase in urease activity. Among FYM treated plots, The urease activity at flowering stage (26.10 µg NH_4^+ - N g^{-1} soil h^{-1}) and at harvest (18.5 µg NH_4^+ - N g^{-1} soil h^{-1}) were highest when the treatment received combined application of 150 kg N ha^{-1} + FYM + Bio-fertilizer (T_{12}), which was on par with T_9. The lowest enzyme activity was observed in T_{13} treatment (no nitrogen). Enhancement of urease activity with increased rate of nitrogen application along with FYM to soil might be due to added organic manures which acted as sole source of carbon and energy for microbes by which their population increased resulting in increased enzymatic activity (Qureshi *et al.*, 2005).

There was a significant increase in dehydrogenase activity with increase in nitrogen up to 150 kg N ha^{-1} in all combinations. Among FYM treated plots the dehydrogenase activities at flowering (72.89 µg g^{-1} 24 h^{-1}) and harvest (49.78 µg g^{-1} 24 h^{-1}) were highest when the treatment received combined application of 150 kg N ha^{-1} + FYM + Bio fertilizers (T_{12}), which were on par with T_9 and $T_{11,}$ respectively. The lowest enzyme activity was observed in T_{13} treatment (no nitrogen). The soil dehydrogenase activity increased with addition of organic carbon through FYM. The enzyme activity was maximum at flowering compared to harvest. This could be due to higher root exudates from the plant roots at flowering over harvesting stage (Hale *et al.*, 1978) [2]. The increase in dehydrogenase activity in FYM treated plots could also be attributed to increase in microbial population.

Table 1: Effect of Nitrogen Levels, Bio Fertilizers and Fym on Yield

Treatments	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
T_1 - 90 kg N ha^{-1}	21.4	53.1
T_2 - 120 kg N ha^{-1}	26.7	59.1
T_3 - 150 kg N ha^{-1}	29.1	61.4
T_4 - 90 kg N ha^{-1} + Bio - fertilizers	22.5	53.9
T_5 - 120 kg N ha^{-1} + Bio- fertilizers	27.3	59.8
T_6 - 150 kg N ha^{-1} + Bio- fertilizers	29.7	62.9
T_7 - 90 kg N ha^{-1} + FYM	27.9	60.1
T_8 - 120 kg N ha^{-1} + FYM	33.4	66.4
T_9 - 150 kg N ha^{-1} + FYM	34.7	68.5
T_{10} - 90 kg N ha^{-1} + FYM + Bio - fertilizers	28.4	60.8
T_{11} - 120 kg N ha^{-1} + FYM + Bio - fertilizers	34.1	68.1
T_{12} - 150 kg N ha^{-1} + FYM + Bio - fertilizers	35.8	69.4
T_{13} - No nitrogen	17.2	47.9
SEm±	1.39	1.73
CD @ 0.05	4.0	5.1
CV (%)	7.4	8.6

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 quality parametrs

Treatments	Protein (%)	Carbohydrates (%)
T_1 - 90 kg N ha^{-1}	10.81	45.0
T_2 - 120 kg N ha^{-1}	11.44	42.8
T_3 - 150 kg N ha^{-1}	12.06	41.8
T_4 - 90 kg N ha^{-1} + Bio - fertilizers	10.94	45.2
T_5 - 120 kg N ha^{-1} + Bio- fertilizers	11.31	44.3
T_6 - 150 kg N ha^{-1} + Bio- fertilizers	11.81	43.2
T_7 - 90 kg N ha^{-1} + FYM	11.56	42.8
T_8 - 120 kg N ha^{-1} + FYM	12.06	41.6
T_9 - 150 kg N ha^{-1} + FYM	12.12	44.0
T_{10} - 90 kg N ha^{-1} + FYM + Bio - fertilizers	11.69	45.0
T_{11} - 120 kg N ha^{-1} + FYM + Bio - fertilizers	12.19	44.7
T_{12} - 150 kg N ha^{-1} + FYM + Bio - fertilizers	12.25	43.6
T_{13} - No nitrogen	10.18	40.7
SEm±	0.23	0.90
CD (0.05%)	0.61	NS
CV (%)	5.58	6.9

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 Enzyme Activity in Soils

Treatments	Urease activity		Dehydrogenase activity	
	Flowering	Harvest	Flowering	Harvest
T_1 - 90 kg N ha^{-1}	14.1	11.5	60.29	39.87
T_2 - 120 kg N ha^{-1}	17.1	13.8	64.06	42.89
T_3 - 150 kg N ha^{-1}	19.8	15.4	68.08	45.29
T_4 - 90 kg N ha^{-1} + Bio - fertilizers	15.7	11.9	60.84	40.09
T_5 - 120 kg N ha^{-1} + Bio- fertilizers	18.4	14.1	64.37	43.92
T_6 - 150 kg N ha^{-1} + Bio- fertilizers	21.2	16.9	69.28	46.62
T_7 - 90 kg N ha^{-1} + FYM	17.2	13.3	63.04	40.04
T_8 - 120 kg N ha^{-1} + FYM	19.9	15.5	66.49	43.44
T_9 - 150 kg N ha^{-1} + FYM	23.8	17.1	71.42	47.24
T_{10} - 90 kg N ha^{-1} + FYM + Bio - fertilizers	20.5	14.8	63.42	42.47
T_{11} - 120 kg N ha^{-1} + FYM + Bio - fertilizers	23.3	16.9	67.24	45.04
T_{12} - 150 kg N ha^{-1} + FYM + Bio - fertilizers	26.1	18.5	72.89	49.78
T_{13} - No nitrogen	11.3	9.2	57.08	37.89
SEm±	0.87	0.61	0.85	0.56
CD (0.05%)	2.6	1.5	2.08	1.35

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

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