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Long Term effect of Manuring and Fertilization on Soil Biological Properties and Productivity of Sorghum under Sorghum-wheat Sequence

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Abstract: *The Long Term Fertilizer Experiment (AICRP) on sorghum-wheat sequence is continued since 1988-89 at Akola. The present experiment was studied to assess the impact of long term manuring and fertilization on soil biological properties and productivity of sorghum during 2009-10 (22nd cycle). The treatments comprised of 50% RDF, 100% RDF, 150% RDF, 100% RDF (-S), 100% RDF + 2.5 kg Zn ha^{-1} to wheat crop only, 100% RD of NP, 100% RD of N, 100% RDF + FYM @ 10 tonnes ha^{-1}, 100% RDF + S @ 37.5 kg ha^{-1}, FYM @ 10 tonnes ha^{-1}, 75% RDF and Control. The results of the present experiment revealed that, application of 100% NPK + FYM @ 10 t ha^{-1} recorded significantly highest microbial count viz; bacteria (30.5 cfu × 107 g^{-1} soil), fungi (15.5 cfu × 104 g^{-1} soil) and actinomycetes (16.25 cfu × 106 g^{-1} soil). The highest soil respiration was found under treatment of 100% NPK + FYM @ 10 t ha^{-1} (41.52 mg kg^{-1}) followed by 150% NPK and FYM @ 10 t ha^{-1}. The soil microbial biomass nitrogen (SMB-N) was highest with the use organics along with chemical fertilizers (249 mg kg^{-1}). The dehydrogenase enzymes activity was influenced significantly with the application 100% NPK + FYM @ 10 t ha^{-1} (47.70 µg TPF g^{-1} 24 h^{-1}) as compared to control (32.62 µg TPF g^{-1} soil 24 h^{-1}). The grain (65.92 q ha^{-1}) and fodder yield (150.95 q ha^{-1}) of sorghum and wheat was increased significantly with the application of 100% NPK along with FYM and 150% NPK.*

Key Words: *Soil microbial biomass, enzyme activity, sorghum, wheat, dehydrogenase.*

INTRODUCTION

Sorghum is the premier food grain crop of the peninsular central India in general and Maharashtra in particular. Increase in production was achieved through increase in area as well as productivity. It is major dual purpose crop which is used as sources of food and also important sources of fodder. Green grains of wani / hurda sorghum at soft dough stage are used for consumptions as a roasted or parched grain. Sorghum is widely grown in various parts of India like Maharashtra, Karnataka, Madhya Pradesh and Rajasthan. Sorghum grains contains about 10.4% protein, 72.6% carbohydrates, 1.9% fat, 5.6-7.3% starch, 1.65% mineral matter. In India, sorghum is grown on an area of 37.70 lakh ha in kharif with an annual production 39.50 lakh tonnes and 1048 kg ha^{-1} productivity (Anonymous, 2007). In Maharashtra, total area under sorghum is 47.20 lakh ha, with an annual production 42.20 lakh tones and 1032 kg ha^{-1} productivity. The nutrients need to be applied in balanced proportion to maintain the productivity of soil. In India the standard ratio for the use of various nutrients has been assumed to be 4:2:1 but it was 5.6:2.2:1 during 2005-06. Adequate plant nutrient supply holds the key for improving the food grain production and sustaining soil health. Integrated use of inorganic and organic sources of plant nutrients has a tremendous potential not only sustaining agricultural productivity and soil health but also substituting part of fertilizer requirement by organics for different cropping systems. Continuous application of chemical fertilizers poses problems like toxicity due to high amounts of salts as a residues of fertilizer and deterioration of physico-chemical properties. Organic manure ameliorates this problem as organic matter helps in increasing adsorptive power of soil for cations and anions particularly phosphate and nitrate. The microbial biomass, which is the sum of all microorganisms present in soil, serves as a temporary sink for nutrients including nitrogen

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and can be considered as an index of soil fertility. Microbial population accounts for only 1-3 per cent of soil organic carbon but it is the eye of the needle through which all the organic material that enters the soil must pass through (Jenkinson, 1988). The continuous use of chemical fertilizers over a long period may cause imbalance in microbial population and there by indirectly affect the biological properties (Manikanchan and Venkataraman, 1972). It is well known that microbes take care of man's agriculture persuades. The production and turnover of the microbes is pivotal to our understanding of nutrient cycling. Studies of enzyme activity in soils are important as they indicate the potential of soil to support biochemical process which are essential for the maintenance of soil fertility (Dkhar and Mishra, 1983). The dehydrogenase enzyme activity is commonly used as an indicator of biological activity in soils. Therefore, studies on the activities of dehydrogenase enzyme in the soil is very important as it may give indication of the potential of the soil to support biochemical processes which are essential for maintaining soil fertility as well as soil health. Keeping in view, the present investigation was aimed to study long term effect of manuring and fertilization on soil biological properties and productivity of sorghum under sorghum-wheat sequence.

MATERIALS AND METHODS

The long term fertilizer experiment under sorghum-wheat sequence initiated during 1988 at National Highway Block, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). Akola is situated in subtropical zone about 307.42 m above MSL and geographically situated on $22^0 42'$ N latitude and 77°02'E longitude. The climate is subtropical semi, total rainfall received during 2009-10 was 699.5 mm. Minimum and maximum temperatures recorded during period of experimentation were 13.6°C and 42.7 °C respectively. The soil of experimental site is medium to deep clayey black soil i.e. vertisol (particularly montmorillonitic type). The initial analysis indicated that soils are low in organic carbon (4.6 g kg ha^{-1}) and available N (120 kg ha^{-1}), very low in available P (8.4 kg ha^{-1}) and high in available K (358 kg ha^{-1}). The treatments consisted of (T_1) 50 % RDF, (T_2)100 % RDF, ((T_3) 150 % RDF, (T4) 100 %; RDF (S free), (T_5) 100 % RDF plus 2.5 kg Zn ha^{-1} to wheat, (T_6) 100 % RD of NP, (T_7) 100 % RD of N, (T_8) 100 % RDF + FYM @ 10 t ha^{-1} (to sorghum only), (T_9) 100 % RDF + sulphur @ 37.5 kg ha^{-1}, (T_{10}) FYM @10 t ha-^{1}, (T_{11}) 75 % RDF and (T_{12}) control. The treatments were given to each crop every year. FYM was added on oven dry basis before sowing of sorghum. It contains 0.58% N, 0.21% P and 0.62% K. Zinc and sulphur was applied through zinc sulphate and gypsum respectively. The experiment was laid out in Randomized block design with four replications having plot size 10 x 10 m^2. Sowing of sorghum was done by drilling. Plot wise surface (0-15 cm) soil samples were collected after harvest of sorghum in 2009-10 (23^{rd} cycle). Soils were analysed for biological properties by using standard procedures. The microbial population was determined by serial dilution plate technique (Dhingra and Sinclair, 1993), CO_2 evolution of soil was estimated by alkali trap method (Anderson,1982), soil microbial biomass carbon (SMBC) was determined by fumigation extraction method (Jenkinson and Powlson, 1976) and dehydrogenase enzyme can be assayed by incubation with Triphenyle tetrazolium chloride (TTC) method (Klein *et al.* 1971). The data was statistically analyzed as per Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Microbial Count

Bacteria

It is well known fact that soil harbours a vast array of living organisms. The application of organics in combination with inorganics favourably helps in augmentation of beneficial microbial population and their activities. The results on bacterial population showed significant effect of incorporation of FYM in combination with 100% RDF. The highest bacterial population (30.5 cfu × 10^7 g^{-1} soil) was recorded in treatment 100% NPK + FYM @10 t ha^{-1} (T_8) followed by 150% NPK (22.75 cfu X10^7) . However, the lowest (6.25 cfu × 10^7 g^{-1} soil) value was recorded in control plot. Application of 100% NPK (T_2) had significant influence on bacterial population over 100% N (T_7), it indicates the favourable effect of balanced fertilization. The decline in microbial population under optimum level of N alone may be due to increased soil acidity and high concentration of nitrogen. Similar results were also reported by (Jain *et al.* 2003), Sharma (1998) and Bedi *et al.* (2009).

Fungi

The fungal population increased significantly due to various treatments. The highest fungal population (15.5 cfu × 10^4) was recorded under 100% NPK + FYM @ 10 t ha^{-1} followed by treatment 150% NPK (13.5 cfu

× 10^4) . The fungal population was increased as the doses of fertilizers increased from 50 per cent to 150 per cent NPK. However, it was recorded significantly lower in the treatment 100% NPK + S @ 37.5 kg ha^{-1} which might be due to fungicidal nature of sulphur. These results are in confirmation with the findings reported by Singh *et al*., 1998. However, the lowest fungal population (4.5 cfu × 10^4 g^{-1} soil) was recorded in control plot. Similar results were reported by Sharma (1998) and Bedi *et al*. (2009).

Actinomycetes

The data (Table 5) in respect of actinomycetes population influenced by long term effect of manures and fertilizers was found to be significant. The highest actinomycetes population (16.25 cfu × 10^6 g^{-1} soil) recorded under 100% NPK + FYM @ 10 t ha^{-1} (T_8) followed by (13.5 cfu × 10^6 g^{-1} soil) 150% NPK. However the lowest value was (5 cfu × 10^6 g^{-1} soil) recorded in control plot. The highest microbial count was recorded in 100% NPK + FYM @ 10 t ha^{-1} might be due to role of FYM played in improving microbial activity. However, in general bacterial count was comparatively higher as that of fungi and actinomycetes. Similar results were reported by Sharma (1998).

Biological Properties

CO_2 Evolution

The CO_2 evolution of various treatments ranged from 22 to 41.52 mg 100 g^{-1} (Table 6). Application of 100% NPK + FYM @ 10 t ha^{-1} and 150% NPK recorded significantly higher CO_2 evolution i. e. 41.52 and 40.42 mg 100 g^{-1} respectively. The treatments of optimal NPK (T_2) dose of fertilizer recorded 44 per cent increase in CO_2 evolution as compared to control, whereas, 100% NPK + FYM @ 10 t ha^{-1} (T_8) increased the CO_2 evolution by 31.30 per cent over optimal NPK. The CO_2 evolved increased with increase in inorganic fertilizer dose from 50 per cent to 150 per cent. However, it was recorded significantly higher under 150% NPK (T_3). Similarly, application of FYM @ 10 t ha^{-1} (T_{10}) had beneficial effect on CO_2 evolution (38.22 mg 100 g^{-1}) followed by 100% NPK + S @ 37.5 kg ha^{-1} (35.47 mg 100g^{-1}). The maximum CO_2 under FYM @ 10 t ha^{-1} as compared to optimal dose of fertilizer may be due to the addition of carbon which helps in improving soil condition. Similar results recorded by Bedi *et al*.(2009), Selvi *et al.* (2004).

Soil Microbial Biomass Carbon

The soil microbial biomass carbon influenced by long term use of manures and fertilizers ranged from 137.81 to 249.01 mg kg^{-1} (Table 6). There was a gradual increase in microbial biomass carbon concentration of the soil for the graded levels of NPK from 50 to 150 per cent. The treatment with 100% N alone recorded lower value of 180.17 mg kg^{-1}. Application of 100% NPK + FYM @ 10 t ha^{-1} and 150% NPK recorded significantly higher microbial biomass carbon i.e. 249.01 and 239.79 mg kg^{-1}, respectively, followed by FYM @ 10 t ha^{-1}. Higher biomass C under FYM @ 10 t ha^{-1} may be due to additive effect organics viz. FYM (Patil and Puranik, 2001). The treatment of optimal NPK dose recorded 57 per cent increase in microbial biomass carbon as compared to control whereas; the integration of FYM with optimal NPK (T_8) increased the biomass carbon by 15.07 per cent over optimal NPK. Selvi *et al.* (2004) also reported increased biomass C due to application of 100% NPK + FYM.

Dehydrogenase Activity (DHA)

Biological activity of soil is the function of number of microorganisms present in soil and their physiological efficiency. Monitoring of dehydrogenases which are respiratory enzymes and integral part of all organisms, is measure of biological activity of soil. The results in relation to dehydrogenase activity are presented in Table 6. The dehydrogenase activity increased with the increase in the doses of fertilizer from 50 to 150% NPK. Application of 100% NPK + FYM @ 10t ha^{-1} recorded significantly highest dehydrogenase activities (47.70 ug TPF g^{-1} soil 24 h^{-1}) than all other treatments. The application of FYM @ 10 t ha^{-1} increased dehydrogenase activity as compared to optimal dose of fertilizer. The treatment 100% NPK (41.19 µg TPF g^{-1} soil 24 h^{-1}), 100% NP (39.57 µg TPF g^{-1} soil 24 h^{-1}), were at par with each other however, these treatments recorded significantly higher DHA than 100% N (36.28 µg TPF g^{-1} soil 24 h^{-1}) treatment, which enforced the balanced application of inorganic fertilizers. The results corroborate with the findings reported by Jain *et al.,* (2003). The dehydrogenase activity was recorded significantly lowest under 100% N as compared to all other treatments except control, which can be attributed to the presence of nitrate and nitrite that serve as alternative electron acceptors (Kukareja *et al*., 1991).

Productivity of Sorghum

The grain and fodder yield of sorghum (Table 3) was significantly influenced by long term manuring and fertilization. Increasing levels of NPK fertilizers from 50 to 150 per cent significantly increased the grain yield of sorghum from 32.14 to 59.12 q ha^{-1}. The

Table 1
Long term effect of manures and fertilizers on microbial population at harvest of sorghum

Treatment		*Bacteria* (*cfu* $\times 10^7$)	*Fungi* (*cfu* $\times 10^4$)	*Actinomycetes* (*cfu* $\times 10^6$)
T_1	50% NPK	9.50	7.25	6.00
T_2	100% NPK	15.5	11.25	11.75
T_3	150% NPK	22.75	13.25	13.5
T_4	100% NPK (S free)	14.75	12.0	10.5
T_5	100% NPK + Zn @ 2.5 kg ha^{-1}	17.75	11.5	12.0
T_6	100% NP	13.0	8.25	8.75
T_7	100% N	8.75	6.25	5.75
T_8	100% NPK + FYM @ 10 t ha^{-1}	30.5	15.5	16.25
T_9	100% NPK + S @ 37.5 kg ha^{-1}	20.25	9.00	12.25
T_{10}	FYM @ 10 t ha^{-1}	22.5	12.5	13.0
T_{11}	75% NPK	12.5	7.75	10.0
T_{12}	Control	6.25	4.50	5.0
	SE (m±)	0.71	0.67	0.60
	CD at 5%	2.05	1.94	1.74

Table 2
Long term effect of manures and fertilizers on soil biological properties at harvest of sorghum

Treatment		*CO_2 evolution* (*mg 100 g^{-1}*)	*SMBC* (*mg kg^{-1}*)	*DHA(µg TPF g^{-1} 24 h^{-1})*
T_1	50% NPK	27.35	197.49	37.60
T_2	100% NPK	31.62	216.39	41.19
T_3	150% NPK	40.42	239.79	46.10
T_4	100% NPK (S free)	29.42	206.40	41.16
T_5	100% NPK + Zn @ 2.5 kg ha^{-1}	32.72	218.70	42.28
T_6	100% NP	28.32	204.39	39.57
T_7	100% N	26.07	180.17	36.28
T_8	100% NPK + FYM @ 10 t ha^{-1}	41.52	249.01	47.70
T_9	100% NPK + S @ 37.5 kg ha^{-1}	35.47	221.05	44.45
T_{10}	FYM @ 10 t ha^{-1}	38.22	227.13	44.48
T_{11}	75% NPK	28.32	199.83	38.69
T_{12}	Control	22.00	137.81	32.62
	SE (m±)	0.73	5.17	0.76
	CD at 5%	2.10	14.88	2.20

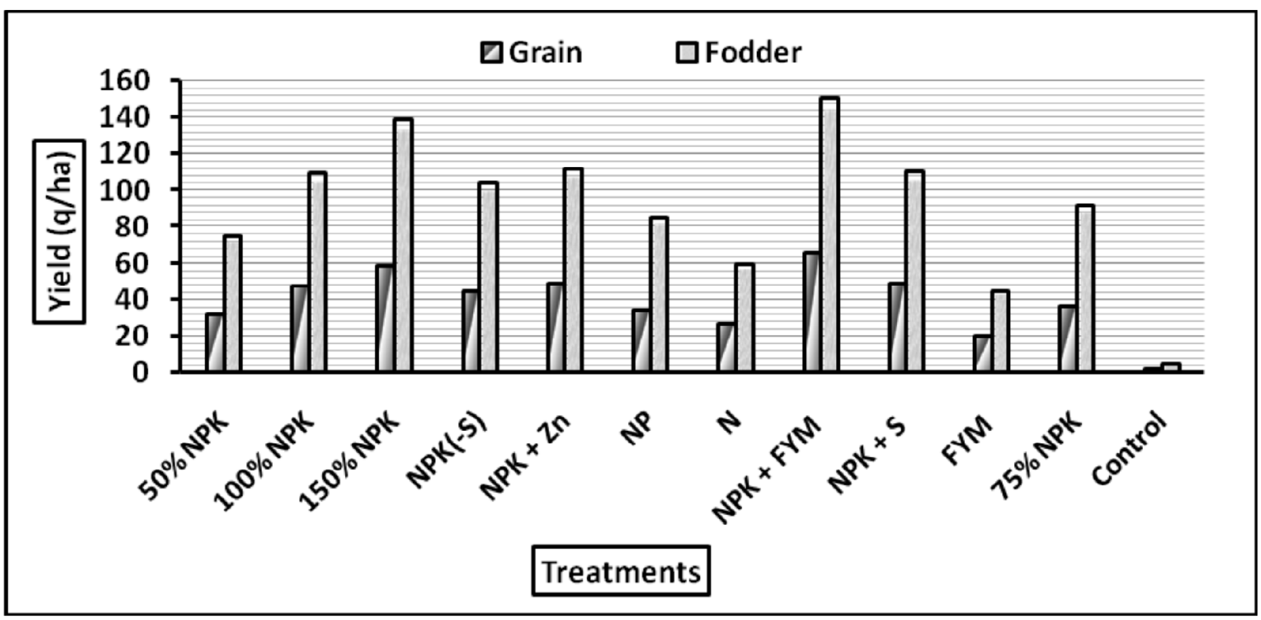

Figure 1: Long term effect manures and fertilizers on grain and fodder yield of sorghum

application of 100% NPK + FYM @ 10 t ha^{-1} recorded significantly higher grain yield i.e. 65.92 q ha^{-1} followed by 150% NPK (59.12 q ha^{-1}) which was superior over rest of the treatments. The yield obtained from 100% N, 100% NP and 100% NPK showed significant increasing trend from N to NPK. This suggests the importance of balance fertilization of primary nutrient in achieving higher productivity of crop. Application of Zn @ 2.5 kg ha^{-1} or S @ 37.5 kg ha^{-1} along with 100% NPK recorded 3.13 per cent and 9.29 per cent increase in grain yield as compared to without Zn and S application. Application of FYM produced significantly lower yield as compared to fertilizer alone. By and large similar trend was observed in case of fodder yield of sorghum. Significantly highest fodder yield of sorghum (150.95 q ha^{-1}) was obtained in treatment 100% NPK + FYM @10 t ha^{-1} followed by 150% NPK (139.52 q ha^{-1}) which was superior over all other treatments. Lowest fodder yield was recorded in control (T_{12}) (5.32 q ha^{-1}). Similar results were obtained by Ravankar *et al.* (2005), More and Sangle (2009).

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