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Dynamics of Soil Nutrients, Uptake and Yield under Organically Grown Rainfed Pearl Millet in Vertisol

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ABSTRACT: *The experiment was laid out with eight treatments replicated thrice in Randomized Block Design during* Kharif, *2011. Treatments comprising of absolute control, 2.5, 5.0 and 7.5 ton FYM ha*$^{-1}$*, 1.0, 2.0 and 3.0 ton Vermicompost ha*$^{-1}$*, and combination of 2.5 ton FYM ha*$^{-1}$ *+ 1.0 ton Vermicompost ha*$^{-1}$*. Soil chemical analysis was carried out at sowing, 45 days after sowing and at harvest of crop. While, nutrient uptake and yield were recorded at harvest. The organic carbon content and available nutrients (N, P and K) in soil were found significantly highest in the treatment receiving 7.5 ton FYM ha*$^{-1}$ *followed by the application of 2.5 ton FYM ha*$^{-1}$ *+ 1.0 ton Vermicompost ha*$^{-1}$*. The soil fertility in terms of nutrient availability was significantly improved with the addition of organic manures over control. The highest yield (grain and fodder) of pearl millet was recorded in treatment 7.5 ton FYM ha*$^{-1}$ *followed by 2.5 ton FYM ha*$^{-1}$ *+ 1.0 ton Vermicompost ha*$^{-1}$*. These treatments found at par with each other. Similarly, maximum nutrient uptake (N, P and K) by pearl millet was also noticed in same treatments. However, increasing levels of FYM and vermicompost increased the nutrient uptake and yield of pearl millet. Highest B:C ratio (2.09) was noticed with the combined application of 2.5 ton FYM ha*$^{-1}$ *+ 1.0 ton vermicompost ha*$^{-1}$ *followed by the application of 7.5 ton FYM ha*$^{-1}$ *(2.00).*

Key words: *Organic farming, soil nutrients, uptake, yield, pearl millet*

INTRODUCTION

The food grain production is decreasing day by day due to deterioration of soil health and imbalanced use of nutrients particularly secondary and micronutrients. Under such situation scientific management of land for soil fertility through organic recycling has to play key role in achieving sustainability in agriculture production (Prasad and Powar, 1991). Soil fertility and organic matter are crucial components of production system. In organic farming system, application of organic matter is found to be altering the soil properties and organic carbon. Under tropical condition, it is very difficult to inverse and maintains the organic carbon content of the soil at high level which has a prime importance in soil fertility. The management of nutrients to maintain productivity and quality in organic farming systems is a challenge that must be met through a combination of organic amendments and management of soil organic matter. The maintenance of soil organic matter is the problem in tropical countries like India, hence, the application of organic residues is essential for the maintenance of fertility level. Pearl millet (*Pennisetum glaucum*) is the most widely grown millet in India, where, it is grown comparatively on large scale under rainfed condition. The use of organic manure not only supply sufficient nutrient but also improve physicochemical and biological properties of soil. Moreover, release of many organic acids during decomposition of FYM convert unavailable soil nutrients into available nutrients (Lakum *et al*., 2011). Keeping above in view, the present investigation was carried out with an objective to know the soil nutrients dynamics and yield of pearl millet as influenced by graded levels of organic manures under rainfed condition.

MATERIALS AND METHODS

A field experiment was conducted at pearl millet Research Farm, College of Agriculture, Dhule, Maharashtra State during *Kharif* 2011 and laid out with eight treatments replicated thrice in Randomized

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Block Design using pearl millet variety GHB-558 with spacing 45 x 15 cm. Treatments were as follows, T_1-Control, T_2-2.5 ton FYM ha^{-1}, T_3-5.0 ton FYM ha^{-1}, T_4-7.5 ton FYM ha^{-1}, T_5-1.0 ton Vermicompost ha^{-1}, T_6-2.0 ton Vermicompost ha^{-1}, T_7-3.0 ton Vermicompost ha^{-1}, and T_8-2.5 ton FYM ha^{-1} + 1.0 ton Vermicompost ha^{-1}. The sowing was done by dibbling method. The required cultural practices (thinning and weeding) were done at proper time. As this was organic farming experiment, no pesticides and insecticides were used throughout the crop growth.

Experimental soil was initially analyzed for its initial properties (Table 1). For this investigation, the farm yard manure and vermicompost were used as organic manures. They were analyzed for chemical and biological properties (Table 2). The organic manures viz., FYM and vermicompost were applied in field as per the treatments before ten days of sowing of crop. The respective doses of manures were applied as per treatments. For estimation of organic carbon and available N, P and K, the soil samples were collected at sowing, 45 DAS and at harvest of crop. Nutrient uptake (N, P and K) and yield (grain and fodder) were recorded at harvest. Physical and chemical properties of soil like mechanical analysis (Bouyoucos 1928) and field capacity (Klute and Dirksen 1986), soil pH, EC, organic C, available N (Subbiah and Asija 1956), Olsen's P and available K (NH_4OAc-extractable) were analyzed following the procedure described by Jackson (1973). The experimental data of soil were statistically analyzed to draw conclusion of significance by using the methods prescribed by Panse and Sukhatme (1995).

Table 1
Physical and chemical properties of the initial soil

Soil properties	*Values*
Mechanical composition (%)	
Sand	32.22
Silt	20.46
Clay	47.35
Texture	Clay
Field capacity (%)	52.13
Chemical properties	
pH	7.8
EC (dSm^{-1})	0.34
Organic carbon (g kg^{-1})	6.1
Available Nitrogen (kg ha^{-1})	186.12
Available Phosphorus (kg ha^{-1})	16.90
Available Potassium (kg ha^{-1})	352.46
Total nitrogen (%)	0.060

Table 2
Chemical and biological composition of FYM and vermicompost

Parameters	*FYM*	*Vermicompost*
Total nitrogen (%)	0.61	1.2
Total phosphorous (%)	0.39	0.42
Total potassium (%)	0.79	0.99
Organic Carbon (%)	12	15
C:N Ratio	19.67	12.50
Fungal count ($\times 10^4 g^{-1}$ soil)	12	9
Bacterial count ($\times 10^7 g^{-1}$ soil)	22	20
Actinomycetes count ($\times 10^6 g^{-1}$ soil)	17	19

RESULTS AND DISCUSSION

The experimental soil was clay in texture with field capacity 52.13%, pH 7.8, EC 0.34 dSm^{-1}, organic carbon 6.1 g kg^{-1}, available N 186.12 kg ha^{-1}, P 16.90 kg ha^{-1} and K 352.46 kg ha^{-1} (Table 1). The locally available organic manures such as FYM and vermicompost were analyzed for the evaluation of the manurial value. The data regarding chemical and biological composition of organic manures are given in table 2. The nitrogen, phosphorus, potassium and organic carbon content were highest in vermicompost. The fungal and bacterial counts were highest in FYM while, higher actinomycetes count was recorded in vermicompost.

Organic carbon and available N, P and K content

The changes in soil fertility in terms of organic carbon, available N, P and K due to addition of graded levels of organic manures were recorded at sowing, 45 days after sowing and at harvest of pearl millet (table 3). The maximum content of organic carbon (7.1 g kg^{-1}), available N (297.30 kg ha^{-1}), available P (23.71 kg ha^{-1}) and available K (596.14 kg ha^{-1}) were recorded in the treatment receiving 7.5 ton FYM ha^{-1} at 45 DAS followed by the application of 2.5 ton FYM ha^{-1} + 1.0 ton vermicompost ha^{-1}. Although, it was noticed that increasing levels of FYM from 2.5 to 7.5 and vermicompost from 1.0 to 3.0 ton ha^{-1} significantly increased the organic carbon, available N, P and K content in soil over control. Similar results were noted at sowing and at harvest stage. The incorporation of various composts indicates a significant increase in the organic carbon content was observed by Srikanth *et al.* (2000). Further, it was observed that the content of organic carbon and available N, P, K were increased with crop growth and gradually declined at harvest of crop indicating the higher turnover at 45 days after sowing. Similar findings were recoded by Patil and

Table 3
Organic carbon, N, P and K influenced by graded levels of organic manures

Treatments	*Organic carbon (g kg⁻¹)*			*Available N (kg ha⁻¹)*			*Available P (kg ha⁻¹)*			*Available K (kg ha⁻¹)*		
	At sowing	*45 DAS*	*At harvest*	*At sowing*	*45 DAS*	*At harvest*	*At sowing*	*45 DAS*	*At harvest*	*At sowing*	*45 DAS*	*At harvest*
T_1	6.06	6.26	6.16	188.30	195.60	190.45	16.90	18.09	17.61	352.71	358.64	348.21
T_2	6.30	6.70	6.50	202.94	230.17	210.88	17.68	21.67	19.67	371.24	410.45	388.15
T_3	6.36	6.76	6.46	205.15	248.30	226.37	17.86	22.32	19.94	382.07	425.70	397.18
T_4	6.40	7.10	6.70	215.26	278.47	243.28	18.36	23.71	20.72	393.72	495.22	435.40
T_5	6.16	6.46	6.36	189.20	210.37	194.85	17.21	20.34	18.42	360.62	375.86	364.38
T_6	6.23	6.50	6.40	196.35	221.45	205.92	17.40	20.85	18.92	364.50	390.46	372.27
T_7	6.26	6.56	6.50	202.47	229.73	209.63	17.62	21.26	19.19	370.12	412.75	387.12
T_8	6.26	7.00	6.60	210.68	270.40	237.83	18.26	23.45	20.43	390.00	467.27	421.48
CD (P=0.05)	0.12	0.15	0.19	2.79	2.13	2.51	0.06	0.17	0.22	1.89	3.13	1.57

Varade (2006). The increase in soil nutrient contents is perhaps due to addition of organic manures which were also stimulated the growth and activity of microorganisms.

N, P and K Uptake

A perusal of the data (table 4) indicated the effect of graded levels of organic manures on nutrient uptake by pearl millet. Application of 7.5 ton FYM ha^{-1} followed by 2.5 ton FYM ha^{-1} + 1.0 ton vermicompost ha^{-1} recorded higher uptake than rest of the treatments. Control treatment recorded significantly lowest N, P and K uptake. During the present study, the highest N (50.85 kg ha^{-1}), P (5.12 kg ha^{-1}) and K (22.71 kg ha^{-1}) uptake by grain and the highest N (62.43 kg ha^{-1}), P (35.19 kg ha^{-1}) and K (225.12 kg ha^{-1}) uptake by fodder was noticed with 7.5 ton FYM ha^{-1}. It was observed that, as the levels of FYM and vermicompost increases, the nutrient uptake was also significantly increases in both grain and fodder over control. This might be due to the higher availability of nutrients under these organic treatments. The findings are in consonance with those of Kumar *et al.* (2007).

Grain and fodder yield

It was revealed from the results (table 5) that the highest grain yield (28.02 q ha^{-1}) was produced with the application of 7.5 ton FYM ha^{-1}(T_4) followed by the treatment (T_8) which received combine application of 2.5 ton FYM ha^{-1} + 1.0 ton vermicompost ha^{-1} (27.21 q ha^{-1}). The yield produced under these both the treatment found at par with each other. The increased in yield might be due to the higher availability of nutrients as previously recorded in this study. Besides these treatments, application of 3.0 ton vermicompost ha^{-1} (T_7) produces the higher yield (24.99 q ha^{-1}). Yield recorded above treatments found significantly higher

Table 4
N, P and K uptake by grain and fodder of Bajra under organic treatments

Treatments	*Grain uptake (kg ha⁻¹)*			*Fodder uptake (kg ha⁻¹)*		
	N	*P*	*K*	*N*	*P*	*K*
T_1 Control	22.17	1.74	7.82	43.36	17.08	154.08
T_2 2.5 ton FYM ha^{-1}	30.74	2.31	12.40	49.12	22.70	182.14
T_3 5.0 ton FYM ha^{-1}	38.42	3.14	16.60	54.31	28.14	191.64
T_4 7.5 ton FYM ha^{-1}	50.85	5.12	22.71	62.43	35.19	225.12
T_5 1.0 ton Vermicompost ha^{-1}	27.84	2.10	10.92	47.36	21.76	178.02
T_6 2.0 ton Vermicompost ha^{-1}	34.31	2.75	14.45	51.93	26.47	186.27
T_7 3.0 ton Vermicompost ha^{-1}	42.69	3.69	15.17	56.25	30.40	198.84
T_8 2.5 ton FYM ha^{-1} +1.0 ton vermicompost ha^{-1}	48.12	4.98	20.82	60.54	34.15	216.57
SE (m) ±	0.87	0.20	0.25	1.66	1.51	0.89
CD at 5%	1.87	0.43	0.55	3.55	3.24	1.91

Table 5
Grain and fodder yield of Bajra as influenced by graded levels of organic manures

Treatments	*Grain yield (q ha⁻¹)*	*Fodder yield (q ha⁻¹)*	*B:C Ratio*
T_1 Control	20.37	53.58	1.89
T_2 2.5 ton FYM ha^{-1}	21.68	56.59	1.80
T_3 5.0 ton FYM ha^{-1}	22.59	62.34	1.81
T_4 7.5 ton FYM ha^{-1}	28.02	64.75	2.00
T_5 1.0 ton Vermicompost ha^{-1}	20.94	60.31	1.82
T_6 2.0 ton Vermicompost ha^{-1}	21.26	60.86	1.85
T_7 3.0 ton Vermicompost ha^{-1}	24.99	62.99	1.70
T_8 2.5 ton FYM ha^{-1} + 1.0 ton Vermicompost ha^{-1}	27.21	63.30	2.09
SE (m) ±	1.38	0.78	
CD at 5%	4.18	2.37	

over control. The grain yield in respect of treatments T_4, T_8 and T_7 were increased over control by 37.53, 33.57 and 22.68 per cent respectively. Although, it was observed that increasing the levels of FYM and vermicompost also increases the grain yield of pearl millet. Similar effect of treatments on fodder yield of crop was recorded with maximum yield (64.75 q ha^{-1}) under the treatment receiving 7.5 ton FYM ha^{-1} (T_4) followed by the treatment (T_8) 2.5 ton FYM ha^{-1} + 1.0 ton vermicompost ha^{-1} (63.30 q ha^{-1}). Fodder yield also increases with the increased in graded levels of organic manures. The fodder yield in respect of treatments T_4, T_8 and T_7 were increased over control by 20.84, 18.14 and 17.56 per cent respectively. Application of organic materials such as FYM and compost increase the yield considerably was also noticed by Dikshit and Khatik (2002) and Gupta *et al.* (2003).

B:C ratio

Benefit: cost ratio was calculated on the basis of cost of production and profit from the respective organic treatments. Data (table 5) indicated that the highest B:C ratio (2.09) was noticed with the combined application of 2.5 ton FYM ha^{-1} + 1.0 ton vermicompost ha^{-1} followed by the application of 7.5 ton FYM ha^{-1} (2.00). The lowest B:C ratio (1.70) was observed for application of 3.0 ton Vermicompost ha^{-1}. The differences in the B:C ratio are attributed to both yield differences and varying costs when different organic manures were added. It is evident that organic manures such as FYM and vermicompost can be used in combination for more profitable income under rainfed conditions.

CONCLUSION

The management of soil organic matter requires active inputs of crop residues and organic amendments to supplement losses through decomposer activities and uptake of nutrient by crop. This is especially true for organic systems relaying almost exclusively on a mineralizable pool of nutrients. The accumulation of soil organic matter under organic amendment can often lead to enhance soil fertility through the sequestration of plant nutrients, especially N, and ultimately soil productivity in terms of crop yield.

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