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Effect of Integrated Nutrient Management Practices on Physico-chemical Properties of Soil under Different Growth Stages of Finger Millet

Chikkaramappa.T.[1], Shivanna, B.[2], Prashanth, G.M.[3] and Prakash,S.S.[4]

[1]Dept. of SS&AC UAS, Bangalore-65
[2,3]Ph.D Scholar, Dept.of SS & AC UAS, Bangalore-65
[4]COA Mandya Dept. of SS&AC UAS, Bangalore-65
E-mail: [1]tcramappa@rediffmail.com, [3]shivannab2009@gmail.com

Abstract: *The field experiment was conducted in kharifseason of 2002 and 2003 to study the effect of integrated nutrient management practices on physicochemical properties of soil under different growth stages of Finger millet grown in eastern dry zone of Karnataka. The results revealed that application FYM+100% Rec. NPK+Azospirillum (T_4) significantly increases the water holding capacity, organic carbon, pH, EC, N, P, K, Ca, Mg and S content of soil under different growth stages of finger millet and it is on par with the treatment receivingsilkworm litter compost+100% Rec. NPK+Azospirillum (T_7).*

1. INTRODUCTION

Finger millet is the third most important millet crop in India next to sorghum and pearl millet, covering an area of 1.27 million hectares with annual production of 1.89 million tones. In Karnataka, it is grown in an area of 0.8 m ha with an annual production of 1.34 m t. Finger millet grown on marginal land provides a valuable resource in times of famine. Integrated nutrient management (INM) is an approach that involves the management of both organic and inorganic plant nutrients for optimal production of cultivated crops, forage and tree species, while conserving the natural resource base essential for long-term sustainability. Integrated nutrient management can reduce plant requirements for inorganic nitrogen fertilizer and reduced use of purchased fertilizer nutrients can result in a significant saving of scarce cash resources for small farmers. It also ensures the conservation and efficient use of native soil nutrients, recycling of organic nutrient flows, enhancing biological nitrogen fixation and soil biological activity.Addition of any form of organics has been found to improve the soil health, soil buffering capacity, water retention capacity, chelation and release of micronutrients. Using biodegradable wastes along with mineral fertilizers have been found to be effective for sustainable crop production in many cereals and pulses. Thus, complimentary use of available renewable sources of plant nutrients in the form of organic sources becomes important in maintaining a proper balance of soil health for sustainable crop production [14]. Farmyard manure and silkworm litter compost act directly in increasing the crop yield by supplying nitrogen, phosphorus and sulphur in available form in addition to micronutrients to the plants through biological decomposition. Nutrients present in FYM and silkworm litter compost are not fully available to the crop in the season of its application. Less than 30 per cent is generally available to first crop.Intensive cultivation and growing of exhaustive crops have made the soil deficient in macro as well as micronutrients. Use of only nitrogenous and phosphatic fertilizers creates nutrient imbalance in soil, particularly of secondary and micronutrients. Hence the present study was taken up to study the effect of integrated nutrient management practices on physicochemical properties of soil under different growth stages of Finger millet in eastern dry zone of Karnataka.

2. MATERIALS AND METHODS

The field experiments were conducted atMuthenahatti village, Kolar district of Karnatakaduring kharifseason of 2002 and 2003.The experimental site is located at latitude of 13°8′ N, longitude of 78°8′ E and at an altitude of 925 m above the mean sea level.The topography of the experimental site was slightly slopy from North to South. The soils of this region are shallow to medium in depth and yellowish red in colour.The soil comes under isohyperthermicoxicpaleustalfs.The experiment was laid out in Randomised Complete Block Design (RCBD) with eight treatments and three replications. The details of the treatment combinations are as follows T_1 :Control, T_2 :FYM+50% Rec. NPK+Azospirillum, T_3 : FYM+75% Rec. NPK+Azospirillum, T_4 : FYM+100% Rec. NPK+Azospirillum, T_5 : Silk worm litter compost+50% Rec. NPK+Azospirillum, T_6 : Silk worm litter compost+75% Rec. NPK+Azospirillum, T_7 : Silk worm litter compost+100% Rec. NPK+Azospirillum, T_8 : 100% NPK only.

Table 1: Initial soil characteristics of experimental site.

Soil characteristics	Values	Methods / References
Mechanical composition (%)		
Coarse sand	48.15	Hydrometer method (Bouyoucos, 1927)
Fine sand	16.28	
Silt	10.70	
Clay	24.87	
Textural class	Scl	
Physical properties		
Maximum water holding capacity (%)	21.66	Keen's Cup method. (Piper, 1966)
Chemical properties		
Soil pH (1:2.5)	6.40	Potentiometry (Jackson, 1973)
Electrical conductivity (dS m-1)	0.05	Conductometry (Jackson, 1973)
Organic carbon (%)	0.33	Wet oxidation method (Jackson, 1973)
Available N (kg ha-1)	213.30	Alkaline potassium permanganate method (Subbaiah and Asija, 1956)
Available P2O5 (kg ha-1)	15.50	Bray's no.1 extractantcolorimetry (Jackson, 1973)
Available K2O (kg ha-1)	169.29	Neutral normal NH4O AC method (Jackson, 1973)
Exchangeable calcium (cmol (P+) kg-1)	3.99	Versenate titration method (Jackson, 1973)
Exchangeable magnesium (cmol (P+) kg-1)	2.82	
Available sulphur (ppm)	4.82	CaCl2 extraction and turbidiometry (Jackson, 1973)

The surface soil samples were collected from each plot randomly at the time of tillering, earhead initiation and harvesting stages of Fingermillet crop and samples were dried in shade, powdered and passed through 2 mm sieve and preserved for further analysis.

3. RESULTS AND DISCUSSION

The initial soil properties of the experimental site showed that soil is slightly acidic (pH 6.40) in nature(Table 1). The organic carbon and electrical conductivity were 0.33 per cent and 0.05 dS m^{-1}respectively. The soil was low in available nitrogen (213.30 kg ha^{-1}), phosphorus (15.50 kg ha^{-1}) and sulphur (4.82 ppm). However the available potassium (169.29 kg ha^{-1}) was found to be medium in the experimental site.

Organic carbon content and water holding capacityof soil were found to vary significantly at tillering, earhead initiation and harvesting stages of Finger milletcrop in both the seasons due to various nutrient management practices (Table 2).

Combined application of FYM, 100% recommended NPK and Azospirillum (T_4) recorded significantly higherorganic carbon content and water holding capacityof soil at different growth stageswhereas the treatment which received only chemical fertilizers (100% NPK alone) recorded significantly lower organic carbon content and water holding capacity.The increase inorganic carbon content of the soil could be attributed to the addition of organic manure which results in decrease in bulk density and increase in porosity of soil [7].Significant increase in organic carbon content of soil due to addition of FYM or silkworm litter compost may beattributed to the higher production of biomass [1].The lower organic carbon content in NPK alone applied plots may be due to production of less biomass [1]The organic carbon status was higher at tillering stages and then decreased at ear head initiation, harvest and then again increased after harvest. The decreased organic carbon at earhead initiation and harvest may be due to rapid oxidation of organic matter [15] and increase in organic carbon at harvest may be due to addition of root and leaf biomass.

Table 2: Effect of integrated nutrient management practices on water holding capacity (%) and organic carbon (%) of soil in Finger millet crop.

Treatments	Kharif-2002						Kharif-2003					
	MTS		EHI		HS		MTS		EHI		HS	
	WHC	OC	WHC	OC	WHC	OC	WHC	OC	WHC	OC	WHC	OC
T1	21.66	0.4	21.66	0.31	20.66	0.29	21.66	0.53	21.66	0.44	21.33	0.42
T2	26.66	0.46	26.66	0.36	25.66	0.35	27.33	0.56	27.33	0.46	26.66	0.44
T3	29.66	0.54	29.66	0.43	27.66	0.42	29.33	0.59	29.66	0.51	29	0.49
T4	32	0.62	32	0.52	31.66	0.5	31.66	0.69	31.66	0.6	31.66	0.58
T5	25.66	0.43	25.33	0.33	25.33	0.31	26.33	0.55	26	0.45	25.66	0.43
T6	29.66	0.5	30	0.4	26.33	0.38	29.66	0.59	29.66	0.49	29.33	0.47
T7	31.66	0.6	31.66	0.5	31.66	0.47	31.66	0.66	31.33	0.56	31.66	0.54
T8	23.33	0.43	23	0.34	23.66	0.3	23.33	0.56	22.33	0.47	22	0.45
SEm±	0.321	0.008	0.396	0.008	0.429	0.009	0.396	0.004	0.381	0.003	0.359	0.003

CD(0.05)	0.974	0.025	1.201	0.024	1.303	0.027	1.201	0.013	1.154	0.01	1.089	0.011

MTS-Maximum TilleringStage EHI-EarHead Initiation HS-Harvesting Stage

Combined application of FYM+100% Rec. NPK+Azospirillum(T_4) shown higher pH (Table 3) and EC at different growth stages. Continuous use of only chemical fertilizers reduced the pH compared to the control. The increase in pH due to FYM application or integration of FYM with fertilizers can be attributed to presence of calcium in FYM or due to reduction of Fe and Mn oxides byformation of organic complexes during the decomposition. The raise in pH under continuous use of FYM was attributed to deactivation of Fe^{3+} and Al^{3+} by chelating effect and concomitant release of basic cation upon its decomposition. The increase in electrical conductivity in treatments other than control can be attributed to addition of salts through fertilizers or through FYM [8].

Application of FYM+100% Rec. NPK+Azospirillum(T_4) found to show higher available nitrogen and phosphorus at different growth stages in both the seasons which was on par with treatment receiving Silkworm litter compost+100% Rec. NPK+Azospirillum (T_7). It may be attributed to the availability of nitrogen through transformation of applied fertilizers, FYM, Silkworm litter compost and biofertilizer. It might also be ascribed to the fact that the addition of mineral nitrogen along with organic sources narrowed the C:N ratio of organic manures and it might have enhanced the rate of mineralization resulting in rapid release of nutrients from the organic matter. However, the available nitrogen status was higher at tillering and earhead initiation stages later it decreased at harvesting stage. The decreasedavailable nitrogen at harvest stage may be due to rapid oxidation of organic matter and high demand for N at flowering and maturity stage [16]. Increase in available P_2O_5 status of soil due to integration ofFYM or Silkworm littercompost and NPK fertilizers is due to enhanced solubalization of native P in soil and additionof P throughdecomposition of organic residues [4].The P_2O_5 status was higher in tillering stage and decreased marginally at earhead initiation stage and drastically reduced at harvest stage in both the seasonBut at the establishment of next crop the P_2O_5 content of soil was increased. This can be attributed to decomposition and utilization of P_2O_5. The decomposition and release of P_2O_5 maintained the high status at tillering stage and then decreased at earhead initiation and harvest because of high demand for phosphorus at later stages. The P_2O_5 status of soil was increased after the harvest of first and second crops of Fingermillet due to addition of organic matter through leaf fall and root biomass.

Table 3: Effect of integrated nutrient management practices on soil pH and EC (dSm^{-1}) on Fingermilletcrop.

Treatments	Kharif-2002						Kharif-2003					
	MTS		PIS		HS		MTS		PIS		HS	
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
T1	6.51	0.08	6.85	0.10	7.18	0.12	6.90	0.11	7.19	0.07	7.21	0.07
T2	6.32	0.19	6.95	0.19	7.35	0.19	6.81	0.20	6.85	0.20	7.41	0.20
T3	6.29	0.23	6.82	0.23	7.39	0.24	6.81	0.25	6.84	0.25	7.43	0.25
T4	6.26	0.29	6.78	0.29	7.43	0.29	6.92	0.31	6.89	0.31	7.48	0.31
T5	6.31	0.20	6.88	0.20	7.35	0.20	6.81	0.20	6.80	0.20	7.41	0.20
T6	6.29	0.23	6.81	0.23	7.38	0.23	6.81	0.25	6.80	0.25	7.43	0.25
T7	6.26	0.29	6.75	0.29	7.44	0.29	6.93	0.30	6.90	0.30	7.46	0.30
T8	6.24	0.24	6.52	0.24	6.83	0.24	6.13	0.22	6.12	0.22	6.59	0.21
SEm±	0.017	0.003	0.013	0.004	0.006	0.005	0.011	0.007	0.015	0.006	0.014	0.003
CD(0.05)	0.051	0.009	0.038	0.011	0.018	0.014	0.032	0.021	0.047	0.020	0.042	0.010

MTS-Maximum Tillering Stage EHI-Ear Head Initiation HS-Harvesting Stage

Table 4. Effect of integrated nutrient management practices on soil available nitrogen (kg ha^{-1}) and phosphorus (kg ha^{-1}) in Finger millet crop.

Treatments	Kharif-2002						Kharif-2003					
	MTS		EHI		HS		MTS		EHI		HS	
	N	P	N	P	N	P	N	P	N	P	N	P
T1	325	7.64	348	5.65	271.7	4.43	269.6	9.79	291.6	8.41	282.2	7.66
T2	347	9.48	384.6	10.8	290.4	9.02	335.5	13.6	343.9	15.4	312.5	14
T3	410.8	10.4	435.9	17.4	303.1	15.4	370	15.4	394	18.5	327.1	16.6
T4	448.5	14	459.6	19.1	314.6	17.2	378.4	17.1	402.4	22.6	348	20.3
T5	396.1	9.3	383.6	10.2	284.5	8.87	329.2	13.3	334.5	14.9	303.1	13.4
T6	396.1	10.2	417	17.1	303.1	14.8	338.6	15.3	382.5	17.2	320.9	15.1
T7	449.5	13.8	457.8	18.5	314.6	16.3	372.7	16.3	397.8	20.6	346	19.5
T8	449.4	9.7	462	8.56	313	7.64	304.1	14.9	361.6	12.6	308.3	10.7
SEm±	9.496	0.147	9.777	0.175	0.769	0.187	1.872	0.114	3.766	0.178	1.504	0.195
CD(0.05)	28.8	0.44	29.659	0.532	2.332	0.569	5.679	0.345	11.425	0.54	4.561	0.591

MTS-Maximum Tillering Stage EHI-Ear Head Initiation HS-Harvesting Stage

The exchangeable calcium and magnesium increased significantly due to integrated application of FYM or silkworm litter compost and inorganic fertilizers (Table 6). It is attributed to the organic matter contains abundant quantity of calcium and magnesium. It is reported that FYM is being a good source of calcium and magnesium, increases calcium and magnesium content of plots added with FYM or Silkworm litter compost. Application of NPK fertilizers alone showed lesser calcium and magnesium content due to replacement of calcium and magnesium by the H^+ due to reduction of soil pH by application of fertilizers [11]. The Ca and Mg status of soils were higher in tillering stage and marginally increased at earhead initiation stage but drastically decreased at harvest stage of the crop. But after establishment of next crop, the Ca and Mg content of soil was increased. This can be attributed to decomposition and utilization of calcium and magnesium from crop residues and added organic manures.

Table 5: Effect of integrated nutrient management practices on soil exchangeable calcium and magnesium (cmol $(P^+)kg^{-1}$) in Finger millet

Treatments	Kharif-2002						Kharif-2003					
	MTS		EHI		HS		MTS		EHI		HS	
	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg
T1	2.80	1.50	2.66	1.45	2.17	1.38	2.62	1.44	2.49	1.41	2.07	1.34
T2	3.51	1.97	3.94	2.51	2.25	1.49	3.81	2.08	4.02	2.59	2.34	1.58
T3	3.97	2.09	4.87	2.60	2.63	1.57	4.10	2.13	5.02	2.72	2.76	1.64
T4	4.51	2.22	5.08	2.80	2.90	1.78	4.68	2.26	5.13	2.91	2.99	1.89
T5	3.47	1.92	3.85	2.53	2.23	1.47	3.78	2.03	3.99	2.57	2.30	1.53
T6	3.91	1.95	4.84	2.56	2.60	1.56	4.01	2.10	4.99	2.69	2.71	1.61
T7	4.47	2.19	5.01	2.76	2.88	1.72	4.60	2.20	5.08	2.87	2.95	1.82
T8	3.54	2.00	3.98	2.57	2.34	1.52	3.89	2.09	4.07	2.61	2.37	1.61
SEm+	0.008	0.007	0.013	0.009	0.008	0.014	0.009	0.008	0.010	0.008	0.015	0.007
CD(0.05)	0.024	0.021	0.040	0.026	0.025	0.043	0.029	0.024	0.029	0.026	0.044	0.022

Table 6: Effect of integrated nutrient management practices on soil available potassium (kg ha^{-1}) and sulphur (ppm) in fingermillet crop.

Treatments	Kharif-2002						Kharif-2003					
	MTS		EHI		HS		MTS		EHI		HS	
	K	S	K	S	K	S	K	S	K	S	K	S
T1	168.85	7.50	157.15	10.69	141.61	7.57	178.04	9.61	157.15	11.50	127.74	7.98
T2	215.87	9.60	203.78	15.16	184.79	12.99	224.50	12.68	217.60	15.03	189.97	13.60
T3	309.13	11.64	303.95	15.29	255.59	13.26	322.87	15.43	317.76	16.65	265.95	15.99
T4	383.40	17.06	373.37	19.73	276.29	19.60	405.84	18.68	397.21	22.67	283.23	19.76
T5	212.42	9.48	203.78	14.07	183.06	12.31	220.85	11.91	210.69	14.89	219.85	13.53
T6	307.40	11.23	298.77	14.84	252.14	13.00	316.04	14.88	307.40	16.38	265.95	14.89
T7	381.67	16.65	367.85	18.95	271.12	16.92	402.39	17.87	386.85	21.66	283.23	19.36
T8	215.87	11.23	205.51	15.29	191.70	13.61	226.23	12.45	208.96	15.56	193.42	14.34
SEm ±	1.921	0.133	1.901	0.153	1.528	0.158	1.244	0.082	1.889	0.158	11.864	0.134
CD(0.05)	5.828	0.404	5.767	0.465	4.635	0.478	3.773	0.249	5.731	0.479	35.989	0.405

Available potassium and sulphur content of soil were found significantly higher in both the seasons ofFinger millet with combined application of FYM+100% Rec. NPK+Azospirillum (T_4) which was on par with T_7 treatment (Table 2).It may be attributed to the buildup of available potassium due to addition of organic manure in combination with fertilizers [4]. Farmyard manure is reported to be not only a source of potassium but also minimizes potassium loss due to leaching by retaining potassium at exchange sites [2].The decrease in available potassium content in treatment of 100%NPK alone (T_8) due to less amount of K being added and loss of K from the soil due to leaching or erosion. The available potassium was found to be higher in tillering stage and decreased marginally at ear head initiation stage and drastically reduced at harvest stage in both theseasons. But after harvest or establishment of next crop, the potassium content of soil was increased. The decomposition and release of potassium from organic manures maintained the potassium status higher at tillering stage and then decreased at ear head initiation and harvest.It is attributed to the fact that plants mine more potassium from soil at later stages. Integrated application of FYM or Silkworm litter compost and inorganic fertilizers significantly increased available sulphur content of the soil [9].It may be due to contribution of sulphur from sulphur containing amino acids of FYM and Silkworm litter compost. Addition of sulphur containing fertilizers along with organics would substantially increase the available sulphur status of the soil. It is also observed from the results that continuous application of inorganic fertilizers alone resulted inhigher available sulphur than the control suggesting substantial contribution of available sulphur from the inorganic fertilizers [16]. The available sulphur status was found to be higher in tillering and marginally increased at earhead initiation stage and drastically decreased at harvest stage of finger millet I[st] and IInd crop. But after sometime of harvest or establishment of next crop, the sulphur content of soil was increased. This can be attributed to decomposition and utilization of sulphur from crop residues and added organic manures.

4. CONCLUSION

Incorporation of organic manures combined with fertilizers and biofertilizers significantly increased the water holding capacity, organic carbon, pH, EC, N, P, K, Ca, Mg and S content of soil at different growth stages of Fingermillet grown in two seasons. The available status of different nutrients varied under different stages due to utilization by the crop and mineralization of the nutrients from crop residues and added organic manures.

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