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Efficacy of long-term integrated plant nutrient management on importan soil properties of an Inceptisol

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Abstract: A long-term field experiment conducted since 1972 on Vertic Ustropep indicated that application of 10 t ha^{-1} of farmyard manure along with 100 per cen NPK recorded significantly lower bulk density. Farm yard manure application wit 100 per cent inorganics increased the hydraulic conductivity, water stable aggregates porosity and water holding capacity. There was increase in CEC, organic carbon an total N content of soil due to incorporation of organics with inorganics. There wa no marked changes in soil pH and EC due to various treatments. Available majo and micronutrients increased significantly when organics was incorporated along with inorganic sources of nutrients.

Key words : Long term effect, Fertilizers, Manures, Soil properties.

Introduction

With the advent of green-revolution which triggered all types of resource management to meet the requirements of high yielding and potentialy responsive crop varieties, a need arose to provide data base information on changes in soil fertility and productivity under intensive cropping to serve as an input for decision support system on agricultural policy. Keeping this in view, the Indian Council of Agricultural Research in colloboration with State Agricultural Universitieis initiated the All India Co-Ordinated Research Project on Long Term Fertilizer Experiments (LTFE) in 1972 in different eleven centres including Coimbatore centre. Long term use of fertilizers and manures is known to maintain soil fertility and soil productivity (Bellakki *et al.* 1998). India is a vast country with many soil groups, wide varieties of crops grown and more wide are the sources of organic materials. The objectives of field experiment, the resutls of which are reported here, were to assess the long term use of organics for its beneficial effect on soil and crop yield in an Inceptisol.

Materials and Methods

The investigation was carried out in the on-going long-term fertilizer experiment laid out since 1972 for studying the effect of various fertilizer treatments on a fixed cropping rotation consisting finger millet-maize-cowpea. The climate of this area is semiarid tropical with a dry season from January to June and wet season up to December. Temperature varies from 31° (May-June) to 21°C (December-January). Th soil of the experimental site is fine montmorilloniti isohyperthermic, Vertic Ustropept sitated at 11° latitude, 77°E longitude and 427 m above MSI The ten treatments with four replications i a randomized block design are presented i table 1.

Application of fertilizers is being mad for each crop in rotation; farmyard manure applied only once in a year. Fertilizers wer surface applied on the sides of the ridge The plots were of 10m x 20m size with m wide strip separating each replication. Th soil samples collected after 26th cropping cycl were analysed for physical and chemical propertie using standard procedures. The important initia characteristics of the soil were as follows: pH 8.2, EC 0.20 dSm^{-1}, CEC 25.20 C mol (p+ kg^{-1}, $KMnO_4$N, Olsen-P and NH_4OAc-K wer 89, 5.5, 405 mg kg^{-1} respectively, sandyclay loam texture and DTPA-Zn (2.58 mg kg^{-1} and Mn (2.74 mg kg^{-1}) were in fair supply in soil but the availability of Cu (0.42 mg kg^{-1}) and Fe (2.74 mg kg^{-1}) was insufficien to meet the crop needs. The data were subjected to statistical scrutiny.

Results and Disucussion

Soil Physical Properties (Table 2)

The lowest bulk density (1.30 Mgm^{-3}) was recorded with farmyard manure incorporatio along with 100 per cent NPK (T_8), whereas

Table 1. Treatment details

Treatment No.	Treatments		
	Finger millet	Maize	Cowpea
T_1	45:22.5:8.75 kg N, P_2O_5 & K_2O ha^{-1}	67.5:33.75:17.5 kg N, P_2O_5 & K_2O ha^{-1}	12.5:25:0 kg N, P_2O_5 & K_2O ha^{-1}
T_2	90:45:17.5 kg N, P_2O_5 & K_2O ha^{-1}	135:67.5:35 kg N, P_2O_5 & K_2O ha^{-1} (RDF)	25:50:0 kg N, P_2O_5 & K_2O ha^{-1} (RDF)
T_3	135:67.5:26.25 kg N, P_2O_5 & K_2O ha^{-1}	202.5:101.25:52.5 kg N, P_2O_5 & K_2O ha^{-1}	37.5:75.0 kg N, P_2O_5 & K_2O ha^{-1}
T_4	90:45:17.5 kg N, P_2O_5 & K_2O ha^{-1} + HW	135:67.5:35 kg N, P_2O_5 & K_2O ha^{-1} + HW	25:50:0 kg N, P_2O_5 & K_2O ha^{-1} HW
T_5	90:45:17.5 kg N, P_2O_5 & K_2O ha^{-1}	135:67.5:35 kg N, P_2O_5 & K_2O ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}	25:50:0 kg N, P_2O_5 & K_2O ha^{-1}
T_6	90:45 kg N, P_2O_5 ha^{-1}	135:67.5 kg N, P_2O_5 ha^{-1}	25:50:0 kg N_1 P_2O_5 & K_2O ha^{-1}
T_7	90 kg N ha^{-1}	135 kg N ha^{-1}	25 kg N ha^{-1}
T_8	90:45:17.5 kg N, P_2O_5 & K_2O ha^{-1} + FYM @ 10 t ha^{-1}	135:67.5:35 kg N, P_2O_5 K_2O ha^{-1}	25:50:0 kg N_1 P_2O_5 & K_2O ha^{-1}
T_9	90:45:17.5 (-S) kg N, P_2O_5, K_2O ha^{-1}	135:67.5:35 (-S) kg N, P_2O_5, K_2O ha^{-1}	25:50:0 (-S) kg N_1 P_2O_5 & K_2O ha^{-1}
T_{10}	Absolute control	Absolute control	Absolute control

RDF : Recommended dose of fertilizer; HW : Hand weeding; FYM : Farm yard manure

the highest bulk density was recorded (1.44 Mg m^{-3}) in control (T_{10}) and 100 per cent NPK (-S) treatments. Lowering of bulk density in organic manure applied with NPK plots might be due to higher organic C, more pore space and good soil aggregation. Sheeba and Kumarasamy (2001) observed a decrease in bulk density with increase in organic matter content. The changes in bulk density in NPK applied plots were found to be non-significant. Continuous application of organics in combination with inorganics significantly increased the hydraulic conductivity of soil. The increase in hydraulic conductivity was due to addition of organic matter and subsequent increase in porosity of soil (Bhatia and Shukla, 1982). There was a gradual increase in hydraulic conductivity values with increase in the NPK content from 50 to 150 per cent. The water stable aggregates ranged from 72.64 in control to 83.62 per cent in FYM + 100 per cent + NPK. Porosity, water stable aggregates and water holding capacity were significantly higher in plots where organics was incorporated with inorganics than the fertilizer alone. This may be ascribed to the improvement in physical condition of the soil and to the increased organic matter content. These observatios were in confirmity with the findings of Badanur *et al.* (1990) and Bellakki *et al.* (1998).

Soil Chemical Properties (Table 3)

The highest organic carbon (7.0 g kg^{-1}) was observed due to continuous application of fertilizers incorporated with FYM, whereas the lowest (4.2 g kg^{-1}) was recorded in the control plot. The increase could be attributed to addition of organic matter and also due to better root growth, more plant residues after harvest of

Table 2. Physical properties of the inceptisol after 26th cropping cycle in a long term fertilizer trial

Treatments	Bulk density (mg m^{-3})	Hydraulic conductivity (cm hr^{-1})	Water holding capacity (%)	Porosity (%)	Water stabl aggregates (%)
T_1	1.42	1.50	49.26	52.38	80.85
T_2	1.40	1.81	49.76	56.14	82.26
T_3	1.41	1.87	50.38	56.98	81.48
T_4	1.39	1.62	48.48	55.14	81.24
T_5	1.38	1.99	49.76	56.39	82.90
T_6	1.42	1.66	44.36	52.11	80.48
T_7	1.36	1.73	44.20	52.24	80.40
T_8	1.30	2.61	52.58	58.85	83.62
T_9	1.44	1.83	48.50	56.21	79.48
T_{10}	1.44	1.44	44.65	50.18	72.64
CD (P=0.05)	0.063	0.22	2.52	2.04	2.86

Table 3. Chemical properties of the inceptisol after 26th cropping cycle in a long term fertilizer tria

Treatments	pH	EC (dSm^{-1})	Org. C (g kg^{-1})	CEC (C mol (P^+) kg^{-1})	Total N (per cent)	Exchangeable cations (C mol (P^+) kg^{-1})	
						Ca^{2+}	Mg^{2+}
1972 (Initial)	8.26	0.20	3.0	25.20	0.0428	-	-
T_1	8.29	1.17	5.4	24.47	0.0612	24.32	14.00
T_2	8.26	1.18	5.8	26.52	0.0708	26.24	15.84
T_3	8.27	1.28	6.7	24.64	0.0726	25.64	15.26
T_4	8.33	1.20	5.4	26.38	0.0674	25.92	15.83
T_5	8.32	1.25	5.6	25.83	0.0686	26.47	15.15
T_6	8.32	1.21	5.2	24.38	0.0692	24.13	14.06
T_7	8.20	1.10	5.0	24.03	0.0702	23.19	13.50
T_8	8.26	1.24	7.0	29.11	0.0754	29.23	16.57
T_9	8.35	1.33	5.2	25.33	0.0644	25.98	14.43
T_{10}	8.33	1.08	4.2	23.69	0.0530	21.73	12.68
CD (P=0.05)	NS	0.045	0.41	1.1	0.0037	1.19	1.05

the crop and indirect influence on the physico-chemical characteristics of the soil. (Bhandari *et al.* 1992). Continuous addition of 10 t FYM per hectare (to fingermillet alone) with recommended dose of NPK incerased the organic C content by 133 per cent, the increase were 93 per cent and 40 per cent in 100 per cent NPK and control respectively. Incerase in fertilizer levels from 50 to 100 per cent RDF gradually increased the CEC of soil due to indirect addition of organic matter through plant roots. The combined application of organics and inorganic sources of nutrients resulted in significant increase in CEC over control. Similar increase in CEC due to inorganic manuring has earlier been reported by Subramanian and Kumarasamy (1989). This may be attributed to the build-up of soil humus due to application of organic manure and higher amounts of crop residues. The CEC was the lowest when 100 per cent N only was added and in control. Sharma *et al.* (1988) also reported the same, while comparing the CEC of plots receiving 100 per cent N and 100 per cent NP, a considerable increase in CEC was evident in plots receiving P in addition to N, probably due to better proliferation of

roots with consequent higher addition of organic matter to the soil and party ascribed to the P source (SSP) which contain appreciable quantities of Ca and Mg. This is in confirmity with the results of Udayasoorian *et al.* (1989).

Continuous addition of different levels of inorganics alone and with FYM did not alter the soil pH significantly. This is in accordance with the findings of Prasad *et al.* (1983) which was due to the fact that the quantity and nature of fertilizers being applied are such that they do not alter the soil pH appreciably. Besides, the experimental soil itself is highly buffered due to its calcareous nature. There was a considerable increase in salt content observed with FYM + 100 per cent NPK and a gradual increase with increasing levels of inorganics. Such an increase in salt content was observed earlier by Bhriguvanshi (1988) in sandy loam and clay loam soils.

The total N content was the highest in plots receiving optimal NPK + FYM which is in conformity with studies of Chaudhary *et al.* (1981) who reported that continuous manuring with organics especially FYM besides compensating the losses of soil N due to crop removal was able to improve the soil N status. Besides, the NPK application had also aided in build up to soil N availability especially when applied at higher levels (Verma *et al.* 1987).

The exchangeable Ca and Mg increased with the application of 100 per cent NPK + FYM. This might be due to the high adsorptive capacity of FYM which have adsorbed the Ca and Mg that would otherwise be leached thus making them available to plant roots when needed. Prasad and Singh (1981) reported that the application of FYM + NPK had increased the level of exchangeable Ca and Mg. The lower Ca and Mg contents in N applied plots, may be due to the enhanced uptake of Ca and Mg by crops (Patiram and Singh, 1993). Choromanska *et al.* (1987) reported a decline in exchangeable Ca and Mg contents in plots continuously fertilized especially in the upper 20 cm of the soil.

Soil Fertility (Table 4)

The highest available N content of the soil compared the initial value was due to the application of 100 per cent NPK + FYM which was due to the higher organic carbon content. Also the N content was enhanced with graded levels of NPK (Kapur *et al.* 1986). Besides FYM @ 10 t ha^{-1} on an average had added around 50 kg N every year. Consequently, the crop yield and biomass addition were higher resulting in marked improvements in the organic C and total N content of soil. The favourable soil conditions due to FYM addition might have helped in the mineralisation of soil N leading to the build up of higher available

Table 4. Content of available nutrients on the Inceptisol after 26th cropping cycle in a long term fertilizer trail

Treatments	Major nutrients (kg ha^{-1})			Micro nutrients (mg kg^{-1})			
	N	P_2O_5	K_2O	Zn	Fe	Mn	Cu
T_1	192	7.46	548	0.52	5.04	16.32	0.92
T_2	206	8.94	556	0.60	5.72	16.22	0.96
T_3	224	13.00	560	0.64	5.80	16.06	0.96
T_4	188	9.44	558	0.48	4.98	15.14	0.90
T_5	196	10.48	548	0.48	4.98	15.14	0.90
T_6	194	1012	546	0.48	4.76	14.98	0.90
T_7	160	3.64	502	0.42	4.40	15.28	0.78
T_8	220	19.48	578	1.06	5.84	18.46	0.94
T_9	184	12.16	550	0.54	4.90	15.94	0.84
T_{10}	180	3.64	538	0.34	3.94	12.96	0.70
CD (P=0.05)	18.0	1.27	26.9	0.225	0.587	1.30	0.155

N (Bharadwaj and Omanwar, 1994). The build up in available P compared to the initial due to addition of 100 per cent NPK + FYM might be due to FYM as it, itself the direct source of P which have solubilized the native P during the process of decomposition through release of various organic acids (Bellakki *et al.* 1998). The available K content of the soil was significantly increased on combined application of FYM and inorganics, though a depletion over years was observed. This was due to the additional K being added through the FYM and also could be due to minimised losses of K through leaching as a result of fixation of K ions on the cation exchange sites due to organic manure addition (Aravind, 1987).

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