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Effect of continuous application of organic and inorganic fertilizers on micronutrient status of an Inceptisol

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Abstract

A long term fertilizer experiment laid down on an Inceptisol at Tamil Nadu Agricultural University, Coimbatore during 1972 in a randomised block design for growing finger millet-maize-cowpea (fodder) in sequence involving varying doses of N, NP, NPK with FYM (finger millet) and Zn (maize), indicated that there was a sharp decrease in DTPA-Zn and an increase in Fe, Cu and Mn content of the surface soil after 25 yrs. Application of $ZnSO_4$ to maize resulted in an increase in the available Zn content of the soil, whereas 100% NPK+FYM increased DTPA-Fe, Cu and Mn contents. There was no significant difference in micronutrients availability within the graded levels of NPK but control plot had lower availability of micronutrients.

Additional key words : Long term fertilizer experiments, cropping systems, nutrient management systems.

Introduction

The principal aim of Long Term Fertilizer Experiments (LTFE) set up in the country in 1885 has been to evaluate the long term effect of the organic and inorganic manuring on crop production and soil health under high-input soil management technology. To carry out these experiments the ICAR sponsored the All India Co-ordinated Research Project on Long Term Fertilizer Experiments (Nambiar and Abrol 1989, Nambiar 1994) in different agro climatic regions of India since 1971. The results from permanent plot experiments conducted in India during 1885-1987 indicated a declining trend in productivity even under balanced application of N, P and K fertilizers. One of the reasons for deterioration in productivity was found to be associated with micronutrient deficiencies under intensive cropping system. Yadav and Alok Kumar (1998) reported that the depletion rate of DTPA-extractable micronutrients was higher in soils treated with chemical fertilizers alone as compared to the plots treated with green manures and fertilizers after completion of 12 cycles of rice - wheat sequence in an Inceptisol. Zinc had a pronounced effect on maize crop cultivated on Ustochrepts (Brar and Biswas 1997, Brar and Pasricha 1998). A decline in DTPA extractable Zn and no significant changes in DTPS - extractable Fe, Mn and Cu (Nand Ram 1998) in Aquic Hapludoll was reported in the on-going

Long Term Fertilizer Experiment at Pantnagar. Brar *et al.* (2001) reported that the application of FYM in conjunction with 100% NPK raised its initial DTPA extractable Zn level of 1.10 to 1.70 mg/kg after 29 cycles of crop rotations. The DTPA extractable Cu and Fe content of the soil also increased whereas the DTPA-extractable Mn decreased in all the treatments of Long Term Fertilizer Experiment which is in progress since 1971 in loamy sand (Ustochrept) soil. It is essential that in such LTFE which reflects an intensive system of crop husbandary, monitoring the changes in available micronutrients are to be made periodically (Sharma *et al.* 1985). So far very few attempts have been made in the ongoing LTFE operations in Coimbatore centre and hence, the present investigation was undertaken to study the long term effect of application of N, P, K and FYM to finger millet - maize-fodder cowpea annual system on the changes in soil available micronutrient status in their 23rd cycle.

Materials and methods

The experiment is located in field No. 37 of the Eastern block of TNAU farm, Coimbatore at an elevation of 426.7 m above MSL. It is dark greyish brown, deep, imperfectly drained, sandy clay loam in texture and developed from reddish brown calcareous alluvial material. The soil moisture regime is Ustic and temperature regime is isohyperthermic. The soil reaction at the start of the experiment was slightly alkaline. There were 10 treatments viz. T_1-50% NPK; T_2-100% NPK (optimal); T3:150% NPK; T4:100% NPK with hand weeding, T5:100% NPK + $ZnSO_4$ (maize); T6:100% NP; T7:100% N alone; T8:100% NPK+FYM (finger millet); T9:100% NPK (S free) and T10:Control, replicated 4 times in a randomized block design applied to finger millet-maize-cowpea (fodder) sequence in a plot size of 200 m^2 (20x10m). The soil samples were analysed as per the standard procedures (Table 1).

The optimal amounts of N, P_2O_5 and K_2O (100% NPK) were 90:45:17.5, 135:67.5:35 and 25:50.0 kg ha^{-1} for finger millet, maize and cowpea (fodder), respectively. Urea, single super phosphate and muriate of potash were used in all the treatments as sources of N, P and K, respectively, except in 100% NPK (S free) treatment where DAP, urea and muriate of potash were the nutrient sources. $ZnSO_4$ is applied @ 25 kg ha^{-1} to maize and FYM @ 10.0 tonnes ha^{-1} to finger millet. In 100% NPK, treatment, weeding was done by hand, whereas in other plots chemical weed control was followed. Statistical analysis was done as per the standard statistical procedure (Panse and Sukhatme 1978).

Results and discussion

The salient properties of the initial soil have been presented in Table 1. The micronutrient status of the soil is discussed as under :

Table 1. Physical and chemical properties of the initial soil

Particulars	Content	References
Physical properties		
Clay (%)	32.60	Piper (1966)
Silt (%)	4.80	
Fine sand (%)	15.10	
Coarse sand (%)	39.40	
Textural class	Sandy clay loam	
Physical & chemical properties		
PH	8.20	Jackson (1973)
EC (d S m^{-1})	0.20	Jackson (1973)
CEC (c mol (p^+)/kg)	25.20	Piper (1966)
Fertility properties		
Organic C (%)	0.30	Walkley and Black (1934)
Total N (mg/kg)	428.00	Piper (1966)
Total P (mg/kg)	490.00	Jackson (1973)
Total K (mg/kg)	3964.00	Jackson (1973)
$KmnO_4$–N (mg/kg)	89.00	Subbaiah & Asija (1956)
Olsen-P(mg/kg)	5.50	Olsen *et al.* (1954)
NH_4 Ac–K (mg/kg)	5.50	Olsen *et al.* (1954)
DTPA–Zn (mg/kg)	2.58	-
DTPA–Mn (mg/kg)	2.74	Lindsay & Norvell
DTPA –Fe (mg/kg)	2.74	(1978)
DTPA – Cu (mg/kg)	0.42	

Available Zinc : The data in Table 2 indicated significant depletion of available zinc (0.31 ppm) from its initial status (2.82 ppm) after the harvest of 67th crop. There was no marked difference within the graded levels of NPK application from 50% to

150% on available zinc content of the soil. Skipping the application of P lowers the DTPA-Zn content of the soil, whereas the changes in DTPA-Zn due to skipping of K was not significant. The available zinc in soils under different treatments declined further after completion of 23rd cycle of fingermillet-maize-fodder cowpea. The decrease in available zinc content with N/NP/NPK+ hand weeding NPK (S free) treatments as compared to control plot was not significant whereas the increase in zinc with 100% NPK+FYM was significant. Prasad and Singh (1980) showed with experimental evidences that the addition of FYM containing 40 ppm Zn at 20 tonnes/ha contributed 1.8 ppm of DTPA-Zn. However with 100% NPK+$ZnSO_4$ treatment, the soil Zn availability was maintained at a higher level than other treatments for all crops. The availability of Zn has possibly increased partly due to the release of Zn from Zn_3 $(PO_4)2$ $4H_2O$ through dissolution of zinc phosphate as reported by Jurinak and Invouye (1962).

Further, Zn addition has resulted only in enrichment of soil Zn status, whether it is present in the soil solution form or in the exchangeable form or both. The stimulatory effect of higher levels of N/K on plant growth as reflected in higher crop yields, also naturally increased Zn requirements of crops and thus reduced the soil Zn reserve and availability (Tisdale *et al.* 1993). The FYM/$ZnSO_4$ applied plots registered higher DTPA-Zn values in soil (Kher 1993) which may be due to their higher content of Zn. FYM significantly increased the applied and native micronutrients and the increase was in the order of Zn>Mn>Cu>Fe. FYM addition may have resulted in the formation of organometallic complexes of higher extractability (Mann *et al.* 1978). The enhancement in available Zn observed due to the addition of FYM can be ascribed to the release of organically bound Zn released during decomposition.

Available Iron : An increase in available Fe content (Table 2) was observed even in the control plots with continuous cropping as compared to Fe status at the start of the experiment. The mean of three crops in the 23rd cycle ranged from 3.72 to 4.16 mg kg^{-1}. Continuous application of increasing levels of NPK increased the available iron content, but the magnitude of increase between the graded levels of NPK was not significant. The skipping of K fertilizer viz., NP treatment recorded a higher value of DTPA-Fe (4.32 mg kg^{-1}) than the respective N application. The build up in Fe content in the soil occurred in the plots receiving fertilizer P in combination with N or NK. Application of fertilizer K did not produce any signficant effect on available Fe status. The enhancement in DTPA-Fe due to the addition of organic substances may be ascribed to their ability to form stable water soluble complexes preventing the reaction of soil constituents and also increasing the Fe content by releasing it from the native reserves in the presence of Zn (Gupta *et al.* 1988).

The available Fe status under different treatments after completion of 23rd cycle of finger millet-maize-fodder cowpea i.e. after fodder cowpea harvest was 3.79 to 4.98 mg kg^{-1} and that was higher than the DTPA-Fe recorded after the harvest of maize crop. Maximum increase was noticed in 100% NPK+FYM treatments as compound to initial DTPA-Fe. The trend of increasing Fe content among different treatments was almost the same as observed for all the crops in the cropping system. The increase in Fe status can be attributed to the increase of Fe in these plots as a contaminant through super phosphate (Arora *et al.* 1975) The presence of an appreciable quantity of iron in farmyard manure may have enhanced the Fe availability by the transformation of Fe in solid phase to soluble metal complexes (Nagendra Rao *et al.* 1988) which are readily available by extractants such as DTPA, citric acid, etc.

Table 2. Effect of treatments on available Zn and Fe (ppm) of the surface soil (0-15 cm)

Treatments	Available Zn				Available Fe			
	Finger millet (65th)	Maize (66th) (67th)	Fodder (67th)	Mean of all crops	Finger millet (65th)	Maize (66th)	Fodder cowpea	Mean of all crops
T_1	0.42	0.40	0.49	0.44	4.12	4.20	4.34	4.22
T_2	0.48	0.46	0.44	0.46	4.20	4.14	4.38	4.24
T_3	0.51	0.48	0.47	0.49	4.21	4.18	4.06	4.15
T_4	0.40	0.39	0.42	0.40	3.80	3.68	4.62	4.03
T_5	1.58	2.68	2.44	2.23	3.92	3.56	4.52	4.00
T_6	0.42	0.42	0.39	0.41	3.90	4.45	4.62	4.32
T_7	0.32	0.31	0.37	0.33	3.76	3.42	4.12	3.77
T_8	0.54	0.56	0.72	0.61	3.92	3.58	4.98	4.16
T_9	0.34	3.00	0.37	0.35	3.90	3.74	3.79	3.81
T_{10}	0.26	0.28	0.39	0.31	3.64	3.68	3.84	3.72
SED	0.05	0.05	0.06	-	0.16	0.16	0.15	-
CD (P=0.05)	0.11	0.09	0.12	-	0.33	0.32	0.31	-

Available Copper : Available Cu content of the soil has increased due to different treatment combinations (Table 3). The Cu content in the control plot increased (0.75 ppm) from its initial content (0.42 ppm) after growing 67 crops in succession. There was not much variation among the treatments in available Cu content after all the crops. The effect of graded levels of NPK was not significant.

Application of P/K did not show any significant effect on available copper content of the soil after all the crops. The effect of FYM along with 100% NPK on available Cu was at par with NPK application alone. The absence of pronounced effect by addition of FYM may be due to the formation of organo-metallic complexes (Gupta *et al.* 1988). The available copper content of the control plot as well as of all other treatment plots were found to increase as compared to the initial value.

Available Manganese : The available Mn content also increased from its initial status under different fertiliser treatments (Table 3). The Mn after the harvest of 65, 66 and 67th crops varied from 12.82 to 17.46, 13.04 to 16.20 and 13.16 to 15.92 mg kg^{-1} respectively. The mean of all the three crops showed that the maximum increase was 16.47 mg kg^{-1} in 100% NPK+FYM treatment whereas in the control plot, the increase was lower (13.01 mg kg^{-1}). There was no definite trend of increase in available Mn content within the graded levels of NPK.

Table 3. Effect of treatments on available Cu and Mn (ppm) of the surface soil (0-15 cm)

	Available Zn				Available Fe			
Treat ments	Finger millet (65^{th})	Maize (66^{th})	Fodder (67^{th})	Mean of all crops	Finger millet (65^{th})	Maize (66^{th})	Fodder cowpea (67^{th})	Mean of all crops
T_1	0.88	0.89	0.91	0.89	16.32	15.84	15.18	15.78
T_2	0.88	0.88	0.90	0.89	15.48	14.12	14.96	14.85
T_3	0.92	0.90	0.91	0.91	16.16	16.20	15.75	16.04
T_4	0.80	0.84	0.91	0.85	14.60	14.28	14.80	14.56
T_5	0.78	0.80	0.95	0.84	15.78	16.16	15.92	15.95
T_6	0.76	0.74	0.87	0.79	15.00	15.08	15.14	15.07
T_7	0.88	0.75	0.86	0.83	15.04	14.32	14.78	14.71
T_8	0.88	0.92	0.93	0.91	17.46	16.04	15.92	16.47
T_9	0.74	0.76	0.87	0.79	15.68	14.24	14.98	14.97
	0.70	0.72	0.84	0.75	12.82	13.04	13.16	13.01
T_{10}	0.04	0.04	0.04	-	0.82	0.60	0.38	-
SED CD (P=0.05)	0.08	0.08	0.09	-	1.66	1.23	0.79	-

The available Mn increased with the addition of FYM. This is because addition of organic matter releases Mn^{2+} bound to organic legends and accelerates the reduction of Mn^{4+} to Mn^{2+}. The increased availability of Mn may be due to the extended period of composting of organic manure which readily liberated the Mn into labile pool (Selvi and Augustine Selvaseelan 1997).

Conclusions

The results of the present study indicate that continuous addition of $ZnSO_4$ to maize crop alone resulted not only in the increae of DTPA-Zn content in the soil but also sustained it at a higher level. The incorporation of 100% NPK+FYM in a long run, increased the availability of micronutrients in soil.

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