

Change in Available Micronutrient Status Over Years Under Long Term Fertilizer Management

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Abstract

The long term fertilizer experiment, which was initiated in 1986-87 with fingermillet-maize sequence completed twenty crop cycles. The soil (Typical Kandiestalfs) was sandy clay loam texture with initial pH of 6.17. Initial available N, P and K contents of the soil are 256.7, 34.3 and 123.1 kg/ha respectively. The surface samples (0—15 cm) collected after 1986, 1996 and 2006 cropping sequence were analyzed for available micronutrients. The results indicated that although, the available zinc increased significantly in the initial years till 1996, but later decreased significantly over the years in all the treatments except in treatment T₈ (100% NPK + FYM) and T₁₀ (100% NPK + FYM + Lime). The available iron increased significantly over first ten years with application of inorganic and organic source of nutrients but subsequent change from 1996 to 2006 was non-significant while a definite trend of significant decrease in the available manganese over the years was observed in all the treatments. The available copper, zinc, iron and manganese were found to be negatively correlated with pH, exchangeable Ca and Mg but positively with exchangeable acidity. Significant positive correlation was recorded only with available zinc in spite of phosphorus build up.

Key words : Long term fertilizer experiment, Micronutrient, Finger millet-maize sequence, Phosphorus build up, NPK.

Productivity of food grains has reached stagnation in the recent years, may be attributed to unscientific method of fertilizer management and reduction in use of organic manures. The micronutrient deficiencies are being reported especially with high yielding varieties under intensive cropping. The depletion depends not only on soil fertility level but also on cropping sequence followed (1). In this regard, long term experiments provides best possible means of studying changes in properties and fertility level in soil. Therefore, the present study was undertaken in the established AICRP on long term fertilizer experiments, Bangalore to assess the periodical changes in available micronutrient status under Finger millet-maize cropping sequence.

Methods

The long term fertilizer experiment sponsored by ICAR was started at Bangalore, India in 1986-87 with fingermillet-maize cropping system. The soil is Kandic paleustalfs with sandy clay loam texture and pH of 6.17. Initial available N, P and K contents of the soil

were 256.7, 34.3 and 123.1 kg/ha respectively. Every year the crops are raised in the permanently laidout plots for each treatment (11 in number), which were replicated. The surface samples (0—15 cm) collected after 1986, 1996 and 2006 cropping sequence were analyzed for available micronutrients using DTPA + CaCl₂ + TEA extractant (2) to assess the changes in status over the years influenced by different treatments. The soil properties related to the availability of micronutrient determined by adopting standard procedures in order to find out the relationship with the available micronutrients.

Results and Discussion

The results indicated that the zinc was significantly increased in the initial years till 1996 but later decreased significantly over the years in all the treatments (Table 1). Highest available zinc in treatment T₈ (100% NPK + FYM) and T₁₀ (100% NPK + FYM + Line) could be attributed to high rate of mineralization of applied FYM (3) and the decrease in Available zinc with the increase in fertilizer dosage may be

Table 1. Influence of long-term fertilizer application on soil micronutrients (ppm) over the years. Y_1 = Year 1986, Y_2 = Year 1996, Y_3 = Year 2006, T_1 : 50% NPK, T_2 : 100% NPK, T_3 =150% NPK, T_4 : T_2 + HW, T_5 : T_2 + Lime, T_6 : 100% NP, T_7 : 100% N, T_8 : T_2 + FYM, T_9 : T_2 (S-free), T_{10} : T_2 + FYM + Lime, T_{11} : control.

Treatments	Zinc				Copper			
	Y_1	Y_2	Y_3	Mean	Y_1	Y_2	Y_3	Mean
T_1	1.46	1.59	1.47	1.51	2.13	1.36	1.33	1.61
T_2	2.29	1.56	1.41	1.75	2.09	1.40	1.40	1.63
T_3	1.70	1.42	1.35	1.50	1.85	1.48	1.47	1.60
T_4	1.83	1.61	1.46	1.63	2.44	1.37	1.42	1.74
T_5	1.93	1.50	1.29	1.57	2.44	1.32	1.29	1.68
T_6	1.94	1.64	1.55	1.71	2.16	1.58	1.71	1.82
T_7	1.93	1.68	1.41	1.67	2.35	1.72	1.63	1.90
T_8	1.73	3.64	3.30	2.89	2.53	1.62	1.62	1.92
T_9	2.07	1.68	1.62	1.79	3.07	1.74	1.68	2.16
T_{10}	1.63	3.13	2.95	2.57	2.11	1.22	1.27	1.53
T_{11}	1.83	1.46	1.42	1.57	2.35	1.28	1.20	1.61
Mean	1.01	1.90	1.75	1.88	2.32	1.46	1.46	1.75
Comparing of means	SE		CD at 5%		SE		CD at 5%	
Year (Y)	0.04		0.10		0.04		0.11	
Treatment (T)	0.07		0.20		0.08		0.21	
$Y \times T$	0.12		0.34		0.13		0.37	

Table 1. Continued.

Treatments	Zinc				Copper			
	Y_1	Y_2	Y_3	Mean	Y_1	Y_2	Y_3	Mean
T_1	8.53	9.36	10.13	9.34	130.55	38.80	33.02	67.46
T_2	5.83	14.00	13.21	11.01	131.43	42.40	35.46	69.76
T_3	5.90	17.12	16.40	13.14	113.48	53.40	46.96	71.28
T_4	8.83	13.04	13.80	11.89	128.75	42.60	38.96	70.10
T_5	7.88	6.45	6.58	6.97	134.18	32.40	19.75	62.11
T_6	8.08	14.02	15.90	12.66	138.08	48.40	46.93	77.80
T_7	7.38	14.79	15.78	12.65	132.73	58.20	53.43	81.45
T_8	7.05	14.27	16.13	12.48	128.75	37.00	33.03	66.26
T_9	6.43	15.85	19.96	14.08	132.30	56.60	46.36	78.42
T_{10}	5.65	6.50	5.91	6.02	125.63	28.40	15.11	56.38
T_{11}	6.28	7.42	6.38	6.69	135.05	28.80	19.99	61.28
Mean	7.07	12.07	12.74	10.63	130.08	42.45	35.36	69.30
Comparing of means	SE		CD at 5%		SE		CD at 5%	
Years (Y)	0.34		0.95		1.26		3.55	
Treatment (T)	0.65		1.81		2.42		6.79	
$Y \times T$	1.12		3.14		4.19		11.76	

attributed to excess removal of native zinc by the crop (4).

Significant decrease in available copper also recorded during first ten years but the change was non-significant during subsequent years. This suggests that the replenishment of copper from the mineral source to available pool was maintained (5).

The available iron increased significantly over first ten years with application of inorganic and or-

ganic source of nutrients but subsequent change from 1996 to 2006 was non-significant. The increase over years might be due to relatively rapid increasing H^+ activity caused as a result of fertilizer application especially in T_3 (150% NPK), T_6 (100% NP) and T_7 (100% N alone) (6, 7). Significant decrease in plots treated with lime (T_5 and T_{10}) may be attributed to formation of insoluble hydroxides of Fe at soil pH near neutral (8).

Table 2. Soil properties related to micronutrient availability.

Treatments	pH	OC (%)	Exch acidity (meq/100 g soil)	Av P	kg/ha Exch Ca	Exch Mg
T ₁ : 50% NPK	5.96	0.55	0.037	35.81	1359.25	329.0
T ₂ : 100% NPK	5.21	0.61	0.069	108.20	1317.00	334.50
T ₃ : 150% NPK	4.54	0.55	0.125	169.90	1276.75	335.0
T ₄ : T ₂ + HW	5.06	0.51	0.062	109.80	1348.00	357.00
T ₅ : T ₂ + Lime	5.86	0.52	0.053	110.00	2015.50	339.50
T ₆ : 100% NP	4.75	0.49	0.062	175.50	1851.75	377.00
T ₇ : 100% N	4.63	0.49	0.093	7.00	1116.25	328.25
T ₈ : T ₂ + FYM	6.13	0.64	0.037	198.20	1781.25	339.00
T ₉ : T ₂ (S-free)	4.73	0.52	0.072	122.50	1126.25	290.00
T ₁₀ : T ₂ + FYM + Lime	6.35	0.68	0.040	205.70	2125.25	395.25
T ₁₁ : control.	6.51	0.45	0.050	11.32	1470.25	398.25
SE ±	0.105	0.019	0.018	3.44	18.48	10.79
CD (at 5%)	0.30	0.06	0.03	9.93	53.36	31.16
Initial values (1986)	6.17	0.46	0.04	34.30	1456.00	415.20

A definite trend of significant decrease in the available manganese over the years was observed in all the treatments. The manganese was found to be higher in the initial years, significantly reduced during subsequent years without replenishment from the mineral source (5).

Decline in soil pH was recorded by treatments where chemical fertilizers were applied over the years and such an effect was not observed in case of control (Table 2). It is a well known that chemical fertilizers, particularly N carriers would help in generating H⁺ ions in the soil upon undergoing various chemical changes in the soil (9). Decrease in soil pH due to continuous use of only fertilizers and increase in pH due to FYM and lime application (10, 11).

The plots applied with FYM and lime (T₈ and T₁₀), however had significantly higher contents of organic carbon as compared to rest of the plots. A build up of organic matter in the soil was due to continuous addition of organic manure and crop residue (12, 13). The reason for the relatively higher amounts of organic carbon in the plots fertilized with only chemical fertilizers as compared to control could be attributed to increased crop growth and consequent addition of biomass to the soil by way of roots and crop residues (14).

Significant increase in exchangeable acidity due to the application of fertilizer at 150% NPK (T₃) level and 100% N alone (T₇) indicating application of N alone has similar effect as that of higher dose of nitro-

gen applied along with P and K with regards to development of acidity in soil. The treatments with lime and FYM (T₅ and T₁₀) reduced soil exchangeable acidity to greater extent compared to other treatments attributing to the neutralization of exchangeable Al³⁺ and H⁺ by liming (15).

Maximum available phosphorus in T₁₀, where inorganic fertilizers applied with FYM and lime over control and initial value. The available P status of the soil may be attributed to enhanced solubilization of native P in soil and addition of P through decomposition products of FYM. Increase in available P status of soils due to addition of FYM and NPK fertilizers (16). Continuous liming reduced the acidity to a greater extent by neutralizing Fe and Al hydroxides there by releasing the P from such oxides. Removal of labile P by the crops in a soil not nourished by the addition of P from external sources might be the reason for significant reduction in available P content of the soil in plots treated with only N and also in control plots (17).

Significant reduction in exchangeable calcium content of soil was observed in the plots treated with only chemical fertilizers suggesting removal of calcium by the crops at quantities greater than that was added from external sources (18, 19) increase in the exchangeable calcium content of the soil in lime amended plots (T₅ and T₁₀) was due to a direct consequence of addition of calcium in the form of calcium carbonate over the years.

Table 3. Correlation coefficient of available micronutrients with soil properties. *Significant at 5%, **Significant at 1%.

	pH	OC	Av P ₂ O ₅	Exch acidity	Exch Ca	Exch Mg
Av Zn	-0.488**	0.770**	0.466**	0.478*	-0.530*	0.228
Av Cu	-0.696**	-0.098	0.265	0.409**	-0.281	-0.490**
Av Fe	-0.791**	-0.102	0.196	0.606**	-0.572**	-0.652**
Av Mn	-0.913**	-0.324*	-0.070	0.706**	-0.670**	-0.569**

Exchangeable magnesium was found to be relatively lower in plots subjected to only NPK fertilizers, in comparison to plots treated with fertilizers and FYM along with lime (T₈ and T₁₀). Farmyard manure has been reported to be a fairly good source of Mg and contribute substantial amounts of Mg to the soil upon its decomposition (20). Very low crop removal of magnesium from soil reserve in treatments T₁₁ and T₆ may be attributed to higher available magnesium in those plots.

Relationship Between Available Micronutrients and Soil Properties

The available copper, zinc, iron and manganese were found to be negatively correlated with pH, exchangeable Ca and Mg but positively with exchangeable acidity (Table 3). Soil pH which acts as major factor for availability of micronutrients in soil has reduced with continuous fertilizer application in treatments T₃ (150% NPK) recording lowest pH (4.54) followed by T₇ (100% N) and T₆ (100% NP) may be the cause for greater availability of micronutrients. Significant positive correlation of available phosphorus was recorded only with zinc which is contrary to the reports of many workers. This suggests that soil conditions prevailing due to fertilizer application were not favorable for the formation of insoluble compounds. Soil pH beyond 7.7 is reported to be favorable for formation of insoluble compounds such as zincate [Zn(OH)₄²⁻], ZnCO₃ and Zn₃(PO₄)₂.

Since the pH varied from 4.5 to 6.3 in soil, further the dominant species of phosphorus is either mono (H₂PO₄⁻) or di (HPO₄²⁻) phosphate in acidic condition the possibility of formation of insoluble compound was less. Brown et al. (21) reported that rate of phosphorus did not affect extractable zinc but tended to increase zinc rather to decrease at low pH and concluded that solubility of Zn₃(PO₄)₂ · 4H₂O but not P induced zinc deficiency through precipitation.

The study showed that the depletion of copper or zinc was observed initially but later on maintained through replenishment from mineral source but the rate of depletion is comparatively gradual and more in case of manganese due to intensive cropping. Integrated nutrient management through application of both fertilizer and FYM would be the best way to maintain micronutrients in soil with sustainable productivity level.

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