

# Status of zinc and copper in the wet-patana soils of Sri Lanka

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In recent years attempts have been made to bring the patana soils of the montane areas of Sri Lanka under cultivation. The morphology of the *wet-patana* soils and their macronutrient contents were studied in detail by Kalpage and Thenabadu (1969). One of the significant characteristics of these soils is their high organic matter contents. Conflicting reports are available regarding the effect of such high organic matter contents on the availability of micronutrients. The manganese contents of these soils and fixation studies with manganese have been already reported (Pavanasasivam, 1973). Their zinc and copper contents are discussed here.

## EXPERIMENTAL

Soils were sampled from three locations viz: Bopatalawa, Ambawela, and Horton Plains. At each location samples were taken from the forested area on top of the hill, on the slope in the typical *wet-patana* and from the water logged *deniya* at the bottom of the hill.

Texture was determined by the hydrometer method, pH on a 1:4 soil-water suspension using a Beckman pH meter, CEC by the ammonium saturation procedure, and organic matter by Walkley and Black's rapid titration method.

Total zinc in a  $\text{Na}_2\text{CO}_3$  fusion extract (Kanehiro and Sherman, 1965), and exchangeable zinc and 'available' zinc extracted by 1N  $\text{NH}_4\text{OAc}$  (pH 7) and dithizone in  $\text{CCl}_4$  respectively were estimated using a 'Grating Monochromator' atomic absorption spectrophotometer.

Total copper was determined in the  $\text{Na}_2\text{CO}_3$  fusion extract by the isoamyl acetate-carbamate method (Jackson, 1958). Fractions of copper were extracted with 1N  $\text{NH}_4\text{OAc}$  (pH 7) and with 0.05N EDTA (pH 7) respectively.

## RESULTS AND DISCUSSION

The physico-chemical characteristics of the soils have been reported by Pavanasivam (1973). Soils are mostly sandy loam to sandy clay loam and the pH varies from 4.55 to 5.82 with the exception of one sample (pH 6.88). Their organic matter values range from 2.1 to 23.9 per cent. (average : 10.2 per cent) and CEC from 10.5 to 56.8 me per cent. (average : 32.0 me per cent).

Total zinc, exchangeable zinc, 'available' zinc, exchangeable copper and EDTA-extractable copper values are given in Table 1, and the ranges of these values in the surface soils and subsoils at the three locations are given in Table 2.

*Total Zinc and Copper*

Total zinc contents vary from 35 to 121 ppm with an average of 75 ppm and the total copper contents range from 13 to 68 ppm with a mean of 38 ppm. Compared with the values reported by Swain (1955), Rosell and Ulrich (1964), Tripathi *et al.* (1969) and Murthy and Mehta (1970) for total zinc and by Chestor *et al.* (1957), Purves and Ragg (1962) and Mehta *et al.* (1964) for total copper, the contents of zinc and copper in the soils studied are normal.

On an average, total zinc contents of Bopatalawa, Ambawela and Horton Plains are 83, 87 and 50 ppm respectively whereas total copper contents are 41, 33 and 23 ppm.

Total zinc shows a tendency to increase with depth in Bopatalawa and Horton Plains profiles, on an average the surface soils containing 75 and 40 ppm and the subsoils 87 and 58 ppm respectively. However, the average total copper content of subsoils is more than that of the surface layers at all three locations, the overall averages being 40 ppm for subsoils and 23 ppm for surface soils. Although a fairly accurate picture of the distribution of micronutrients could be obtained by studying the surface and subsoils, it cannot be assumed that these elements are distributed in the soils according to any regular pattern. The subsoils stratum may or may not be richer in these elements than the surface soils.

Normally, the concentration of zinc is highest in the horizons having a higher percentage of finer particles or organic matter. In the present study, total zinc content is effected by texture and not by organic matter. Total zinc is positively and very significantly correlated ( $r = + 0.5320$ ) with the finer fractions, silt and clay combined, of the soils. This is in agreement with the findings of Rosell and Ulrich

(1964) who concluded that fine textured soils generally contain more total zinc. Total copper did not show a significant correlation either with organic matter or with finer fractions of soils.

Forest profiles, on an average, contain more amounts total zinc (86 ppm) than patana (74 ppm) and deniya profiles (63 ppm). The total copper contents do not vary very much.

#### *Fractions of Zinc and Copper*

Exchangeable zinc varies from 0.04 to 0.76 ppm with an average of 0.21 ppm, being 0.05 to 0.84 per cent. (average : 0.32 per cent.) of total zinc. Dhingra and Kanvar (1963) fixed 0.34 to 0.44 ppm as the critical level of exchangeable zinc. On this basis, nearly 85 per cent. of the samples studied may be regarded as deficient.

Exchangeable copper varies from 0.04 to 0.30 ppm with an average of 0.10 ppm and , when expressed as percentage of total copper, it ranges from 0.11 to 2.10 Wood (1945) and Bhumbla and Dhingra (1964) opined that, for normal growth, 0.5 ppm of exchangeable copper in soils indicates the boundary between deficient and sufficient amounts. In the light of this critical limit, all the samples studied may be considered deficient in exchangeable copper.

' Available ' zinc ranges from 1.0 to 15.0 ppm with a mean of 5.7 ppm, being 0.9 to 32.9 per cent. (average : 9.1 per cent.) of total zinc. Shaw and Dean (1952) and Brown *et al.* (1964) noted that plant growth response to soil zinc application could be expected when Dithizone-extractable zinc values drop below 0.55 ppm. Judging from this observation, none of the soils studied can be considered as deficient in plant ' available ' zinc.

EDTA-extractable copper ranges from 0.8 to 4.1 ppm with an average of 2.1 ppm, and this fraction of copper forms 1.9 to 22.4 per cent. of the total copper. Considering the critical limit of 1 ppm of EDTA-extractable copper (Mitchell *et al.* 1957), it is seen that, except for two samples in Horton Plains, all the other samples contain sufficient amounts.

According to Wallace and Müller (1959), only electrolytically bound cations are removed by IN  $\text{NH}_4\text{OAc}$  (pH 7), but complexing agents, in addition, extract cations from humus complexes as well. Thus, because the soils studied contain relatively high amounts of organic matter, it is probable that a major portion of the potentially ' available ' zinc and copper, held complexed with organic matter, is not extracted by IN  $\text{NH}_4\text{OAc}$  (pH 7). This is evidenced by the fact

that, while only an average of 0.32 per cent. of the total zinc and 0.42 per cent. of the total copper are present in the exchangeable form, about 9.2 per cent. of total zinc and 7.7 per cent. of total copper are present as dithizone-extractable and EDTA-extractable respectively.

Reports (Wallace and Mueller, 1959, Randive *et al.* 1964) indicate that organically-bound cations are available to plants, and Schlichting (1955) observed a better availability of complexed cations over a pH range of 3.5-6.0. The soils studied here also have pH values within this range. Therefore, it might be concluded that although these soils contain very low amounts of exchangeable zinc and copper, they cannot be considered deficient as their dithizone-extractable zinc and EDTA-extractable copper contents are normal.

Averages of different fractions of zinc and copper at different locations are given in Table 3. There is no consistency in their distribution among the three locations, when expressed as ppm. However, when expressed as percentages of total, it is seen that the Horton Plains soils give the highest percentages of all fractions except the EDTA-extractable copper. This may be due to the wetter climatic conditions and high soil moisture content at Horton Plains which favour a better breakdown of minerals and release of available forms as suggested by Mitchell (1963).

In general, surface soils contain more of exchangeable and extractable forms of zinc and copper. This is in agreement with observations made by several workers (Barrows *et al.* 1960; Kavinadan *et al.* 1964; Grewa *et al.* 1969). This surface enrichment of zinc is suggested as a major cause responsible for zinc deficiencies in deep rooted plants.

Various soil factors have been shown to influence the degree to which soil zinc and copper are available to plants. These include the amount of soil fractions, content and nature of organic matter, soil pH, amount of  $\text{CaCO}_3$ , CEC, effect of other elements, and microorganisms. Frequently several factors are effective together. In the present study, significant correlations have been observed between EDTA-extractable copper and pH ( $r = -0.9165$ ) and between exchangeable copper and organic carbon ( $r = +0.5911$ ). Such correlations are not observed between other factors. However, when individual soil samples are grouped together on the basis of organic carbon content and CEC, a trend is evident for the exchangeable and extractable forms of zinc and copper to increase with increase in organic carbon. Also, exchangeable zinc and copper and EDTA-extractable copper show a trend to increase with increase in CEC.

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TABLE I

Contents of different forms of zinc and copper

Sample No.	Total Zn (ppm)	Exchangeable Zn		Available, Zn		Total Cu (ppm)	Exchangeable Cu		EDTA Extractable Cu		
		ppm	% of total	ppm	% of total		ppm	% of total			
BOPATALAWA											
Forest	1 ..	59	0.20	0.34	7.0	11.86	13	0.04	0.31	2.8	21.54
	2 ..	90	0.18	0.20	3.0	3.33	61	0.07	0.11	2.8	4.59
	3 ..	90	0.14	0.16	11.5	12.78	44	0.10	0.23	1.1	2.50
Upper patana	4 ..	73	0.20	0.27	3.0	4.11	37	0.10	0.27	2.5	6.76
	5 ..	79	0.14	0.18	6.5	8.23	68	0.08	0.12	1.5	2.21
	6 ..	84	0.06	0.07	6.5	7.74	68	0.10	0.15	1.3	1.91
	7 ..	84	0.04	0.05	6.5	7.74	47	0.05	0.11	1.4	2.98
Lower patana	8 ..	65	0.18	0.28	3.3	5.08	23	0.21	0.91	2.3	10.00
	9 ..	70	0.20	0.29	1.0	1.43	30	0.04	0.13	2.1	7.00
	10 ..	96	0.14	0.15	7.0	7.29	34	0.10	0.29	1.3	3.82
Deniya	11 ..	104	0.28	0.27	13.0	12.50	33	0.08	0.24	4.1	12.42
	12 ..	101	0.14	0.14	13.0	12.87	39	0.10	0.26	3.5	8.97
AMBAWELA											
Forest	13 ..	97	0.28	0.29	1.5	1.55	19	0.11	0.58	3.8	20.00
	14 ..	121	0.14	0.12	3.0	2.48	41	0.12	0.29	3.4	8.29
	15 ..	111	0.76	0.68	1.0	0.90	50	0.10	0.20	3.4	6.80

TABLE I—(contd.)  
Contents of different forms of zinc and copper

Sample No.	Total Zn (ppm)	Exchangeable Zn		Available, Zn ppm % of total	Total Cu (ppm)	Exchangeable Cu		EDTA Extrac- table Cu	
		ppm	% of total			ppm	% of total		
Upper patana 16	85	0.18	0.21	4.0	40	0.10	0.25	1.9	
17	104	0.10	0.10	3.0	25	0.07	0.28	1.3	
18	83	0.18	0.22	3.0	43	0.10	0.23	2.3	
19	110	0.06	0.05	5.5	41	0.06	0.15	1.3	
Lower patana 20	74	0.06	0.08	1.0	21	0.10	0.48	2.0	
21	63	0.42	0.67	1.0	44	0.16	0.36	1.1	
Deniya 22	55	0.42	0.76	8.0	21	0.09	0.43	2.5	
23	50	0.14	0.28	9.0	18	0.07	0.39	2.5	
HORTON PLAINS									
Forest 24	50	0.42	0.84	15.0	14	0.09	0.64	1.9	
25	67	0.36	0.54	3.3	15	0.08	0.53	1.4	
Upper patana 26	48	0.20	0.42	6.5	14	0.30	2.14	1.0	
27	43	0.10	0.23	5.0	14	0.05	0.36	1.2	
28	69	0.20	0.29	5.0	21	0.12	0.57	1.0	
Lower patana 29	35	0.28	0.80	11.5	15	0.11	0.73	0.8	
30	67	0.10	0.15	7.0	36	0.09	0.25	1.3	
Deniya 31	28	0.06	0.21	6.5	19	0.22	1.16	2.2	
32	43	0.32	0.74	3.0	61	0.08	0.13	3.6	

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TABLE 2

Ranges of zinc and copper contents at the three locations  
(ppm)

Form	Bopatalawa		Ambawela		Horton Plains	
	Surface soils	Sub-soils	Surface soils	Sub-soils	Surface soils	Sub-soils
Total zinc	59-104	70-101	55-97	50-121	28-50	43-69
Exchangeable zinc	0.18-0.28	0.04-0.20	0.06-0.42	0.10-0.76	0.06-0.42	0.10-0.36
'Available' zinc	3.0-13.0	1.0-13.0	1.0-8.0	1.0-9.0	6.5-15.0	3.0-7.0
Total copper	13-40	30-68	19-40	18-50	14-19	14-61
Exchangeable copper	0.04-0.21	0.04-0.10	0.09-0.11	0.06-0.16	0.10-0.30	0.08-0.12
EDTA-extractable copper	2.3-4.1	1.1-3.5	1.9-3.8	1.1-3.4	0.8-2.2	1.0-3.6



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