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STATUS OF AVAILABLE MICRONUTRIENT CATIONS IN THE SOILS OF KERALA

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The soils of Kerala (except in a few pockets) are acidic, and in general belong to the class 'oxisols'. Extreme leaching has left the soils very low in nutrient cations. The soils are characterised by the presence of high amounts of iron, in the available form. Though, in the acidic condition, the availability of micronutrient cations get increased, the condition of high leaching and other factors have modified this picture. The available micronutrient cations in the soils, as obtained by a survey conducted in the State, is reported in this paper.

Materials and Methods

From the surface 15 cm of soil, 478 samples were collected from different revenue districts of Kerala using an aluminium tool to avoid contamination with micronutrient cations. Each sample was the composite of soils collected from ten spots. Each sample was analysed for pH, organic carbon, available zinc, copper, iron and exchangeable manganese. Available zinc was extracted with 0.01 % dithizone in neutral normal ammonium acetate (Shaw and Dean 1951), converted into HCl phase and estimated by using the absorption line 2139°A in Varian Techtron-120 atomic absorption spectrophotomater. Available copper was extracted with normal ammonium ecetate (Cheng and Bray, 1953) and by using the absorption line 3247°A. Exchangeable manganese was extracted with neutral normal ammonium acetate (Sherman *et al* 1942) and estimated by noting the absorption at 2795°A. Organic carbon was "determined by the method of Walkley and Black as described by Jackson (1958). pH was estimated in 1 : 2 soilwater suspension.

Results and Discussion

Available micronutrient cations, organic carbon and phi are presented in Tables 1 and 2. For fixing the critical value of the nutrients (the micronutrient in the soil below which response to micronutrient nutrition could be expected) the schedule followed was 0.5, 0.5, 2.0, and 2ppm for available zinc, copper, iron and exchangeable manganese respectively. The critical limit of 05 ppm zinc, was considered good for soils of pH below 6.5 (Jackson 1958). This limit is likely to be valid for most of the soils in Kerala since non-acidic soils is restricted to a few pockets of the state only.

The critical limit of 0.5 ppm is fixed for available copper (Cheng and Bray, 1953). Most of the soil test-crop-response studies conducted in India show that the critical limit of copper is between 0.4 and 0.7 ppm. For iron and manganese the critical limits proposed are 2.0 (Olson and Carlson, 1950) and 3.0 (Sherman and Harmer, 1943) ppm respectively.

An assessment of micronutrient status, based on the above critical limits (See Figure) revealed that the soils of Kerala were most deficient in 'available copper' and 'available zinc'. In some districts like Palghat, Trichur and Cannanore, the samples tested gave no indicaticn of available copper. The mean value of available copper in all the districts fell below the level of sufficiency. In the districts of Kottayam, Quilon, Ernakulam, and Trichur there was 100% deficiency of copper and Palghat had the least deficiency (62%).

The two important factors that govern availability of copper in soils are the organic matter content and pH, The pH influences the kind of organic matter and its reactions in me soil There was a high degree of correlation between pH and available copper in Alleppy district (r = -0.4823^{**}). The pH varies between 3.5 and 8.3 which is the greatest range observed in Kerala. As the pH of the solution becomes higher than 6.5, the complex iron $Cu(OH)^+$ becomes dominant and above this any one of several precipitates may occur, decreasing the copper ions in the soil solution. Available copper was negatively and significantly correlated with organic carbon of the soil in Alleppy (r= -0.1698^{*}) and positively and very significantly in the districts of Trivandrum and Trichur (r= $+0.4316^{**}$ and $+0.5485^{**}$ respectively). Even though the micronutrient cations are more available at lower pH their complexes with organic matter may alter the degree of availability. The optimum pH for stable complexes of humic matter with copper falls between 2.5 and 3.5, (Mitchell, 1955). Humic complexes of copper are highly unavailable and therefore fixation of copper by organic matter of Kerala soils is a distinct possibility. Hodgson *et al* (1936) have stated that over 99 per cent of copper in the soil may be complexed by organic matter. However the availability of complexed copper will depend on the kind of ligands on the organic molecule. Mercer and Richmond (1971) showed that copper associated with compounds having a molecular weight less than 1000, was readily available to crops, but those associated with compounds of mol. wt. of 5000 or more was much less available. The difference in the organic matter make-up of the soils of Alleppy district, therefore, is likely to be tho reason for the different picture of correlation with organic carbon seen in this district.

In the case of zinc the greatest deficiency was observed in the Palghat district (42%). The districts of Kottayam, and Trichur also had appreciable number of samples deficient in available zinc. Among the factors which induce zinc deficiency, the pH of the soil, absorption by clay, $CaCO_3$ and humus are

Table 1

The status of available micronutrients Zn, Cu and Fe and exchangeable manganese in the soils of the various districts of Kerala.

District	Available zinc ppm			Available copper ppm			Available iron ppm			Exchangeable manganese ppm		
	Range	Mean	% Deficiency	Range	Mean	% Deficiency	Range	Mean	% Deficiency	Range	Mean	% Deficiency
Alleppey	0.30—10.5	1.56	27	0.08—0.96	0.32	82	3.2—516	98.60	Nil	3.0—48.0	15.12	Nil
Trivandrum	0.20—10.0	1.03	22	0.16—0.80	0.27	97.6	20—660	111.50	Nil	1.2—80.6	35.1	1.2
Kottayam	0.30—1.20	0.56	40	0.16—0.28	0.17	100	8.8—216	30.20	Nil	13.0—30.5	22.4	Nil
Quilon	0.60—1.60	1.09	Nil	0.08—0.22	0.16	100	13.6—588	90.00	Nil	4.0—80.0	30.2	Nil
Ernakulam	0.50—4.80	2.25	Nil	0.08—0.48	0.21	100	109.0—1140	405.7	Nil	1.0—80.0	40.5	7.1
Trichur	030—2.40	110	37	Nil—0.80	0.19	100	2.0—660	177.7	Nil	020—37 0	10.53	30.0
Palghat	0.10—4.0	1.13	42	Nil—1.40	0 49	62	9.2—5065	692.1	Nil	1.0-80.0	139.7	2.9
Calicut	Nil—2.90	1.14	23	Nil—2.0	0.40	83	1.6—200	41.0	1.4	0.2—220	23.3	17.0
Cannanore	0 60—1.80	0.65	Nil	0.16—0.66	0.28	87.5	8.0—120	54.3	Nil	3.0—130	26.6	Nil

considered important. it is also possible, in acidic soils of low adsorption capacity, for the available zinc to get leached out during heavy and intense rainfall, as happens during the monsoon in Kerala. The available zinc status of Kerala soils, however, seems to be better than that of the neighbouring State or Tamil Nadu, (Rajagopal *et al* 1975).

Available zinc was found to be significantly and negatively correlated with soil pH in the districts of Alleppey and Palghat, where the range of pH (Table 2) extends from alkalinity to acidity. No relationship could be established in the other districts; might be due to absence of soil having higher pH. in these districts.

Table 2 Soil reaction and organic carbon in the soils of Kerala

D st•	Soil Reaction (pH) Range	Mean	Soil Organic carbon % Range	Mean
Alleppey	3.5 8.3	5.3	0 07 - 0.7S	0.51
Trivandrum	35 -6.4	4.5	0.24 — 0.96	0.60
Kottayam	•1 *1* -5.4	48	0.34 — 0 82	0.77
Quilon	*42* -5.2	4.5	0.12 - 1.50	0.37
Ernakulam	4.0 - 6.2	4.7	0 10 - 069	0.48
Trichur	3.5 — 6.1	4.8	Nil - 0.69	0.31
Palghat	3 8 -83	5.2	0.13 — 1.13	0 94
Calicut	24 — 6.2	5.5	0.04 - O.SS	0 46
Cannanore	4.7 5.9	5.5	0.15 — 1.80	0 59

The relation between organic carbon and available z>nc was found to be highly significant and negative in the district of Alleppey. Rajagopal *et a! (1974)* working with Nilgiri soils observed that the negative correlation of organic matter with available zinc was seen only when the organic carbon was > 3.0 per cent. According to Felbech Jr. (1965) the main difference in the organic matter fractions was that of molecular weight and the fulvic fraction was thought to be more soluble and active. It is therefore quite possible that different ligands binding the micronutrinet ion in the Alleppey soils could be responsible for favouring high fixation of zinc.

Iron was found to be plentifully available in Kerala soils the values ranging from 1.6 to 5066 ppm. The high amount of iron in the soil might result in iron-induced deficiencies, especially of potassium, calcium and zinc. Positive and significant correlation between organic carbon and available iron was found in the districts of Trivandrum and Trichur. This points to the existence of organic combination of iron in the form of chelates, which are highly available, in these districts. As is expected, iron was found to be significantly and negatively correlated with pH in the districts of Alleppey and Palghat.

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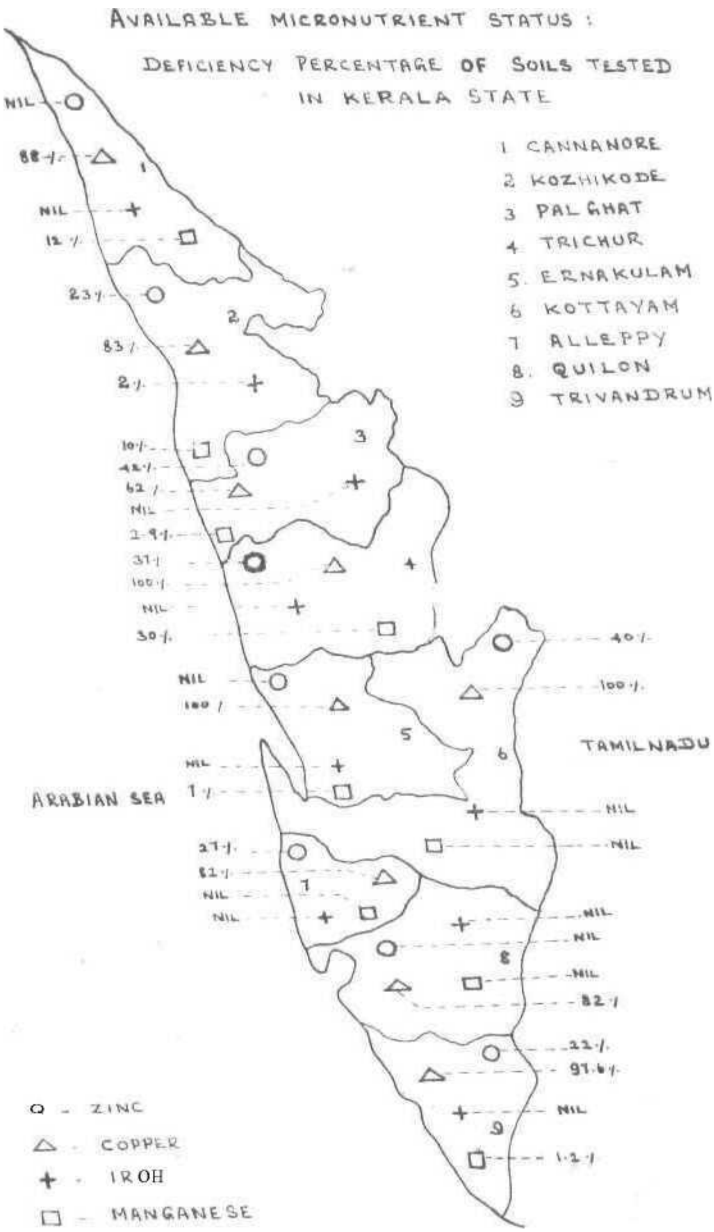

Table 3

Results of Statistical analysis showing the relationship between organic carbon and available soil micronutrients in the different districts of Kerala

District	Rrlationship between	Correlation coefficient	No. of pairs	Regression equation
Alleppey	i Organic Carbon and available copper in the soil.	—.1698*	155	Cu = —.1825 OC + 382995
	ii Organic Carbon and available zinc in the soil.	—.2242**	155	Zn = —1.6480 OC + 2.20798
	iii Organic Carbon and exchangeable manganese in the soil	+ 2698**	155	Mn = 25.6198 OC + 12.64
Trivandrnm	i Organic Carbon and available copper in the soil.	+.4316**	85	Cu = .2972 OC + .08999
	ii Organic Carbon and available iron in the soil.	+.5134**	85	Fe = 497 3852 OC — 162.2421
	iii Organic Carbon and exchangeable mnnganese in the soil.	—.5702**	58	Mn = —15.7748 OC + 43.5635
Trichur	*i* Organic Carbon and available iron in the soil.	+.5485**	28	Fe — 620.7625 OC + 28.6662

OJ — Organic Carbon per cent.

Exchangeable manganese was not found to be deficient in the districts of Alteppey, Kottayam, Quilon and Cannanore. In the other districts the deficfencies ranged from 1. 2 to 30 per cent. Trichur had 30 per cent deficfency and Calicut 17. 0 per cent. Heavily leached soils and those containing high humus are likely to become deficient in manganese (Schmitt, 1976). Existence of such

Table 4 Results of statistical analysis showing the relationship between pH and available soil micronutrients in the different districts of Kerala.

District	Relationship between	Correlation coefficient	No. of pairs	Regression equation
Alleppey	i pH and available zinc in the soil.	—.3543**	155	Zn = .2644 pH + 2.6851
	ii pH and available copper in the soil.	—.4823**	155	Cu = . 1301 pH + .9232
	i i i pH and available iron in the soil.	—.6582**	155	Fe = 31.4962 pH + 273 03003
	iv pH and exchangeable Manganese in the soil.	—.554**	155	*MR* - 1.2317 pH + 37.0495
Palghat	i pH and available iron in the soil.	—.2813**	103	Fe = 282.2969 pH + 2238.2701

soils in the various parts ot Kerala might have contributed to the deficiencies in the exchangeable manganese. When reduced conditions in the soil exist manganese becomes more available as the Mn^{++} ion is very soluble and its activity will determine the exchangeable manganese in the soil. The divalent manganese ions in the soil solution will also become predominant when the soil becomes more acidic. There was very significant negative correlation between exchangeable manganese and pH in Alleppey soils.

With regard to organic carbon, correlations with exchangeable manganese were established in Alleppey and Trivandrum districts. In Alleppey the correlation was significant and negative while in Trivandrum it was positive. Here also the nature of the complexing organic ion would have determined the kind of the organo-metallic complexes formed. The negative relationship in the Trivandrum destrict could be attributed to the formation of unavailable metallic complexes of manganese and the positive relationship in the Alleppey soil to that of soluble chelate formation. The investigations recorded in this paper have highlighted the necessity for conducting intensive studies on the organic matter make-up of the Kerala soils for finding out the nature of organic ligands involved in the metallo-organic linkages pertaining to micronutrients. This will enable prediction of the fate of micronutrients added to soils of the different regions and adoption of possible remedial measures for counteracting the fixation of micronutrients in the soil.

Summary

Fourhundred and seventyeight soil samples collected from all over Kerala State, were analysed for available zinc, copper, iron and exchangeable manganese. The pH and organic carbon of the soils were also determined. Available copper was found to b3 deficient in all the districts of Kerala. Available zinc and exchangeable manganese also were found deficient in many districts. The status of available iron was quite good in all the districts and might be reaching toxic levels in some areas. The relationship of micronutrients with pH, and organic carbon were discussed. The study highlights the necessity to investigate the nature of organic matter in relation to micronutrient availability, so that appropriate measures can be adopted for lessening fixation of micronutrients applied to soil.

Acknowledgement

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സംഗ്രഹം

കേരളത്തിലെ മണ്ണിൽ ലഭ്യമായ തുത്തനാകം, ചെമ്പ്, ഇരുമ്പ്, എക്സ്ചേഞ്ചബിൾ മാങ്കനീസ് എന്നിവ കണ്ടുപിടിച്ചതിന്റെ ഫലമായി ലഭ്യമായ ചെമ്പിന്റെ അളവ്

വളരെ പരിമിതമായിട്ടാണിരിക്കുന്നതെന്ന് തെളിഞ്ഞിരിക്കുന്നു. തുത്തനാകത്തിന്റെ അളവും പലേടങ്ങളിലും കുറവായിട്ട് കാണുന്നുണ്ട്. നേരെ മറിച്ച്, ലഭ്യാവസ്ഥയിലിരിക്കുന്ന ഇരുമ്പ് അധിക അളവിൽ ഉണ്ടെന്നു കണ്ടു. ചില സ്ഥലങ്ങളിൽ ഇത് ഏറ്റവും അധികമായി കാണുന്നതിനാൽ ചെടികളുടെ വളർച്ചക്ക് ആപൽക്കരമായിരിക്കുവാൻ സാധ്യതയുണ്ട്. മണ്ണിൽ എക്സ്ചേഞ്ചബിൾ മാങ്കനീസിന്റെ കുറവ് അത്ര ഗൗരവമുള്ളതല്ല. ലഭ്യമായ സൂക്ഷ്മാംശ പോഷകങ്ങളും, പി. എച്ച്, ഓർഗാനിക് കാർബൺ, എന്നിവയും തമ്മിലുള്ള ബന്ധങ്ങളും സ്റ്റാറ്റിസ്റ്റിക്കൽ ഗണിതരൂപത്തിൽ ഈ പ്രബന്ധത്തിൽ ചേർത്തിട്ടുണ്ട്.

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