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A Comparative Study of the Efficacy of the Different Extractants for Zinc and Manganese in Relation to Plant Availability

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One hundred and fifty one different soil samples belonging to 8 groups of rice soils viz. Coastal sandy alluvium, lateritic alluvium, *Kayal*, *Kari*, *Karapadom*, *Kole*, *Pokkali* and Poonthalpadam were Studied for their extractable zinc and manganese contents using different extractants such as 0.1 N Hc1 (1 hr shaking and 1:10 soil extractant ratio) 0.05 N. Hc1+0.025 N H_2SO_4 (1 hr shaking and 1:10 soil extractant ratio) 0.02 N. EDTA (1 hr shaking and 1:10 soil extractant ratio) 1 N Ammo. acetate buffered at pH 4.8 (1 hr shaking and 1:10 soil extractant ratio) and 0.005 M. DTPA (1:2 soil: extractant ratio and 2 hrs shaking) Hundred seeds of rice (Var. Jaya) was grown for a period of 17 days by a modified Neubauer technique in all the soils to determine the actual plant available zinc and manganese in these soils. Correlations were made between extractable zinc and manganese and actual plant available zinc and manganese to decide ths most suitable extractant for each group of soil as well as for the soils of Kerala in general. The results indicate that DTPA is the most versatile extractant for all types of soils of the State. The results further show that a determination of the total status of the elements is quite inadequate in the prediction of plant availability.

Literature on the micronutrient status as well as factors governing their availability are abundant for neutral or slightly alkaline soils (Biswas 1951, Randhawa *et. al*. 1961 and Mehra *et.al*. 1977) However information regarding the occurrence and distribution of zinc and manganese on acid rice soils are scanty and meagre (Aiyer *et al* 1975, Rajagopal *et. al* 1977). Further very little studies have been conducted to evaluate and improve methods for the estimation of plant available manganese and zinc in such soils. Thus the standardization of a suitable extractant for available manganese and zinc in the acid rice soils of the State have been attempted in the present work.

MATERIAL AND METHODS.

One hundred and fifty one samples of surface soil (0-6") typical of the 8 paddy soil types of Kerala namely Poonthalpadom, (Vertisol) Kole (Entisol) Pokkali (Alfisol) Kari (Entisol) Karapadom (Entisol) Kayal (Entisol) Coastal sandy allvium (Entisol) and lateritic alluvium (Oxisol) were collected for the present study.

Five soil test methods were used to evaluate the available manganese and zinc status in these soil types. Distilled water obtained from a three stage all glass pyrex still was used for the preparation of reagents. Chemicals of A. R. quality only were used for the preparation of reagents. Blanks were simultaneously run for all determinations of

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manganese and zinc to avoid and correct for contaminations. The manganese and zinc concentrations in all the extracts were determined by feeding the solution into an Atomic Absorption Spectrophotometer.

Total zinc and manganese were estimated as per procedure outlined by Wahhab and Bhatti (1958). The final extract in normal hydrochloric acid was fed into the Atomic Absorption Spectrophotometer.

The actual plant available zinc and manganese were determined by a modified Neubauer technique for all the 151 samples. The only modification made in the Standard Neubauer technique was to sow hundred good quality seeds (100% germination) of rice (Var. Jaya) instead of rye. The duration of the experiment was also 17 days as prescribed. The sprouted seeds were irrigated periodically with triple distilled water. Two replicaions were kept for each soil. Hundred seeds grown in 50 g of the acid washed sand represented the control. Seventeen days after sowing the plants were harvested by cutting them close to the base. The harvested meterial was washed in 0.1 *N* HCL' dried, weighed and powdered for chemical analysis. The Samples were analysed for manganese and zinc by by triple acid digestion with a mixture of HNO_3, H_2SO_4 and $HClO_4$ prepared in the ratio 10:1:4 as detailed by Jackson (1958). The clear plant digest was made upto 100 ml with Normal HCl and the manganese and zinc determined by feeding the solution into Atomic Absorption spectrophotometer.

Simple correlation coefficients were worked out for the relationship between extractable manganese and zinc with the actual plant available manganese and zinc to decide the most suitable extractant for each group of soil, as well as for the soils of Kerala in general. Extractable manganese and zinc were also correlated with their respective totals in the soils.

RESULTS AND DISCUSSION.

Tables 1 and 2 indicate the maximum and minimum values for available manganese and zinc with different extractants and for total manganese and zinc to highlight the variation in the range of values obtained. Tables 3 and 4 present data on correlation coefficients worked out between extractable zinc and manganese with actual plant available zinc and manganese, extractable with total zinc and manganese for each soil type as well as extractables with total and plant availables for all the pooled samples.

A close scrutiny of the data indicates the capacity of acid extractants to extract generally more available manganese and zinc than organic chelates like EDTA and DTPA. Ammonium acetate (pH 4.8) extracts only moderate amounts of manganese and zinc. The organic chelate DTPA extracts the lowest amounts of the elements. However, a critical study of the data shows that a greater degree of spread in the extracted available manganese and zinc values are achieved with

DTPA than with other extractants. Data on total manganese and zinc show that in general, except for a few particular locations distributed in a few soil types; all the other soils are abundantly supplied with the two elements.

Among the 8 soil groups studied with the five different extractants the highest correlation coefficients with plant available manganese were obtained with DTPA for 6 soil types namely the Poonthalpadom, Kole, Pokkali, Kari, Kayal and Sandy alluvium. In the Karapadom and lateritic alluvium the highest correlation coefficients were obtained with EDTA and double acid extractions respectively. Thus among the five extractants DTPA appears to be more versatile and of uniform applicability. Data on pooled correlations also give similar results (Table-4).

From the data it is evident that the available manganese give significant positive correlation coefficients with total manganese in the case of Kole, Karapadom and laterite alluvium while none of the extractants give significant correlation coefficients in the case of Kari, Pokkali and Sandy alluvium. In the case of Kayal and Poonthalpadom soils except NH_4OAc all other extractants give significant correlation coefficients for the former while all the extractants exceqt DTPA for the latter.

For pooled analysis all the extractants give significant correlation coefficients but the lowest value for DTPA contrary to the highest correlation with neubauer values.

In the case of zinc among the various extractants used DTPA is the only extractant which give significant correlations in all the soil types (Table-3). In the pooled analysis all the extractants are found to give significant correlation values, but the highest value of 0.856 is obtained for DTPA.

These results are thus in agreement with the reports of Lindsay and Norvell (1978) who identified DTPA as the best extractant for the estimation of available manganese and zinc in soil

Correlations with total zinc in soil give no significant values for the Pokkali, Kari, Karapadom, Kayal, Sandy alluvium and lateritic alluvium soils This clearly brings down the importance of total zinc status of the soil in deciding the actual plant available fraction However pooled correlations are found to be significant in the case of all extractants other than NH_4OAc. Though significant these correlation coefficients are of low magnitude. The weakness of the correlation between available zinc and total zinc only emphasises that factors affecting the release or fixation of zinc have a greater bearing in determining available zinc status. Further work is needed to delineate their role particularly in acid and highly acid soil situations to evolve strategies for zinc management in such soils with out resorting to application of zinc.

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Table 1. Available manganese and zine (range of values) extracted by different extractants

Soil type		HCl		HCl + H_2SO_4		EDTA		NH_4OAC		DTPA	
		Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)	Minimum (ppm)	Maximum (ppm)
Poonthal padoms	a	9	541	7	570	5	597	6	364	6	39.2
	b	1	10	1	6	1	9	3	16	0.4	7.8
Kole	a	19	255	19	280	19	237	16	215	6	46
	b	1	10	2	14	1	9	1	13	0.4	2.6
Pokkali	a	4	14	5	14	5	15	5	15	2.8	15.6
	b	1	9	2	13	2	12	3	12	0.9	9.4
Kari	a	1	12	2	11	2	12	2	10	2	9.2
	b	1	6	1	9	1	7	2	16	0.4	5.6
Karapadom	a	20	196	17	268	19	292	13	125	8	45
	b	1	9	2	7	1	6	2	14	1	7.8
Kayal	a	36	551	56	515	60	538	14	106	10	50
	b	2	16	2	21	2	8	3	21	0.2	10.1
Sandy alluvium	a	0	10	0	16	1	10	0	9	0 6	7.2
	b	1	4	1	6	0	4	1	12	0.4	3
Lateritic alluvium	a	1	52	2	46	1	44	1	41	2	40
	b	2	8	2	8	1	4	1	12	0 8	5

a – Available manganese
b – Available zinc.

Table 2. Total zinc, manganese and Neubauer values (range of values)

Soil type	Total Mn (ppm)		Neubauer (Mn) values mg/100 g soil		Total Zn (ppm)		Neubauer values Zn. mg/100 g soil	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Poonthalpadoms	92	600	0.398	1.909	36	660	0.196	1.654
Kole	130	375	1.155	2.692	23	400	0.108	0.675
Pokkali	73	145	0.034	0.184	79	270	0.163	1.132
Kari	64	191	0.016	0.113	58	140	0.091	0.766
Karapadom	88	330	0.527	3.180	30	700	0.109	1.210
Kayal	230	1400	1.364	3.536	60	445	0.098	1.213
Sandy alluvium	76	790	0.015	0.264	49	160	0.059	0.696
Lateritic alluvium	37	165	0.267	1.760	65	540	0.086	0.537

Table 3. Simple correlation coefficients for extractable manganese and zinc with Neubauer values and totals

		Correlation Coefficient 'r' (Manganese)					Correlation Coefficient 'r' (zinc)				
		HCl	$HCl+H_2SO_4$	EDTA	NH_4OAC	DTPA	HCl	$HCl+H_2SO_4$	EDTA	H_4OAC	DTPA
Poonthalpadom	a	0.136	0.135	0.133	0.371	0.780*	-0 025	0.127	0.434	0.919*	0.968*
	b	0.873*	0.829*	0.892*	0.769*	0.180	0.344	0.765*	0.871*	0,666*	0.588*
Kole	a	0.625*	0.614*	0.638*	0.661*	0 849*	0.588*	0,815*	0.788*	0.806*	0.953*
	b	0,962*	0 959*	0.966*	0,961*	0.788*	0.705*	0.482	0,713*	0.134	0.434
Pokkali	a	0.507*	0,499*	0.596*	0.399	0.837*	0.812*	0 585*	0.629*	0,602*	0.863*
	b	0,177	0,017	0.045	-0.029	0.098	0,300	0.100	0 688*	0.205	0.299
Kari	a	0.677*	0.568*	0.380	0.617*	0.878*	0.846*	0.679*	0.731*	0,733*	0.951*
	b	0.159	-0.166	-0.286	-0.285	-0.523*	0,460	0 292	-0,038	0.112	0.469
Karapadom	a	0.711*	0.726*	0.933*	0.354	0.674*	0.874*	0.192	0.535*	0.759*	0.958*
	b	0.878*	0.926*	0.643*	0.589*	0.608*	-0,918*	0,038	0.156	0.044	0.045
Kayal	a	0.243	0.254	0.174	0.014	0.507*	0 849*	*0.855*	0.670*	0.721*	0.967*
	b	0.866*	0.854*	0.744*	0.349	0.532*	0.167	0.153	0.251	0.211	0.072
Sandy alluvium	a	0.218	0.267	0.278	0.351	0.539*	0.374	0.265	0.028	-0.017	0.949*
	b	-0.318	-0.237	-0.283	0.080	-0.288	0 091	0.109	0.038	-0.323	0.024
Lateritic alluvium	a	0.747*	0.809*	0.807*	0.758*	0.500*	0,297	0.338	0.409*	0.204	0,817*
	b	0.650*	0.666*	0,671*	0.621*	0.498*	0.229	0.123	-0.338	-0.088	0.159

* Significant at 0 05 level.
a. extractables Vs Neubauer values
b. extractables Vs totals.

Table 4. Pooled correlation coefficients for extractable Mn and Zn with Neubauer values and totals.

Extractants		'r' (Manganese)	'r' (zinc)
HCl	a	0.587*	0.464*
	b	0.861*	0.273*
HCl + H_2SO_4	a	0.606*	0.397*
	b	0.843*	0.259*
EDTA	a	0.623*	0.500*
	b	0.832*	0.208*
NH_4OAC	a	0.450*	0.528*
	b	0 445*	0.133
DTPA	a	0.752*	0.856*
	b	0.408*	0.194*

*Significant at 0.05 level.

a — extractable Vs Neubauer values.

b — extractables Vs Totals.