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Availability of Iron, Manganese and Zinc in Paddy Soils of South Gujarat

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ABSTRACT

Nearly sixty one per cent of paddy soils in the region between Mindhola and Kaveri rivers in South Gujarat contained adequate quantity of available Zn, Fe and exchangeable Mn, while less than 8 per cent of soils were deficient in Zn and Fe and rest of them had medium status. Iron deficient soils were largely confined to the northern part of the paddy growing region, while Zn deficiency was evenly spread barring soils from Navsari and Mahuva talukas. On the basis of exchangeable content, the deficiency of Mn was to the extent of 39 per cent, however, taking into consideration the high amount of easily reducible Mn, all but one could be rated as sufficient in Mn. Generally, negative correlations existed between the available contents and soil pH, $CaCO_3$ and silt + clay contents, while it was positive with organic matter. However, significant relationships were noted only in the case of available Fe when correlated with either $CaCO_3$ or organic matter content. (Key words: Paddy soils; submerged soils; micronutrient availability; micronutrient status).

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INTRODUCTION

Response to application of micronutrient in different parts of the country are largely confined to upland crops. The use of micronutrients in paddy fields has not received adequate attention. The nutritional problems of field grown paddy involving micronutrients are mainly concerned either with Fe, Mn and Zn deficiencies or sometimes with Fe toxicity. Such problems could be attributed to considerable variation arising in redox potential on account of alternate wetting and drying of paddy soils. As there is no systematic survey pertaining to availlability of Fe, Mn and Zn in paddy soils of south Gujarat, the present study was undertaken to assess micronutrient status and to find their associationships with some of the soil characteristics, which generally influence the availability of a nutrient.

MATERIAL AND METHODS

One hundred and three surface soil samples (0-22 cm) were collected from paddy growing region between rivers Mindhola and Kaveri in south Gujarat,

comprising of Navsari, Gandevi and Chikhali talukas of Valsad district and Palsana, Bardoli, Mahuva, Valod and Vyara talukas of Surat district. These soil samples were analysed for soil pH, mechanical separates, $CaCO_3$, organic matter, total N, available P and exchangeable K_2O contents (Table 1) by conventional methods as described by Jackson (1958). Among micronutrients, available Fe (Olson and Carlson, 1950), Zn (Shaw and Dean, 1952) and exchangeable and easily reducible Mn (Sherman *et al.*, 1942) were determined by using Varian Techtron Atomic Absorption Spectrophotometer (AA-120 model) after the usual extraction procedure. Correlation coefficients 'r' were worked out for different soil characteristics and aforesaid micronutrients.

For convenience only talukawise ranges and means are presented.

TABLE 1

Physico-chemical characteristics of paddy soils in South Gujarat.

Sr. No.	Name of the Taluca	pH (1 : 2.5)	EC mmhos/cm (1 : 2.5)	$CaCO_3$ (%)	Organic matter (%)	Silt + Clay (%)	Total N (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Valsad District									
1	Navsari	7.2-8.7	0.18-1.80	0.66-1.86	0.84-1.55	59.7-90.0	0.05-0.09	34-203	252-538
2	Gandevi	8.1-8.6	0.14-0.36	0.66-2.16	0.62-1.74	59.7-68.8	0.04-0.10	18-225	101-342
3	Chikhali	7.3-8.9	0.15-0.96	0.56-2.56	0.48-1.36	51.8-87.0	0.01-0.08	23-146	224-560
Surat District									
4	Palsana	7.1-8.5	0.17-0.67	0.76-1.86	0.45-2.02	57.6-78.3	0.05-0.07	34-124	347-560
5	Bardoli	7.7-8.3	0.10-0.52	0.46-1.76	0.95-1.95	66.6-78.9	0.05-0.09	63-158	179-438
6	Mahuva	8.1-8.7	0.21-0.62	0.46-1.66	0.83-1.62	50.2-64.3	0.05-0.09	41-225	358-560
7	Valod	7.3-8.5	0.16-0.30	0.46-1.26	0.62-1.79	56.1-75.5	0.04-0.10	23-225	134-338
8	Vyara	7.3-8.9	0.19-0.87	0.46-1.26	0.78-1.79	55.5-80.8	0.06-0.09	14-225	234-560
		7.1-8.9	0.10-1.80	0.46-2.56	0.45-2.02	50.2-90.0	0.01-0.10	14-225	101-560

RESULTS AND DISCUSSION

These soils, in general, are clay to clay loam in texture and not easily workable during monsoon season. Soil reaction was around neutrality to alkaline with calcium carbonate content varying from 0.46 to 2.56 per cent. The salt accumulation was below the harmful limit in all the soils. They were low in organic matter and nitrogen

TABLE 2

Ranges and averages for available Fe, exchangeable and easily reducible Mn and available Zn contents in paddy soils to South Gujarat.

Sr. No.	*Name of the Taluka*	*No. of samples*	*Available Fe (ppm)*		*Exchangeable Mn (ppm)*		*Easily Reducible Mn (ppm)*		*Available Zn (ppm)*	
			Range	*Average*	*Range*	*Average*	*Range*	*Average*	*Range*	*Average*
Valsad District										
1	Navsari	16	1.5-25.5	6.5	0.8-13.2	4.7	84-444	304	0.8-2.1	1.3
2	Gandevi	13	1.8-24.2	5.9	0.4-12.1	3.2	204-577	347	0.4-2.4	1.2
3	Chikhali	12	2.9-18.5	6.7	1.1-13.2	5.1	244-524	367	0.6-4.0	1.4
Surat District										
4	Palsana	12	1.2-7.5	4.3	1.5-22.0	5.8	280-595	404	0.6-1.7	1.0
5	Bardoli	16	1.3-33.4	8.0	1.0-11.1	4.7	213-639	379	0.6-1.7	1.2
6	Mahuva	10	4.8-46.6	17.1	2.0- 9.3	5.4	222-400	333	0.9-2.1	1.5
7	Valod	12	5.3-52.8	17.2	1.6-10.0	5.0	244-710	409	0.6-2.3	1.1
8	Vyara	12	4.8-30.8	14.3	0.7-10.0	3.2	276-533	389	0.5-1.3	1.0
		103	1.2-52.8	9.6	0.4-22.0	4.6	84-710	365	0.4-4.0	1.2

contents, medium in phosphate and adequate in potash (Table 1).

Available Fe: It ranged from 1.2 to 52.8 ppm in the soil from Palsana and Valod talukas respectively, with an average of 9.6 ppm (Table 2). Among different talukas, the average Fe content for Palsana (4.3 ppm) was the least, but it was nevertheless lower than the critical limit of 2 ppm suggested by Olson and Carlson (1950) to obtain response to Fe application.

To study the pattern of Fe distribution, the soils were grouped into three classes viz. low (< 2 ppm), medium (2 to 5 ppm) and high (> 5 ppm) on the basis of available Fe content. It is revealed (Table 3) that none of the paddy soils collected from villages of Chikhali taluka in Valsad district as well as Mahuva, Valod and Vyara talukas in Surat district could be rated as Fe-deficient as the content was always higher than 2 ppm. The Fe deficient soils arel argely confined in the northern part of this paddy growing region having relatively light-textured soils. Talukawise percentage for Fe deficient soils was 6.2 in Navsari, 7.7 in Gandevi, 16.7 in Palsana and 25 in Bardoli. Overall Fe deficiency was to the tune of 7.8 per cent in this paddy growing region of south Gujarat, while it was sufficient in 61 per cent of the soils. Hence, Fe application is likely to

prove beneficial on soils containing either less than 2 ppm or marginal quantity of available Fe. Rest of the 31 per cent soils containing moderate quantity of Fe may or may not respond to Fe application as the nourishment of plants is greatly influenced by the concentration of other interacting ions. Moreover, plant genotypes differ in their responses to levels of soil fertility.

Thus, it can be deduced that the soils of paddy growing region in south Gujarat contained fairly adequate quantity of available Fe. The results are in line with those reported by Reddy and Mehta (1962), while establishing the relationship between Co and Fe status for soils of Gujarat.

Available Mn: Generally, water soluble Mn being quite negligible, this was not differentiated from the exchangeable form, in the present study. The results (Table 2) showed that both exchangeable and easily reducible Mn contents of these paddy soils ranged from 0.4 to 22.0 ppm with an average of 4.6 ppm and from 84 to 710 ppm with an average of 365 ppm, respectively. The minimum exchangeable content was observed in a soil from Gandevi taluka in Valsad district, while the maximum was found in a soil from Palsana taluka in Surat district. The least content of easily reducible Mn was 84 ppm in soil from Navsari taluka, whereas the highest 710 ppm was in a soil from Valod taluka, both belonging to Valsad district. Ranges and means for exchangeable and easily reducible Mn recorded here are in agreement with those reported by Patel *et al.* (1972) and Anon (1975-76).

The least average exchangeable Mn content (3.2 ppm) was noted for the soils from two talukas viz. Gandevi (Valsad district) and Vyara (Surat district) while the highest (5.8 ppm) was noted for the soils from Palsana taluka (Surat district). Soils from the villages of Navsari taluka (Valsad district) contained the minimum (304 ppm) easily reducible Mn, while those from villages of Valod taluka (Surat district) had the maximum (409 ppm) content. It was noticed that more than 60 per cent of the soils from Gandevi and Vyara talukas had exchangeable Mn less than 3 ppm, whereas percentages of such deficient soils were 20 in Mahuva, 25 in Valod and Palsana, 31 in Navsari, 33 in Chikhali and 44 in Bardoli talukas (Table 3). Averaged over all the soils only 39 per cent may be considered deficient in respect of exchangeable Mn. However, from a consideration of the easily reducible Mn, these deficient soils may be considered to have adequate Mn supplying capacity. This emphasizes the fact that Mn status of the soil need not be assessed on the basis of exchangeable content only but easily reducible form should also be considered, as Sherman and Harmer (1943) have suggested that productive neutral to alkaline soils should have at least either 3 ppm exchangeable Mn or 100 ppm of easily reducible Mn or both to be free from Mn deficiency. Moreover, Leeper (1947) showed that alternate water-logging and draining of a soil increases the supply of Mn^{2+} in that soil. Therefore, plants growing on the soils containing less than 3 ppm exchangeable Mn never suffered from the deficiency of Mn nor its deficiency symptoms were exhibited, as those very

TABLE 3

Iron, manganese and zinc status of paddy soils in South Gujarat (on percentage basis)

Sr. No.	Name of Taluka	No. of samples	Available Fe			Exchangeable Mn**		Available Zn		
			D*	M*	A*	D	A	D	M	A
Valsad District										
1	Navsari	16	6.2	31.3	62.5	31.2	68.8	0.0	25.0	75.0
2	Gandevi	13	7.7	61.5	30.8	61.5	38.5	7.7	23.1	69.2
3	Chikhali	12	0.0	50.0	50.0	33.3	66.7	8.3	33.3	58.4
Surat District										
4	Palsana	12	16.7	50.0	33.3	25.0	75.0	16.6	41.7	41.7
5	Bardoli	16	25.0	31.3	43.7	43.7	56.3	6.2	31.3	62.5
6	Mahuva	10	0.0	10.0	90.0	20.0	80.0	0.0	10.0	90.0
7	Valod	12	0.0	0.0	100.0	25.0	75.0	8.3	41.7	50.0
8	Vyara	12	0.0	8.3	91.7	66.6	33.4	8.3	50.0	41.7
		103	7.8	31.0	61.2	39.0	61.0	6.8	32.0	61.2

*D = Deficient, M = Medium, A = Adequate

**Content of easily reducible Mn was more than 100 ppm in all but one soil.

soils contained fairly high amounts of easily reducible Mn. Thus, there appears to be a little chance to obtain a positive response to Mn application in these paddy soils. The results are similar to those reported under Coordinated Micronutrient Project (Anon., 1975-76).

Available Zn: Dithizone ammonium acetate extractable Zn content in soils under paddy cultivation in south Gujarat varied from 0.40 to 3.98 ppm with an average of 1.21 ppm (Table 2). The least content was noted in a soil from Gandevi taluka whereas the highest one was from Chikhali taluka both belonging to Valsad district. According to Brown *et al.* (1962), the critical limit for dithizone-extractable Zn below which responses to zinc could be expected is 0.55 ppm. However, the experience with black soils has shown that this limit may be elevated to 0.8 ppm (Kanwar, 1976). Work done under All India Co-ordinated Scheme of *Micronutrients in Soils and Plants*, (Anon, 1975-76) has indicated 0.63 ppm as the critical limit for paddy soils on the basis of pot-studies. In order to have critical evaluation, the soils of different talukas were classified into three groups considering below 0.65 ppm as deficient, 0.65 to 1.00 ppm as medium and above 1.00 ppm as adequate. Taluka-wise evaluation (Table 3) revealed that none of the soils collected from Navsari and Mahuva talukas contained less than 0.65 ppm available Zn, while about 17 per cent of the soils from Palsana taluka (Surat district) had the content below the critical level of 0.65 ppm. In each of the remaining talukas only about 6 to 8 per cent soils contained less than 0.65 ppm of available Zn. Except for

the region of Navsari and Mahuva talukas, Zn deficient soils were evenly distributed in different parts of paddy growing area. It seems that in general, 61 per cent of these paddy soils were capable of supplying sufficient amount of Zn (> 1.00 ppm) for normal requirement of plants, while about 32 per cent of the soils containing moderate quantity of Zn (0.65 to 1.00 ppm) may or may not respond to Zn application depending upon the other soil environmental factors. Response is probable when the content of interferring ions like Fe or P is in excessive quantity and especially very much so in the case of high yielding paddy varieties grown under submergence. However, there is a need to establish Zn critical level for low land paddy soils of south Gujarat as these soils are rich in available Fe content.

Correlation coefficients : Amongst soil factors, pH, $CaCO_3$, silt + clay and organic matter content, the first three were found to alter the available Fe content negatively, but the relationship was significant only in case of $CaCO_3$ ($r = -0.293$ **) while the organic matter content had positive significant relationship ($r = 0.269$ **) with available Fe content. These results are in line with those reported by Misra and Pande (1976) for water-logged soils of U.P. Rest of the relationships between the available content and some of the physico-chemical properties were non-significant.

From the simple correlation studies, it was noticed that both available Mn (exchangeable and easily reducible forms) and Zn were not significantly related with any of the soil characteristics individually, stressing the fact that the availability of a nutrient is largely influenced by the integrated effects of all the factors like soil pH, $CaCO_3$, silt clay and organic matter contents. Similar relationships for Mn were also reported by Mann *et al.* (1977). Non-significant associationships of Zn with soil characteristics are in consonance with those stated by Rai *et al.* (1970) for deep black soils of M.P.

Thus, about 8 per cent of the paddy soils indicated deficiency of Fe and Zn. Available Fe content of soils showed significant positive associationship with organic matter while it was negative with respect to free lime content.

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