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Delineation of Micronutrient Status of Surface Soils of Sivagangai Block, Tamil Nadu

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Abstract : Two hundred and ninety five soil samples drawn from 49 villages covering the entire block of Sivagangai in the State of Tamil Nadu were assessed for the total and available micronutrients (Zn, Fe, Mn, and Cu). The total micronutrient status of surface soils in villages of Sivagangai block were highly variable and ranged from 13 to 128, 870 to 11779, 40 to 550 and 20 to 90 ppm for zinc, iron, manganese and copper, respectively. The average values for available Zn, Fe, Mn and Cu varied from 0.36 to 1.44, 10.6 to 65.2, 8.28 to 29.5 and 1.20 to 3.88 ppm, respectively. The data on village level micronutrient status revealed that available zinc appears to be deficient in two-third of the soils in Sivagangai block (74.60 %). The available copper and manganese status were deficient by 4.40 % and 5.1 %, respectively. On the other hand, available iron status of Sivagangai block has shown to be sufficient in all the soil samples derived from the Sivagangai block. The data suggest that micronutrient status decreased with pH, free calcium carbonate and available phosphorous content while the availability of zinc and copper increased with increasing clay content and organic carbon status.

Key words: Micronutrient cations, Soil properties, Surface soil.

Introduction

Micronutrient deficiency in soil is one of the major causes for yield reduction for a wide array of crops. Continuous cropping of high yielding varieties without proper substitution of inorganic fertilizers, non-addition of micronutrients, and less or no application of organic manures have caused excessive removal of essential nutrients from the soil reserves that eventually led to the deficiencies of micronutrients in soils. Among the micronutrients, Zn appears to be deficient in most part of Indian soils at varying intensities with the exception of acidic soil regions. There is an urgent need to target the problem correctly and specifically for precise fertilizer prescription. In order to correct the micronutrient deficiency, it is quite appropriate to delineate the micronutrient status that facilitates on the establishment of a strong soil database that can be used for crop planning and its management. Sivagangai block in Tamil Nadu carries highly weathered nutritionally poor soils and crops grown in these soils are often exposed a wide array of micronutrient deficiencies. This research work is a pioneering effort to examine the micronutrient status of Sivagangai block in Tamil Nadu and their interrelationships with soil characteristics.

Materials and Methods

Sivagangai block in Tamil Nadu State spreads over 49 villages covering an extent of 42875 hectares of land. To delineate the soil micronutrient status 295 surface soil samples representing the whole Sivagangai block region were collected. The soil samples collected from surface soils (15 cm) were processed (< 2

mm sieve) and analyzed for physicochemical properties following standard procedures (Jackson, 1973). The available micronutrients (Fe, Mn, Cu and Zn) in these soil samples were extracted by DTPA extractant (Lindsay and Norvell, 1978) and determined by Atomic Absorption Spectrophotometer (Varian 200, Australia). The critical level used to delineate the deficiency and sufficiency level for different micronutrients were 3.7 ppm for iron, 2ppm for manganese, 1.2 ppm for zinc and copper.

Results and Discussion

Soil properties

The data on surface soil properties (Table 1) in Sivagangai block indicated wide variations. The texture of the soil was generally in the range of loamy sand to sandy clay carrying clay content in the range of 3.4 to 40.7 per cent. The data suggest that the soils in the upland regions are usually in the order of light textured soils while the lowland regions carry heavy textured soils. The distinct difference in textural class is due to the occurrence of elluviation and illuviation in the upland and lowland regions, respectively. This is in line with the studies made by Kadambavanasundaram (2000).

The soils of Sivagangai block generally maintained neutral pH ranging from 6.5 to 7.5 that is ideally suited for the cultivation of wide range of crops with no limitations. There was a digital divide between upland and lowland regions where slightly acidic and slightly alkaline pH was observed, respectively. It is reasonable that light textured soil carry slightly acidic pH due to the migration of bases from surface to subsurface soils. On the other hand, heavy textured soils retain bases that in turn cause alkalinity in the surface horizons of the low-lying regions. Majority of soil samples in Sivagangai block registered low salinity level that may be attributed to the sandy nature of soil. The results are in conformity with the findings of Alagu Nagendiren (1997).

In Sivagangai block, 85 per cent of soils carry free calcium carbonate content less than 1 per cent indicating that the soils are non-calcareous. This may be attributed to the removal of calcium from the surface horizon to the sub-surface horizon .Similar results were reported by Sujatha *et al.* (1999). The organic carbon content of Sivagangai block showing equal per cent of low, medium and high status depending on the levels of decomposition in the soil. Similar observations were also made by Sharma *et al.* (1999).

In Sivagangai block, 80 per cent of the surface soils were medium to high in available P status and the remaining soils were categorized as low in P status. The data suggest that, the soil of this region is relatively sufficient in terms of labile status of P. The available P status is enigmatic and very sensitive to pH. As the soils of Sivagangai block maintained soil pH in the range of 6.5 to 7.5, which is highly favorable for the availability of P status. A strong relation between pH and available P status is well established.

Micronutrient status

The total micronutrient status of surface soils in villages of Sivagangai block (Table 2 & 3) were highly variable and ranged from 13 to 128, 870 to 11779, 40 to 550 and 20 to 90 ppm for zinc, iron, manganese and copper, respectively. The total number of soil samples had been analysed for available (DTPA-extractable) micronutrient status and samples were grouped as deficient or sufficient based on the critical limits fixed for the soils. The data have shown that among the micronutrients, zinc appears to be deficient in two-third of the soils in Sivagangai block (74.60 %). The

Table 1. Soil properties of villages in Sivagangai block

Name of the Village	Sample size	Clay (%)	Textural Class	pH	$CaCO_3$ (%)	OC (%)	Available P (kg ha^{-1})
Alagamaneri	5	3.36	Is	6.54	0.85	0.46	28.6
Alagichipatti	5	23.63	scl	7.22	0.90	0.79	50.7
Alavakottai	5	15.52	si	6.33	1.00	0.70	11.5
Arasani	5	34.30	scl	7.61	0.76	0.37	11.0
Arasanur	10	14.36	si	7.25	0.91	0.43	25.3
Cholapuram	5	8.52	Is	6.27	0.81	0.66	22.6
Idayamelur	10	16.45	si	7.16	1.13	0.43	22.8
Illupakudi	5	16.25	si	6.45	0.66	0.29	17.2
Kadambangulam	5	6.35	Is	6.46	0.95	0.41	19.5
Kallaradhinipatti	5	14.36	si	6.85	0.87	0.50	22.5
Kallurani	5	21.41	scl	7.70	0.97	0.99	26.4
Kandangipatti	5	7.33	Is	6.67	0.71	0.17	12.5
Kangirangal	10	15.45	si	6.32	0.93	0.83	22.8
Kannayiruppu	5	36.70	sc	6.82	1.30	0.58	54.7
Kattanipatti	5	8.63	Is	6.46	0.82	0.33	6.5
Kayankulam	5	37.20	sc	6.70	0.85	0.58	12.5
Keelapoongudi	5	20.12	scl	6.17	0.86	0.97	5.50
Kilathari	10	6.33	Is	6.45	0.78	1.03	5.8
Kilkandani	5	30.85	scl	6.07	0.80	0.62	7.80
Kottagudi	5	23.47	scl	5.63	0.81	0.99	21.9
Kovanur	5	22.36	scl	7.54	0.57	0.32	32.8
Kumarapatti	5	5.35	Is	6.87	0.71	1.12	15.8
Kutturavupatti	5	23.85	scl	6.82	0.88	0.54	35.9
Madagupatti	10	17.45	sl	5.66	0.61	0.46	14.8
Malampatti	10	25.8	scl	6.66	0.97	0.87	18.2
Mangudi	5	31.40	scl	5.66	0.96	0.50	24.6
Maraniusilangulam	5	26.41	scl	7.30	0.82	0.91	28.9
Mathur	5	3.36	sl	6.80	0.92	0.58	12.8
Melapoongudi	5	23.63	sl	7.55	0.83	0.50	27.6
Melavani yankudi	5	15.52	sl	6,56	0.82	0.79	21.6
Mudikandam	5	34.30	sl	6.90	1.07	1.03	18.9
Nallukottai	5	14.36	sl	6.04	0.62	0.41	17.2
Namanur	10	8.52	scl	6.50	0.98	0.25	30.6
Okkur	10	16.45	cl	7.59	0.85	0.29	10.1
O. Puthur	5	16.25	scl	5.92	0.85	0.87	6.8
Padamathur	5	6.35	scl	7.68	1.12	0.17	61.4
Panaiyur	5	14.36	sc	7.77	1.42	1.12	25.8
Perunkudi	5	21.41	sc	7.10	0.87	0.40	5.55

Table 1. Contd...

Name of the Village	Sample size	Clay (%)	Textural Class	pH	$CaCO_3$ (%)	OC (%)	Available P (kg ha^{-1})
Pillur	5	7.33	si	7.05	0.70	0.33	12.5
Ponnakulam	5	15.45	ls	6.25	0.88	0.50	12.7
Pudhupatti	10	36.70	ls	6.57	0.86	0.66	8.7
Salur	*5*	8.63	ls	6.57	0.72	0.53	10.8
S endiudayanathapuram	10	37.20	scl	6.47	0.87	0.62	17.6
Sundanadappu	5	20.12	scl	6.51	0.73	1.03	17.2
Tamarakki - Therkku	5	6.33	si	6.68	0.72	0.74	10.5
Tamarakki - Vadakku	5	30.85	scl	7.48	0.75	1.03	21.6
Teraniyendal	5	23.47	ls	6.71	0.50	0.35	40.6
Thirumalai	5	22.36	scl	6.61	0.98	0.64	12.9
Valuthani	5	5.35	sc	7.37	1.21	0.79	16.8
Range		3.36-40.70		5.63-7.77	0.50-1.42	0.17-1.12	55-61.4
Mean		19.26		6.74	0.86	0.62	20.39
S.D.		11.11		0.56	0.17	0.27	12.31
CV (%)		57.68		8.30	19.76	43.55	60.37

available copper and manganese status were deficient by 4.40 % and 5.1%, respectively. On the other hand, the available iron status of Sivagangai block has shown to be sufficient in all the soil samples derived from the Sivagangai block.

Interaction between soil properties and available micronutrients status (Table 4)

To assess the interaction between soil properties and available micronutrient status, the soil samples were grouped according to the variations in clay content (< 15, 15-25, > 25%), pH (<6, 6-7.5, > 7.5), free $CaCO_3$ (O.75, 0.75-1.0, >1.0%), organic carbon (<0.5, 0.5-0.75, >0.75%) and available phosphorous (<11, 11-22, >22 kg ha^{-1}).

The clay content had synergistic effect on the availability of zinc and copper. The increasing clay content increased the availability of zinc and copper. The adsorbed metal ions usually stay in the soil solution in equilibrium. Thus, a soil having greater quantity of clay provides extensive surface area for ion exchange and thus contributing towards DTPA extractable forms of zinc and copper. These results are in conformity with the findings of Murthy *et al.* (1997) and Minakshi *et al.* (2005). From this study, it is observed that availability of iron and manganese decreased with increasing clay content that may be attributed to the fixation of these metal ions under heavy clay condition. This result was in line with the findings of Sharma *et al.* (2005).

In the alkalinity condition, the availability of zinc, iron, manganese and copper is reduced due to the precipitation process. In alkaline

Table 2. Micronutrient status of surface soils of villages in Sivagangai block

Name of the Village	Sample size	Total micronutrients (ppm)				Available micronutrients (ppm)			
		Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
Alagamaneri	5	82	4644	220	20	0.60	49.4	27.88	1.88
Alagichipatti	5	25	9265	60	70	1.08	23.44	15.4	3.52
Alavakottai	5	75	3680	80	30	1.06	38.60	29.48	3.0
Arasani	5	20	11148	270	30	0.36	21.52	26.00	1.32
Arasanur	10	20	6705	40	40	0.91	29.3	16.41	2.48
Cholapuram	5	20	10734	110	50	0.82	16.46	23.76	2.00
Idayamelur	10	50	10757	180	60	0.64	28.57	9.27	1.65
Illupakudi	5	20	6966	50	20	0.80	11.56	18.52	1.84
Kadambangulam	5	50	9904	230	60	0.44	30.4	24.04	1.88
Kal laradhinipatti	5	30	11779	340	40	0.64	27.54	23.56	1.80
Kallurani	5	84	8009	110	80	1.08	24.20	13.48	1.88
Kandangipatti	5	20	9205	350	40	1.16	18.72	16.52	2.56
Kangirangal	10	30	10058	130	50	0.66	37.50	25.31	2.10
Kannayiruppu	5	20	7890	70	50	1.28	12.6	10.88	2.64
Kattanipatti	5	40	7606	260	30	0.68	65.2	23.32	1.84
Kayankulam	5	30	10165	120	40	0.6	32.28	17.56	2.76
Keelapoongudi	5	20	3271	90	20	0.96	35.96	21.88	2.92
Kilathari	10	51	8989	140	70	0.94	25.67	26.84	2.46
Kilkandani	5	78	7168	380	20	1.04	31.84	14.44	2.80
Kottagudi	5	48	7890	310	30	0.56	33.12	18.2	2.2
Kovanur	5	70	8909	70	90	0.64	22.84	8.28	1.60
Kumarapatti	5	80	11291	220	50	1.12	28.24	21.6	1.52
Kutturavupatti	5	58	8589	180	20	1.12	16.68	21.24	2.64
Madagupatti	10	46	10888	440	20	1.06	39.10	21.08	3.08
Malampatti	10	36	10118	130	40	0.84	21.24	17.04	2.02
Mangudi	5	90	9976	220	70	0.60	31.16	25.56	2.08
Maraniusilangulam	5	30	10829	360	40	1.28	32.56	19.68	3.0
Mathur	5	112	11670	180	80	0.54	33.18	18.84	1.24
Melapoongudi	5	90	6978	210	90	1.00	24.6	13.72	2.44
Melavaniyankudi	5	20	11279	290	30	0.80	18.6	26.16	1.56
Mudikandam	5	40	11765	260	40	0.56	41.72	22.46	1.20
Nallukottai	5	20	10343	320	30	0.88	19.08	19.24	3.20
Namanur	10	53	8554	260	30	0.89	32.26	9.54	1.72
Okkur	10	13	870	93	20	0.92	12.77	12.04	2.02
0. Puthur	5	22	10094	100	40	0.88	32.56	26.92	2.08
Padamathur	5	20	7701	120	30	0.84	14.52	10.16	2.48

Table 2. Contd...

Name of the village	Sample size	Total micronutrients (ppm)				Available micronutrients (ppm)			
		Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
Panaiyur	5	63	8542	270	40	1.08	10.64	12.04	3.68
Perunkudi	5	60	10165	130	30	0.92	22.2	16.08	2.60
Pillur	5	38	6184	330	20	0.88	15.48	12.88	2.88
Ponnakulam	5	20	7487	240	30	0.76	19.52	23.40	1.80
Pudhupatti	10	26	10401	400	30	0.90	24.0	26.85	3.88
Salur	5	36	5236	85	50	0.88	18.00	27.96	2.92
Sendiudayanatha-puram	10	38	9620	250	30	0.67	20.52	23.57	1.96
Sundanadappu	5	82	8435	550	80	1.44	21.42	19.60	3.20
Tamarakki - Therkku	5	60	10260	230	60	0.76	24.92	23.00	2.76
Tamarakki-Vadakku	5	90	9976	520	40	1.36	19.36	10.88	3.12
Teraniyendal	5	45	3471	75	20	0.80	19.16	19.12	1.92
Thirumalai	5	128	10331	150	40	1.24	20.34	21.88	2.48
Valuthani	5	40	10947	290	50	0.82	17.2	12.56	3.48
Range		13-128	870-11779	40-550	20-90	0.36-1.44	10.64 -65.20	8.28-2948	1.20-3.88
Mean		47.12	8709	214	42.65	0.87	26.56	19.87	2.38
S.D.		28.38	2469	123	19.77	0.26	10.80	5.67	0.67
CV (%)		60.23	28.34	57.47	46.35	29.88	40.66	28.53	28.15

Table 3. Delineation of available micronutrient status of Sivagangai Block

Micronutrient	Critical limit (ppm)	No. of Soil samples	Percent samples	
			Deficient	Sufficient
Zinc	1.2	295	74.6	25.4
Iron	3.7	295	Nil	100.00
Manganese	2.0	295	5.1	94.9
Copper	1.2	295	4.4	95.60

range (above pH 7.5), zinc forms negatively charged ions due to the fraction of hydroxides. The change in pH may alter the stability of soluble and insoluble organic complexes of zinc or the solubility of antagonistic ions (Singh and Singh, 1996). Reduction in availability of iron with an increase in pH may be attributed to conversion of Fe^{++} ions to Fe^{+++} ions. At high pH, iron may precipitate as insoluble $Fe(OH)_2$ (Samantha *et al.,* 2002; Sharma

et al., 2003). With increase in pH, divalent form (Mn^{2+}) may convert into trivalent or polyvalent forms that are insoluble and not easily available to the plants. The results indicated that the reduction in availability of copper with increasing soil pH and this may probably be due to precipitation of copper as its hydroxides. Thus newly formed hydroxides of copper would have either become the part of lattice or occluded with the hydroxides of iron, aluminium and manganese.

The availability of iron and manganese was decreased at the range of more than one per cent calcium carbonate due to the possibility of precipitation or oxidation of Fe to Fe^{3+} oxides or transformation of availability iron into carbonates or retention by free $CaCO_3$ presence and fixation of manganese by adsorption on the surface of the calcium carbonate particles (Sharma *et al.,* 2003). The organic carbon content of the soil increases the available zinc and copper status due to the supply of chelating agents and thereby protects the metal ions from precipitation into unavailable forms. This result was in line with the findings of Sharma *et al.* (2003). The available iron, manganese and copper decreased with the increasing amount of available P due to the precipitation of iron, manganese and copper with its respective phosphate compounds. This was in accordance with the findings of Maji *et al.* (1993) and Sana *et al.* (1996).

Table 4. Interaction between soil properties and available micronutnents

Soil properties	Range	Available micronutnents status (ppm)			
		Zn	Fe	Mn	Cu
Clay (%)	<15	0.82	28.59	23.17	2.23
	15-25	0.84	27.46	19.27	2.30
	>25	0.95	22.03	16.44	2.55
pH	<6	0.78	33.98	23.71	2.36
	6-7.5	0.92	26.35	20.30	2.40
	>7.5	0.85	18.72	13.81	2.20
$CaCO_3$(%)	<0.75	0.95	21.68	18.96	2.50
	0.75-1.0	0.85	28.26	20.66	2.30
	>1.0	0.80	20.88	12.90	2.50
Organic carbon (%)	<0.5	0.79	26.59	17.13	2.18
	0.5-0.75	0.87	24.52	21.92	2.45
	>0.75	0.97	26.46	19.62	2.48
Phosphorus (kg ha^{-1})	<11	0.90	29.31	21.93	2.63
	11-22	0.80	25.00	20.11	2.30
	>22	0.78	25.20	16.99	2.30

The micronutrient status of Sivagangai block indicated that zinc, copper, manganese and iron were deficient to the tune of 74.6, 4.4, 5.1 and 0 per cent, respectively. The overall data suggest that soils of Sivagangai block are severely or moderately deficient in zinc, manganese and copper while iron was found to be sufficient. The deficiencies of zinc and copper mostly associated with alkalinity, high free lime status or low organic carbon content. Application of organic manure in conjunction with micronutrient fertilization would assist in promoting availability of micronutrients and restore soil productivity.

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