



Original Research Article

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Vertical Distribution of Micronutrient Cations in Thoubal and Bishnupur District, Manipur (India)

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ABSTRACT

Keywords

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The depth wise distribution of DTPA-extractable micro-nutrient cations (Zn, Cu, Fe and Mn) and their relationship with other soil properties were worked out in twenty eight (28) typical soil profiles of paddy fields of Thoubal and Bishnupur district, Manipur. DTPA-extractable Zn, Cu, Fe and Mn content were higher in the surface soils than the sub-surface soils and varied from 0.27 to 1.48, 1.00 to 8.00, 17.00 to 287.00 and 6.00 to 141.00 mg kg⁻¹, respectively. DTPA-extractable micro-nutrient cations were well sufficient in the surface layer (0 – 20 cm) of all the soil profiles. Multiple regression analysis indicated that the DTPA-extractable Zn, Cu, Fe and Mn content were influenced by pH, EC, CEC, OC, N, sand and clay to the degree of 0, 44, 24 and 82, respectively, however, their influenced were insignificant.

Introduction

Soil fertility is one of the important factors controlling crop yield. Productivity of the crop is related with physico-chemical properties of the soils. Soil testing provides the information of the nutrient availability of the soil upon which the fertilizer recommendation for maximum yield is made. Zinc, copper, manganese, iron, boron etc. are essential micro-nutrients for plant growth. Through their involvement in various enzymes and other physiologically active molecules, these micro-nutrients are important for gene expression, synthesis of protein, nucleic acids, growth substances, chlorophyll and secondary

metabolites, metabolism of carbohydrates and lipids, stress tolerance, etc. (Singh, 2004, Rengel, 2007 and Gao, *et al.*, 2008). Micro-nutrients are very important for maintaining soil health and also in increasing productivity of crop (Rattan *et al.*, 2009). The exploitive nature of modern agriculture involving the use of high analysis NPK fertilizers coupled with limited use of organic manure and less recycling of crop residues are the important factors contributing towards accelerated exhaustion of micro-nutrients from the soil (Sharma and Choudhary, 2007). Therefore, the deficiency of micro-nutrients has become a major constraint to productivity and sustainability in many Indian soils (Athokpam *et al.*, 2016). The availability of micro-

nutrients to plants is also influenced by the distribution within the soil profile (Singh and Dhankar, 1989). The knowledge of profile distribution of micro-nutrients is important as roots of many plants go beyond the surface layers of the soils. Also, the availability of micro-nutrients are depend upon the physico-chemical and biological properties of the soils. However, no systematic and exhaustive study had been made the distribution of micro-nutrient cations in the paddy field of Thoubal and Bishnupur district of Manipur. Therefore, the present study has been undertaken to assess the distribution of micro-nutrient cations of the paddy fields and also to find out the relationship between the soil properties and micro-nutrient cations.

Materials and Methods

Typical twenty eight (28) soil profiles were exposed and depth wise i.e. 0-20, 20-40 and 40-60 cm soil samples were collected. All the soil samples were air-dried, ground and passed through 2 mm sieve for physico-chemical analysis like soil texture, pH, EC, (1: 2.5 soil : water), organic carbon, CEC, available N, P and K, Ca and Mg using standard laboratory procedures outline by Bouyoucos (1951), Borah *et al.*, (1987), Bray and Kurtz (1945), Chopra and Kamwar (1976), Jackson (1973), Subbiah and Asija (1956) and Walkley and Black (1934).

The DTPA-extractable Zn, Cu, Fe and Mn in the soil samples were extracted with a solution of 0.005M DTPA, 0.01M CaCl₂ and 0.1M triethanolamine adjusted to pH 7.3 as outlined by Lindsay and Norvell (1978). The concentration of micronutrient cations in the extract was determined using atomic absorption spectrophotometer. Multiple regression equations computed between DTPA-extractable micronutrients and soil properties was done by adopting standard statistical procedures (Panse and Sukhatme,

1961).

Results and Discussion

The physico-chemical properties of the representative soil profiles are presented in Table 1. There were no definite patterns in the distribution of sand, silt, and clay content in all the profiles. Sand content varied from 5.0 to 42.5 per cent, silt ranged from 5.0 to 37.6 per cent and clay contents were varied from 37.5 to 82.5 per cent. The soils were strongly acidic to slightly neutral (pH 4.72 – 6.98). The EC varies from 0.04 to 0.19 dSm⁻¹ and organic carbon content from 3.0 to 27.0 g kg⁻¹. Surface soil layers contained more organic carbon than the sub-surface layers. CEC ranged from 9.0 to 21.6 [cmol(p⁺)]kg⁻¹ soil. The exchangeable Ca and Mg content in the soils ranged from 2.1 to 6.0 and 0.7 to 4.0 [cmol(p⁺)]kg⁻¹ soil, respectively, both bases decreased with increased in depth in all the soil profiles. The available N, P and K content in the soils were 62.72 to 376.32, 4.48 to 18.78 and 67.20 to 343.39 kg ha⁻¹, respectively. These macro-nutrients content decreased with increase in the depth in all the soil profiles.

DTPA-extractable micronutrients status

Zinc

DTPA-extractable Zn in the studied soil profiles ranged from 0.27 to 1.48 mg kg⁻¹ in the paddy fields of Thoubal and Bishnupur district of Manipur. Sen *et al.*, (1997) reported the available Zn content vary from 0.2 to 1.4 mg kg⁻¹ and decreased down the profile. Similar observations were also reported by Athokpam *et al.*, (2013), Athokpam *et al.*, (2016) and Athokpam *et al.*, (2018). Considering 0.6 mg kg⁻¹ as the critical limit of available Zn as suggested by Takkar and Mann (1975), Zn was found sufficient in all the surface soils of the profiles. DTPA-extractable Zn showed non-significant

multiple regressions with soil properties in all the soil layers.

Copper

DTPA-extractable Cu content in the profiles varied from 1.00 to 8.00 mg kg⁻¹. All the twenty eight typical soil profiles were found sufficient, and is being 0.2 mg kg⁻¹ as critical value (Lindsay and Norvell, 1978). DTPA-extractable Cu content was higher in the surface soils and decreased gradually in all the

profiles. Similar results were also reported by Gupta *et al.*, (2003), Verma *et al.*, (2007), Athokpam *et al.*, (2016) and Athokpam *et al.*, (2018). The multiple correlation and regression analyses indicated that the Cu content was influenced by sand and clay; however, their influences were not significant. Their predictability was 14.4, 44.3 and 22.3 per cent variability by all factors taken together in the 1st, 2nd and 3rd layers in the profiles, respectively (Table 2).

Table.1 Some physico-chemical properties of the soils

Soil properties	Soil depth	Range	mean
Sand (%)	-	5.0 – 42.5	-
Silt (%)	-	5.0 – 37.6	-
Clay (%)	-	37.5 – 82.5	-
pH	0 – 20	4.78 – 6.56	5.61
	20 – 40	4.72 – 6.76	6.16
	40 - 60	5.07 – 6.98	6.36
EC (dSm ⁻¹)	0 – 20	0.06 – 0.19	0.13
	20 – 40	0.05 – 0.14	0.08
	40 - 60	0.04 – 0.11	0.07
CEC [cmol(p ⁺)]kg ⁻¹	0 – 20	11.6 – 21.6	16.67
	20 – 40	9.0 – 19.8	15.16
	40 - 60	9.6 – 20.4	13.41
Ca [cmol(p ⁺)]kg ⁻¹	0 – 20	2.5 – 6.0	4.33
	20 – 40	3.2 – 5.1	4.03
	40 - 60	2.1 – 3.9	3.12
Mg [cmol(p ⁺)]kg ⁻¹	0 – 20	1.5 – 4.0	3.13
	20 – 40	1.3 – 3.9	2.71
	40 - 60	0.7 – 3.0	2.15
OC (g kg ⁻¹)	0 – 20	6.0 – 27.0	17.8
	20 – 40	3.0 – 18.3	9.1
	40 - 60	3.0 – 9.3	6.3
N (kg ha ⁻¹)	0 – 20	125.44 – 376.32	286.72
	20 – 40	125.44 – 316.60	244.16
	40 - 60	62.72 – 250.88	150.08
P (kg ha ⁻¹)	0 – 20	7.43 – 18.78	12.85
	20 – 40	6.19 – 15.10	10.78
	40 - 60	4.48 – 13.55	8.35
K (kg ha ⁻¹)	0 – 20	94.08 – 343.39	180.69
	20 – 40	70.56 – 216.72	138.77
	40 - 60	67.20 – 134.74	109.69
Zn (mg kg ⁻¹)	0 – 20	0.58 – 1.48	1.11
	20 – 40	0.38 – 1.03	0.86
	40 - 60	0.27 – 0.78	0.64
Cu (mg kg ⁻¹)	0 – 20	1.50 – 7.75	4.08
	20 – 40	1.25 – 8.00	3.98
	40 - 60	1.00 – 7.00	3.59
Fe (mg kg ⁻¹)	0 – 20	50.0 – 283.0	132.21
	20 – 40	17.0 – 287.0	79.14
	40 - 60	21.0 – 175.0	59.57
Mn (mg kg ⁻¹)	0 – 20	7.5 – 129.0	63.45
	20 – 40	7.0 – 141.0	26.02
	40 - 60	6.0 – 49.2	19.50

Table.2 Effect of soil characteristics on predictability of micronutrient cations

Micronutrients	Equations	R ² x 100
Zn		
0 – 20 cm	-	-
20 – 40 cm	-	-
40 – 60 cm	-	-
Cu		
0 – 20 cm	= 5.315 – 0.078 sand	14.4*
20 – 40 cm	= 0.634 + 0.070 clay – 0.052 sand	44.3
40 – 60 cm	= 1.834 + 0.035 clay – 0.037 sand	22.3*
Mn		
0 – 20 cm	= - 34.598 + 334.927 EC + 0.217 N	24.4*
Fe		
0 – 20 cm	= 359.55 – 60.102 pH + 490.14 EC + 39.192 OC + 0.019 N	61.0**
20 – 40 cm	= 529.929 – 68.167 pH + 258.644 EC + 15.626 OC – 0.549 clay	82.3**
40 – 60 cm	= 387.687 – 0.172 clay – 55.205 pH + 3.371 CEC – 0.268 silt	72.2**

Iron

DTPA-extractable Fe content in the profiles varied from 17.0 to 287.0 mg kg⁻¹ and are comparable with those reported by Mondal and Mete (1991) in some rice growing alluvial soils of West Bengal. DTPA-extractable Fe content in the surface layer was higher and decreased with increased in the depth. All the surface soils as well as sub-surface soil layers had sufficient amounts of available Fe, considering 4.5 mg kg⁻¹ as critical limit (Lindsay and Norvell, 1978). Surface soils contained more available Fe than the sub-surface soil layers. There were no significant multiple regression in all the soil horizons. Multiple correlation and regression analyses indicated that 61.0, 82.3 and 72.2 per cent variability in the DTPA-extractable Fe in the profiles was due to the combine effect of pH, EC, CEC, OC, N, sand and clay in the soils.

Manganese

DTPA-extractable Mn in the profiles varied from 6.0 to 141.0 mg kg⁻¹. Similar finding was also reported by Mandal and Mete

(1991). The surface soils content higher Mn and decreased with increased in depth (Gupta *et al.*, (2003), Verma *et al.*, (2007), Athokpam *et al.*, (2016) and Athokpam *et al.*, (2018). Considering the critical limit of 1.0 mg kg⁻¹ (Lindsay and Norvell, 1978), the surface soils and sub-surface soils were well above the critical limits. Multiple correlation and regression analyses indicated that 24.4 per cent variability of the available Mn content could be attributed to the combined effect of CE and N content in the profiles but their effect is not significant.

The different range of values in the available micronutrients among and within the soil profiles might be the result of variable intensity of different pedogenic processes taking place during the soil development. The surface layers contained higher amounts of available Zn, Cu, Fe and Mn which progressively decreased with increased the soil depth in all the soil profiles. Similar distribution pattern of micronutrients within the profiles was also reported by Sharma *et al.*, (1999) and Sharma and Choudhary (2007), Athokpam *et al.*, (2016) and Athokpam *et al.*, (2018). This might be due to

low pH values and high amounts of organic carbon content in the surface soils. Decomposition of organic matter releases micronutrients and some organic acids, in turn, help in increasing solubility of micronutrients from the soil mineral.

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