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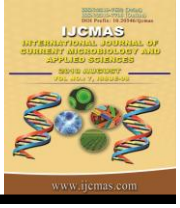

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Vertical Distribution of Micronutrient Cations in Imphal East and West District, Manipur (India)

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ABSTRACT

Keywords

DTPA, Micronutrient cations, Paddy Field, Profile

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Vertical distribution of DTPA-extractable micronutrient cations (Zn, Cu, Fe and Mn) and their relationship with various soil properties were studied in thirty profiles of paddy field of Imphal east and west district of Manipur. The content of DTPA-extractable Zn, Cu, Fe and Mn were higher in surface (0 – 20 cm) horizons and decreased with depth in most of the profiles and ranged from 0.14 to 2.48, 0.26 to 1.26, 1.96 to 21.46 and 2.00 to 24.20 mg Kg^{-1}, respectively. DTPA-extractable Zn was found deficient in 75.56 per cent and sufficient in 22.44 per cent in the soil samples, Cu was found in 81.11 per cent sufficient and 18.89 in deficient and Mn 86.67 per cent was found sufficient and 13.33 per cent in deficient category, While Fe content in the surface soils were well sufficient in all the profile except one profile. Distribution of Zn, Cu, Mn and Fe were influenced positively by OC, CEC, EC, Ca, Mg and N content in the soil. Multiple regression co-efficient analysis showed that DTPA-extractable Zn, Cu, Fe and Mn were influenced by OC, K and N to the level of 44, 40, 21 and 40 per cent, respectively. However, only OC, K and N contributed significantly towards these nutrient cations content in the soils.

Introduction

Micronutrients play various important role in plant is well established. It plays an active role in plant metabolism i.e. cell wall development, respiration, photosynthesis, chlorophyll formation, enzyme activity, hormone synthesis, atmospheric nitrogen fixation, etc. The requirement of micronutrients for crop plants are relatively very small, however, if any deficiencies of it, the crop yield is drastically reduced. Micronutrients are very important for maintaining soil health and also increasing productivity of crops (Rattan *et. al.* 2009). However, exploitive nature of modern agriculture involving use of high analysis NPK fertilizers couple with limited use of organic manure and less recycling of crop residues are important factors contributing towards accelerated exhaustion of micronutrients from the soil (Sharma and Choudhary, 2007). Continuous negligence of micronutrient application and avoidance of organic manures are the major causes of deficiency of these micronutrients (Srivastava *et al.,* 2017). Thus, the deficiency of micronutrients has become a major constraint to productivity and sustainability in many Indian soils. The availability of micronutrients to plants is also influenced by the distribution within the soil profile (Singh and Dhankar, 1989). The knowledge of vertical distribution of micronutrients is important as roots of many plants go beyond the surface layer and thus draw a part of the nutrient requirement from the subsurface layers of the soils. The distribution of micronutrient cations of paddy fields of Imphal east and west district of Manipur was not yet studied. Therefore, the present work has been undertaken to assess the distribution of micronutrient cations of the paddy fields and to find out the relationship between the soil properties and micronutrients.

Materials and Methods

Typical thirty 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 Borah *et al.,* (1987), 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 $CaCl_2$ 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 were computed between DTPA-extractable micronutrients and soil properties was done by adopting statistical procedures (Panse and Sukhatme, 1961).

Results and Discussion

The relevant soil characteristics of the representative soil profiles are describe in table 1. There were no definite pattern found in the distribution of sand, silt, and clay content in the profile. Sand content varied from 10.4 to 28.8 per cent, silt ranged from 15.0 to 25.0 per cent and clay contents were varied from 57.1 to 86.2 percent. The soils were strongly acidic (pH 4.21 – 5.34). The EC ranges from 0.01 to 0.21 dSm^{-1} and organic carbon content from 0.60 to 3.0 per cent. Surface soil layers content more organic carbon than the sub-surface layers. CEC ranged from 10.0 to 24.0 $[cmol(p^+)]kg^{-1}$ soil. The exchangeable Ca and Mg content in the soils varied from 0.46 to 6.03 and 0.46 to 4.60 $[cmol(p^+)]kg^{-1}$ 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 118.16 to 344.96, 3.14 to 23.52 and 22.40 to 259.39 kg ha^{-1}, respectively. These nutrients content decreased with increased the depth in the soil profile.

DTPA-extractable micronutrients status

Zinc: DTPA-extractable Zn in the studied soil profiles varied from 0.04 to 2.48 mg kg^{-1} in the paddy fields of Imphal east and west 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) and 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 deficient in 75.56 per cent and sufficient in 22.44 per cent in the soil samples. DTPA-extractable Zn showed non-significant regression with soil properties in the surface layer (0 - 20 cm) and sub-surface layer (40 – 60 cm) as evident from the data in table 2.

Table.1 Some physico-chemical properties of the soils

Soil properties	**Soil depth**	**Range**	**mean**
Sand (%)	-	10.4 – 28.8	-
Silt (%)	-	15.0 – 25.0	-
Clay (%)	-	57.1 – 86.2	-
pH	0 – 20 20 – 40 40 - 60	4.56 – 5.12 4.21 – 5.21 4.40 – 5.34	4.75 4.79 4.87
EC (dSm^{-1})	0 – 20 20 – 40 40 - 60	0.04 – 0.21 0.02 – 0.16 0.01 – 0.10	0.096 0.067 0.034
CEC [cmol(p^{+})]kg^{-1}	0 – 20 20 – 40 40 - 60	14.0 – 24.0 10.0 – 22.2 11.2 – 20.1	17.75 16.09 14.74
Ca [cmol(p^{+})]kg^{-1}	0 – 20 20 – 40 40 - 60	0.89 – 6.03 0.46 – 4.21 0.73 – 3.06	2.22 2.17 1.36
Mg [cmol(p^{+})]kg^{-1}	0 – 20 20 – 40 40 - 60	1.15 – 4.60 0.78 – 3.86 0.46 – 3.50	3.10 2.33 1.49
OC (%)	0 – 20 20 – 40 40 - 60	1.20 – 3.00 0.76 – 2.70 0.60 – 1.80	1.72 1.41 1.10
N (kg ha^{-1})	0 – 20 20 – 40 40 - 60	219.50 – 344.96 188.16 – 282.24 188.16 – 250.88	264.55 241.47 204.64
P (kg ha^{-1})	0 – 20 20 – 40 40 - 60	6.27 – 23.52 4.60 – 18.81 3.14 – 15.68	15.89 12.32 8.35
K (kg ha^{-1})	0 – 20 20 – 40 40 - 60	55.78 – 259.39 51.97 – 157.02 22.40 – 112.00	142.99 103.53 65.89
Zn (mg kg^{-1})	0 – 20 20 – 40 40 - 60	0.14 – 2.48 0.10 – 1.12 0.04 – 1.00	0.69 0.40 0.22
Cu (mg kg^{-1})	0 – 20 20 – 40 40 - 60	0.26 – 1.26 0.12 – 1.22 0.06 – 1.22	0.48 0.38 0.29
Mn (mg kg^{-1})	0 – 20 20 – 40 40 - 60	1.96 – 21.46 0.58 – 23.40 0.12 – 4.56	9.86 5.25 2.04
Fe (mg kg^{-1})	0 – 20 20 – 40 40 - 60	2.00 – 24.20 1.64 – 21.40 0.22 – 13.08	13.76 7.58 4.64

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

Micronutrients	Equations	R^2 x 100
Zn		
0 – 20 cm	= - 0.013 + 0.136 Ca – 0.088Mg	28.5*
20 – 40 cm	= 1.797 – 0.315 pH + 0.210* OC – 0.002* K	43.8*
40 – 60 cm	= - 0.230 + 0.004CEC + 0.278 OC – 0.001	27.6*
Cu		
0 – 20 cm	= - 0.191 + 1.518 EC – 0.011 CEC + 0.242 OC + 0.001 N	39.6*
20 – 40 cm	= - 0.042 + 0.019 CEC + 0.214 OC – 0.001 N	25.0
40 – 60 cm	= - 0.254 + 0.019 CEC + 0.233	19.9*
Mn		
0 – 20 cm	= - 6.037 + 0.046 N + 1.061 Ca	20.7*
Fe		
0 – 20 cm	= - 37.377 + 0.307 CEC – 8.838 OC + 0.201*N + 0.363 P	40.1**
20 – 40 cm	= - 10.303 + 3.191 OC + 0.055 N	20.2*

The multiple regression equations presented in the table 2 indicate a predictability value of 28.5 per cent by all factors taken together in the 1st layer. Significant regression with OC (0.210*) and K (0.002*) in the 2nd layer (20 – 40 cm) and 3rd layer (40 – 60 cm) and their predictability were 43.8and 27.6 per cent, respectively.

Copper: DTPA-extractable Cu content in the profiles ranged from 0.06 to 1.26 mg kg^{-1}. Out of the thirty profiles, DTPA-extractable Cu content in the soils, 81.11 per cent sufficient and 18.89 in deficient, 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 EC, CEC, OC, and N, however, their influenced were not significant. Their predictability was 39.6, 25.0 and 19.9 per cent variability by all factors taken together in the 1st, 2nd and 3rd layers in the profiles, respectively.

Iron: DTPA-extractable Fe content in the profiles ranged from 0.22 to 24.20 mg kg^{-1} and are comparable with those reported by Gupta *et al.*, (2003), Sharma and Choudhary (2007) in the soils of Madhya Pradesh and north-west Himalaya (H.P.) and Athokpam *et al.*,(2016), respectively. Almost all the surface soils had sufficient amounts of available Fe, except one profile, considering 4.5 mg kg^{-1} as critical limit (Lindsay and Norvell, 1978). Surface soils content more available Fe than the sub-surface soils. It showed significant regression coefficient with N (0.201*) in the 1st layer. Multiple correlation and regression analyses indicated that 40.1 and 20.2 per cent variability in the DTPA-extractable Fe in the profiles was due to the combine effect of CEC, OC, N and P in the soils.

Manganese: DTPA-extractable Mn in the profiles varied from 0.12 to 23.40 mg kg^{-1} with a mean value of 5.72 mg kg^{-1}. 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 were well above the critical limits. Multiple correlation and regression analyses indicated that 20.7 per cent variability of the available Mn content could be attributed to the combine effect of N and Ca content in the profiles but their effect is not significant.

The variations in the available micronutrients among and within the 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 declined with 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 may be ascribed to low pH values and higher amounts of organic carbon content in the surface soils. Decomposition of organic matter releases micronutrients and some organic acids which in turn help in increasing solubility of micronutrients from the soil mineral. Significant positive regression coefficients of EC with DTPA-extractable micronutrients have also been reported by Randhawa and Singh (1995) and Sharma *et al.*, (2006).

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