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Physico-Chemical Characterization of Farmland Soil in Some Villages of Chandel Hill District, Manipur (India)

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ABSTRACT

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To study the soil fertility and micro-nutrient status and their relationship with each other, a study of the macro- and micro-nutrients of some soils of Chandel district, Manipur (India) was carried out. Investigation of 26 samples of surface soil (0 to 30 cm) was done for diethylene-triamine penta acetate (DTPA) - extractable soils. The mean values for DTPA-extractable Zn, Cu, Mn, Fe and hot water extractable B in relation to some chemical properties in the soils. The mean values for DTPA-extractable Zn, Cu, Mn, Fe and hot water extractable B were 0.23, 0.55, 8.87, 22.93 and 0.48 mg kg⁻¹, respectively. The average values of available N, P₂O₅, K₂O and SO₄-S were found to be 495.7, 15.6, 241.3 and 1.7 kg ha⁻¹, respectively. Distribution of Zn, Cu, Mn, Fe and B were influenced positively by pH, EC and organic carbon content of the soil. Results indicated that the micro-nutrient cations were significantly correlated with each other suggesting about the dynamic equilibrium among them. All the soil samples were sufficient in available micro-nutrient cations except zinc.

Introduction

The soil of Manipur belongs to 4 orders, 8 suborders, 13 greatgroups and 23 subgroups. It is observed that the Inceptisols are the dominant soils followed by Ultisols, Entisols and Alfisols and occupy 38.4%, 36.4%, 23.1% of the total geographical area of the State, respectively. Lakes and marshy lands occupy 1.9 percent. Soil testing provides the information about the nutrient availability of the soil upon which the fertilizer recommendation for maximizing crop yield is

made. Zinc (Zn), Copper (Cu), Manganese (Mn), Iron (Fe) and Boron (B) 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, biosynthesis of proteins, 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).

Micronutrients are essential elements that are used by plants in small quantities. For most micronutrients, crop uptake is less than one pound per acre. In spite of this low requirement, critical plant functions are limited if micronutrients are unavailable, resulting in plant abnormalities, reduced growth and lower yield. There are many soil and environmental factors that affect the availability of micronutrients to plants. The primary factors include soil pH, organic matter content, soil texture which affects leaching and organic matter content, soil water content, nutrient interactions, and temperature.

Micronutrient deficiencies are widespread. 51% of world cereal soils are deficient in zinc and 30% of cultivated soils globally are deficient in iron. Steady growth of crop yields during recent decades (in particular through the Green Revolution) compounded the problem by progressively depleting soil micronutrient pools. Due to higher yields, commodity prices and crop input costs, growers are reviewing all potential barriers to top grain production, including micronutrient deficiencies.

In general, farmers only apply micronutrients when crops show deficiency symptoms, while micronutrient deficiencies decrease yields before symptoms appear. Some common farming practices (such as liming acid soils) contribute to widespread occurrence of micronutrient deficiencies in crops by decreasing the availability of the micronutrients present in the soil. Also, extensive use of glyphosate is increasingly suspected to impair micronutrient uptake by crops, especially with regard to manganese, iron and zinc. Micronutrients are nutrients required by organisms throughout life in small quantities to orchestrate a range of physiological functions. For people, they include dietary trace minerals in amounts generally less than 100 milligrams per day, as

opposed to macro minerals, which are required in larger quantities.

Many plant symptoms associated with micronutrient deficiencies, including stunting and chlorosis, may have a variety of causes, including disease, insect or herbicide damage, or environmental conditions. Soil and plant analysis are both useful in determining if the cause is truly nutritional. Though adequate for this purpose, micronutrient soil tests are not as precise as soil pH, phosphorus, and potassium tests.

The most reliable micronutrient soil tests are for zinc, boron, copper, and manganese. Because interpretations are soil specific, it is best to use locally calibrated recommendations. Soil tests for iron and molybdenum are considered to be of little value in predicting the supply of these nutrients in soils. When sampling for micronutrients, sample the root zone from 0 to 8 inches deep.

Micro-nutrient availability to plants can be determined in direct uptake experiments or estimated with techniques that correlate the quantities of micro-nutrients extracted chemically from the soils (Kabata-Pendias, 2001). Micronutrient cycling is quite different among various terrestrial ecosystems (Han *et al.*, 2007). India is the second largest consumer of mineral fertilizers in the world after China, consuming about 26.5 million tons (Jaga and Patel, 2012). The micronutrients such as boron, chlorine, copper, iron, manganese, molybdenum, and zinc are used in small amounts, but they are as important to plant development and profitable crop production as the major nutrients. However, major focus of the Indian fertilizer sector policy has been on primary (macro) nutrients. The application of essential plant nutrients particularly major and micro nutrients in optimum quantity and right

proportion through correct methods and time of application is the key to increased and sustained crop production.

Therefore, it is important to understand fertilizers use behavior in the country over time as well as role of factors influencing fertilizer consumption at the national and regional / state level because intensity of fertilizer use varies from state to state and area to area. Shifting cultivation (SC) is one of the main forms of crop husbandry in North Eastern Region (NER) of India and it is locally known as *jhuming* whereas the cultivators are known as *jhumias*. Shifting cultivation (SC) in its more traditional and integrated form is ecologically and economically viable system of agriculture as long as the population densities are low and *jhum/fallow* cycles are long enough to maintain soil health including fertility.

Rice is the major staple food crop of the state and occupying almost 90% of the total cultivable area during the summer (kharif) season. The recommended dose of minerals for its maximum production is 60: 40: 30 Kg of N, P₂O₅, and K₂O ha⁻¹. Application of major nutrients (nitrogen, phosphorus, potassium) became common; therefore, the crops started responding to micronutrient fertilizers. Concerted efforts have been made through the All India Coordinated Research Project on Micronutrients to delineate the soils of India regarding the deficiency of micronutrients. At present about 48.1% of Indian soils are deficient in diethylene-triamine penta-acetate (DTPA) extractable zinc, 11.2% in iron, 7% in copper and 5.1% in manganese. Apart from the deficiency of these micronutrients, deficiencies of boron and molybdenum have also been reported in some areas. Areas with multi-micronutrient deficiencies are limited, thus simple fertilizers are sufficient to exploit the potential of crops and cropping systems (Gupta, 2005).

The application of mineral fertilizers is the most advantageous and the fastest way to increase crop yields and their deficiency leads to various types of disorders in many commercially important crops (Duarah *et al.*, 2011). Keeping in view the above importance of mineral fertilizers for crop growth and yield, this study on the status of soil macro and micro nutrients was carried out with the following objectives (i) to assess the macronutrients, that is, NH₄⁺, H₂PO₄⁻, K⁺ and SO₄⁼ and micronutrients, that is, Zn⁺, Cu⁺, Mn⁺⁺, Fe⁺⁺ and B⁺⁺⁺ distribution on the surface soils and (ii) to explore the relationships among micro- nutrients with other soil properties.

Materials and Methods

The present study was carried out to assess the Physico-Chemical characterization of farmland soil in some villages of Chandel district, Manipur (India) (Fig. 1). The district has a geographical area of 496 sq. km with 2.22 % of the total geographical area of the state. The district (24°40' N latitude and 93°50' E longitude), is located in the south-eastern part of Manipur and it experiences hot summer and cold winter. The mean annual temperature exceeds 22°C and experiences summer temperature to the range of 35 to 46°C. The mean annual precipitation varies from 2000 to 2400 mm. The area belongs to warm, humid agro-ecological zone with thermic ecosystem and length of growing period of 300-330 days. The vegetation is predominated by pine including woody and herbaceous species. The soil types of Chandel district are mostly coarser, varying from fine loamy, loamy to sandy in texture and deep in soil depth. Soils of the study area fall under three major soil orders: ultisol, inceptisol and alfisols. 10 representative soil samples (0 to 30cm) were collected from 26 villages of the district. Soil samples were collected with wooden tools to avoid any contamination of

the soils. 8 spots were dug for each composite sample. All the samples were stored in the polythene bags for further analysis. Soil pH and electrical conductivity (EC) were determined by potentiometry and direct reading conductivity meter using 1:2.5 soil water suspensions (Jackson, 1973). The composite soil samples were analyzed for available nitrogen (Subbiah and Asija, 1956), available P_2O_5 (Bray and Kurtz, 1945), neutral ammonium acetate extractable K_2O (Jackson, 1973), organic carbon (Walkley and Black, 1934), and available SO_4-S (Chesnin and Yien, 1951).

The available Zn, Cu, Mn and Fe extracted with DTPA (Lindsay and Norvell, 1978) was determined on an Atomic Absorption Spectrophotometer. The hot water soluble B was estimated by UV-VIS Spectrophotometer (Wear, 1965). The relationship between various soil properties and micro-nutrients distribution were established by using simple correlation coefficient.

Results and Discussion

Two hundred and sixty surface soils (0 to 30 cm) of Chandel district, Manipur (India) were investigated. The results of soil pH, EC, organic carbon (OC), available N, P_2O_5 , K_2O , SO_4-S and DTPA- extractable Zn, Cu, Mn, Fe and hot water extractable B are presented in Table 1.

Result shows that pH of the soils ranged from 4.4-6.8 (mean 5.8), EC varied from 0.01-0.25 dSm^{-1} (mean 0.03 dSm^{-1}) and organic carbon content ranged from 0.22-2.02 % with a mean value of 0.68 %. The available N, P_2O_5 , K_2O and SO_4-S varied from 219.5-878.1 (mean 495.7), 3.9-96.2 (mean 15.6), 69.4-542.1 (mean 241.3) and 0.4-3.9 (mean 1.7) $kg\ ha^{-1}$, respectively. The soils were very strongly acidic to neutral in reaction. Acidic in reaction of the district might be due to the high rainfall leading to the leaching losses of bases from

the surface soils. Application of nitrogenous fertilizers and decomposition of organic residues hastened the soil acidity. The wide variation of EC of the soils might be due to the different concentration of basic cations in the soils. The high organic carbon content in the soil is due the luxuriant growth of grasses along with the seasonal decomposition of vegetative parts and roots. Chemical properties of the soils were positively and significantly correlated with each other pH, EC and available P_2O_5 .

Available micronutrients status and influence of soil chemical characteristics

Iron

Available Fe contents in the surface soils ranged from 3.751 to 56.65 $mg\ kg^{-1}$ with a mean value of 22.93 $mg\ kg^{-1}$ (Table 1). All the soils had significant amount of Fe considering 4.5 $mg\ kg^{-1}$ as critical limit as suggested by Lindsay and Norvell (1978). It showed positive and significant correlations with pH ($r = 0.627^{**}$), EC ($r = 0.687^{**}$), OC ($r = 0.540^{**}$), available N ($r = 0.728^{**}$), available P_2O_5 ($r = 0.645^{**}$), K_2O ($r = 0.750^{**}$), SO_4-S ($r = 0.597^{**}$). Similar results were also reported by Verma *et al.*, (2005), Jiang *et al.*, (2009) and Bassirani *et al.*, (2011)

Manganese

Available Mn in the surface soils varied from 0.078 to 31.605 $mg\ kg^{-1}$ with a mean value of 8.87 $mg\ kg^{-1}$. Considering 1.0 $mg\ kg^{-1}$ as critical limit for Mn deficiency (Lindsay and Norvell, 1978), all the soils had sufficient amounts of available Mn. In simple correlation coefficient studies (Table 2), available Mn showed significant and positive correlation coefficients with pH ($r = 0.811^{**}$), EC ($r = 0.621^{**}$), OC ($r = 0.840^{**}$), N ($r = 0.703^{**}$), P ($r = 0.737^{**}$), K ($r = 0.920^{**}$), SO_4-S ($r = 0.835^{**}$).

Table.1 Some major chemical characteristics of the soils of Chandel District

Soil characteristics	Mean	Range
pH	5.8	4.4-6.8
EC (dSm ⁻¹)	0.03	0.01-0.25
Organic Carbon (%)	0.68	0.22-2.02
Available N (kg ha ⁻¹)	495.7	219.5-878.1
Available P (kg ha ⁻¹)	15.6	3.9-96.2
Available K (kg ha ⁻¹)	241.3	69.4-542.1
Available S04- S (kg ha ⁻¹)	1.7	0.4-3.9
Fe (mg kg ⁻¹)	22.93	3.751-56.65
Mn (mg kg ⁻¹)	8.87	0.078-31.605
Cu (mg kg ⁻¹)	0.55	0.08-1.974
Zn (mg kg ⁻¹)	0.23	0.021-0.557
B (mg kg ⁻¹)	0.48	0.26-0.53
Ca (mg kg ⁻¹)	0.72	0.27-1.16

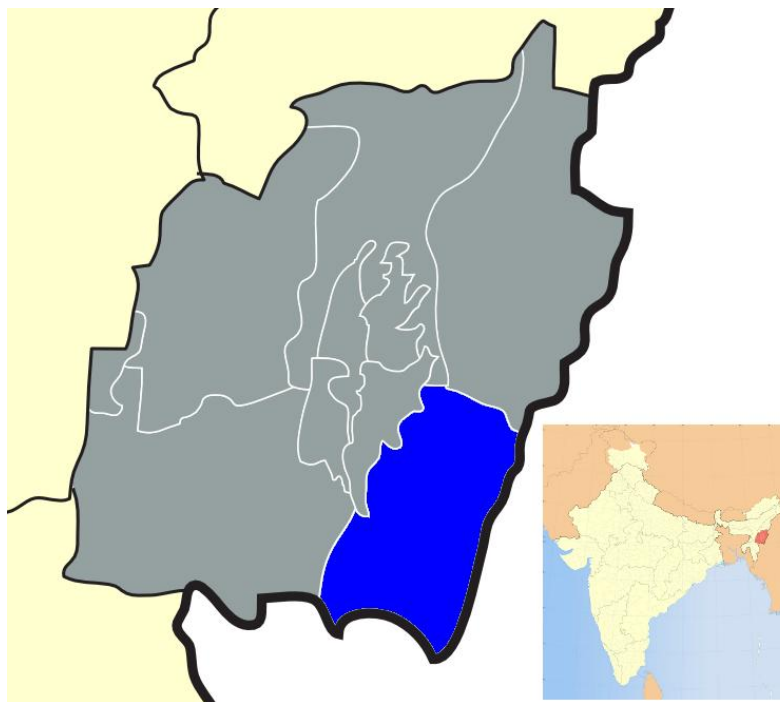
Table.2 Correlation amongst the different soil parameters under study

	<i>PH</i>	<i>E.C</i>	<i>O.C</i>	<i>N</i>	<i>P</i>	<i>K</i>	<i>S</i>	<i>Fe</i>	<i>Cu</i>	<i>Zn</i>	<i>Mn</i>	<i>B</i>
<i>E.C</i>	0.518**											
<i>O.C</i>	0.662**	0.605**										
<i>N</i>	0.623**	0.562**	0.649**									
<i>P</i>	0.550**	0.902**	0.790**	0.602**								
<i>K</i>	0.897**	0.658**	0.832**	0.747**	0.723**							
<i>S</i>	0.768**	0.474*	0.701**	0.546**	0.560**	0.805**						
<i>Fe</i>	0.627**	0.687**	0.540**	0.728**	0.645**	0.750**	0.597**					
<i>Cu</i>	0.644**	0.227	0.749**	0.646**	0.503**	0.724**	0.692**	0.518**				
<i>Zn</i>	0.823**	0.525**	0.576**	0.664**	0.581**	0.828**	0.615**	0.713**	0.638**			
<i>Mn</i>	0.811**	0.621**	0.840**	0.703**	0.737**	0.920**	0.835**	0.721**	0.705**	0.728**		
<i>B</i>	0.472*	0.255	0.268	0.399*	0.317	0.566**	0.577**	0.515**	0.524**	0.473*	0.457*	
<i>Ca</i>	0.773**	0.471*	0.580**	0.623**	0.480*	0.805**	0.641**	0.817**	0.570**	0.835**	0.782**	0.454*

** Correlation is significant at the 0.01 level (2- tailed)

* Correlation is significant at the 0.05 level (2- tailed)

Fig.1 Location map of Chandel district, Manipur



Available Mn also had positive significant correlations with other micro-nutrient cations content in the soils. Soil micro-nutrient cations like Fe ($r = 0.721^{**}$), Cu ($r = 0.705^{**}$) and Zn ($r = 0.728^{**}$) have significant correlation with available Mn, suggesting variation in their distribution dependent upon common soil factors (Follett and Lindsay, 1970).

Copper

Available copper content in the surface soils ranged from 0.08 to 1.974 mg kg⁻¹ with a mean value of 0.55 mg kg⁻¹. Considering 0.2 mg kg⁻¹ as critical limit for Cu deficiency (Lindsay and Norvell, 1978), all the soils were found to be in adequate range. The micro-nutrient cation showed significant and positive correlation coefficient with pH ($r = 0.644^{**}$), OC ($r = 0.749^{**}$), available N ($r = 0.646^{**}$), available P₂O₅ ($r = 0.503^{**}$), available K₂O ($r = 0.724^{*}$), SO₄-S ($r = 0.692^{**}$) and also positive and significant correlations with other micro-nutrient cation

like Fe ($r = 0.518^{**}$). This finding was in conformity with that of Singh *et al.*, (2006), Verma *et al.*, (2007), Jiang *et al.*, (2009) and Bassirani *et al.*, (2011).

Zinc

Available Zn in the studied surface soils varied from 0.021 to 0.557 mg kg⁻¹ with a mean value of 0.23 mg kg⁻¹. Similar finding was also reported by Raina *et al.*, (2003) in apple growing soils of Himachal Pradesh, India. Considering 0.6 mg kg⁻¹ as critical limit of available Zn as suggested by Takkar and Mann (1975), some per cent of the studied soils were fell under deficient categories. Available Zn showed significant and positive correlation coefficient with pH ($r = 0.823^{**}$), EC ($r = 0.525^{**}$), OC ($r = 0.576^{**}$), available N ($r = 0.664^{**}$), available P₂O₅ ($r = 0.581^{**}$), available K₂O ($r = 0.828^{*}$), SO₄-S ($r = 0.615^{**}$) and also positive and significant correlations with other micro-nutrient cation like Fe ($r = 0.713^{**}$) and Cu ($r = 0.638^{**}$). This finding is in agreement with the earlier

findings of Venkatesh *et al.*, (2003), Verma *et al.*, (2005) and Sharma and Chaudhary (2007). It also showed positive and significant correlation with other micronutrient cations. This result is also supported by the finding of Bassirani *et al.*, (2011). Amount of zinc required for alleviating zinc deficiency varied with severity of deficiency, soil types, nature of crops and cultivars. In majority of instances 5.5 kg zinc ha⁻¹ was found to be ideal dose. Zinc deficiency can be best alleviated with the use of 11 kg Zn ha⁻¹ to wheat, rice and maize; 5.5 kg Zn ha⁻¹ to soybean, mustard, raya, sunflower and sugarcane and with 2.5kg Zn ha⁻¹ to groundnut, ragi, gram, linseed, green gram, lentil etc.

Boron

Hot water soluble B content in the surface soils ranged from 0.26 to 0.53 mg kg⁻¹ with a value of 0.48 mg kg⁻¹. The range of available B in soils of different states of India varied from traces to 12.2 mg kg⁻¹ (Das, 2000). The micro-nutrient cation showed significant and positive correlation coefficient with available K₂O ($r = 0.566^*$), SO₄-S ($r = 0.577^{**}$) and also positive and significant correlations with other micro-nutrient cation like Fe ($r = 0.515^{**}$) and Cu ($r = 0.524^{**}$). The chemical properties of the soils influence the B content in the soils as evident by the correlation studies. The relationship between the soil properties and hot water soluble B was positive and significant correlation with other micro-nutrient cations (Table 2).

Organic matter and manure applications affect the immediate and potential availability of micronutrient cations (Rengel, 2007). The micronutrient cations react with certain organic molecules to form organometallic complexes as chelates and soluble chelates can increase the availability of the micro-nutrient and protect it from precipitation

reactions. These chelates may be synthesized by the plant roots and released to the surrounding soil. The chelate may also be present in the soil humus or may be synthetic compound added to the soil to enhance micronutrient availability (Brady and Weil, 2002). In this study, soil organic matter related to chemical indices, including soil organic carbon and nitrogen were positively and significantly correlated with DTPA-extractable micro-nutrient cation. Again, DTPA-extractable micro-nutrient cations are positively and significantly correlated with soil pH. This might be due to leaching losses of water soluble micronutrients with the high rainfall leading to the low content of micro-nutrients in the soils even though these micro-nutrients are most soluble and readily available under acidic condition.

Deficiency of macronutrients and micronutrients greatly hinders the productivity and sustainability in soils. A combination of macronutrients and micronutrients give the soil its optimum health. It is very important to have a balance of macronutrients and micronutrients in the soils. Therefore, the role of micronutrients in balanced plant nutrition is well established. The response of plants to micronutrients, however, is an all-or-nothing affair. Within a narrow range of application rates, a plant grows well, indifferent to the precise rate; but outside this range it manages poorly or dies. Micronutrients are very important for maintaining soil health and also in increasing productivity of crops (Rattan *et al.*, 2009). From the present investigation, it was observed (Table 1) that soil pH varied from very strongly acidic to nearly neutral. Organic carbon, available nitrogen and potassium were found to be high and available phosphorus underwent a variation from very low to very high in status. On the other hand, the soils are having a high concentration of Fe, some soils are low in Zn and B

availability. Based on the analysis, farmers are advised on soil fertility management through rational use of manure, fertilizers and amendments to make agriculture more productive and sustainable.

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