

Full Length Research Paper

## Soil macro- and micro- nutrient status of Senapati district, Manipur (India)

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**A study of the macro- and micro-nutrients of some soils of Senapati district, Manipur (India) was carried out to study the soil fertility and micro- nutrient status and their relationship with each other. Surface soil (0 to 30 cm) was investigated for diethylene-triaminepentaacetate (DTPA)- extractable Zn, Cu, Mn, Fe and hot water extractable B in relation to some chemical properties in 20 representative soils. The mean values for DTPA-extractable Zn, Cu, Mn, Fe and hot water extractable B were 2.36, 1.52, 113.93, 766.03 and 0.10 mg kg<sup>-1</sup>, respectively. The mean values of available N, P<sub>2</sub>O, K<sub>2</sub>O and SO<sub>4</sub>-S were 382.04, 38.31, 208.86 and 22.65 kg ha<sup>-1</sup>, 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 in Senapati district.**

**Key words:** Diethylene triamine pentaacetic acid, zinc, copper, manganese, iron and boron.

### INTRODUCTION

Soil fertility is one of the important factors controlling the crop yield. Soil related limitations affecting the crop productivity including nutritional disorders can be determined by evaluating the fertility status of the soils. 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). Original geologic substrate and subsequent geochemical and pedogenic regimes determine the total amounts of micro- nutrients in soils. However, total amount is rarely indicative of the availability by plant, because availability depends on soil pH, organic matter content, adsorptive surfaces and other physical, chemical and biological conditions in the rhizosphere. 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). Micro-nutrient cycling is quite different among various terrestrial ecosystems (Han et al., 2007). India is the second largest

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consumer of mineral fertilizers in the world after China, consuming about 26.5 million tons (Jaga and Patel, 2012). 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). Stunted growth is a symptom for many deficiencies, especially stunted stems with nitrogen deficiency and stunted roots in phosphorus deficiency. Chlorosis, that is, decreased chlorophyll synthesis or increased chlorophyll degradation, is observed with magnesium, nitrogen, and iron deficiencies. Magnesium is the central atom for the electron cloud of chlorophyll from which electrons flow through the light reactions. Necrosis, dead spots or zones, is observed when magnesium, potassium or manganese deficiencies are present. Color changes such as excessive anthocyanin production is observed in stems with phosphorus deficiency. They generally pick up an intense purple color sometimes extending onto the leaves (Koning, 1994).

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, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O ha<sup>-1</sup>. 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-triaminepentaacetate (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).

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 macro-nutrients, that is, NH<sub>4</sub><sup>+</sup>, H<sub>2</sub>PO<sub>4</sub><sup>-</sup>, K<sup>+</sup> and SO<sub>4</sub><sup>=</sup> and micro-nutrients, that is, Zn<sup>+</sup>, Cu<sup>+</sup>, Mn<sup>++</sup>, Fe<sup>++</sup> and B<sup>+++</sup> distribution on the surface soils and (ii) to explore the relationships among micro- nutrients with other soil properties.

## MATERIALS AND METHODS

The present investigation was carried out to assess some macro and micro-nutrient status of the soils of Senapati district, Manipur (India). The geographical area of the district is 3271 sq. km with 14.56% of the total geographical area of the state. The average temperature ranges from 4°C to 32°C and average annual rainfall varies from 671 to 1454 mm. It is located between 24° 30'N latitude and 93° 30'E longitude over the globe. The altitude of the district

ranges from 800 to 4000 m above MSL. Senapati district has alluvium, lateritic black regur and red ferruginous type of soil (Anonymous, 2009). 10 representative soil samples (0 to 30cm) were collected from 20 villages of the district. Soil samples were collected with wooden tools to avoid any contamination of the soils. 6 spots were dug for each composite sample. All the composite soil samples were air-dried, ground and passed through 2 mm sieve for chemical analysis. 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<sub>2</sub>O<sub>5</sub> (Bray and Kurtz, 1945), neutral ammonium acetate extractable K<sub>2</sub>O (Jackson, 1973), organic carbon (Walkley and Black, 1934), and available SO<sub>4</sub>-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

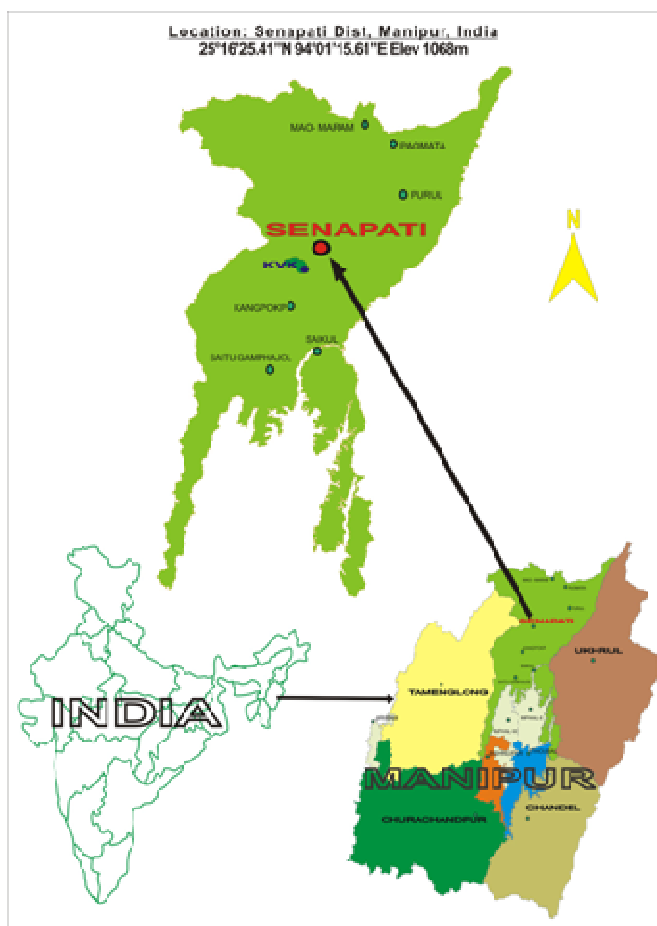
Two hundred surface soils (0 to 30 cm) of Senapati district, Manipur (India) were investigated. The results of soil pH, EC, organic carbon (OC), available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, SO<sub>4</sub>-S and DTPA- extractable Zn, Cu, Mn, Fe and hot water extractable B are presented in Table 1. Result shows that pH of the soils ranged from 5.08 to 6.97 (mean 5.93), EC varied from 0.02 to 0.22 dSm<sup>-1</sup> (mean 0.07 dSm<sup>-1</sup>) and organic carbon content ranged from 6.0 to 25.2 g kg<sup>-1</sup> with a mean value of 14.74 g kg<sup>-1</sup>. The available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and SO<sub>4</sub>-S varied from 290.20 to 893.17 (mean 382.04), 24.62 to 64.37 (mean 38.31), 55.60 to 359.11 (mean 208.86) and 6.20 to 95.10 (mean 22.65) kg ha<sup>-1</sup>, respectively. The soils were 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 grasses growth along with the seasonal decomposition of vegetative parts and roots. Chemical properties of the soils were positively and significantly correlated with each other except S which was significantly correlated with pH, EC and available P<sub>2</sub>O<sub>5</sub>.

### Available micronutrients status and influence of soil chemical characteristics

Nutrient removal per tonne of economic produce was of the following order (Aulakh, 1985): groundnut -Fe 2 284 g, Zn 109 g, Mn 93 g, and Cu 36 g ha<sup>-1</sup>, pigeonpea- Fe 1 440 g, Zn 38 g, Mn 128 g and Cu 31 g; chickpea- Fe 1 302 g, Zn 57g, Mn 105 g and Cu 17 g. Nutrient removal

**Table 1.** Some major chemical characteristics of the soils of Senapati District.

Soil characteristics	Mean	Range
pH	5.93	5.08 – 6.97
EC (dSm <sup>-1</sup> )	0.07	0.02 – 0.22
Organic carbon (g kg <sup>-1</sup> )	14.74	6.0 – 25.2
Available N (kg ha <sup>-1</sup> )	382.04	290.20 – 893.17
Available P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	38.31	24.62 – 64.37
Available K <sub>2</sub> O (kg ha <sup>-1</sup> )	208.86	55.60 – 359.11
Available SO <sub>4</sub> -S (kg ha <sup>-1</sup> )	22.65	6.20 – 95.10
Fe (mg kg <sup>-1</sup> )	766.03	11.00 – 1045.00
Mn (mg kg <sup>-1</sup> )	113.93	45.00 – 150.00
Cu (mg kg <sup>-1</sup> )	1.52	0.65 – 2.60
Zn (mg kg <sup>-1</sup> )	2.36	1.30 – 4.90
B (mg kg <sup>-1</sup> )	0.10	0.046 – 1.004

**Figure 1.** Location map of Senapati district, Manipur.

for major cereals in this region was as follows : maize- Fe 2 130 g, Zn 380 g, Mn 340 g, B 240 g, Cu 110 g, Mo 9 g and also 81 kg Cl (IFA, 1992); rice- Fe 150 g, Zn 40 g, Mn 675 g, Cu 18 g, B 15 g (Yoshida, 1981).

**Iron:** Available Fe contents in the surface soils ranged from 11.00 to 1045.00 mg kg<sup>-1</sup> with a mean value of 766.03 mg kg<sup>-1</sup> (Table 1). All the soils had significant amount of Fe considering 4.5 mg kg<sup>-1</sup> as critical limit as suggested by Lindsay and Norvell (1978). It showed positive and significant correlations with pH ( $r = 0.8623^{**}$ ), OC ( $r = 0.8355^{**}$ ), available N ( $r = 0.8302^{**}$ ), available P<sub>2</sub>O<sub>5</sub> ( $r = 0.7812^{**}$ ), and also positive and significant correlations with other micro- nutrient cations. 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 45.00 to 150.00 mg kg<sup>-1</sup> with a mean value of 113.93 mg kg<sup>-1</sup>. Considering 1.0 mg kg<sup>-1</sup> 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 ( $r = 0.8938^{**}$ ), EC ( $r = 0.5166^*$ ), OC ( $r = 0.7882^{**}$ ), available N ( $r = 0.7994^{**}$ ), Available P<sub>2</sub>O<sub>5</sub> ( $r = 0.8364^{**}$ ), and available K<sub>2</sub>O ( $r = 0.5402^*$ ). Available Mn also had positive significant correlations with other micro-nutrient cations like Fe, Cu and Zn 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 0.65 to 2.60 mg kg<sup>-1</sup> with a mean value of 1.52 mg kg<sup>-1</sup>. Considering 0.2 mg kg<sup>-1</sup> 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 ( $r = 0.8220^{**}$ ), OC ( $r = 0.7422^{**}$ ), available N ( $r = 0.7590^{**}$ ), available P<sub>2</sub>O<sub>5</sub> ( $r = 0.7840^{**}$ ) and available K<sub>2</sub>O ( $r = 0.5161^*$ ). 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 1.30 to 4.90 mg kg<sup>-1</sup> with a mean value of 2.36 mg kg<sup>-1</sup>. Similar finding was also reported by Raina et al. (2003) in apple growing soils of Himachal Pradesh, India. Considering 0.6 mg kg<sup>-1</sup> as critical limit of available Zn as suggested by Takkar and Mann (1975), the entire representative soils were under sufficient categories. Available Zn showed significant and positive correlation coefficient with pH ( $r = 0.7500^{**}$ ), OC ( $r = 0.7075^{**}$ ), available N ( $r = 0.6897^{**}$ ), and available P<sub>2</sub>O<sub>5</sub> ( $r = 0.6874^*$ ). 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 micro-nutrient cations. This result is also supported by the finding of Bassirani et al. (2011). Amount of zinc required

**Table 2.** Correlation amongst the different soil parameters under study.

	EC	OC	Available N	Available P	Available K	Available S	Available Fe	Mn	Cu	Zn	B
pH	0.6445*	0.8528**	0.8536**	0.8832**	0.5884*	0.5955*	0.8623**	0.8938**	0.8220**	0.7500**	0.2830
EC		0.5444*	0.5430*	0.5974*	0.6678**	0.5330*	0.4519	0.5166*	0.4861	0.3873	0.1760
OC			0.9100**	0.7742**	0.5281*	0.4879	0.8355**	0.7882**	0.7422**	0.7075**	0.1982
Available N				0.7821**	0.5545*	0.4845	0.8302**	0.7994**	0.7590**	0.6897*	0.2088
Available P					0.6562*	0.6083*	0.7813**	0.8364**	0.7840**	0.6874*	0.2414
Available K						0.4683	0.4563	0.5402*	0.5161*	0.3995	0.2386
Available S							0.4860	0.4976	0.4784	0.4102	0.1820
Available Fe								0.8491**	0.7675**	0.7201**	0.2050
Mn									0.8260**	0.7594**	0.2657
Cu										0.7798**	0.3918
Zn											0.2689

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<sup>-1</sup> was found to be ideal dose. Zinc deficiency can be best alleviated with the use of 11 kg Zn ha<sup>-1</sup> to wheat, rice and maize; 5.5 kg Zn ha<sup>-1</sup> to soybean, mustard, raya, sunflower and sugarcane and with 2.5kg Zn ha<sup>-1</sup> to groundnut, ragi, gram, linseed, green gram, lentil etc.

**Boron:** Hot water soluble B content in the surface soils ranged from 0.046 to 1.004 mg kg<sup>-1</sup> with a mean value of 1.00 mg kg<sup>-1</sup>. The range of available B in soils of different states of India varied from traces to 12.2 mg kg<sup>-1</sup> (Das, 2000). The chemical properties of the soils did not 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 but statistically non-significant (Table 2).

All the studied micro-nutrients except B had significant correlation with organic carbon content of the soil due to complexing with them. Iron, Mn, Cu and Zn are most soluble under acid conditions.

Organic matter and manure applications affect the immediate and potential availability of micro-nutrient cations (Rengel, 2007). The micro-nutrient 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 micro-nutrient 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 cations, however, S content of the soils do not show the significant correlation with DTPA-extractable micro-nutrients, indicating the role of organic matter enhancing available micro-nutrients. Again, DTPA-extractable micro-nutrient cations are positively and significantly correlated with soil pH. This might be due to leaching losses of water soluble micro-

nutrients 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.

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