AATCC Review

09 April 2025: Received
30 May 2025: Revised
06 June 2025: Accepted
08 July 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Micronutrient Dynamics in Major Soil Orders of Renapur Tahsil and their correlation with Physiochemical Properties

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ABSTRACT

A study assessed micronutrient levels and their relationship with soil properties in Renapur Tahsil, Latur District. From 20 villages, 100 soil samples were classified into Inceptisols, Entisols, and Vertisols. In Inceptisols, Fe, Zn, Mn, and B ranged from low to high levels, while Cu was uniformly high. Entisols showed low to medium Fe and Zn, high Mn and Cu, and varied B levels. Vertisols had moderate Fe, low Zn and Mn, high Cu, and mostly low B. Overall, Zn was largely deficient (59%), followed by Fe (33%), Mn (42%), and B (34%) at low to moderate levels; Cu was high in all samples. Nutrient indices rated Zn as low, Fe, Mn, and B as moderate, and Cu as high. Micronutrients negatively correlated with pH and $CaCO_3$, but positively with organic carbon. The findings highlight the need for soil order-specific micronutrient strategies to improve fertility and productivity.

Keywords: *Inceptisols, Entisols, Vertisols, Fe, Zn, Mn, Cu, B, correlation.*

INTRODUCTION

A nutrient element is defined as one that is essential for an organism to complete its life cycle, and whose deficiency results in specific physiological or morphological symptoms. In soil, nutrient elements exist in various chemical forms that are typically in dynamic equilibrium, collectively constituting the available nutrient pool from which plants absorb essential elements. Essential nutrients are those required by plants to complete their life cycle. Based on the quantity needed, these nutrients are classified as either macronutrients or micronutrients.

Micronutrients are the nutrients that are required in tiny amounts yet are vital to the plant. They include Fe, Zn, Mn, Cu and B. These nutrients are obtained by the plants from soil minerals and organic materials, as well as from organic and inorganic fertilizers [17]. Chlorophyll is produced and other nutrients are absorbed with the aid of iron, essential for the production of the chloroplast-stored proteins. Zinc is a component of multiple enzyme systems that control different metabolic processes in plants. It is connected to the plant's water relations and water uptake. Manganese functions as a catalyst in oxidation and reduction processes inside plant tissues, aids in the production of chlorophyll, promotes iron mobility within the plant, and mitigates the negative effects of inadequate aeration. In enzymes, copper serves as an "electron transporter" and helps in the usage of iron in chlorophyll synthesis. The cell membrane contains boron, which is necessary for cell division. It helps the plant absorb nitrogen and move sugars across the plant, acting as a regulator of the potassium/calcium ratio.

In India, widespread Zn, Fe, and B deficits are linked to specific soil conditions and cropping systems. Because of the deterioration in soil fertility, loss of soil organic matter and non-application of deficient nutrients based on soil tests, boron and zinc deficiencies are becoming more prevalent in Indian soil. Furthermore, the research on crop yield development, particularly through the green revolution, has exacerbated the situation by gradually depleting the soil micronutrient pool. Unless adequate measures are implemented, this trend will continue. As a result, it is critical to examine the micronutrient and beneficial nutrient balance in soils as soon as possible [18].

Soil physicochemical properties—such as pH, EC, calcium carbonate, and organic carbon—significantly affect nutrient availability and, consequently, crop productivity. Proper monitoring and management of these parameters are essential to ensure sufficient nutrient supply for plant growth.

Renapur Tahsil in the Latur district of Maharashtra's Marathwada region was selected for this study due to its diverse soil types. The investigation aimed to assess the micronutrient status and its relationship with key soil properties in soybean-growing areas of Renapur.

MATERIALS AND METHODS

The Latur district is situated between 18^0 05' to 18^0 75' north latitude and 76^0 25' to 77^0 25' East latitude. The region covers 7166 square kilometers and receives 787 millimeters of rain annually. The district's maximum and lowest temperatures are 39.6^0 C and 13.9^0 C, respectively. The height is 725 to 750 meters above sea level, and it is located in the semiarid Central Marathwada Plateau Agro-climatic Zone. The weathering of Deccan trap rock, which is rich in lime, magnesia and iron forms the soils of Latur. Renapur Tahsil has a total size of 557.91 square kilometers. Due to the presence of minerals including smectite, kaolinite, and vermiculite, the soils of Latur district are varied in colours.

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DOI: https://doi.org/10.21276/AATCCReview.2025.13.03.358
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These soils were light-textured and deep to shallow black. Soybean, sugarcane, pigeon pea, gramme, sorghum, wheat, peanut, sunflower, and various horticultural crops are the main crops grown in this region.

A total of 100 soil samples were collected from the Renapur tahsil's soybean producing region. These samples were used for further studies. Twenty villages were chosen as typical, and five samples were taken from each village. A total of a hundred typical surface soil samples (15-20 cm depth) were taken. According to USDA categorization, the soils were placed in distinct orders. The depth of the soil and the physical features of the soil were used to categorize them. At the time of soil sample collection, the latitude and longitude of the soil surface sample were recorded, and the soil samples were processed for further examination.

They were brought to the lab, thoroughly mixed, allowed to air dry in the shade, ground with a wooden mortar and pestle, and then put through a 2 mm sieve. In preparation for a subsequent study, the sieved soil samples were placed in polythene bags that were labelled. To prevent contamination, each and every safety measure recommended by Jackson [7] was meticulously followed.

The available Fe, Zn, Mn and Cu in soil samples were extracted with DTPA (0.005 M DTPA + 0.01 M CaCl2 + 0.1 M triethanolamine, pH 7.3) as per method described by Lindsay and Norvell (1978). The concentration of Fe, Zn, Mn and Cu in the DTPA extracts was determined using an atomic absorption spectrophotometer. Available Boron was determined by hot water-soluble boron extract with the Azo-methine method given by Berger and Troug [2].

The formula of nutrient index (NI) and classification of available nutrients as low (< 1.67), medium (1.67 – 2.33) and high (>2.33) as suggested by Ramamurthy and Bajaj, 1969 was evaluated as follows:

$$NIV = \frac{\text{No of samples under low category} \times 1 + \text{No. of samples under medium category} \times 2 + \text{No. of samples under high category} \times 3}{\text{Total number of samples}}$$

For available Fe, Zn, Mn, Cu and B the critical limits are taken as per given by Rattan et al., [15] ISSS. DTPA-Fe is rated low (<2.5), medium (2.5–5.8), and high (>5.8); DTPA-Mn is rated low (<2.0), medium (2.0–4.0), and high (>4.0); DTPA-Zn is rated low (<0.5), medium (0.5–1.0), and high (>1.0); DTPA-Cu is rated low (<0.2), medium (0.2–0.5), and high (>0.5); Boron is rated low (<0.5), medium (0.5–1.0), and high (>1.0).

RESULTS AND DISCUSSION

Micronutrient Status in Soils of Renapur Tahsil

DTPA - Fe

The available iron in the Inceptisol, Entisol, and Vertisol soil orders of the Renapur tahsil ranged from 0.11-11.98, 0.65-6.92 and 0.18-13.86 mg kg^{-1}, respectively, with average values of 3.30, 2.92, and 6.78 mg kg^{-1}. Out of 100 samples, 33 % were low, 50 % were medium, and 17 % samples were high in iron content, indicating that these soils were low to high in case of available iron. In Inceptisol, Entisol and Vertisol soils 32.15, 42.31 and 22.22 percent soil samples were low, 60.71, 7.69 and 61.11 percent soil samples were medium, and 7.14, 7.69 and 61.11 percent soil samples were high in category, respectively. Malewar and Ismail (1999) reported that available Iron content varied from 0.36 to 25.14 mg kg^{-1} in soils of Marathwada. Similar results were also in agreement with the findings by Patil *et al*. [11], Shinde *et al.* [16] and Nadaf *et al*. [9].

DTPA - Zn

The available zinc varied from 0.16 to 3.14 mg kg^{-1}, 0.23 to 0.88 mg kg^{-1}, and 0.33 to 0.92 mg kg^{-1} in the Inceptisols, Entisols, and Vertisols of the Renapur tahsil, with corresponding mean values of 0.59, 0.48, and 0.56 mg kg^{-1}. In Inceptisols, 60.71, 30.35 and 8.93 percent soil samples were low, medium and high, respectively. In Entisols, 65.38, 34.62 percent soil samples were low and medium. In Vertisols in the case of zinc 44.44 and 55.56 percent soil samples were low and medium, respectively. Out of 100 soil samples, 59 % were low, 36 % were medium and 5 % soil samples were high in zinc. Therefore, the zinc content in these soils was in low to medium range. Its availability decreases because Zn cations in calcareous soil are in an oxidized condition. Zn availability in soil was reduced by a rise in pH. Pharande *et al*. [12] reported that the available zinc ranged from 0.21 to 3.94 mg kg^{-1} in western Maharastra. Similar observations were reported by Rajput and Polara [13], Desai *et al*. [5], and Shinde *et al*. [16].

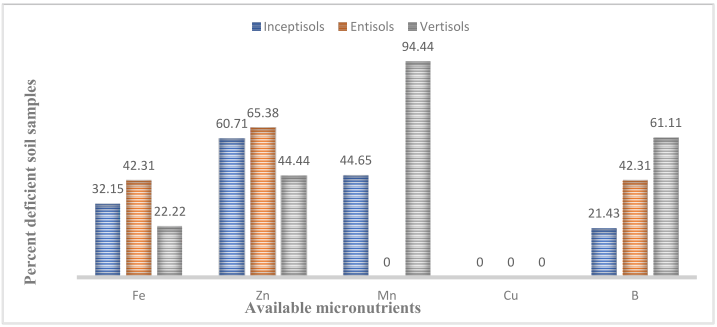

Fig. 1. Status of available micronutrients in three soil orders

DTPA - Mn

The available manganese ranged from 1.18 to 10.89, 2.41 to 11.37 and 0.3 to 8.89 mg kg^{-1} in the Inceptisol, Entisol, and Vertisol soil orders of the Renapur tahsil, with average values of 3.61, 6.15 and 1.05 mg kg^{-1}, respectively. Out of 100 samples, 42 percent were low, 23 percent were medium and 35 percent samples were in the high category. In Inceptisols, Entisols and Vertisols, 44.65, 0 and 94.44 percent soil samples were low, 30.35, 23.08 and 0 percent soil samples were medium, and 25, 76.92 and 5.56 percent soil samples were high in category. Hence, these soils were low to high in available manganese. This may be due to the soil's increased magnetite mineral pressure. Waghmare and Takankhar [19] reported that available manganese content ranged from 1.23 to 13.57 mg kg^{-1} in the soils of Ausa tahsil of Latur district. Similar findings were also noted by Shinde *et al*. [16].

DTPA - Cu

In the Inceptisol, Entisol, and Vertisol soil orders of the Renapur tahsil, the available copper ranged from 1.22 to 3.81, 1.23 to 4.7, and 1.69 to 6.07 mg kg^{-1}, with averages of 2.22, 2.38, and 2.83 mg kg^{-1}, respectively. All the 100 soil samples collected from Renapur tahsil were high in available copper. The high copper concentration in these soils is likely a result of copper-bearing minerals such as cuprite and chalcocite present in the parent material. Nadef *et al*. [9] reported that available copper content ranged from 1.54 to 7.62 mg kg^{-1} in the soils of northern Karnataka. These results are in confirmatory with the results of Hadole *et al*. [6] and Paragi *et al*. [10].

Available B

The available boron varied from 0.1 to 1.57, 0.1 to 1.1, and 0.04 to 1.62 mg kg^{-1} in the Inceptisols, Entisols, and Vertisols of the

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Renapur tahsil, with corresponding means of 0.71, 0.56, and 0.56 mg kg^{-1}. Out of the 100 samples collected from the Renapur tahsil, 34% were low, 53% were medium and 13% were high. In Inceptisol, Entisol and Vertisol soils, 21.43, 42.31 and 61.11 percent soil samples, respectively were low, 62.5, 53.84 and 22.22 percent soil samples were medium, while 16.07, 3.84 and 16.67 percent soil samples were high in available boron. These soils were low to medium in available boron. These soils contain a sufficient range of available boron content. This may be due to the accumulation of boron in a highly soluble form, along with calcium and sodium, which tends to concentrate in the surface soil. Chavan *et al*. [3] reported that available boron content ranged from 0.05 to 1.97 mg kg^{-1} with a mean of o.57 mg kg^{-1} in different agro-climatic zones of Maharastra. These results are in close agreement with those reported by Bansal *et al*. [1] and Chinchamalatpure *et al*. [4].

Soil Nutrient Index

In Renapur Tahsil, the nutrient status of different soil orders varies notably. In Inceptisol soils, zinc levels were low, while iron, manganese, and boron were moderate, with nutrient index values of 1.75 for iron, 1.48 for zinc, 1.80 for manganese, and 1.94 for boron. Entisol soils showed low levels of iron, zinc, and boron, but high levels of manganese, with respective values of 1.65, 1.34, 2.76, and 1.61. In Vertisol soils, zinc, manganese, and boron were low, whereas iron was high, with nutrient index values of 2.38 for iron, 1.55 for zinc, 1.11 for manganese, and 1.55 for boron. Copper consistently recorded a high nutrient index value of 3.00 in all three soil orders, indicating its sufficient availability across the region.

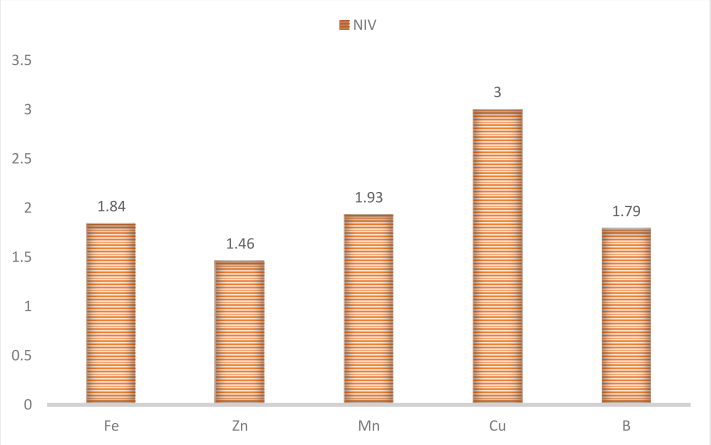

Fig. 2. Nutrient Index Values of Available Micronutrients in Renapur Tahsil

Table 1. Status of available micronutrients in three soil orders

Micronutrients (mg kg^{-1})	Inceptisols				Entisols				Vertisols			
	Range	Mean	S.E.	C.V. (%)	Range	Mean	S.E.	C.V. (%)	Range	Mean	S.E.	C.V. (%)
Iron	0.11–11.98	3.30	0.28	63.70	0.16–3.14	0.59	0.07	95.95	0.18–13.86	6.78	0.97	61.04
Zinc	0.16–3.14	0.59	0.07	95.95	0.23–0.88	0.48	0.03	36.22	0.33–0.92	0.56	0.04	35.24
Manganese	1.18–10.89	3.61	0.39	81.16	1.22–3.81	2.22	0.08	28.64	0.30–8.89	1.05	0.46	86.73
Copper	1.22–3.81	2.22	0.08	28.64	1.23–4.70	2.38	0.17	38.14	1.69–6.07	2.83	0.29	44.56
Boron	0.10–1.57	0.71	0.04	42.66	0.10–1.10	0.56	0.05	45.79	0.04–1.62	0.56	0.11	83.85

Table 2. Nutrient index of available micronutrients of three soil orders

Micronutrients	Soil orders		
	Inceptisols	Entisols	Vertisols
Iron	1.75	1.65	2.38
Zinc	1.48	1.34	1.55
Manganese	1.80	2.76	1.11
Copper	3.00	3.00	3.00
Boron	1.94	1.61	1.55

CONCLUSION

The study on the micronutrient status of Inceptisol, Entisol, and Vertisol soils in Renapur tahsil revealed considerable variability in the availability of DTPA-extractable micronutrients. Iron levels ranged from low to high, with Vertisols exhibiting the highest average content and nutrient index, indicating better iron availability. Zinc was predominantly deficient across all soil orders, particularly in Entisols, due to factors such as high pH and calcareous conditions that reduce its availability. Manganese content varied widely, being high in Entisols but notably deficient in Vertisols. Copper was consistently sufficient across all soil types, with a uniformly high nutrient index attributed to the presence of copper-bearing minerals in the parent material. Boron levels were generally in the low to medium range, with Vertisols showing the highest deficiency. These results highlight the need for targeted zinc and manganese management to address nutrient imbalances and support optimal crop productivity in the region.

CONLICTS OF INTEREST: All authors declare that they have no conlicts of interest.

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