MICRONUTRIENTS ~~VIZ A VIZ~~ PLANTS AND ECOSYSTEM: A REVIEW

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Abstract:

Though mostly ignored, micronutrients are most important. Reducing the negative effects of micronutrient shortages requires the use of effective techniques like vitamin supplements and dietary diversification. It is known that when agricultural yields are reduced because of inadequate soil micronutrient concentration, malnutrition may result. Deficits in soil micronutrients can result from a number of variables, such as the use of intensive cropping practices, micronutrient leaching, soil characteristics, and decreased use of farmyard waste. The availability of micronutrients in the soil is determined by a number of factors, including pH of the soil, and organic matter status of the soils. Numerous factors, including as the structure of root hairs, the release of organic acids, sugar, and several root enzymes, as well as interactions between microorganisms and plants, affect how well plants absorb and use micronutrients. Numerous studies have been carried out to investigate the soil's micronutrient absorption and bioavailability. In order to improve crop utilisation of soil nutrients, the discussion also included an analysis of the relationships between plant functions and soil nutrients.

Keywords: *Soils; Micronutrients; Plants; Grains; Ecosystem*

1. Introduction:

Crop production and quality have decreased throughout the years as a result of inadequate management of soil resources, which includes intensive crop cultivation without sufficient nutrient replenishment, few crop rotations, and little to no addition of organic matter. Globally, there has been a rise in micronutrient deficiencies in soils, crops, animals, and humans (Bhatt *et al.,* 2016; Bhatt *et al.,* 2021). The evidence that is currently available is adequate to establish the role that micronutrients play in the growth and reproduction of plants, animals, and humans. Vital micronutrients for plant development include zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), chlorine (Cl), and nickel (Ni). Because it keeps the body from losing calcium and magnesium, boron is a trace element that is thought to be advantageous for both humans and other animals (Dhaliwal *et al.,* 2022c). Every micronutrient has a distinct function in the metabolism of plants, animals, and humans; therefore, a shortfall in one nutrient cannot be compensated for by an excess of another.

In several states across the nation, crop productivity is being hindered by micronutrient deficiencies, particularly in Zn, Fe, and B (Kumar *et al.,* 2022). The relatively low fertility of Indian soils is made worse by the slow development of micronutrient deficits caused by their quicker removal during agricultural growth. According to the latest estimations, out of the 263 million tonnes (Mt) of food grains produced, 188.4 thousand tonnes (Tt) of micronutrients were lost. Out of these, the following were eliminated: 23.9 Tt of Zn, 110.6 Tt of Fe, 37.4 Tt of Cu, 63.3 Tt of Mn, 9.2 Tt of B, and 0.99 Tt of Mo. Zn, Fe, Mn, Cu, and B deficiencies were found in 36.5%, 12.8%, 7.1, 4.2, and 23.4% of the over 2 lakh soil samples examined in order to evaluate the micronutrient condition of the soil (Shukla and Behera, 2017). Micronutrient deficiencies in crops and soil have a detrimental effect on yield, animal and human health, and associated variables (Shukla, 2014).

Micronutrient deficiencies in animals lead to a range of physiological effects because these nutrients are needed for metabolic processes that affect growth, reproduction, and overall health. Although subclinical micronutrient insufficiency may not impact growth and feed efficiency, it can impact immunity and reproduction. Agroclimatic circumstances and increasing population pressure have forced the world system to prioritise food security and safety over nutrition by increasing agricultural productivity. Recent years have seen an increase in the prevalence of micronutrient deficiencies due to the introduction of contemporary, high-yielding crop varieties, increased soil erosion, and unbalanced fertilizer use. Significant research is required to completely comprehend micronutrients, their agroecological complexity in the system, and the best strategies to use them. Crops must be biofortified using various techniques to boost their micronutrient content (Sandhu *et al.*, 2020). Future crops will significantly degrade due to the ongoing rise in micronutrient deficiencies. Given the significance of micronutrients in plant sciences, agronomic solutions for enhancing micronutrient use efficiency in crops are required to ensure the nutritional security of food production.

Micronutrients *viz-a-viz* Ecosystem:

In order to use micronutrients in agricultural soil, they are frequently extracted from the earth's crust. Add mined minerals to agricultural soils to compensate for deficiencies in micronutrients. The weathering and decomposition of soil minerals and organic components produces the majority of micronutrients. There are complexes in the fluid that attach to organic matter and clay as well as free, soluble nutrient ions. Micronutrient availability is influenced by a number of soil parameters, including ion interaction, redox potential, organic matter, acidity, and alkalinity. Soils with low fertility can receive micronutrients from animal feed additives and mined minerals. Micronutrients and organic amendments can increase crop yields and water efficiency when there is a water shortage (Molden *et al.*, 2010).

Plant availability and Zn ? solubility are controlled by the adsorption-desorption process (Alloway, 2004). According to Hussain *et al.* (2016), zinc fertiliser increased grain absorption and mobilisation. Agronomic biofortification reduces the quantity and quality of agricultural productivity, which is impacted by a lack of soil micronutrients. Mineral shortages result from insufficient soil replenishment of parent material and adsorbed complexed fractions. Nutrient deficiencies in agricultural soils were caused by natural processes, soil pH, human activities, and intensive farming without fertilizer (Dhaliwal *et al.*, 2017). Although micronutrient deficiencies in soil are common, their severity varies by geography and nutrient (Voortman & Bindraban, 2015). Micronutrient deficits are common in crops such as grains, oilseeds, pulses, and vegetables that are cultivated extensively. The micronutrient deficiencies of zinc (Zn) 40%, iron (Fe) 12.6%, copper (Cu) 4.5%, manganese (Mn) 6.0%, and boron (B) 22.8% in soils have been reported across the country. The manganese deficiency is emerging extremely fast, particularly in wheat crops grown after rice in Haryana (12%) and Punjab (18%) due to leaching of Mn from the upper surface of the coarse-textured soils (Kumar et al, 2020). Application to the soil and the leaves is advised for crops lacking Zn, B, and Mo; for Fe and Mn, only application to the leaves is advised.

Micronutrient *viz-a-viz.* Plant System:

The average amounts of chlorine, iron, manganese, boron, zinc, copper, molybdenum, and nickel needed per kilogramme of dry matter are 100, 50, 20, 20, 6, 0.1, and 0.1 mg, respectively. When vitamin concentrations fall below critical levels or when they become malnourished, plants exhibit symptoms of deficiencies. Deficits in micronutrients affect the physiological and biochemical functions of plants. Understanding each micronutrient's function within the plant system is necessary to comprehend the mechanisms governing their availability in soil. The majority of soil micronutrient cations are divalent (trivalent iron is possible), and negatively charged humus and clay effectively absorb them. The life cycle, environment, and genetics of the plant determine its nutritional ratio. Through a beneficial interaction, micronutrients increase the nutritional content of crops (Dimkpa *et al.,* 2015). Specific nutrients are absorbed by plants. As a result, their nutritional ratios are different from the soil's. Without micronutrients, the metabolism of other macro and micronutrients by plants would not function as efficiently. To comprehend plant micronutrient transport, precise membrane micronutrient flux measurements are required. Compared to macronutrients, these elements have lower internal demands. It is important to comprehend how minerals are absorbed by plant roots in their available forms, as well as the limits of their supply and phytoavailability. Plant mineral element accumulation is determined by the supply of mineral elements and phytoavailability.

Micronutrient Accessibility Deciding Factors:

Soil pH affects micronutrient availability to plants as well as their ionic form, mobility, and solubility (Fageria *et al.,* 1997). A decrease in micronutrient availability, i.e., Zn, Fe, Cu, Mn, B, etc., and Mo become more available when soil pH rises. These micronutrients are often adsorbed onto soil surfaces as sesquioxide. Sharma *et al.* (2007) report that for every unit of soil pH increase, the solubility of Mn, Cu, and Zn decreases by approximately 100 and 1000 times, respectively. Soil pH has a direct effect on zinc mobility and availability; when pH rises, zinc availability falls (Saeed and Fox, 1999). Zn adsorption as hydrous oxides of Fe, Al, and Mn happens when soil pH rises over 5.5 (Moraghan and Mascagni 1991). Zn content in soil solution is increased by OM solubilization; nevertheless, Zn $(OH)^+$ develops in the soil at pH values more than seven (Barber 1995). Zn concentration in acidic soils decreases thirty times for every unit increase in soil pH between 5.0 and 7.0, according to McCride and Blasiak (1979).

Soil Organic Matter (SOM) also effected the micronutrient availability. Compounds that are categorised as either water-soluble or water-insoluble make up soil organic matter. Fulvic acids are soluble in water and have a comparatively large molecular weight. On the other hand, humic compounds, or humic acids, are insoluble in water because they include anionic oxygen groups like phenolic hydroxyl, alcoholic hydroxyl, carboxyl, and aliphatic carboxyl (Tate, 1987). It has been shown that humic acids and metals can undergo ionic bonding or complexation reactions (Stevenson, 1986). Organic acids of low molecular weight, such malic, citric, and acetic acids, have strong ionic interactions or metal complexes. Because organic matter forms soluble complexes with organic molecules like fulvic acids or amino acids, it increases zinc availability in soil. The formation of insoluble zinc-organic complexes with soil organic matter (SOM) affects zinc's solubility. Exudation from roots and mineralizing bacteria promote complex formation in the rhizosphere, which increases Zn availability to plants (Lindsay, 1972).

Micronutrient improvement methods??? What scholars said to mitigate the factore of micronutrient Accessibility deciding????

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Conclusions:

Micronutrient deficits in sustainable agriculture have received a lot of attention lately, particularly when intensive cropping techniques are used. Numerous factors contribute to this significant issue, including the high demand for nutrients, nutrient loss via leaching and topsoil erosion, the use of acid soil additives, the scarcity of farmyard manure, fertiliser impurities, and the farming of marginal lands. The pH levels, organic matter content, and microbial activity all influence the availability of minerals. The range of their application rates is 0.2 kg ha^{-1} to 100 kg ha^{-1}, contingent upon the soil type, crop requirements, and method of application. Micronutrients are typically better absorbed from the soil than from foliar sprays, despite the fact that they are required in lesser quantities and are frequently added to fertilisers containing macronutrients. It is crucial to cultivate genotypes that use micronutrients more effectively if farming is to produce more in the future.

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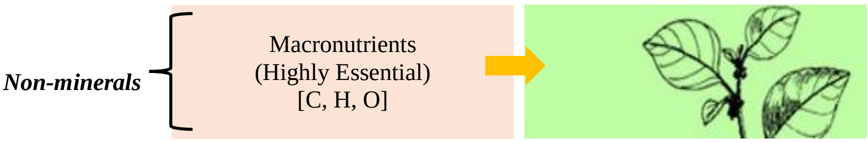


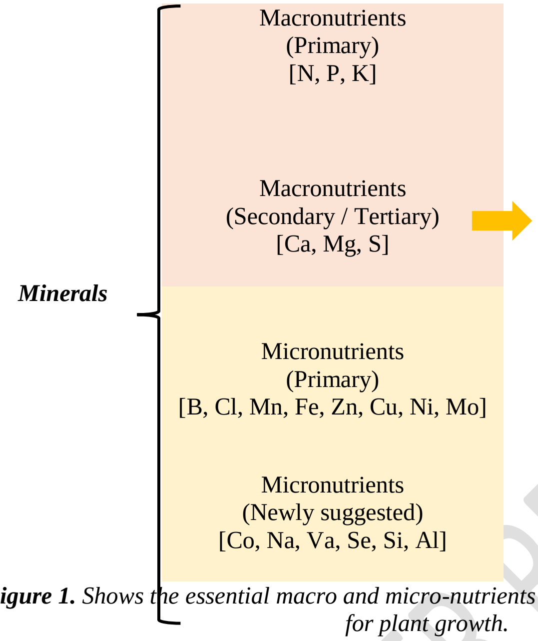
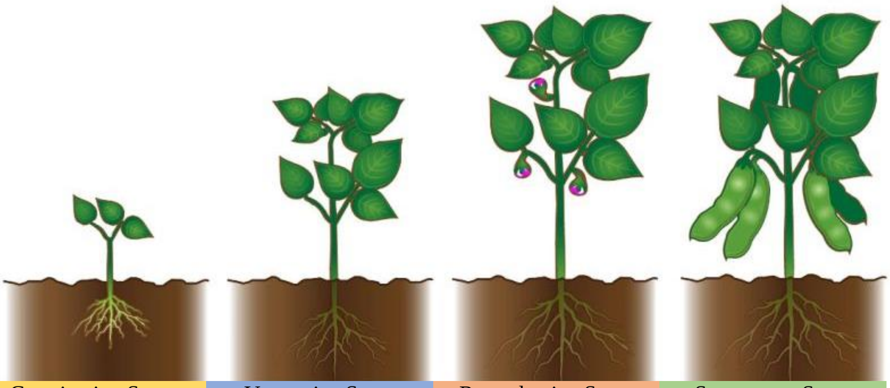


Figure 1. *Shows the essential macro and micro-nutrients [both minerals and non-minerals] for plant growth.*



Germination Stage	Vegetative Stage	Reproductive Stage	Senescence Stage
Establishment of Roots	Plant Growth	Flowering	Plant Maturity

Micronutrients utilized in each stage of plant

Germination Stage	Vegetative Stage	Reproductive Stage	Senescence Stage
Fe, Zn, Mn	Fe, Zn, Mn, Cu, B	Fe, B	Cu, Mo, B

Figure 2. *Micronutrients are essential in all stages of a plant's growth and development.*

Table 1. Roles of micronutrients *viz-a-viz* plants

Elements	***Taken Form***	***Roles / Functional Contributions***
Iron	Fe^{2+} / Fe^{3+}	❖ *Promotes formation of chlorophyll* ❖ *Enzyme mechanism which operates the respiratory system of cells* ❖ *Reactions involving cell division and growth*
Manganese	Mn^{2+}	❖ *Predominant in metabolism of organic acids* ❖ *Activates the reduction of nitrite and hydroxylamine to ammonia* ❖ *Role in important enzymes involved in respiration and enzyme synthesis* ❖ *Activator of enzyme reactions such as oxidation / reduction, hydrolysis* ❖ *Direct influence on sunlight conversion in the chloroplast*
Zinc	Zn^{2+}	❖ *Formation of growth hormones (Auxin)* ❖ *Seed and grain formation* ❖ *Promotes maturity* ❖ *Plant height* ❖ *Protein synthesis* ❖ *Transformation and consumption of carbohydrate*

Boron	$B[OH]_3$ Or as H_2BO_3 (Depends on pH)	❖ *Protein synthesis* ❖ *Formation of plant hormones* ❖ *Promotes maturity* ❖ *Increase in flowering set* ❖ *Affects nitrogen and carbohydrate metabolism* ❖ *Water relation in plant*
Copper	Cu^{2+}	❖ *Enzyme activator* ❖ *Major function in photosynthesis and reproductive stage* ❖ *Indirect role in chlorophyll production* ❖ *Increase sugar content* ❖ *Function in respiratory system* ❖ *Intensifies colour* ❖ *Improves flavour in fruits and vegetables*
Molybdenum	MoO_4	❖ *Essential for nitrogen fixation, nitrate reduction and plant growth*
Chlorine	Cl^-	❖ *Activator for the enzyme that releases oxygen from water during photosynthesis* ❖ *Regulating turgor pressure and growth of cells and is important in drought resistance* ❖ *Counter ion to the positively charged "cations" in the cells*
**Ni will not be reviewed since it has minor importance in agricultural practices.*		