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# Micronutrients and Their significance in Agriculture: A Mini Review with Future Prospects

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**Abstract**
Soils in many places throughout the globe have acquired multi-micronutrient deficiencies as a consequence of the widespread adoption of high-yielding cultivars, intensive farming techniques, micronutrient-free fertilizer application, non-addition of organic manures, and imbalanced plant nutrition. These factors have all contributed to the depletion of soil micronutrients.Micronutrients are believed to be trace elements since plants often only take in extremely minute amounts of them, despite the fact that they are widely accessible in the soil.Even though plants only need relatively little amounts of micronutrients like B, Cu, Fe, Mn, and Zn, these elements nonetheless play an essential role in the expansion and maturation of plant life.Micronutrients are essential for nutrient intake management, plant metabolism,chlorophyll synthesis, fruit and seed production, reproductive development,and carbohydrate production. Their impact on plant product quality makes their importance clear. This is possible due to the fact that each critical element in plants is responsible for a distinct group of functions. Nutrients availability can be affected by a wide variety of factors like soil moisture, microbial activity in soil, clay content, organic matter, aeration or permeability of soil,

redox potential and soil reactivity. Other soil properties that might have an effect on plant availability of micronutrients include aeration and redox potential.In the near future, micronutrient insufficiency will cause agricultural crops to degrade significantly. Science, breeding, and ingenuity are studying this topic. This article explains micronutrients' amazing importance in plant sciences and briefly outlines how agricultural crop plants acquire micronutrients.

**Keywords:** Agriculture, Micronutrients, Deficiency, Toxicity, Soil organic matter, Food security

## Introduction

The idea of sustainability is one that has garnered a lot of attention in recent years, and its application has grown widespread in many different parts of our lives, notably in agriculture as a result of the influence that various crop production practices have on the environment in their immediate vicinity[1].Maintaining the biological diversity, productivity, regeneration capacity, vitality, and ability to function of the agricultural ecosystem is the goal of sustainable agriculture. This allows the agricultural ecosystem to fulfill significant ecological, economic, and social functions at the local, national, and global levels without causing harm to other ecosystems. Thus, sustainable agriculture does not affect ecosystems. Sustainable agriculture protects the agricultural ecosystem's biological diversity, productivity, regeneration capacity, vitality, and ability to function[2].On the other hand, it is conceivable that the addition of chlorine to the soil, either in the form of fertilizers or by some other approach, would aid prevent its scarcity under field circumstances. This would be the case if chlorine were provided to the soil in some other manner.

The capability of agriculture to preserve its sustainability has been faced with some of the most significant difficulties throughout the course of the last many years[1]. There is a wide variety of barriers, the most notable of which are as follows: (i) first and foremost, the rapid growth of the human population and the rising demand for agricultural land and resources; (ii) overdependence on fossil fuels and the high monetary and environmental costs of non-renewable resources; and (iii) a lack of variety in the population of the world. (iii) global climate change[3], and (iv) globalization[1]. These persistent concerns are creating a larger challenge than at any other moment in history for agriculturalists to design management systems that are more ecologically friendly.In order to satisfy the needs of a population that is growing at a more rapid pace for food and nutrition, agriculture will need to extend beyond its traditional focus on production and begin to include enhancements to public health, social well-being, and environmental sustainability[1]. Additionally, it is vital to discover alternative ways for the control of plant diseases that are not detrimental to the natural environment and which, at the same time, raise productivity and enhance the quality of the product[4].

Nutrients are not only necessary for the development and growth of plants and microorganisms, but they are also crucial components in the process of preventing and treating illness[5].Every essential nutrient has the potential to have an effect on the severity of the illness[6].However, there is no one rule that can be said to apply to all circumstances. This is due to the fact that a single nutrient may lessen the severity of one sickness while at the same time raising the severity of the disease incidence of another disease, or it may have the exact opposite effect in an environment that is completely different[7].

There are seventeen different nutrients that are considered to be important for plants and are required for healthy growth and development. The amounts of essential nutrients that are necessary for the plant's growth and development are quite variable, despite the fact that each plays an equally important function in the plant's growth and development.It is generally agreed that nitrogen (N), phosphorus (P), and potassium (K) are the major nutrients. Most of the time, it is vital to include them as part of the crop fertilization strategy since they are the ones that provide the required nutrients.In addition to this, the plants want the highest possible concentration of them in the form of chemical fertilizers. Secondary nutrients are calcium (Ca), magnesium (Mg) and sulphur (S).Even though they are needed in much lower quantities than the primary nutrients, these three are essential for the survival of the vast majority of plant species.Plants need eight micronutrients: zinc (Zn), iron (Fe), copper (Cu), manganese (Mn), molybdenum (Mo), boron (B), nickel (Ni), and chlorine (Cl).Most scientists prefer to use micronutrients to refer to critical plant components that are needed in smaller levels.These elements are rare in soils and plants, although they are as important as primary or secondary plant nutrients.They are the building blocks of enzymes as well as coenzymes.There is a considerable negative impact on the growth, production, and overall quality of the crop if one or more of the micronutrients are missing, and this is strongly correlated with the phenomenon.In circumstances such as these, the application of extra micronutrients in the form of commercial fertilisers and foliar sprays, in addition to the integration of appropriate microbial inoculants into the soil, becomes an absolute need[8].

**Micronutrients in Plant Health**

Research demonstrates that critical plant processes are greatly harmed if any required element is deficient in soil or not balanced with other nutrients, resulting in poor plant growth and many irregularities and directly affecting crop yield and quality.Micronutrients, which plants take in little amounts, are crucial to plant metabolism, growth, and development.Plant micronutrients are essential as catalysts or coenzymes in metabolic biochemical processes.All of these, with the exception of zinc, are able to fulfill the role of "electron carriers" in the enzyme systems that are responsible for the oxidation and reduction processes that take place in plants. Zinc is the only exception to this rule[9]. Table 1 explains the most important roles that critical trace elements play in the human body.

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| Micronutrients | Role in Plants |
|---|---|
| Boron | Activates some dehydrogenase enzymes<br>Essential in plant maturity<br>Essential for the formation of the seed coat and the cell wall<br>Helps in the transport of sugars as well as the production of nucleic acids and plant hormones |
| Zinc | Essential to the manufacture of chlorophyll<br>Stimulates the production of growth hormones as well as starch<br>Existing in a number of different enzymes, such dehydrogenases, proteinases, and peptidases<br>Responsible for the development and growth of seeds |
| Copper | Enhances fruit and vegetable flavors<br>Exist inside laccase in addition to a number of additional oxidase enzymes<br>Indirect contribution to the synthesis of chlorophyll |
| Molybdenum | Important for both the fixation and absorption of nitrogen<br>Nitrogen is fixed by the enzyme nitrogenize, while nitrate is reduced by the enzyme nitrate reductase.<br>Essential for the plant's process of transforming inorganic phosphates into organic forms |
| Manganese | Important in the process of photosynthesis, as well as the metabolism and absorption of nitrogen<br>Activates decarboxylase, dehydrogenase and oxidase enzymes<br>Play an important role in chlorophyll synthesis |

(Source:[10])

**Table-1 shows that micronutrients are essential to plant and microbial growth.**

In addition, micronutrients are an important part of both the prevention and treatment of sickness. In the event that the plant tissues do not have an adequate quantity of zinc, boron, manganese, molybdenum, nickel, copper, or iron, the plants will have an increased risk of getting a number of diseases[11]. It is possible to improve a plant's resistance to many stresses, including infectious illnesses, by ensuring that it has enough quantities of its micronutrients[12]. Copper, when used as a fungicide, has the potential to prevent many infections that are transmitted via the soil. An adequate quantity of vitamin B in plants also reduces the frequency and severity of infections, but a shortage of vitamin B may make some illnesses more severe. Vitamin B deficiency can also make infections more common[13].In addition, research has shown that plants that have enough levels of manganese are less likely to get infected with a variety of plant diseases. This is one of the benefits that manganese provides to plants. In a similar vein, beneficial components are advantageous to the plant not only in terms of its development but also in terms of its resistance to diseases and the stressors of the environment (such as drought, salt, and the toxicity or lack of nutrients). This resistance allows the plant to thrive in a variety of conditions. The beneficial components shield the plant from the potentially harmful effects of some elements and, under certain circumstances, act as a substitute for nutrients that are essential to the development of the plant.Beneficial components such as silicon (Si) have a significant influence on the texture of the soil, as well as its capacity to resist soil erosion, store water, and absorb water.

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| Micronutrients | Function in Plants |
|---|---|
| Aluminium | Increases tea antioxidant enzyme activity<br>Root rot disease suppression<br>Prevents Cu, Mn, Fe toxicity and increases P uptake |
| Cobalt | Substituting sodium, selenium and molybdenum<br>Vital component of vitamin B12 and propionate<br>A necessary component for the development of Rhizobium bacteria |
| Selenium | Possibility of serving as an antidote to the harmful effects of phosphate in hyper accumulators<br>May reduce toxicity caused by phosphorus and stimulate plant growth.<br>Offer protection against potentially dangerous diseases. |
| Silicon | Support plants in resistance of drought as well as heavy metals<br>Offers protection against disease-causing organisms and insect pests<br>Increases in both quality and yield |

(Source:[14])

**The following table 2 provides a summary of the most critical functions that various useful components do.**

In addition to the aspects that were previously discussed, the conditions of the soil may also contribute to deficiencies in micronutrients or toxicity in plants that are in the process of development.In general, soils that have a pH that is extremely high, soils that have a pH that is low, parent materials that already had a low micronutrient content, intensive farming practices that receive excessive quantities of high-analyzing NPK fertilizers, soils that have a high organic matter content, and other factors can all have micronutrient deficiencies[9].

In soil circumstances of low pH, a shortfall of molybdenum was seen, while in soil situations of high pH, deficiencies of zinc, iron, manganese, and copper were observed. In addition, the addition of an excessive amount of $CaCO_3$ (lime) to acidic soils might result in deficits of micronutrient cations.Table 3 shows agricultural plant micronutrient deficit symptoms.

| Micronutrients | Deficiency symptoms |
| --- | --- |
| Boron | Deformed leaves with areas of discoloration, death of growing point, light general chlorosis |
| Zinc | Growth that is stunted, internode length that is decreased and immature leaves that are shorter than typical. |
| Copper | Immature leaves that are shorter than what is expected, as well as growth that is stunted and a reduction in the length of the internode. |
| Molybdenum | Symptoms are comparable to those seen in nitrogen deficiencies that are more common, including overall chlorosis (yellowing) of young plants and chlorosis of the oldest leaves. |
| Manganese | Chlorosis, often known as a yellowing between the veins of young leaves (quite similar to the symptoms of an iron shortage) |

(Source:[14])

**Table-3 Symptoms associated with a general absence of micronutrients**

An excessive supply of any nutrient may cause the plant to grow abnormally and can also cause the plant to become poisonous if it is given too much of that nutrient.Manganese excess may cause young leaf chlorosis, although the symptoms are different from iron deficiency.In a similar vein, excessive amounts of bromine, chlorine, copper, zinc, and manganese, as well as bromine and chlorine, may have negative impacts on the life of plants.The toxicity of those nutrients might be induced by a number of different factors, including an excessive administration of micronutrients as well as certain soil conditions.When the soil conditions were highland, acid sulphate soils often resulted in micronutrient toxicity, which hampered agricultural growth. This was especially true in hilly areas. Rice that was cultivated in soils that were rich in iron may have dangerously high concentrations of the element iron[15].

**Sources of Micronutrients in Soil**

Micronutrients that are inorganic may be found in the forms in which they exist naturally. These forms include the oxides, sulphides, and silicates that are found in the minerals that make up the soil. These trace elements originated in the rocks and minerals of the earth and were carried down through the generations. On the other hand, the degree of fluctuation in the natural supply of micronutrients in soil may vary quite a bit from one kind of soil to another. This is because various types of soil have distinct chemical makeups.Igneous rocks contain all micronutrients in various amounts[10].Zn may also occupy structural positions as moderate replacements for the key elements that make up silicate minerals, while Fe and Mn are found in prominent structural sites in some of the original silicate minerals[10].In the process of soil development, there are several transformations that take place in the minerals of the soil, and micronutrients are released as a byproduct of decomposition in the products of reaction. These micronutrients are essential for the growth of plants[16].Anions such as borate and molybdate may go through an adsorption or reaction in soils that is analogous to the one that phosphate ions go through, and this may result in the formation of new reaction products. During these changes, micronutrient cations such as iron, zinc, copper, and manganese are adsorbed onto soil colloids or transformed into secondary silicate minerals. Both of these processes take place in the soil[9].Also in many reports it has been observed that rainwater adds a lot of chlorine to soils.However, fertilizers and other sources of chlorine in soil avoid its lack in fields.

When it comes to the secondary sources of trace elements in soil, organic matter plays a significant role. The vast majority of micronutrients are firmly bound up in complex chemical structures, making them potentially difficult for plants to access. However, if organic matter decomposes and converts them into a form plants can absorb, they might be a key micronutrient supply[17].The addition of soil amendments and fertilizers to soil also makes a contribution to the micronutrient pools that are present in the soil.Selenium (Se) is efficiently attached to the organic matter that is present in the soil; as a direct result of this binding, selenium is less accessible to the roots of plants[18].The presence of oxalate and citrate decreased the amount of selenate adsorption, which led to an increase in the quantity of selenium that was accessible to plants[19]. Table 4 provides an overview of the most prominent forms of micronutrients that may be found in soil solutions.

| Micronutrients | Dominant soil solution forms |
|---|---|
| Boron | Boric acid ($H_3BO_3$), Dihydrogen borate ($H_2BO_3^-$) |
| Zinc | $Zn(OH)^+$, $Zn2^+$ |
| Copper | $Cu(OH)^+$, $Cu2^+$ |
| Molybdenum | $HMoO_4^-$, $MoO_4^{2-}$ |
| Manganese | $Mn2^+$ |

(Source:[19])

**Table-4 the most prevalent kind of micronutrients found in soil solutions**

**Boron (B)**

Figure 1 demonstrates that vascular plants get trace nutrients from soil.Boron has been identified as one of the microelements that belongs to group III of the extended form of the periodic table. It is also one of the elements that is present in the greatest quantity and is considered to be of the utmost importance. Boron may be found in a wide variety of different substances. Boron is a strongly electronegative element that shows properties that are intermediate between those of metals and non-metals. As a result of these characteristics, boron is easily distinguishable from the other elements that make up its group[20].Even though its typical concentration within the soil solution is 10 ppm, the most optimal range for plants, in which they do not experience either deficiency nor toxicity, is extremely low; specifically, 0.3–1 ppm. This is because plants in this range do not experience either deficiency or toxicity[21]. Boron can be found in virtually every natural environment; nevertheless, the major role that boron plays in maintaining both healthy growth and high output is not yet fully understood. Boron can be found in almost every natural environment.The plant gets boron (B) from undissociated, uncharged boric acid ($H_3BO$), which reacts with the apiose residues of two rhamnogalacturonan II (RGII) molecules to generate borate ester. RGII borate dimers cross-link with cell wall pectins, forming a three-dimensional structure[21].

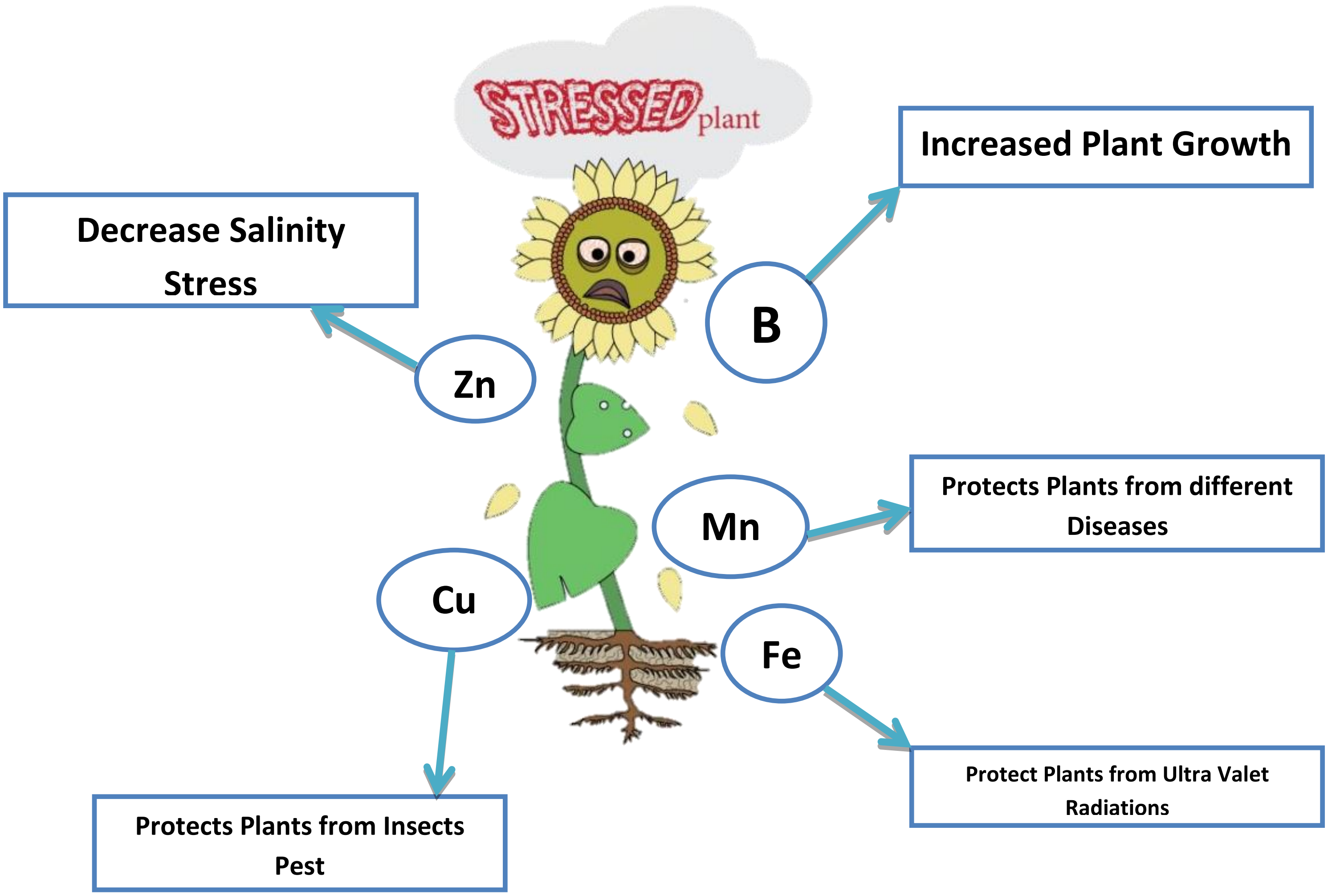


**Fig-1 Role of different micronutrients in plants under different stress environment**

Boron also promotes plant growth and development. However, boron shortage impairs metabolic and physiological processes in these species[22].Boron is crucial to tissue differentiation, vegetative development, phenolic metabolism, membrane integrity, and cell wall and lignification biosynthesis.Additionally, nitrogen fixation and nitrate absorption need boron bioavailability[23], root development[24] and used by plants in oxidative stress[25]. It is damaging to the development of plants and the output of agricultural produce anywhere if it is present in excess of the authorized limit[26].Boron is an essential nutrient that a plant must have in order to maintain healthy growth and development[27].

**Zinc (Zn)**

Zn, which has the atomic number 30 and is another transition element, is found to be the 23rd most abundant element on earth and contains five stable isotopes. This discovery was made after it was found that Zn is a transition element. It is incredible how important zinc (also known as Zn) is to plants as a micronutrient[28].Zinc, unlike iron and copper, is a Lewis acid and the most redox-stable element due to its fully filled d-shell electron orbitals[29].Zn is a key structural or regulatory co-factor in many enzymes and proteins.Because of its role in regulating transcription at the organismal level, the 'zinc finger' structural motif deserves special attention[28].Intake of zinc in its divalent form is often sufficient to ensure the maintenance of good crop development. As a result, being responsible for various significant roles across a variety of plant species, some of which are as follows:

- Plants are shielded from the damaging effects of oxidative stress because to the crucial role that zinc plays in both SOD and CAT.
- The acceleration of the glucose, protein, and auxin metabolisms, as well as the generation of pollen

In addition to this, zinc promotes a number of biochemical activities that are involved in the photosynthetic metabolic process. This is due to the fact that zinc is a component of the structure of the enzyme rubisco[30].Zn has a high affinity for cysteine and histidine, which explains why it can stop Haber-Weiss processes from generating dangerous hydroxyl radicals in the thylakoid lamellae[30].

**Manganese (Mn)**

In addition to iron (Fe), manganese (Mn), which is included in group VII of the extended periodic table, is considered to be one of the most significant and widely dispersed of the microelements that may be discovered on Earth[31].It occurs naturally in oxidation states 0, II, III, IV, and VI, although biological systems prefer II, III, and IV[32].Manganese bioavailability depends on soil redox and pH[33].Despite the fact that its concentration within the soil solution is very high, the plant only takes in a very tiny portion of it in order to ensure that their growth and development is optimized[31]. In addition to its importance in a wide range of metabolic processes, manganese also plays a part, either directly or indirectly, in the mechanism that allows higher plants to tolerate stress. Manganese does this by acting as a cofactor for a number of different antioxidant enzymes[34].In addition, manganese (Mn) is an essential component of photosynthesis because it plays a part in the photolysis of water that takes place at photosystem II. This process supplies electrons that are necessary for the beginning of the electron transport system[33].In the part of photosynthesis known as oxygen evolution, [35]presented convincing evidence that manganese plays a major and effective role in the process.Manganese is also involved in RuBP carboxylase activities, the manufacture of ATP, acyl lipids, proteins, and fatty acids[33].

**Iron (Fe)**

After silicon, oxygen, and aluminum, iron (Fe) is the microelement that is found in the fourth highest abundance on Earth. In the extended form of the periodic table, it may be found in the fourth period and the eighth group. Its atomic number is 26, and its weight is 55.845, and it plays a role in a variety of biological processes[36]. Iron is an essential trace metal that plants need at very low concentrations in order to grow and produce to their full potential. Plants are unable to attain their full potential if they do not have enough iron[37]. It has a low solubility in soil, which means that the bioavailability of this element to the cells of plants in their inorganic condition is limited[38]. Strategy I and Strategy II are the names given to two different successful techniques that plants adopt in order to accumulate iron. These strategies are responsible for the accumulation of iron in plants. These tactics are effective in separate groups of phylogenetic organisms[39].

Iron has been revealed to exist in a range of cellular compartments, such as mitochondria, vacuoles and chloroplasts, according to recent research[40]. In addition to this, it participates in a wide number of cellular metabolic processes in plants as a redox cofactor[36]. Photosynthesis, the manufacture of chlorophyll, cellular respiration, oxygen transport, lipid metabolism, the tricarboxylic acid (TCA) cycle, gene control, the synthesis of metabolic intermediates, and the biosynthesis of DNA all need iron (Fe)[41].

## Conclusion and Future Prospects

Micronutrients, which plants need in tiny amounts (~100 mg kg-1 dry weight), regulate genes, hormones, energy metabolism, signal transductions, and more.Boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn) are the typical examples of the types of substances that are regarded to be necessary micronutrients. This classification is based on the specific requirements that higher plants have for these elements.A comprehensive metal homeostasis networking system is required since every organism requires an adequate supply of these micro elements in order to maintain homeostasis. This system has to take into consideration not only the absorption and accumulation of the micro components inside the plant, but also their mobilization, storage, and intracellular trafficking, among other tasks.Through bio fortification, micronutrients improve crop yield and human and animal health.To provide quality food to the world's growing population, agronomic treatments must be based on a full understanding of soil–plant interactions.The application of micronutrients in the soil, biofertilizers, balanced fertilization, recycling of crop wastes, agronomic biofortification, and so on are all examples of sustainable agricultural practices.Low phyto-availability or supply would reduce agricultural yield globally. For maximum production, plants need these micronutrients throughout their development period. But the overpopulation and heedless exploitation of natural repositories make it impossible for plants to preserve their necessary supply for future reference, thereby challenging science. It's now clear that 2/3 of the world's population is at danger of nutritional deficiencies.However, mineral fertilizers or GM crops with increased metal concentrations may lessen the mineral nutrition shortage. Crop husbandry, breeding, and genetic modification are also effective, current, and dependable methods for enhancing soil mineral status.These methodologies may open up novel opportunities in micronutrient use in plant and agricultural sciences, however more sophisticated and scientific study is needed to attain better outcomes.

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