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Status of Micronutrient Deficiencies in Indian Soil and the Role of cheated micronutrients in Alleviating Micronutrient Deficiency and Agricultural Production –A Review

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ABSTRACT

Crops grown in most soils in India suffer from deficiencies of one or more micronutrients, even though the soils often contain adequate total amounts of the respective elements. Of the 17 elements essential for plant growth, eight are micronutrients: boron (B), chlorine (CI), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), and nickel (Ni). The nature and extent of deficiencies vary with soil type, crop genotype, management, and agro-ecological situations. Among the various micronutirents zinc is a deficiency found in most area. Micronutrient deficiencies are now frequently observed in intensively grown cereals, oilseeds, pulses, and vegetable crops.Due to micronurinet the crop yield losses were observed by 9-35 %. Chelated micronutrinets have been found to increase nutrient utilization efficiency. The chelated fertilizer improves the bioavailability of micronutrients and in turn, contributes to the productivity and profitability of commercial crop production. Chelated fertilizers have a greater potential to increase commercial yield than regular micronutrients. Hence, inclusion of micronutrients in a balanced fertilization schedule would optimize micronutrient supply and availability throughout the entire food consumption cycle.

Keywords: *Micronutrients, Extend of micronutrients, status in Indian soil, function in plant, factors affecting availability, soil properties, deficiency, yield loss, application method, chelated micro nutrients, yield*

INTRODUCTION

Micronutrients are essential to plant nutrients that are found in trace amounts in tissue, but play an imperative role in plant growth and development. Without these nutrients, plant nutrition would potentially lead to declines in plant productivity. Indian soils are generally poor in fertility especially in micronutrients, as these have consistently been mined away from their finite soil source due to continuous cultivation for a very long time without the addition of micronutrient fertilizer resulting in emerging micronutrient deficiency. Crops grown in most soils in India suffer from deficiencies of one or more micronutrients, even though the soils often contain adequate total amounts of the respective elements.

There is increasing interest from the agricultural community in micronutrient fertilization for a variety of reasons including: 1). Soil erosion and long-term cropping have resulted in the removal of micronutrients from soils; 2). Increasing crop yields generally leads to greater micronutrient removal rates in grain and other harvested products; and 3). The widespread replacement of micronutrient-rich manures with mineral fertilizers has reduced micronutrient addition from fertilizer sources.

Micronutrients and their nutrient status in India

India was dependent on external food supplies in the early 1960s. To meet the growing demand for food, fiber, and fuel, high-yielding cultivars were introduced. These high-yielding crop cultivars were highly responsive to fertilizers. Thus, slowly the soils were exhausted of their nutrients. The Green revolution has greatly increased food crop production in India, but continuous cultivation of high-yielding crop varieties has led to the depletion of native micronutrient soil fertility and now most of the soils are showing signs of fatigue for sustaining higher crop production to meet the increasing food demand of the country (Table 1). Among micronutrients, Zn deficiency was found widespread in Indian soils [23].

With the intensive cropping of high-yielding varieties of rice and wheat, deficiency of zinc (Zn) initially, and subsequently deficiencies of iron (Fe) in rice, and manganese (Mn) in wheat, emerged as threats to sustaining high levels of food crop production. Micronutrient deficiencies are now frequently observed in intensively grown cereals, oilseeds, pulses, and vegetable crops .

Micronutrient deficiencies are rampant in the country and on average respectively, the deficiency of two elements, particularly Zn+B in acid soils and Zn+Fe in semi-arid soils is coming up in many cropping systems as an alarm for the future. The seeds grown on micronutrients deficient soils contain micronutrients 2 to 3 times lower than those grown on micronutrients adequate soils [28]

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for germination for 24hrs, 48hrs, 72hrs, and 96hrs. Then the germinated grains were roasted, ground and sieved to fine flour. The flour obtained from 24hrs, 48hrs, 72hrs, and 96hrs germination was coded as Proso Millet Flour (PMF)-1, PMF-2, PMF-3, and PMF-4, respectively while unprocessed proso millet flour was taken as control (C). A schematic diagram of the preparation of proso millet flour is shown in Figure 1.

Table 1. Extend of micronutrient deficiencies in India

S.No.	Name of the micronutrient are deficient	Area deficient (%)	Reference
1.	Zinc , iron, copper, manganese	48.1, 11.2, 7, 5.1	[9]
2.	Zinc, Iron, Copper, Manganese and Boron,	43.0, 12.1, 5.4, 5.6 and 18.3	[28]
3.	Zinc, Boron,, Iron , Molybdenum, copper and Manganese	44, 33, 15, 13, 8 and 6	[26]
4.	Zinc, Iron, Manganese and Copper	67.0, 10.2, 1.80, 0.57	[27]
5.	Zinc, Iron, Manganese, Copper and Boron	36.5, 12.8, 7.1, 4.2 and 23.2	[29]

There were variable and widespread deficiencies of S and micronutrients in different states of India. The deficiencies of S, Zn, and B were higher compared to the deficiencies of Fe, Cu and Mn. There were occurrences of two-nutrient (S + Zn, Zn + B, S + B, Zn + Fe Zn + Mn, S + Fe, Zn + Cu and Fe + B), three-nutrient (S + Zn + B, S + Zn + B and Zn + Fe + B) and four-nutrient (Zn + Fe + Cu + Mn and Zn + Fe + Cu + Mn + B) deficiencies in different extents in agricultural soils of India [31].

Micronutrient sources and factors affecting their availability

Soil micronutrients are capital for the delivery of ecosystem functioning and food provision worldwide [19]. The importance of micronutrients can be realized from their incredible functions in plants that result in quality products, as each essential micronutrients play some specific function in plants. The availability of micronutrients to plants is regulated by various factors (Figure 1 and Table 2).

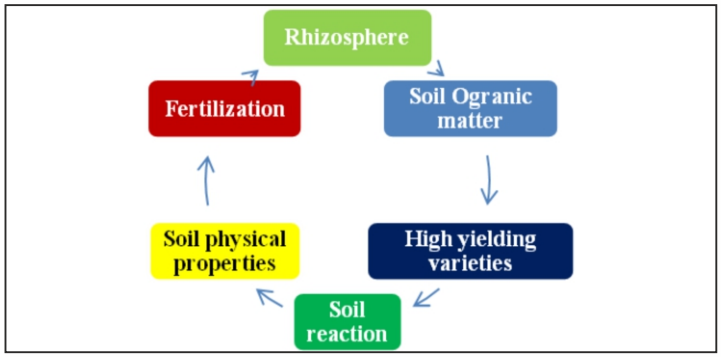


Figure1 .Factors related to availability of micronutrients

Table 2. Reason for micronutrients deficiency in soil

S.No.	Reason	Reference
1.	Soil Texture, soil reaction, organic matter, clay content, soil moisture, nutrient interactions in soil, microbial activity, redox potential and aeration, etc.	[16]
2.	Use of high yield potential and high nutrient requirements crops	[34]
3.	Introduction of HYVs, micronutrient-free high analysing fertiliser, non-addition of organic manures, imbalanced fertilisation, etc	[23]
4.	High-yielding and heavy micronutrient removal	[3]
5.	Exploitive nature of modern agriculture involving use of organic manures and less recycling of crop residues	[38]

The function of Micro nutrients in Plants

All micronutrients are important to complete the life cycle of plant and every nutrients play a specific role in all crops (Table 3). Concentrations of eight micronutrients viz., iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), boron (B), chloride (Cl), molybdenum (Mo), and nickel (Ni) are required very small for crop growth [21].

Table 3. The function of micronutrients in plant

S.No.	Nutrient	Function in plant	References
1.	Boron	growth, development and in several other physiological processes such as Nitrogen metabolism, protein formation, cell division and cell wall formation	[1]
2.	Iron	structural component of porphyrin molecules; cytochromes, hemes, hematin, ferrichrome, and leghemoglobin	[20]
3.	Zinc	essential element in a number of enzymes i.e., dehydrogenase, aldolase, isomerases, proteinase, peptidase and phosphohydrolase	[20]
4.	Copper	Both photosynthesis (reduction of CO_2 to carbohydrates) and respiration (oxidation of carbohydrates to CO_2) involve the transfer of electrons	[21]
5.	Copper	lignin formation in cell walls, carbohydrate and lipid metabolism in plant tissues	[21]
6.	Manganese	electron transfer in photosynthesis	[21]
7.	Chloride	important in the functioning of Manganese in photosynthetic production of carbohydrates from CO_2 and the evolution of O_2	[21]
8.	Molypdenum	component of nitrate (NO_3) reductase, an enzyme concentrated in chloroplasts, which catalyzes the conversion of NO_3 to nitrite (NO_2)	

Impact of nutrient deficiency on Crop growth and yield loss

The yield- losses due to individual micronutrients varied from 10.6-16.3 % during 1993, 14.2-26 % in 1994, and 8.4-18.9 % during 1995. The yield losses caused by the deficiencies of Fe, Mn, Zn, Cu, B, and Mo were to the tune of 9.6-22.2, 8.4-16.7, 13.3-20, 11.9-14.2, 14.5-26, and 13.8-18.9%, respectively. In calcareous soil, micronutrient deficiencies in the form of chlorosis are of a regular occurrence in groundnut which, unless corrected by external application of micronutrients results in a significant loss of crop yield [35]. The Fe, Mn and Zn deficiencies are well known in calcareous soil causing 15.9-32.5 % yield reduction [32].

There is a reduction of yield in lentils due to the deficiency of micronutrients in poor sandy soils. Lentil plants showed loss of P, K, protein, Fe, Mn, and Zn in content in seeds due to lack of any one of these elements, which caused a severe reduction in the uptake of P, K, protein, Fe, Mn and Zn. This shows the importance of macro and micronutrients for the cultivation of lentil plants in sandy soil deficiencies of Fe, Mn, and Zn[41].

Chelated Micronutrients

Micronutrient deficiencies are major constraints in crop production in the present-day agricultural program. Micronutrient fertilizers are gaining importance day by day and will play a major role in bringing stability and sustainability in the production of food grains, pulses, and oilseeds in the coming decade. The three main classes of micronutrient sources are inorganic, synthetic chelates, and organic complexes. Inorganic sources such as sulfates of Cu, Mn, Fe, and Zn are the most common metallic salts used in the fertilizer industry because of their ready plant availability and water solubility. In the past 35-40 years, it has been recognized that compounds containing chelated metals could supply many of the micronutrient requirements of plants. These chelates find use in a wide variety of agricultural crops. Applications for chelates vary from fertilizer additives, and seed dressing to foliar sprays and hydroponics [25].

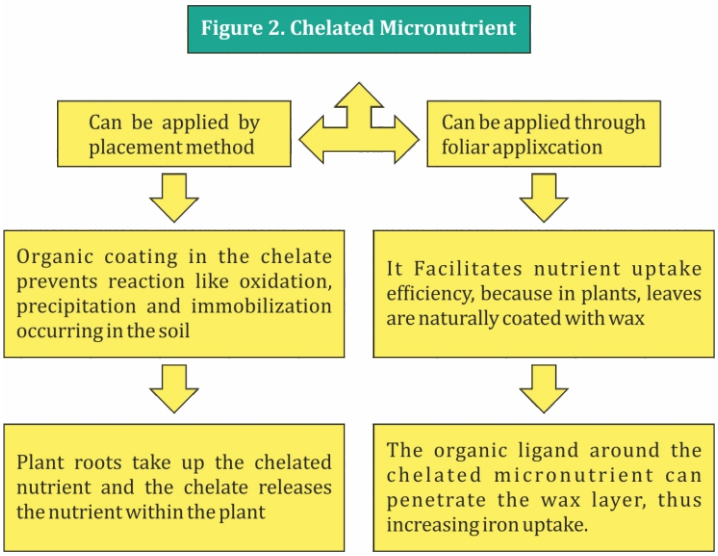
The amino chelates represent a safer and more efficient form of fertilizer, resulting in better plant performance and fewer environmental risks. Aminochelates represent effective fertilizers for both soil and particularly for foliar applications [36]. Micronutrient deficiencies are major constraints in crop production in present-day agricultural program which could be overcome by chelated fertilizers. In the past 35-40 years, it has

been recognized that compounds containing chelated metals could supply many of the micronutrient requirements of plants [25].

Chelated fertilizers have been developed to increase micronutrient utilization efficiency. The chelated fertilizer improves the bioavailability of micronutrients such as Fe, Cu, Mn, and Zn, and in turn, contributes to the productivity and profitability of commercial crop production. Chelated fertilizers have a greater potential to increase commercial yield than regular micronutrients [17].

Application of chelated micronutrients

The concept of chelated-nutrient application will help the farmers not only ascertain the soil quality but also to improve the nutrient use efficiency of micronutrients. The chelated micronutrients are less reactive to soil, by which the bioavailability and plant uptakes are increasing. The application of micronutrient fertilizers mixing with chelates improves the use efficiency, especially in soils with a pH of more than 6.5. Our Indian farmers are using micronutrient fertilizers, as our soils are deficient in micronutrients. If, the farmers apply micronutrients with chelates, it will reduce the input cost as well as increase the yield [12].

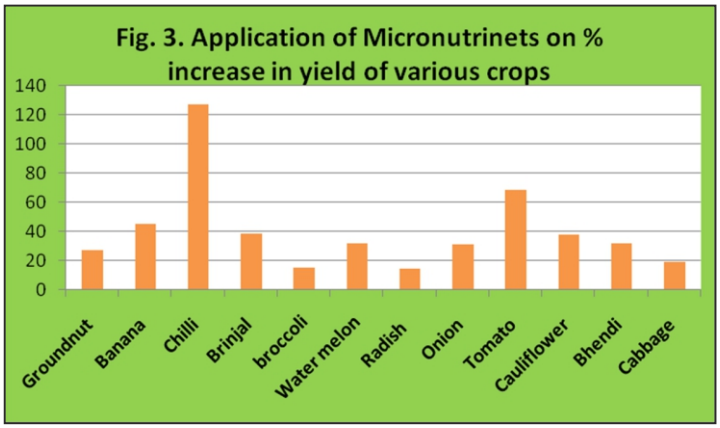


Yield Increase due to Micronutrient application

Micronutrients has a dynamic role to play in agricultural production in order to increase all attribute characters to better meet the requirements of food supply in general as an additional supplementation for nutrients. Micronutrients have been found to show more satisfactory results in yield (Table 4) than control and have immense potential in increasing yield attributes in many crops [39].

Table 4. Yield improvement in various crops due to micronutrients application

S.No.	Crop	% increase in yield	Reference	S.No.	Crop	% increase in yield	Reference
1.	Wheat	25.0	[5] [40]	10.	Brinjal	38.9	[22]
2.	sorghum	25.3	[6]	11.	broccoli	15.2	[31]
3.	Green gram	49.3	[13]	12.	Water melon	31.7	[10]
4.	Maize	35.5	[37]	13.	Radish	14.9	[18]
5.	Potato	51.0	[35]	14.	Onion	31.2	[24]
6.	Paddy	36.0	[11]	15.	Tomato	68.8	[7]
7.	Groundnut	27.4	[33]	16.	Cauliflower	38.0	[2]
8.	Banana	45.23	[15]	17.	Bhendi	31.8	[8]
9.	Chilli	127.0	[4]	18.	Cabbage	19.2	[14]



Future scope of the study

There are eight recognized essential plant micronutrients are essential for humans and livestock. To mitigate the malnurinets problems in human and animals following studied to be carried out.

- Field level research for all types of crops needs to be studied.
- Research is needed on efficient utilization and transportation of micronutrients into the grain.
- Research on crop/ area specific chelated micronutrient mixtures are needed for increasing agricultural productivity.
- Micronurinets deficiency and their interactions with other nutrients need to be studied well.
- Micronurinet use efficiency in all types of soil should be studied.
- Different methods of chelated micronutrients application should be studied well.

Conclusion

It is the right time to make them aware of the technologies for the application of micronutrients, which not only helps in alleviating micronutrients deficiency, but also provides economic gain to the farmers. Micronutrients play a dynamic role in agriculture production to achieve our target and also to meet our food security. It can be concluded from this review of the literature point of view that, micro nutrition in crops has been found beneficial for improving overall growth, yield and quality. The application of micro nutrient fertilizers represents a quick and useful solution to the biofortification of produce that can be easily practiced in the country. There is an urgent need for the adoption of a new fertilizer policy to encourage and promote the production and application of chelated micronutrient fertilizers in India to improve public health, while contributing to crop production.

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Conflict of interest: Nil

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