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Deficiencies of Micronutrients in Indian Soils: New Challenges & Remedies

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INTRODUCTION

Indian agriculture has achieved enormous growth in productivity over various decades with the introduction of high yield cultivars, intensive crop practices, and the subsequent use of chemical fertilizers. However, such intensified practices have caused severe deficiencies of soil micronutrients, which were earlier recognized as spot instances but are increasingly becoming widespread in the country. Soil micronutrients like Zinc (Zn), Iron (Fe), Boron (B), Manganese (Mn), Copper (Cu), and Molybdenum (Mo) are involved in enzymatic reactions, photosynthesis, hormone regulation, and seed development in plants. Deficiencies of such micronutrients hamper various plant processes, causing reduced crop productivity and poor produce quality. Remedy of such deficiencies is therefore critical for sustainable agricultural growth, nutritional security, and healthy soil of Indian agricultural ecosystems.

(Source, Dhaliwal, et al., 2022)

2.2 Importance of Micronutrients for Plant Growth

Micronutrients contribute to important biochemical and physiological reactions in plants. Zinc is a major activator of enzymes, synthesizer of proteins, and hormone secretion, while iron is important for the production of chlorophyll and the transport of electrons in photosynthesis. Boron is important for cell development, the development of pollen, and the transport of sugars, while manganese and copper are involved in redox reactions and photosynthesis. Molybdenum is important in nitrogen metabolism, especially in legumes. A shortage of these elements, no matter how small, interferes with metabolism, with observable results.

3. Status of Micronutrient Deficiencies in Indian Soils

Deficiencies of micronutrients are increasingly being observed in various types of soils in India. Zinc deficiency is the widely observed one, which is found in almost half of the cultivated soils, especially in the densely cropped areas like the Indo-Gangetic Plains. Iron is mostly found to be deficient in calcareous, alkaline, and well-drained soils, especially in arid to semi-arid areas. Boron is found deficient in light-textured soils, acidic soils, and areas of high rainfall. Manganese and copper deficiencies were less frequent, but with intensive decomposition of organic matter or over-lime application, their deficiencies are on the rise. Molybdenum is found mostly in the acidic soils, and it affects nitrogen fixation in legumes.

4. Causes of Micronutrient Deficiencies in Indian Soils

There are various natural as well as human factors that contribute to the rising number of micronutrient deficiencies.

4.1.1 Background of the Topic

Modern high-yielding crop varieties tend to require more nutrients. These cultivars absorb large quantities of micronutrient elements from the soil. When cropping is consistently carried out without adequate replenishment, there is a consequent loss of micronutrient elements in the soil.

4.2 Imbalanced Fertilizer

Nitrogen, phosphorus, and potassium fertilizers are used indiscriminately on a mass scale without using micronutrient fertilizers. This results in an imbalance of nutrients. Additionally, high use of phosphorus causes a deficiency of zinc in the soil, as it decreases the availability of zinc.

4.3 Decrease of Soil Organic Matter

Soil organic matter is important for the chelation of micronutrient elements. Loss of crop residues, reduced use of organic manures, and intensive tillage have decreased the levels of soil organic carbon, thereby reducing the availability of micronutrient elements.

4.4 Soil pH Reaction

Soil reaction helps determine the solubility of micronutrients. In alkaline or calcareous soils, the availability of zinc, iron, manganese, and copper is low, whereas deficiencies of boron or molybdenum occur in the acidic soils.

4.5 Irrigation and Water Quality

Poor-quality water used for irrigation, especially high bicarbonate levels, contributes to high soil alkalinity. Drainage is also another area that affects micronutrient levels. This is attributed to waterlogging.

5. Crop-Specific Deficiencies of Micronutrients

Deficiencies of micronutrients present visible signs that are crop-specific. A deficiency of zinc leads to reduced growth, interveinal chlorosis, and tillering in cereals like rice and wheat. A deficiency of iron causes yellowing of young leaves owing to inhibition of chlorophyll development, which is often noticed in groundnut, soybean, and citrus. A deficiency of boron causes poor flowering, fruit breakage, hollow stem in vegetables, and poor setting of seeds. A deficiency of manganese causes interveinal chlorosis along with brown spots on the leaves, whereas a deficiency of copper causes poor lignification, drooping, or dying of branches and stems. A deficiency of molybdenum affects nitrogen metabolism, causing poor nodulation along with poor growth in legumes.

6. Effects of Deficiencies of Micronutrients on Crop Productivity and Quality

Nutrient deficiencies impair crop yield, productivity, and resistance levels to pests and

diseases. Loss of yield caused by the inability to get adequate zinc is between 20% and 50% for cereals alone. Nutrient deficiencies can also impair protein yield, grain fill, fruit growth, and nutritional value of produce. Moreover, produce from crops that lack nutrients is responsible for suffering from hidden hunger among humans and livestock in India.

7. Emerging Challenges in the Management of Micronutrient Deficient

Some of the challenges involved in managing micronutrient deficiencies include the absence of information for farmers, the poor availability of facilities for testing the soil, limited access to good micronutrient fertilizers, and low promotion of integrated approaches for managing micronutrients. Stresses such as floods and droughts brought about by climate change influence the availability of micronutrients. Marginal farmers could face some economic constraints with regard to using micronutrient ingredients.

8. Strategies for Dealing with Micronutrient

8.1 Soil Testing and Diagnosis

It is important to test the soil regularly for identifying deficient micronutrient levels and preparing a plan accordingly. Schemes such as the Soil Health Card Scheme offer essential information to the farmers.

8.2 Balanced and Integrated Nutrient Management

Using micronutrients along with macronutrients and organic manures helps provide balanced nutrition. Integrated Nutrient Management (INM) helps in effective utilization of nutrients as well as improvement in soil health.

8.3 Use of Micronutrient

Application of zinc sulfate, ferrous sulfate, borax, manganese sulfate, or copper sulfate is beneficial for correcting deficiencies of respective elements. Soil or foliar application depends on the type of crop and soil.

8.4 Organic Amendments and Biofertilzer

Farmyard manure, compost, vermicompost, or green manures improve the availability of micronutrients by chelating or by promoting microbial growth. Biofertilizers like zinc-solubilizing bacteria also improve their uptake.

8.5 Crop Management Practices

Crop rotation, inclusion of legumes, reduced tillage, and retainage of residues can help sustain fertility levels and enhance micropnutrient contents. Application of lime in acidic soils and gypsum in sodic soils can improve micropnutrient availability.

8.6 Biofortification and Improved Vari

Researching or developing more micronutrient-efficient or biofortified crop species could provide enhanced utilization efficiency along with better nutritional qualities.

9. Role of Policy and Extension Services

Policymaker support and extension services must be adequately addressed for effectively overcoming the issue of micronutrient deficiencies. Improving infrastructure for soil testing, subsidizing the use of micronutrient fertilizer, creating mass awareness campaigns, or incorporating the management of micronutrient fertilizer into National Soil Fertility Programs would help improve adoption rates among farm owners.

CONCLUSION

Deficiencies of micronutrients in Indian soils have appeared as a major threat to sustainable agriculture, crop productivity, and nutritional security. To meet this problem, it is important to adopt an integrated approach that takes into consideration soil testing for deficiencies of various micronutrients, balanced fertilization practices, application of organic fertilizers, development of crop varieties, and creating mass awareness about the issue. By using scientifically proven approaches of micronutrient application, India can improve the fertility of its soil, crop productivity, and sustainability of agriculture.

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