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Soil Micronutrients: An Introduction

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Micronutrients are the essential nutrients that are required in very less quantities for the growth of plant and microorganisms. Micronutrients are also called as 'trace elements',' oligo elements' or 'spur elements'. There are 17 essential nutrients for plant growth out of these nutrients 8 are considered as micronutrients. These are – iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), molybdenum (Mo), nickel (Ni) and chlorine (Cl). Amongst these eight micronutrients, the content of iron in soil as well as in plants is the highest and sometimes is higher than even P and S contents. Another element, namely cobalt (Co) is also regarded to be essential for the growth of certain higher plants, animals and microorganism and is likely to be added to the list of these eight elements, as it is also required in small quantity. Of the eight nutrients identified so far, Fe, Mn, Zn, Cu and Ni behave like cations and B, Mo and Cl like anions in soil. Thus, the chemistry of micronutrient cations is different from that of micronutrients anions.

(A) Iron

Iron is taken up as ferrous (Fe^{2+}) by plants. Its concentration in the range of 100-500 mg/kg in mature leaf tissues is regarded sufficient for optimum crop production. Iron is a transition metal, exhibits two oxidation states- Fe (II) and Fe (III) – in plants and forms complexes with organic ligands.

Functions: The functions of iron are:

a) Iron is a constituent of two groups of proteins, viz. (a) Heme proteins containing Fe porphyrin complex as a prosthetic group, and (b) Fe-S proteins in which Fe is coordinated to the third group of cysteine.

b) It plays an essential role in the nucleic acid metabolism.

c) It activates a number of enzymes, included aminolevoliaic acid synthetase.

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Deficiency symptoms: Plants having less than 50 ppm of Fe are usually classified as iron deficient. Deficiency of iron results in interveinal chlorosis appearing first on the younger leaves with leaf margins and veins remaining green. Under condition of severe Fe deficiency, growth cessation occurs with the whole plant turning necrotic.

(B) Manganese

Manganese is absorbed by the plants as manganous ions (Mn^{2+}). Healthy Mn-sufficient mature plants contain 20 to 300 ppm of Mn. Manganese, a transition metal, is present in plants in Mn (II) form but is easily oxidizable to Mn (III) and Mn (IV) forms. Because ot its variable redox status, Mn plays an important role in photosynthesis.

Functions: The functions of manganese are:

a) Manganese is an integral component of the water-splitting enzyme associated with photosystem II.
b) It has a role in tricarboxylic acid in oxidative and non-oxidative decarboxylation reaction.
c) It is a constituent of superoxide dismutase.

Deficiency symptoms: Manganese deficient plants contain less than 25 ppm Mn. Deficiency symptoms of Mn are more severe on middle leaves than on younger ones. Interveinal chlorosis is characterized by the appearance of chlorotic and necrotic spot in the interveinal areas. Chlorotic leaf areas soon become necrotic and turn red, reddish-brown or brown.

(C) Zinc

Plants absorb Zn as zinc ions (Zn^{2+}). Zinc sufficient plants contain 27 to 150 ppm Zn in mature tissues. Since it does not have variable valency, it has no role in influencing redox processes directly.

Functions: The functions of zinc are:

a) Zinc is a constituent of three enzymes i.e., Carbonic anhydrase, Alcoholic dehydrogenase and Superoxide dismutase.
b) Zinc is involved in synthesis of IAA, metabolism of GA and synthesis of RNA.
c) Zinc plays an important role in translocation and transport of P in plants.

Deficiency symptoms: Plants containing less than 15 ppm Zn are regarded deficient in Zn. Common deficiency symptoms of Zn are interveinal chlorosis, reduction in the size of young leaves, bronzing, and purple, violet reddish brown coloration of the foliage. Shorter internode and decrease in leaf expansion in case of dicots.

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(D) Copper

Like other micronutrients cations, copper is absorbed by plant roots as cupric ions (Cu^{2+}). The concentration of the Cu in Cu-sufficient plants varies from 5 to 30 ppm and its toxicity occurs when Cu concentration is between 20 to 100 ppm. Copper is a transition element existing in the plants as a component of a large number of protein and enzymes.

Functions: The functions of copper are:

a) Copper is a constituent of a large number of enzymes.
b) Copper is important in imparting disease resistance to the plants.
c) It enhances the fertility of male flowers.

Deficiency symptoms: Plants having less than 5 ppm Cu are regarded as Cu-deficient. Male flower sterility, delayed flowering and senescence are the most important effects of Cu deficiency. Chlorosis of the younger shoot tissues, white tip, reclamation diseases, necrosis and die-back are the characteristic Cu deficiency symptoms.

(E) Molybdenum

Molybdenum is the only heavy transition metal taken up by the plants as molybdate ions (MoO_4^{2-}). A healthy Mo-sufficient plant contains 0.1 to 2 ppm of Mo. In the plant system under oxidative environment, it exists as Mo(VI) and Mo(V) and Mo(IV) forms. Ability of Mo to exist in variable valence states imparts it a biochemical role.

Functions: The functions of molybdenum are:

a) Molybdenum is a component of nitrate reductase, nitrogenase, dehydrogenase and sulphate oxidase.
b) Biological nitrogen fixation is catalysed by Mo-containing enzymes, nitrogenase which directly transfer electron to N.
c) It is involved in protein biosynthesis through its effects on ribonuclease activity.

Deficiency symptoms: The critical concentration of Mo-deficiency in plants is usually less than 0.1 ppm. Molybdenum deficiencies resemble the N-deficiencies. In plants with reticulate venation, the earlier effects of Mo-deficiency appear as chlorotic mottling between the veins on old or middle leaves all over the surface. Molybdenum deficiency in cauliflower is termed as whip-tail.

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(F) Boron

Boron is absorbed by the plants mainly as boric acid (H_3BO_3). Normal boron sufficient plants have B-contents ranging from 10 to 200 ppm. Boron is neither a constituent of enzymes nor it activates any of the enzymes. Most important property of boron is to form stable complexes with organic compounds with cis-diol configuration.

Functions: The functions of boron are:

a) It is responsible for cell wall formation and stabilization and lignification.

b) It imparts drought tolerance to crops.

c) It plays a role in pollen germination and pollen tube formation.

d) It facilitates transport of K in guard cells as well as stomatal opening.

Deficiency symptoms: Plants having B-concentrations of the order 5 to 30 ppm are suspected to be B-deficient. Boron deficiency symptoms become conspicuous on the terminal buds or youngest leaves, which become discoloured and may die under acute conditions of B deficiency. Internodes become shorter and give a bushy or rosette appearance.

(G) Nickel

Nickel is absorbed by plants as nickel ions (Ni^{2+}). Its concentration in Ni-sufficient plants varies from 0.1 to 10 ppm. It exits in Ni(II) state but can also assume Ni(I) and Ni(III) states.

Functions: The functions of nickel are:

a) Nickel is associated with nitrogen metabolism by way of influencing urease activity.

b) In free-living *Rhizobia*, adequate Ni-supply ensures optimum hydrogenase activity.

c) It facilitates transport of nutrients to the seeds or grains.

Deficiency symptoms: Critical level of Ni deficiency is 0.1 ppm, as concentrations below this are accompanied by reduction in dry-matter weight, decrease in amino acid content and accumulation of nitrates. Characteristics deficiency symptoms of Ni have not been defined adequately.

(H) Chlorine

Chlorine is ubiquitous in nature. It is absorbed as chloride ions (Cl^-) by the plants. Normal healthy plants have Cl-content ranging from 100 to 500 ppm. It has been neglected because it

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is present in abundance and is also supplemented through a large number of fertilizer carriers like MOP. etc. and its deficiencies have not been reported from any-where in India.

Functions: The various functions of chlorine are:

a) It plays a major role in osmoregulation and charge compensation in higher plants.
b) It acts as a cofactor in Mn-containing water splitting enzyme of photosystem II.
c) Chlorine supply improves the nutritional quality of vegetables by preferentially lowering the NO_3-N concentration in tissues.

Deficiency symptoms: Plants having less than 100 ppm Cl are usually designated as deficient. Deficiency symptoms of chlorine are similar to that of Mn-deficiency.