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Physiological Roles of Micronutrient in Various Cereal Crops

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INTRODUCTION

Micronutrients: Micronutrients are those elements required by plant in very small (micro) quantities but are essential for its growth. Sometimes these elements are also referred to as minor or trace elements, but American Society of Agronomy and the Soil Science Society of America encourages the use of term micronutrient. The micronutrients include boron (B), copper (Cu), iron (Fe), chlorine (Cl), manganese (Mn), molybdenum (Mo) and zinc (Zn). The recycling of organic matter like grass clips and leaves of trees is an excellent way to supply the growing plants with micronutrients (and also, macronutrients). Physiological roles and deficiency symptoms of these elements in plants as follows

Iron (Fe)

Physiological role in plants: Iron is an important component in many plant enzyme systems, such as cytochrome oxidase (electron transport) and cytochrome (terminal respiration step). Iron is a component of protein ferredoxin and is required for nitrate (NO_3) and sulfate (SO_4) reduction, nitrogen (N_2) assimilation, and energy (NADP) production. It functions as a catalyst or part of a chlorophyll formation-related enzyme mechanism.

Symptoms

Wheat: In general, plants grown at less than 2.0 ppm iron in the nutrient medium develop visual symptoms of iron deficiency. The most conspicuous effect of the deficiency is the chlorosis of the young leaves. About this stage, the iron deficient plants develop interveinal chlorosis or chlorotic stippling on the young leaves. If the deficiency is acute and persists, chlorosis may extend to the entire lamina and systematically spread from the young leaves to the old and eventually the entire foliage may turn severely chlorotic. The apices of the chlorotic leaves may also turn necrotic and wither. Since iron deficiency causes a reduction in tillering and heading of plants, the iron deficient plants may show severe reduction in grain yield.

Sorghum: When plants supplied 1/10th (0.50 ppm) of normal supplied then chlorosis develop after the emergence of the second leaf with 10 to 15 days of sowing of seeds. Chlorosis initials at the base of the leaf and spreads towards its apex. This is often accompanied by necrotic areas along the margins in the middle of the leaf. The third and the subsequent leaves emerge severely chlorotic. When deficiency is severe, the apex of the chlorotic leaves turn necrotic, papery and withers. The chlorotic leaves may also exude dark viscous fluid during night. Internodes become short.

Manganese (Mn)

Physiological role in plants: Manganese is involved in the oxidation-reduction processes in the photosynthetic electron transport system. It is essential in the photo system II for photolysis, acts as a bridge for ATP and enzyme complex phosphor kinase and phospho transferases, and activates IAA oxidases.

Symptoms

Wheat: Within 4 to 5 weeks the plants develop visual symptoms. The foliage of such becomes severely restricted and the middle leaves develop intervenal chlorotic strips in the middle region. The chlorotic tissue later develops white or buff colored necrotic streaks. These enlarge and coalesce resulting in long irregular necrotic bands, which spread towards the apex and the base of the leaves and later from middle to the young leaves. If deficiency persists, the young leaves emerging after 6 to 7 weeks growth appear chlorotic. Symptoms of manganese deficiency are very conspicuous on the flag leaf. These leaves which are pale-green in appearance exhibit grayish –brown lesions in the middle and rolling of leaf margins near the apex.

Rice: The chlorotic tissue later develops reddish brown necrotic spots which are more conspicuous on the under surface of the leaves. In case of severe deficiency, the intervenal areas of the leave show dark reddish-brown necrotic symptom interspersed with almost bleaching papery areas. The leaves show withering and drying of tips and margins.

Sorghum (Mn at low 0.015 ppm or less): Foliage appears pale green, the middle leaves show marginal yellow and interveinal chlorotic stripes. Later, the chlorotic areas in the middle of the leaves develop reddish-brown necrotic lesions. The necrotic lesions gradually spread longitudinally towards the apex and the base of the leaves and on coalescing form long necrotic stripes that lead to shrinkage of lamina. The symptoms gradually spread from the middle to the younger leaves. The young leaves exhibit severe chlorotic stripping.

Maize: The middle leaves develop interveinal chlorosis. On individual leaves, chlorosis generally spreads from the middle or the basal part to the apex. Severe deficiency leads to discoloration and drying and the entire lamina shows severe chlorosis; the midrib and the area close to the basal part of the chlorotic leaves often turn dark brown and necrotic. Leaves exhibit wavy margins or rolling of the leaf margins due to loss of turgor. Younger leaves of Mn deficient plant may turn severely chlorotic and fail to unroll.

Zinc (Zn)

Physiological role in plants: Zinc is involved in the same enzymatic functions as are manganese (Mn) and magnesium (Mg) with only carbonic anhydrase being activated by Zn.

Symptoms

Wheat: The first effects of zinc deficiency appear in the form of fading of the middle or the lower half of the lamina of the sub-terminal leaves. Generally, the effects appear first on the leaf next to the youngest. Soon afterwards, within 3 to 5 days from the commencement of the fading of the lamina, the affected leaves develop minute reddish-brown spots which tend to coalesce forming reddish-brown lesions. These lesions later turn light brown and limp. The leaf sheaths may also develop light brown or a reddish-brown pigmentation. The leaves affected thus appear withered. As the symptoms intensify on the middle leaves they spread to the younger ones. In general, the visual symptoms of zinc deficiency become marked at the early tillering stage.

Sorghum: 3 weeks old plants usually mild intervenal chlorosis and fading of the basal part of the lamina. Later these develop light reddish-brown or purpose pigmentation. Further deficiency elongation of internodes and expansion of foliage.

Rice: At tillering (3 to 4 weeks old seedling), development of reddish-brown pigmentation in the central part of the middle leaves. The pigmentation intensifies and spreads almost all over the lamina and also on leaf sheaths. Severely pigmented leaves turn necrotic and papery and the leaf tips wither. Rolling or curling of lamina, yellowing or discoloration of young leaves, bronzing.

Maize: Severe discoloration (withering) of the younger growths. "**White bud of maize".** Zinc exhibit fading of the basal part of the middle leaves at about 3 weeks growth. Fading spreads towards the leaf apex and the chlorotic part of the leaf generally becomes dry necrotic. Development of purple pigmentation on the leaves, leaf sheaths and even internodes. Entire plane becomes bronzed. A deep-tinted viscous fluid exudes from the leaf tips and edges of zinc-deficient plants.

Copper (Cu)

Physiological role in plants: Copper is an essential component of plastocyanin, the chloroplast protein. Cu also serves an important part in the electron transport system linking photo system I and II during the photosynthetic process. Protein and carbohydrate metabolism and nitrogen (N_2) fixation are aided by the participation from this element. It is a part of the enzymes that reduce both atoms of molecular oxygen (O_2) (cytochrome oxidase, ascorbic acid oxidase, and polyphenol oxidase).

Symptoms

Wheat: Generally, the deficiency symptoms develop considerably early, much before the deficient plants show depression in growth. The first effects of copper deficiency often appear at the time of initiation of tillering, at about four week's growth, when plants have 4 to 5 leaves. At this stage the tips of the young leaves become severely discolored or bleached. Bleaching later spreads along the leaf margins towards the base of the leaves.

Rice: Rice is fairly to copper deficiency. However, rice plants raised at <0.001 ppm Cu supply showed chlorosis leaves later showed withering of tips. Leaves failed to unroll.

Sorghum: Resistant to Cu deficiency.

Maize: Not very susceptible, at very low supply (<0.001 ppm) shows fading of lamina and failure of young leaves to expand distortion and necrosis of apical growth expansion.

Boron (B)

Physiological role in plants: Boron is believed to be important in the synthesis of one of the bases for RNA (uracil) formation and in cellular activities including division, differentiation, maturation, growth and also respiration, etc. Pollen germination and development along with improving stability of pollen tubes have long been correlated with Boron. Relatively immobile in plants, Boron is mainly transported in the xylem.

Symptoms

Wheat: Boron deficiency leads to the formation of minute chlorotic specks on the older leaves. In case of severe deficiency, such effects may develop in 2 to 3 weeks old plants. The chlorotic specks later develop orange tints, enlarge and coalesce to form large, irregular, bright orange (or yellow) colored areas in the middle of the leaves. These symptoms gradually become severe by the time the tillers develop inflorescence. At this stage, the middle leaves appear stiff and upright

Sorghum: Small white irregular spots in the interveinal areas of the young leaves. These areas gradually elongate and merge into each other form (3 to 10 cm) long white bands. These bonds appear somewhat waxy and raised. Continuous deficiency for a longer period entire lamina turns white and necrotic. Disintegration or breaking of the lamina along the leaf margins. Young leaves fail to unroll; turn necrotic and tips remain entangled in the subtending leaf.

Rice: Plants develop small white necrotic streaks on the youngest unfolded leaf and the one next to it. The streaks later intensify and coalesce to form large white irregular patches. The young emerging leaves generally fail to unroll and remained partially enclosed within subtending leaf.

Maize: very susceptible to boron deficiency, maize is an indicator plant of boron deficiency. At low (<0.01 ppm) boron supply, young leaves develop white irregular areas which gradually spread interveinally and coalesce to form large irregular lesions along which the lamina may split longitudinally. The affected leaves exude some soluble salts. Growth stunted become of very short internodes.

Chlorine (Cl)

Physiological role in plants: Chlorine is involved in the evolution of oxygen (O_2) in photo system II in the photosynthetic process. Chlorine increases the cell osmotic pressure, stimulates stomatal regulation, and also raises plant tissue hydration. Chlorine may be related to the suppression of leaf spot disease in wheat and fungus root disease in oat.

Molybdenum (Mo)

Physiological role in plants: Molybdenum is a component of two major enzyme systems, nitrogenase and nitrate reductase. Nitrogenase is involved in the conversion of nitrate (NO_3) to the ammonium (NH_4). So, if the primary Nitrogen form available to plants is NH_4 the requirement for Mo is reduced considerably.

Symptoms

Wheat: Visual effects of molybdenum deficiency appear first at about 6 week's growth, before the deficient plants show any perceptible growth depression. At this stage, the old leaves of molybdenum deficient plants develop golden yellow coloration along the apex and the apical leaf margins. The coloration gradually intensifies and spreads to cover the middle and young. The severely affected leaf tips turn dry, necrotic and wither.

Maize: <0.001 ppm of Mo after 7 weeks of growth could develop symptoms. Internodes short, leaves appeared chlorotic and more in young leaves. Young leaves appeared overlapped and emerging leaves showed dissected margins.

CONCLUSION

Nutrient deficiencies and toxicities are critical to crop health and can topple productivity to a great extent; they may also result in the appearance of unusual visual symptoms. Understanding the role and mobility of each essential micronutrient in the plant can be helpful in determining the deficient nutrient and the nutrient responsible for toxic symptom. Overall deficiency symptoms usually involve retarded growth, chlorosis, interveinal chlorosis, necrosis and purple or red discoloration. First of all, deficiencies of mobile nutrients appear in older, lower leaves, while the deficiencies of immobile nutrients appear first in younger, upper leaves. Nutrient toxicity is most often the result of over-application, with symptoms including chlorosis, leaf discoloration and necrotic spotting. When in excess, many nutrients will inhibit the uptake of other nutrients, thus potentially causing deficiency symptoms to occur as well. Timely foliar spray of respective nutrient is better for managing the crop loss due to deficiency of particular nutrient in plant system.

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