

Management of

micro-nutrient deficiency and toxicity in rice

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Among the various nutritional disorders, micro-nutrient stresses (deficiency/toxicity) are the most common and widespread in all the rice-growing areas. Although micro-nutrients are taken in small quantities, they play a major role in various plant physiological and biochemical processes. Micro-nutrients used in rice did not receive adequate attention in the farmer's field, albeit the use of macro-nutrient is increasing over the year. Creating adequate awareness of micro-nutrient nutrition in rice and its disorders identification is highly important for long-term sustainable rice production. Thus, in this article, emphasis is given on identification and needed intervention to correct the various micro-nutrient deficiency/toxicity symptoms in rice.

Keywords: Correction measures, Deficiency, Micro-nutrients, Rice, Toxicity

AN essential nutrient is one required to complete the life cycle of the plant and its relative deficiency produces specific deficiency symptoms. These elements are directly involved in the nutrition and metabolism of plants. For optimum growth and development along with high yield, the micro-nutrient levels in the plant should be maintained at the sufficient level. If any micro-nutrient level reaches below the sufficiency level leads to the appearance of deficiency symptoms in the plants. Similarly, if the level exceeds the sufficiency level, it produces toxicity symptoms. The visual symptom may be caused by more than one nutrient. For example, Nitrogen (N) and Sulphur (S) deficiency symptoms are identical (chlorosis). The deficiency of one nutrient may be induced by the addition of an excessive quantity of another nutrient. For example, Manganese (Mn) deficiency may be induced by the addition of large quantities of Iron (Fe). Similarly, it is difficult to distinguish deficiency symptoms in the field, as disease or insect damage can resemble certain

micro-nutrient deficiencies. Thus, intelligence is needed for identifying the nutritional deficiency symptoms which comes with field experience.

Micro-nutrient deficiency in rice Iron (Fe)

Fe deficiency affects photosynthesis and leads to reduced yield and dry matter production. It is commonly noticed in upland direct-seeded rice and aerobic rice. Its deficiency occurs in neutral,

calcareous and alkaline upland soils and in soils with low organic matter status. Lowland soils, irrigated with alkaline irrigation water also show Fe deficiency.

Symptoms: Inter-veinal yellowing and chlorosis of emerging leaves. Entire plant becomes chlorotic and dies if deficiency is very severe. Decreased dry matter production is also seen.

Management: Applying organic matter (e.g. crop residues, manure),



Iron deficiency in rice (Source: Rice knowledge bank)



Manganese deficiency in rice (Source: Rice knowledge bank)

using acidifying fertilizers (e.g. ammonium sulfate instead of urea) on high pH soils and use of fertilizers containing Fe as a trace element helps in management of Fe deficiency in rice.

Manganese (Mn)

Its deficiency occurs in alkaline and sodic soils, with low organic matter, degraded soils containing a large amount of Fe and also in leached and acid sulphate soils. Excessive liming of acid soils also causes Mn deficiency in rice.

Symptoms: Pale greyish-green interveinal chlorosis spreads from the tip of the leaf to the base. Necrotic brown spots develop and the leaf becomes dark brown. Deficiency occurs in the newly developing leaves; leaves become short, narrow and light green. Stems are slender and weak. Distinct green veins and yellow chlorotic streaks of Mn deficiency differentiate it from Fe deficiency.

Management: Applying organic manures like Farmyard manure (FYM), compost or green manure and 25 kg MnSO_4 /ha as basal or spraying of 0.5% MnSO_4 can be useful for rapid management of Mn deficiency. Multiple applications may be required, starting at

tillering when sufficient foliage has developed.

Zinc (Zn)

Its deficiency occurs in calcareous soils with high organic matter content and in alkaline and sodic soils. Fields with exposed subsoil due to quarrying and leveling and those irrigated with water having higher HCO_3^- concentration also shows Zn deficiency. Rice fields irrigated with sewage water with higher PO_4^{3-} or with well water having calcium carbonate at high pH locations show occurrence of Zn deficiency.

Symptoms: Dusty brown spots on upper leaves, stunted plants, increased spikelet and decreased tillering is observed in Zn deficiency in rice. In case of severe deficiency, the entire leaf may give a rusty-brown appearance which is known as Khaira disease. Symptoms usually appear from 2–4 weeks after transplanting or sowing.

Management: Applying ZnSO_4 in nursery beds, dipping seedlings or pre-soaking seeds in a 2–4% ZnO suspension helps in management of Zn deficiency. Applying 5–10 kg Zn/ha (ZnSO_4), or 0.5–1.0% ZnSO_4 /ha spray at tillering stage and after 10 days interval is also beneficial in Zn deficiency management in rice.

Copper (Cu)

Cu deficiency occurs in soils containing high organic matter (Histosols), highly weathered, sandy textured and calcareous soils. Over liming of acid soils and soils with excessive Zn also show Cu deficiency.

Symptoms: Symptoms of Cu are more common in young leaves. Leaves develop chlorotic streaks on either side of the midrib giving



Copper deficiency in rice (Source: Rice knowledge bank)

appearance of bluish-green leaves. Leaf tips become chlorotic with streaks on either side of the midrib, followed by the appearance of dark brown necrotic lesions on the leaf tips. New leaves do not unroll and the leaf tip would have a needle-like appearance, while the leaf base would appear normal. Tillering is also reduced.

Management: Dipping seedling roots in 1% CuSO_4 suspensions for 1 hour before transplanting, spraying 0.1% CuSO_4 helps in quick recovery from Cu deficiency. Applying 5–10 kg CuSO_4 /ha as soil application once in 5 years and avoiding over liming of acid soils (reduces Cu uptake) is suggested.

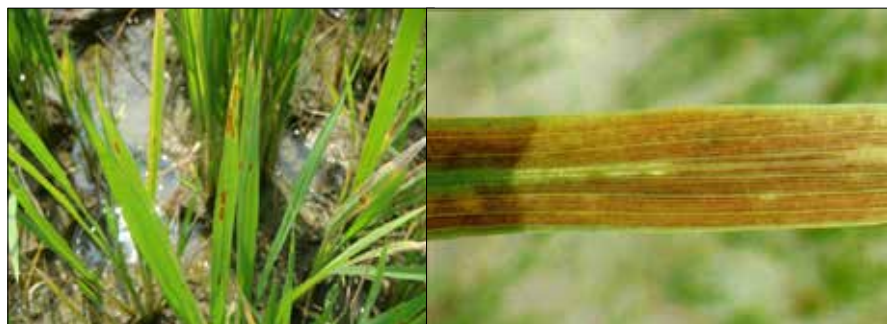
Boron (B)

Highly weathered, acid upland and coarse-textured sandy soils or acid soils derived from igneous rocks show deficiency of Boron. Soils with high organic matter, calcareous soils with excessive liming also shows occurrence of boron deficiency.



Boron deficiency in rice (Source: Rice knowledge bank)

Symptoms: White rolled, reduced height of leaf tips of young leaves, death of the growing point and partial exertion of panicles is observed in B deficiency. In some



Zinc deficiency in rice (Source: Rice knowledge bank)

cases, plants are unable to produce panicles.

Management: Soil application of borax @5–10 kg/ha as basal based on soil testing, spray of borax or boric acid @0.05% is suggested for quick recovery from boron deficiency. It is suggested to avoid excessive leaching (percolation), as boron is mobile in flooded rice soils. For hidden deficiency, spray of 0.2% boric acid or borax at pre-flowering or heading formation stages helps in management of boron deficiency.

Silicon (Si)

Symptoms: Leaves and culms become soft and droopy increasing mutual shading, is observed. Reduced photosynthetic activity, lower/reduced grain yields, reduced panicles/m² and increased occurrence of diseases such as blast (caused by *Pyricularia oryzae*) or brown spot (caused by *Bipolaris oryzae*) is observed in Si deficiency in rice.

Management: Calcium silicate @120–200 kg/ha (or) potassium silicate @40–60 kg/ha is applied for disappearance of symptoms. Silicon



Silicon deficiency in rice
(Source: Rice knowledge bank)

deficiency is prevented by not removing the straw from the field following harvest, and recycling rice straw (5–6% Si) and rice husks (10% Si).

Micro-nutrient toxicity in rice

Iron (Fe) toxicity

Fe-toxicity occurs mostly in Ultisols, Oxisols and acid sulfate soils, high in active iron and potential acidity, irrespective of organic matter and texture. Light

textured, acid soils in valleys receiving interflow water from adjacent higher land are rich in iron. Water logged soils with poor drainage, having high water table and poor nutrient status may cause Fe-toxicity under certain situations.

Symptoms: Tiny brown spots on lower leaves starting from the tip and spreading toward the leaf base or whole leaf are observed. Spots combine on leaf inter-veins and leaves turn orange-brown and die. Leaves appear purple-brown under severe toxicity. Stunted growth with extremely limited tillering, damaged root system with a dark brown to a black coating on the root surface are spotted in Fe toxicity.

Management: Use intermittent irrigation and avoid continuous flooding on poorly drained soils containing a large concentration of Fe and organic matter. Drain the field and keep it free from floodwater (but moist) for about 7–10 days to improve oxygen supply during tillering. Apply sufficient Potassium (K) fertilizer. Apply lime on acid soils. Do not apply excessive amounts of organic matter on soils where drainage is poor. Use urea (less acidifying) instead of ammonium sulfate (more acidifying). Carry out dry tillage after the rice harvest to increase Fe²⁺ oxidation during the fallow period.

Boron (B) toxicity

Rice crops are at risk of boron toxicity in arid irrigated areas, saline soils, sodic soils and volcanic areas. Use of irrigation water with high B content (> 2 ppm) leads to B toxicity.

Symptoms: Appearance of a

light brown or yellowish-white discolouration on the tips and margins of the older leaves is observed. With the progress of toxicity, leaf tips eventually turn brown and die. Later on, elliptical dark brown blotches appear in the discoloured areas. Finally, the entire leaf blade turns light brown and withers. Symptoms appear during early tillering.

Management: Plant Boron toxicity tolerant varieties can be grown for B toxicity management. To reduce the level of boron in the soil solution, use of irrigation water with low boron content to leach boron from the root zone is suggested.

Aluminium (Al) toxicity

Al toxicity occurs in Oxisols and Ultisols as well as in other heavily leached soils such as lateritic soils of the humid tropics. Upland soils with a pH of less than 5 exhibit Al toxicity. However, in most acid sulfate soils during the initial phase of soil flooding, Al toxicity may appear.

Symptoms: Interveneal orange-yellow to white discolouration of the tips of older leaves, (which may later turn necrotic) is observed in plants possessing aluminium toxicity. The roots of affected plants are stunted and deformed, with overall stunted plant growth.

Management: Use of lime to alleviate the soil acidity on upland soils is suggested. Plant Al toxicity tolerant cultivars or delayed planting after flooding can be done so that, pH increases sufficiently. Application of sufficient Mg (through dolomite lime) is also preferred.



Iron toxicity in rice (Source: Rice knowledge bank)



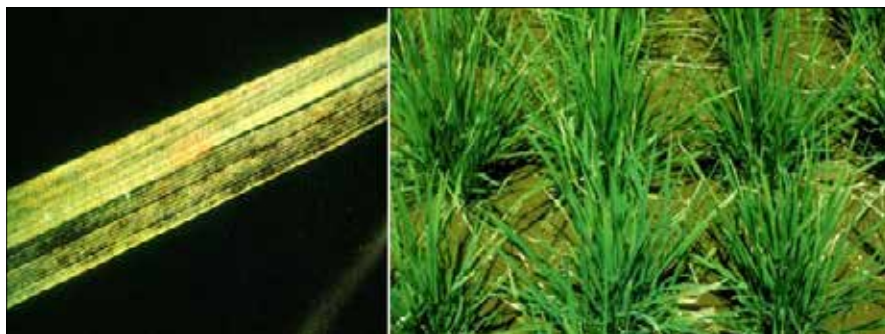
Boron toxicity in rice (Source: Rice knowledge bank)

Manganese (Mn) toxicity

Manganese toxicity is sometimes observed in dryland rice where the soil has a pH of less than 5.5. It rarely occurs in lowland paddy soils, but may occur, if the soil contains very large amounts of easily reducible manganese, or in areas contaminated by manganese

of chlorosis in younger leaves is seen similar to Fe deficiency. Grain yield is markedly depressed because of high spikelet sterility and whole plant is stunted with reduced tillering.

Management: In a temperate climate, coat seeds with oxidants (e.g. Calcium peroxide) to improve germination and seedling emergence

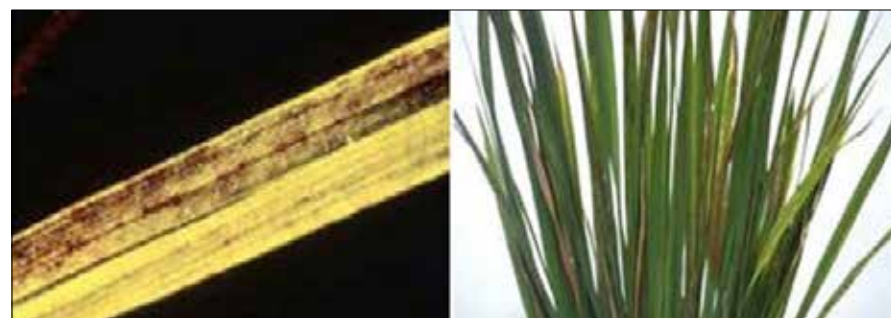


Aluminium toxicity in rice (Source: Rice knowledge bank)

mining. Acid sulfate soils or soil with poor and unbalanced nutrient status particularly having Si, K, P, Ca or Mg deficiency suffers with Mn toxicity.

Symptoms: Mn toxicity symptoms mainly appear in older leaves. Yellowish-brown spots appear between the veins of lower leaf blades and sheaths. Dry leaf tips with brown spots covering the whole leaf can be observed. Development

by increasing the supply of Oxygen (O_2) is suggested for management of Mn toxicity. Mn absorption may be accelerated under conditions of surface drainage hence, water should be managed efficiently. Balanced use of fertilizers (NPK or NPK+lime) is suggested to avoid nutrient stress as a source of Mn toxicity. Application of sufficient Potassium (K) fertilizer, lime on acid soils is done to reduce the concentration of



Manganese toxicity in rice (Source: Rice knowledge bank)

active Mn. Application of excessive amounts of organic matter (manure, straw) on soils containing large concentrations of Mn and organic matter, and on poorly drained soils is discouraged. Recycling of straws or ash to replenish Silicon (Si) and K removed from the field is also suggested measure for management of Mn toxicity in rice.

Way forward

Accurate identification of micro-nutrient deficiency and toxicity in rice crop needs field-level experience. Several tools and technologies have been developed to accurately diagnose deficiency/toxicity symptoms, both in soil and plant. These technologies are not adopted in farmer's fields due to lack of awareness about the technology among the farmers. Thus, extension workers, state government field level officials could create awareness to correct micro-nutrient deficiency and to minimize yield loss. The recent technology i.e. drone-based micro-nutrient spraying will save time and labour costs.

SUMMARY

Abiotic stress management in rice is very important in changing climate scenarios. Among the abiotic stress in rice, the micro-nutrient disorder is the most important cause of yield loss. Though micro-nutrients are taken by rice plants in small quantities, it plays a vital role in the plants. Farmers are not aware of the importance of micro-nutrient management in rice. Nutrient disorders are unique to soil reaction (pH), texture and ecology. The, providing adequate awareness to identify micro-nutrient deficiency/toxicity in rice plants is highly important to maximize rice productivity. Thus, micro-nutrient nutrition deficiency in rice along with toxicity discussed in this article will be highly useful to farmers and other agricultural experts to correctly diagnose the nutrient disorders in the field.

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