# Compendium of Maize Diseases

INDIAN PHYTOPATHOLOGICAL SOCIETY

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*Edited by*
**Robin Gogoi**
**K.S. Hooda**
**M.K. Khokhar**
**Jeevan B.**

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**Photos of Cover Page:** Common rust and banded leaf & sheath blight disease

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# Nutrient Deficiency Disorder

**Smruti R. Padhan, Soumya R. Padhan, Y. Siva Lakshmi and Shankar Lal Jat**

Maize is an exhaustive crop in terms of nutrient acquisition and drain out a large quantity of primary, secondary as well as micronutrient from the soil. For this maize required a high input of nutrient in adequate as well as balanced manner. Any aberration in the supply of these nutrients resulted in display of different nutrient deficiency symptoms in maize plants. Additionally, the high input maize systems' existing nutrient management approaches point to an unbalanced plant nutrition with very high N and low P and insignificant K and micronutrient utilization (Venkatesh et al. 2017). Cu, Zn, B, and S deficiencies (Weil and Mughogho 2000) are currently reported to be limiting maize yields in addition to the known deficiencies of N, P, and K, which are addressed by application of the commonly available inorganic fertilizer containing N, P, and K (Aliyu et al. 2021). A sufficient supply of each of the 17 essential nutrients needed for crop growth and development is also necessary for optimal crop performance, which is constrained by the nutrient with the lowest supply.

## Accessing nutrient management deficiencies in maize

Stunted development, interveinal chlorosis, purplish-red coloring, necrosis, and chlorosis are the five main kinds of symptoms brought on by nutrient deficits. Due to the various functions that, different nutrients play in plants, stunting is a common sign of nutrient deficiency. The signs of maize's nutrient deficiency were the plant's overall appearance of stunted growth and a faded green colour. Small (stunted) plants, light green leaves, and leaf spots or stripes are typical symptoms (IPNI 2007). Most significant nutrient element deficiency symptoms are typically recognizable, but in some complex situations when there is no obvious distinction, an expert is required to pinpoint the issue. It's crucial to distinguish between nutrient deficits and some pest and disease damage indicators, such as striping or spotting.

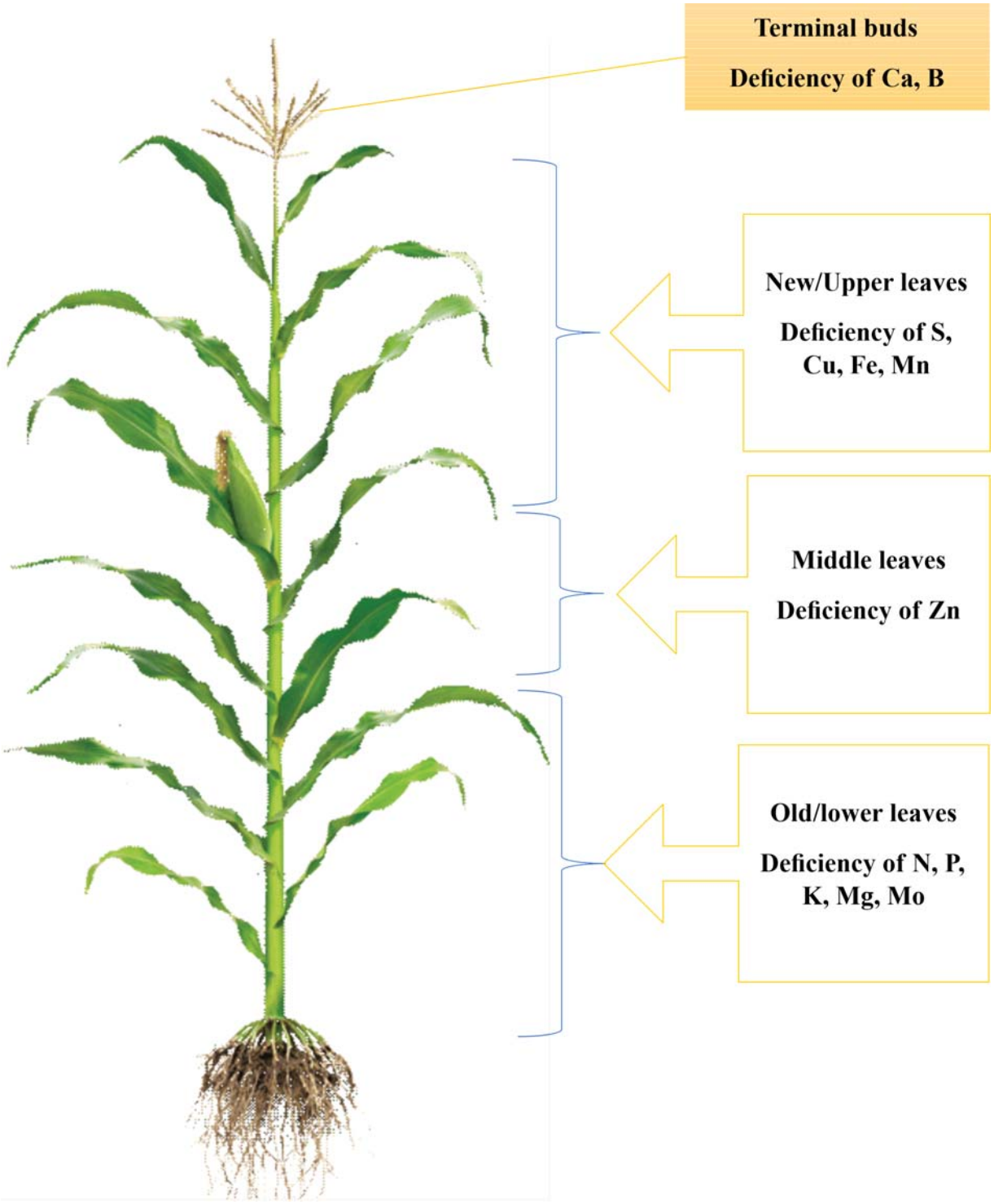


**Figure 1** Nutrient deficiency symptoms at different leaves of maize plant

## Deficiencies of primary nutrients in maize

### 1. Nitrogen deficiency

The most crucial nutrient for plants, nitrogen (N) is involved in all of the fundamental processes of plant growth and development. Because N is the most important part of the chlorophyll and the deficiency of N make the plant unable to synthesize chlorophyll and it can be seen as the most typical N hunger sign i.e., the loss of green colour. Lack of nitrogen results in maize plants that are pale, yellowish green, and have

slender stalks. Because nitrogen is a nutrient that is of mobile nature in plants, symptoms start on the older, lower leaves and move up the plant if the shortage continues(Carciochi *et al*., 2021). On leaves, symptoms take the form of a V-shaped yellowing that moves from the tip toward the leaf base along the midrib many times resulting in the pre-mature death of the plant.

N-deficiency in early stage | 'V' shaped older leaf due to N deficiency | N deficiency in older leaf

**Figure 2** Nitrogen deficiency symptoms in maize

### Causes of N deficiency

Warm tropical climate, water-logged soil, sandy soil with high infiltration rate, low organic matter, high concentrations of low-nitrogen residue (Jat et al. 2019), cold or wet soil, extremely dry soil, insufficient fertilization and leaching from heavy rains etc. encourage the condition of N deficiency.

### Management of N deficiency

- Site specific nutrient management as and when the crop demand by using different methods like point placement (Nayak et al. 2022), band placement and tools like SPAD meter, Green seeker (Jat et al. 2019b), nutrient expert (Shyam et al. 2021) etc.
- Use of inherently slow release or coated fertilizer like prilled urea, urea super granules.
- Amend soil with a source of organic matter like FYM, green manure etc.
- Discouraging water stagnation through proper drainage system as anaerobic soil is prone to N losses by denitrification.
- Crop rotation with legume crops and its residue retention or incorporation (Kadam et al. 2022).
- Fertilize using manure, blood meal, fish meal or inorganic fertilizer

### 2. Phosphorous deficiency

On young maize plants, phosphorus (P) shortage is typically apparent. It is translocated and mobilized easily inside the plant. Older leaves have reddish-purple edges (Marschner 1971) and leaf tips on dark green plants. Developing leaves won't display the purple coloration. Plants with insufficient phosphorus take longer to grow and develop and are typically smaller than plants with enough phosphorus. Symptoms of deficiencies almost typically go away until plants reach a height of three feet or more. The display of

reddish-purple color is not absolute as some hybrids do not exhibit the colour symptoms despite insufficient phosphorus severely limiting yields, and some other maize hybrids have a tendency to exhibit purple colors during the early stages of growth despite adequate phosphorus nutrition.

**Figure 3** Phosphorus deficiency symptoms in maize

### Causes of Phosphorus deficiency

The common causes of P deficiency are inadequate and imbalanced fertilization with phosphatic fertilizers, problematic soils with too high or too low pH, too wet and cold weather soil making the plant uptake difficult, improper root growth due to heavy soil compaction etc. (Yadav et al. 2019).

### Management of Phosphorus deficiency

- Use soil amendment such as lime, to adjust pH to neutral range
- Fertilize the soil using bone meal, rock phosphate, ammonium phosphate or manure or any other substances rich in phosphorus
- Use of P-Solubilizing Bacteria, VAM for increasing phosphorous use efficiency
- Balanced use of NPK fertilizers

## 3. Potassium deficiency

Because potassium (K) is mobile in plants and moves from old to young leaves, symptoms of a persistent deficit advance up the plant. Corn leaf margins begin to yellow and necrosis on the lower leaves, which is the first sign of K insufficiency. Typically, symptoms don't start to show up until 4 to 6 weeks after planting, or around the V6 development stage. When there is a severe K deficiency, older leaves turn yellow and have tissue necrosis along the margins, while top young leaves may still be green. As K plays a vital role in providing strength to plant through strong stalks, its deficiency weaken the stalks and the K-deficient corn often lodges late in the growth season.

K-deficiency K deficient cobs

**Figure 4** Potassium deficiency symptoms in maize

## Causes of Potassium deficiency

K deficiency is favored by circumstances that restrict early root growth, development, and activity, such as root pruning, dry soil, compacted soil. Very wet soil with inadequate aeration, light sandy soil, organic soil, and strongly geologically weathered soils also aggravates the deficiency of K. It is also supplemented by K applied beyond the root forage zone restricting the root to absorb it as K is immobile in soil, absorption of high K by potassium loving crops in the cropping system and some tillage systems, such as ridge-tillage and no-tillage with low level of sub soil K.

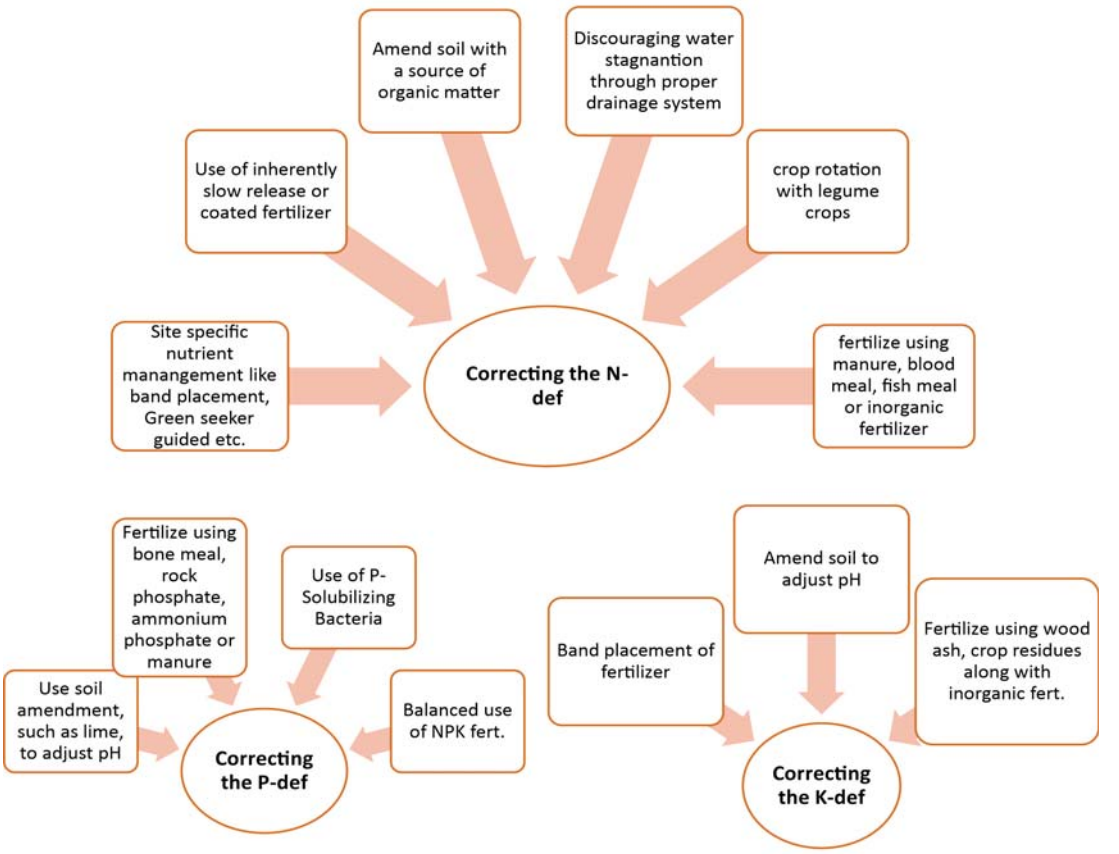


**Figure 5** Correction measures of primary nutrient deficiencies

### Management of Potassium deficiency

- Band placement of K-fertilizer near the crop row zone for easy acquisition (Phares *et al*., 2022).
- Balanced use of NPK fertilizer without ignoring K
- Use of potassium fertilizer through fertigation
- Amend soil to adjust pH
- Fertilize using wood ash, crop residues along with inorganic fertilizer

## Deficiencies of secondary nutrients in maize

### 1. Calcium deficiency

In maize, calcium insufficiency is generally uncommon. Under the conditions of an acidic soil, calcium deficits in maize, often known as "buggy-whipping," are quite typical in a greenhouse or a crop field (CIMMYT, 2022). The most prevalent and problematic calcium issue manifests as damaged and immature emerging leaves in seedlings. It can be seen as leaf tips adhere to the lower leaf, giving the plant a ladder-like look. Because calcium is immobile in plants the symptoms are concentrated to the top young parts of the plant and does not move from calcium-deficient old to growing plant tissue. Sometimes the plant bounces back from that condition itself, but if not, the farmer must manually unfold the leaves with care to conserve the crop.

### Causes of Calcium deficiency

Before calcium shortage symptoms manifest, low soil pH and acid soil issues such high amounts of soluble aluminium and manganese are more likely to arise. Low pH soils (below 5.0 on mineral soils and 4.8 on organic soils), non-limed, severely weathered acid soils, or very high magnesium and potassium and very low calcium on the cation exchange complex all encourage calcium shortage.

### Management of Calcium deficiency

- Proper water management
- Fertilize using gypsum, calcite lime, calcium sulphate, calcium nitrate, calcium carbonate or dolomitic limestone

### 2. Magnesium deficiency

As magnesium (Mg) is a prime constituent of chlorophyll, a lack of sufficient magnesium causes a widespread loss of green colour that first affects the lower leaves and eventually spreads up the stalks, which manifests as distinct and sharply defined series of yellow/green streaks on all leaves. Lower maize leaves with interveinal yellow to white striping are the earliest sign of magnesium insufficiency. Sometimes, circular, dead areas appear next, giving the appearance of beaded streaking. If the deficit is severe, the tips and edges may succumb to necrosis. This occurs as a result of the plant's ability to move magnesium from old to new plant tissue.

### Causes of Magnesium deficiency

Extremely acidic, sandy soils in areas with moderate to heavy rainfall—where magnesium has been substantially leached from the soil profile—are conducive to magnesium insufficiency. High soil potassium levels or high potassium application rates might cause shortage on soils with low crop-available magnesium.

### Management of Magnesium deficiency

- Amend soil to adjust pH
- Fertilize using dolomitic lime, Epsom salts or foliar sprays of magnesium sulphate

### 3. Sulphur deficiency

The deficiency of Sulphur (S) is almost similar to nitrogen deficit except the later one is observed in older leaves and that of S is in younger upper leaves. Due to the difficulty of translocating sulphur within the plant, yellowing of the younger top leaves is more evident with S deficit than with nitrogen deficiency (Liu *et al*., 2021). S deficiency manifests on small maize plants as a widespread yellowing of the foliage. Plant stunting and delayed maturity are other signs. In the youngest leaves, interveinal chlorosis may occur.

S deficiency

Fig 6. Sulphur deficiency symptoms in maize

### Causes of Sulphur deficiency

Acid sandy soils, poor soil organic matter, and cold, dry soils in the spring that postpone the release of sulphur from organic matter are all favorable conditions for this shortage(Ma *et al*., 2021). As temperature and moisture conditions for the mineralization of sulphur from organic matter improve, early-season symptoms may go away or corn roots may reach sulphate that is available to plants in the soil profile.

### Management of Sulphur deficiency

- Use of high analysis NPK fertilizer containing sulphur like SSP
- Amend soil with a source of organic matter because organic matter is the reserve for the sulphur release
- Fertilize using gypsum, ammonium sulphate, calcium sulphate or elemental sulphur

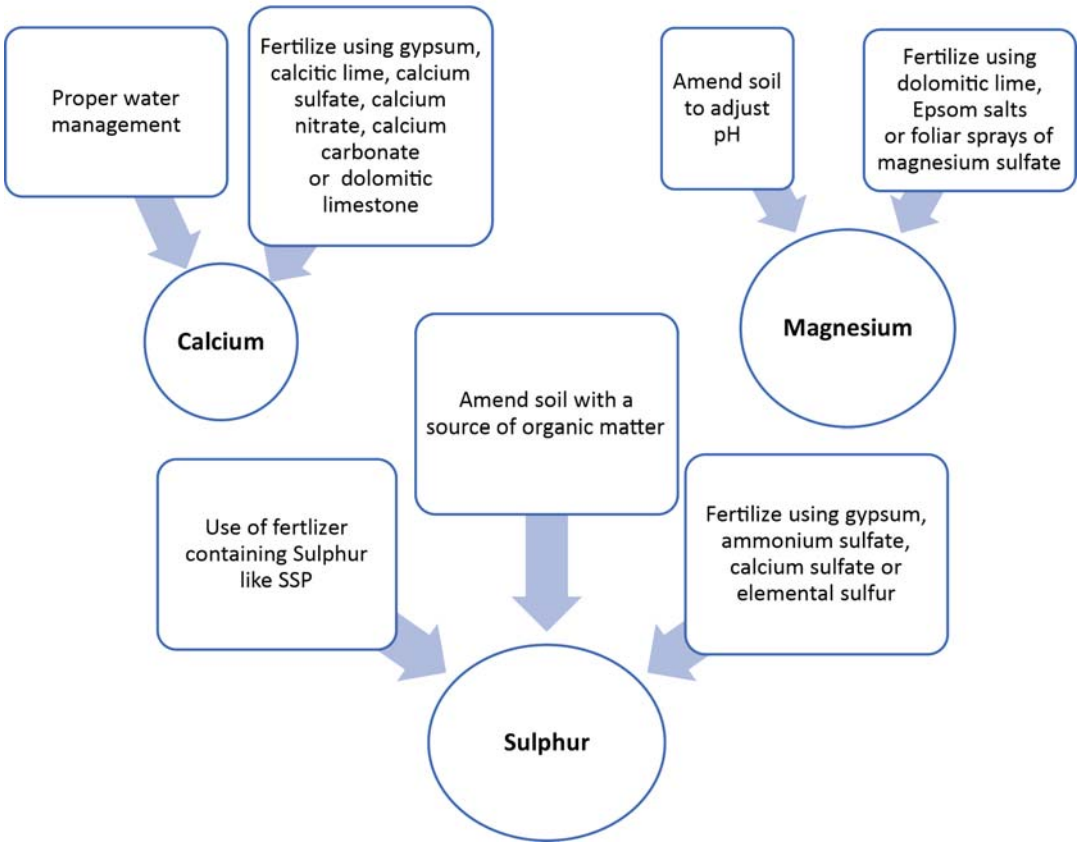


**Figure 7** Correction measures of secondary nutrient deficiencies in maize

## Micronutrient deficiencies in maize

### 1. Zinc deficiency

Interveinal, light striped, or whitish bands commencing at the base extending towards the tip of the leaf are signs of zinc (Zn) deficiency in maize. Normally, the leaf's edges, midrib, and tip all retain their green colour. Because internodes are cut shorter, plants become stunted. In plants, zinc is largely

Zn deficiency

White bud due to Zn deficiency

**Figure 8** Zinc deficiency symptoms in maize

immobile(Greffeuille et al. 2011). A severe zinc shortage may cause “white bud” which is nothing but a physiological nutritional disorder where new leaves that are almost completely white. Unless it is severe, zinc deficiency is typically overcome by plants of their own.

### Causes of Zn deficiency

High soil pH, low organic matter soils with high pH (Liu et al. 2020), chilly, damp soil, high phosphorus fertilizer applications on soils with low zinc availability, albeit high soil phosphorus levels alone don’t cause zinc deficiency, all favor zinc deficit.

## 2. Iron deficiency

The interveinal region along the length of the upper leaves turns pale green to almost white when there is an iron (Fe) shortage. Because iron is immobile inside the plant, it cannot move from ageing to developing plant tissue. When there is general stunted development and improper leaf uncurling, boron deficiency can be misinterpreted for iron insufficiency (Harender et al. 2019).

Fe deficiency

**Figure 9** Iron deficiency symptoms in maize

### Causes of iron deficiency

Due to corn’s low iron need, this shortage is uncommon and only occurs in high pH soils(Sun et al. 2007). Cold, moist, poorly aerated soils and calcareous soils with high soil pH in the surface soil favour iron deficiency.

## 3. Manganese deficiency

In the plant, manganese (Mn) is largely immobile. The signs of a manganese shortage are not always obvious. The newly developed leaves change its colour to olive-green and possibly somewhat spotted. Deficient leaves might become elongated with white streaks that eventually become brown in the centre, degrade, and fall off if the issue is severe. The deficiency of manganese cause dwarfing of maize plants and many a times the maize seeds may fail to germinate entirely (IIMR 2022).

### Causes of Manganese deficiency

High soil pH, sandy soils rich in organic matter, and peat or muck soils are conducive to manganese deficiency.

### 4. Molybdenum deficiency

Rarely, if ever, is molybdenum (Mo) insufficiency detected in corn. The tip, edges, and spaces between the veins of older leaves, if it happens, are necrotic. The deficiency of molybdenum also causes dwarfing of maize plants earlier like manganese but unlike manganese the corn grown under soils low in molybdenum develops yellowing of older leaves and younger leaves usually fail to unroll.

#### Causes of Molybdenum deficiency

Strongly weathered and eroded soils with a very low soil pH, favour this situation.

### 5. Boron deficiency

Lack of boron (B) is found rarely in corn. Leaves are tiny, brittle and feature dead patches. Boron is immobile inside the plants and does not move easily to the upper part in the plant and as a result of which the internodes don't elongate much. The tassels and ear shoots may be absent or if present in a reduced manner. Corn is extra sensitive to fertilizer with boron. Both higher and lower doses from the optimal rates affects the plant is a different manner. The toxicity of boron can be witnessed if fertilizer is administered above the specified rates of recommendations or if applied alongside of the crop rows.

B deficiency B deficient cobs

**Figure 10** Boron deficiency symptoms in maize

#### Causes of Boron deficiency

The deficiency is generally encouraged by drought as drought lowers the release of boron from organic waste, soils with low organic matter content, low-nutrient light sandy soils, and high pH of the soil. Lack of water also delays ear shoot emergence and potential pollination, which means that symptoms may appear simultaneously and may be confused with one another.

### 6. Copper deficiency

In corn, copper (Cu) deficiency is uncommon. Common signs of copper deficiency in young leaves include overall yellowing (chlorosis), whereas in older leaves, the leaf tips curl into pigtails and die. The tips of the youngest leaves may fall as they emerge from the whorl and are yellow in colour. In the plant, copper is largely immobile. The appearance of streaked leaves resembles that of an iron deficit. Its stalk is fragile and soft. As it does in conditions of potassium deprivation, some necrosis of older leaf margins happens.

### Causes of Copper deficiency

Organic soils (extremely high soil organic matter) and high soil pH (above 7.5) favour copper deficiency.

### Management of micronutrient deficiency

- Amend the soil to adjust pH to neutral range
- Amend soil with a source of organic matter like FYM, compost.
- Fertilize using foliar applications of zinc sulphate for Zn-deficiency.
- Fertilize using foliar applications of iron chelates, ferrous sulphate or ferrous ammonium sulphate for Fe-deficiency (Sawyer, 2004).
- Fertilize using manganese sulphate as either a foliar application or soil amendment for Mn-deficiency.
- Fertilize using borax, sodium or calcium borate for B- deficiency.
- Water less and ensure area has adequate drainage along with Cu fertilization for Cu-deficiency.
- Fertilize using sodium molybdate as foliar application or soil amendment for Mo- deficiency.

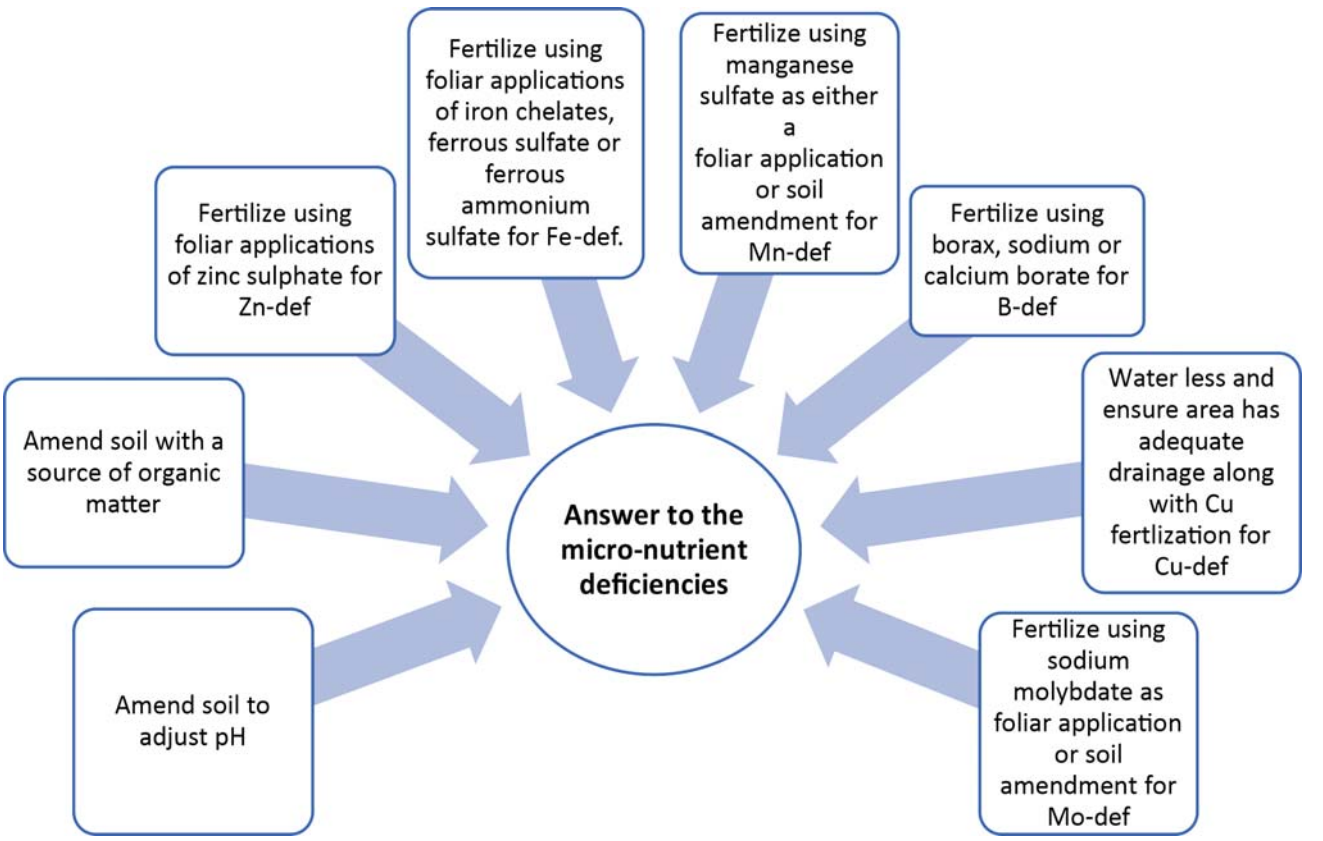


**Figure 11** Correction measures of micro-nutrient deficiencies in maize

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Compiled by:

**Smruti R. Padhan**

Division of Agronomy, ICAR- Indian Agricultural Research Institute, New Delhi-110 012

**Soumya R. Padhan**

Department of Agronomy, Banaras Hindu University, Varanasi-221 005

**Y. Siva Lakshmi**

Maize Research Centre ARI

Professor Jayashankar Telengana State Agricultural University, Hyderabad

**Shankar Lal Jat**

ICAR-Indian Institute of Maize Research, New Delhi-110 012