Chapter 5. Zinc deficiency

RICE (*Oryza sativa* L.)

Plate 92

Plate 93

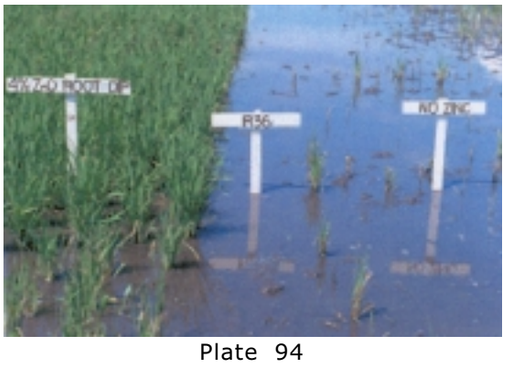

Plate 94

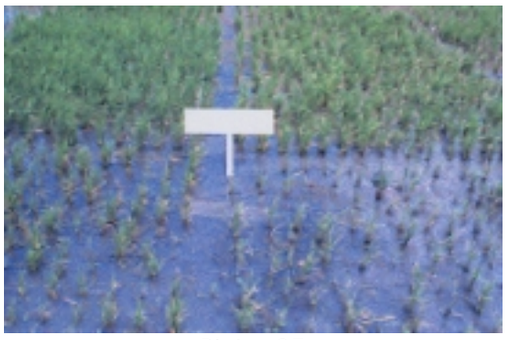

Plate 95

Plate 96

Plate 97

Plate 92. Light brown discoloration of leaves due to zinc deficiency
Plate 93. Rice plants suffering from severe deficiency. Symptoms in the field are patchy.
Plate 94. Amelioration of zinc deficiency in rice on left by root dip of zinc oxide (4% ZnO). The rice on the right has not had any zinc treatment
Plate 95. Varietal differences in tolerance of zinc deficiency
Plate 96. Zinc deficiency of rice in Taiwan is usually indicated by a rusty mottled color on the leaf surface, or small reddish-brown mottles on the leaf surface.
Plate 97. Zinc deficiency shown by reduced tillering, chlorosis in the leaves, and reduced plant size (mature rice plants are only about 50-80 cm high).

Photos 92-95 by the International Rice Research Institute, Philippines
Photos 96, 97 by Mr. Ching-Hsee Lin, Taiwan ROC

Plates 92-95, Philippines: Tropical climate
Plates 96-97, Taiwan ROC: Subtropical climate

Description of symptoms

In rice, the visible symptoms of zinc deficiency vary with soil, variety, and growth stage. Usually, the midrib at the base of the youngest leaf of zinc-deficient rice becomes chlorotic 2-4 weeks after sowing or transplanting. Brown spots then appear on the older leaves. The spots enlarge, coalesce, and give the leaves a brown color. Some varieties exhibit an yellow-orange discoloration of older leaves, spreading from the tip, instead of the brown spots. In severe deficiency, the entire leaf turns orange or brown and the rice plant dies. Zinc deficiency results in stunted growth and depressed tillering. In soils with moderate zinc deficiency, plants may recover after 4-6 weeks, but maturity is delayed and yields of susceptible cultivars are reduced.

Symptoms can easily be confused with those of tungro, a disease in rice caused by virus. The disease symptoms, however, are brighter orange in color, and infestation spreads from one plant outward to other plants around it. Zinc deficiency damage is observed in the field in patches, with plants in depressions showing more severe symptoms. The patchy appearance of a zinc-deficient field often observed around six weeks after transplanting is due to the recovery of some plants and the death of others.

Soil conditions likely to produce zinc deficiency

Zinc deficiency is the most common disorder in wetland rice soils, next to nitraogen and phosphate deficiencies. Zinc deficiency in wetland rice occurs on soils with a pH greater than 7.0, soils with low available zinc or a low total zinc content, and on soils with a high organic matter content. The following soils are likely to be deficient in zinc: calcareous soils, sodic soils, volcanic ash soils, scraped soils, sandy soils and, regardless of pH, soils which are continuously wet. Zinc deficiency is also associated with a high bicarbonate content, a magnesium to calcium ratio in soils which is greater than 1, and high levels of available phosphate and silica. The use of high levels of fertilizers, intensive cropping, the use of high-yielding varieties, prolonged submergence, and irrigation with alkaline water, all tend to induce a state of zinc deficiency in rice.

Diagnosis by soil analysis

The critical deficiency limit in the soil is 1 mg/kg Zn by extraction with 0.05M HCl. Zinc extracted from the soil solution of deficient paddy fields is generally in the range 0.05 - 0.25 mg/L.

Diagnosis by plant analysis

In the rice plant, the critical deficiency limit is 20 mg/kg zinc in the plant tissue at tillering.

Interaction with other elements

High rates of phosphorus application may induce zinc deficiency. So may high levels of organic matter, since organic matter inactivates soil zinc and retards its uptake by the rice. Zinc deficiency is more acute in calcareous or alkaline soils where levels of organic matter are high. The increased availability of calcium, magnesium, copper, iron and phosphate depress the absorption, of zinc by rice. Excess aluminum in acid soils decreases the concentration of zinc.

How to correct the deficiency

The application of 20 to 50 kg/ha of zinc sulfate to the soil is the most common way of correcting zinc deficiency. Dipping the roots of rice seedlings in a 2-4% suspension of zinc oxide before transplanting in the field is effective. Likewise, treating seeds with zinc materials before sowing in nursery beds or direct seeded field is recommended.

Fertilizer application

Caution should be used in applying phosphate fertilizer, as excess phosphate may aggravate the disorder. Growers should use ammonium sulfate if the rice deficiency is caused by a high soil pH.

Other cultivation practices

Thorough aeration (drying) of the soil between rice crops often alleviates zinc deficiency. Growers should also plant zinc-efficient varieties, and practice crop rotation.

Examples of wrong correction

On soils which are moderately deficient in zinc, grain yields of zinc-efficient cultivars may decrease if zinc is applied because of zinc toxicity and resulting mineral imbalances in the plant. It is therefore recommended to apply zinc fertilizer to moderately deficient soils only after zinc deficiency occurs. Excessive use of phosphate fertilizers may induce zinc deficiency, or aggravate an existing problem.

Information from Dr. Corinta Quijano-Guerta, International Rice Research Institute, Philippines

CORN (*Zea mays* L.)

Plate 98

Plate 99

Plate 100

Plate 98. Zinc deficiency in corn plant with stunted leaves ("little leaf")
Plate 99. Zinc deficiency indicated by light yellow stripes in the interveinal area of younger leaves
Plate 100. Zinc deficiency indicated by white stripes in the interveinal area of younger leaves when the zinc deficiency is severe

Taiwan ROC: Subtropical climate

Photos by Mr. Ching-Hsee Lin, Taiwan ROC

Description of symptoms

Zinc deficiency of corn affects the development of the leaves. The leaves are stunted, a condition sometimes known as "little leaf". Chlorosis is common in the interveinal areas of the leaves, which have light yellow stripes and are yellowish in color. The leaves often fall prematurely.

Shortening of the stem internodes results in dwarfism of the plant. Delayed maturity, and the abnormal development of stems, decrease the yield. Under condition of extreme zinc deficiency, the corn yield is almost nil.

Excessive applications of phosphate fertilizer may induce zinc deficiency, and this is aggravated in limestone soils with a high pH (higher than 8).

Soil conditions likely to produce zinc deficiency

A high soil pH, or a calcareous soil, means that zinc is less soluble. Corn and other crops may suffer from zinc deficiency under these soil conditions.

This tends to result in stunted growth and small younger leaves. Corn growing in zinc-deficient soils in Taiwan have small, brown spots on their leaves, and the development of the whole plant is poor.

Diagnosis by soil analysis

The normal range of zinc in the soil solution extracted with water is generally in the range 0.05 - 0.25 mg/L. Levels below 0.05 mg/L are likely to lead to zinc deficiency in the crop. The level of exchangeable zinc in soil extracted with ammonium acetate appears to be in the range 0.1-2 mg/kg.

How to correct zinc deficiency

The application of 30 to 50 kg/ha of zinc oxide (or 80 to 120 kg/ha of zinc sulfate) is recommended for corn production on soils with low available zinc status.

Fertilizer zinc should be mixed with the topsoil to reach the feeding roots, since zinc is very immobile, and does not spread out from the point of application.

Information from Dr. Zueng-Sang Chen, National Taiwan University

GRAPE (*Vitis vinifera* L.)

Plate 101. Grape vines with zinc deficiency usually bear bunches where grapes of normal size are mixed with smaller grapes. These have no seeds, and are light yellow in color.

Taiwan ROC: Subtropical climate

Photo by Dr. Su-San Chang, Taiwan ROC

Description of symptoms

The main symptom of zinc deficiency in grapes is that the grape bunches have grapes of uneven size. Small grapes are mixed with large ones in the same bunches. The smaller grapes are pale yellow in color, and have no seeds.

Soil conditions likely to producd zinc deficiency

A high soil pH or a calcareous soil means that zinc is less soluble. Grape may suffer from zinc deficiency under these soil conditions. Excessive applications of phosphate fertilizer may induce zinc deficiency, especially in calcareous soils.

Diagnosis by soil analysis

Zinc extracted from the soil solution in normal soils is generally in the range 0.05 - 0.25 mg/L. Grapes growing in soils with levels below 0.05 mg/L are likely to suffer from zinc deficiency. The level of exchangeable zinc extracted by ammonium acetate appears to be in the range 0.1 - 2 mg/kg.

Diagnosis by plant analysis

The concentration of zinc in leaves is less than 15 mg Zn/kg.

How to correct zinc deficiency

Thirty to 50 kg/ha of zinc oxide (or 80 to 120 kg/ha of zinc sulfate) is recommended for grape production on soils with a low level of available zinc.

Alternatively, a foliar spray of 0.5-1.5% zinc sulfate ($ZnSO_4$) can be applied repeatedly until the deficiency is corrected. In large grape orchards, foliar application may not be practical. Soil application (80-120 kg/ha zinc sulfate), broadcast and incorporated into the soil, may be preferable. Any fertilizer zinc applied as a dressing should be mixed with the topsoil to reach the feeding roots, as zinc is highly immobile.

Information from Dr. Zueng-Sang Chen, National Taiwan University, Taiwan ROC

CACAO (*Theobroma cacao* L.)

Plate 102

Plate 103

Plate 104

Plate 102, Plate 103, Plate 104. Cacao trees deficient in zinc growing on clay soil (Eutrandept) in Mindanao, Southern Philippines

Philippines: Tropical climate

Description of symptoms

Zinc deficiency of cacao produces symptoms in both the leaves and the bean pods. Leaves develop in a deformed rosette shape, with chlorosis of the interveinal areas, which are colored pale green or yellowish. The leaves are smaller than normal, and often fall prematurely.

Trees with zinc deficiency show delayed maturity, with few leaves and branches, which together with the abnormal development of small pods and flat beans results in low yields. If the zinc deficiency is acute the yield may be almost nil. Should multiple nutrient deficiencies occur, diagnosis through symptoms can be confirmed by soil and plant tissue analysis. Moreover, certain diseases of cacao such as VSD (vascular streak die-back) have symptoms similar to those of zinc deficiency. Branches should be split and checked for a "brown streak" to see whether the problem is zinc deficiency or VSD.

Climatic conditions likely to produce zinc deficiency

Zinc uptake and availability for plants is considered normal between temperatures of 15°C and 40°C. Zinc deficiency because of reduced plant uptake may occur if temperatures are lower than 15°C, with very limited uptake at temperatures below 5°C. Hence, zinc deficiencies are common during cool periods or wet seasons.

Soil conditions likely to produce zinc deficiency

Zinc in soil exists in a number of different forms as part of the mineral structure, as a salt; as soluble and insoluble organic complexes. etc.

Nevertheless, zinc deficiency can be induced by soil pH conditions (lower than pH 4.5 and higher than 7.5). Zinc deficiency is found both in soils with a very high organic matter content

(peat and muck soils) and soils with low level of organic matter. Zinc deficiency is also common in sandy soils, soils with very high native phosphate or excessively fertilized with phosphate fertilizers, and in poorly drained soils.

Diagnosis by soil analysis

The total level of zinc in soils ranges from less than 10 to 200 mg/kg. However, the following guide could serve as a reference for DPTA-extractable zinc. A level of less than 0.2 mg/kg zinc is very low, and cacao crops are almost certainly deficient. A level of 0.2-0.5 mg/kg zinc is low, and crops are likely to be deficient; 0.2 – 0.5 mg/kg zinc is moderate, and crops may be slightly deficient; 0.6-2 mg/kg is high, and crops have a very adequate supply of zinc. More than 2 mg/kg zinc is excessive, and crops may suffer from zinc toxicity.

Diagnosis by plant analysis

Plant tissue analysis should be of samples taken from the second or third leaf (from the apical shoot) of the recently mature flush. Normally, levels of zinc in cacao leaves are 80-170 mg/kg. Levels of 20-30 mg/kg are mildly deficient, and less than 15 mg/kg is severely deficient.

Several factors should be considered in the interpretation of results. Younger leaves contain higher levels of zinc than older ones. Furthermore, the zinc concentration decreases with the age of the tree.

Interaction with other elements

High levels of phosphorus (soil or fertilizer application) reduce the levels of zinc in the leaves. Likewise, excessive levels of calcium, iron and manganese tend to depress the leaf zinc concentration. Excessive aluminum is likely to have an antagonistic effect on zinc in highly acidic soils.

How to correct zinc deficiency

For seedlings, young trees and mature trees, a foliar spray of 1% zinc sulfate ($ZnSO_4$) (23% Zn) or zinc oxide (ZnO) (0-70% Zn) is applied repeatedly until the deficiency is corrected. For larger areas, it may be easier to broadcast zinc fertilizer (10-20 kg/ha zinc sulfate) and incorporate it into the soil. Fertilizer zinc should be mixed with the topsoil to reach the feeding roots, as it is not transferred far from the point of application.

Zinc chelates applied in a band are an alternative method of Zn deficiency correction, but are not often used. They include Na_2Zn-EDTA (synthetic), applied at a rate of 0.5-1 kg/ha, and Zinc polyflavonoids (natural), applied at a rate of 0.5-4 kg/ha.

Some organic fertilizers such as chicken manure contain 200-1500 mg/kg of zinc (Magat 2000). Applications of chicken manure thus not only improve the humus content and physical and biological condition of the soil, but enrich the level of zinc.

According to experience in the field (Mindanao, Philippines), mature cacao trees exhibiting low levels of leaf zinc (less than 50 mg/kg, dry matter) recovered with the application of 25 g tree of zinc sulfate. The production of normal cacao pods and beans was sustained. In fact, the application of zinc sulfate seemed to reduce the number of trees affected with VSD, as well as the number of trees with "VSD-like symptoms" which were in fact zinc-deficient.

Photos and information from Dr. Severino S. Magat, Philippine Coconut Authority

CITRUS (*Citrus senensis, Citrus grandis*)

Plate 105

Plate 106

Plate 107

Plate 108

Plate 105. Leaves of *Citrus sinensis* var. Tungkan with zinc deficiency. There is chlorosis of the interveinal areas, which are yellowish in color.

Plate 106. Leaves of *Citrus grandis* Osbeck var. Yaotzu showing zinc deficiency in younger leaves. The intervein areas are yellowish in color, although the yeins leaf still keep their green color.

Plate 107. Leaves of *Citrus grandis* Osbeck var. Mato-Wentan with zinc deficiency. The interveinal area of younger leaves is bright yellowish in color.

Plate 108. Leaves of citrus (Wentan) showing different conditions of zinc deficiency. The green leaves are normal (lower right) and the white leaves suffer from serious zinc deficiency (upper left).

Taiwan: Subtropical climate

Photos by Mr. Ching-Hsee Lin, Taiwan ROC

Description of symptoms

Zinc deficiency is usually indicated in the leaves. They are deformed in their development, and the interveinal areas are pale green or yellowish.

Climatic conditions likely to produce zinc deficiency

Zinc deficiencies of citrus are related to heavy precipitation.

Soil conditions likely to produce zinc deficiency

Zinc deficiency may occur if zinc is present as part of the mineral structure, as ferromagnesium minerals (augite, biotite and hornblende). It is also common on sandy alluvial soils with a low zinc

content, calcareous soils with a high pH (close to 8), and poorly aerated soils. The excessive application of N, P, and K to the soils will inhibit zinc uptake by the trees, thus inducing zinc deficiency.

Diagnosis by soil analysis

Zinc extracted from the soil solution of normal soil is generally in the range 0.05 - 0.25 mg/L. The level of zinc extracted with ammonium acetate from normal soil appears to be in the range 0.1 - 2 mg/kg. Below the level of 0.05 - 1 mg/kg, symptoms of zinc deficiency are likely to appear.

How to correct zinc deficiency

In seedlings, young trees and mature trees, apply a foliar spray of 0.5-1.5% zinc sulfate repeatedly until the deficiency status has been corrected.

For large areas, a foliar application may not be practical. Thus, the soil application of 80-120 kg/ha of zinc sulfate may be preferred, broadcast and incorporated into the soil. The fertilizer zinc should be mixed into the topsoil so it reaches the feeding roots, as it is immobile from the point of application.

Information from Dr. Zueng-Sang Chen, National Taiwan University,Taiwan ROC.