Rice Technology *Bulletin*

Department of Agriculture
Philippine Rice Research Institute (PhilRice) **ISSN 0117-9799** **2000 No. 32**

Management of Zinc-Deficient Soils

Rice Technology Bulletin Series

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Foreword

Zinc (Zn) deficiency is the third most important factor limiting rice yield. It is referred to as *taya-taya* in Visayas, *lana* in Ifugao, and *lisao* in Kalinga.

In the Philippines, a total of 500,000 ha continuously submerged soils planted to rice has been reported to be deficient in Zn. Another 500,000 ha lowland soils are considered potentially Zn-deficient areas. Management of Zn-deficient soils in these areas could increase rice yield by about 1 ton/ha.

Developing varieties that are tolerant to Zn deficiency is one of the ways to solve the problem. However, it is costly and long-term. Cultural and nutrient management practices offers a more direct and faster approach to increase productivity of Zn-deficient soils.

This bulletin presents the cultural and nutrient management practices in managing Zn-deficient rice areas. It also gives information on Zn and its role in the growth of the rice plant, causes of Zn deficiency, and characteristics that are common to Zn-deficient lowland rice soils. Photos showing symptoms and degree of Zn deficiency are included to help readers identify correctly a Zn-deficient field. As symptoms of Zn deficiency are commonly mistaken for tungro disease, we included the list showing the basic differences between the two, which was published by the International Institute of Rural Reconstruction.

We hope that the information in this bulletin will be of help to technicians, extension workers, and farmers in managing Zn-deficient ricefields.

LEOCADIO S. SEBASTIAN
Executive Director

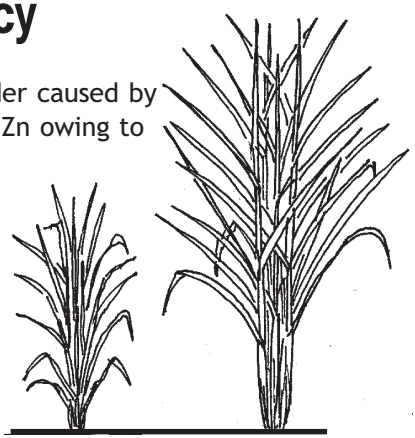
Zinc and its role in the growth of the rice plant

Zinc (Zn) is one of the 16 essential elements for the growth of the rice plant. It is a micronutrient that is needed by the rice plant in small amount. At least 300 grams of Zn is needed to produce one ton of rice yield. It is essential in maintaining high chlorophyll to carotenoid (yellow pigment) ratio in the rice plant.

Causes of zinc deficiency

Zinc deficiency is a nutritional disorder caused by the inability of the rice plant to take up Zn owing to the following reasons:

- the level of extractable Zn in the soil is low;
- the Zn in the soil is not in the form readily available for absorption by the rice plant; and
- there is imbalance in the level of Zn compared with other nutrients such as phosphorus, magnesium, iron, manganese, and copper.



Zinc deficiency is associated with high soil pH (above pH 6.8) and soils with high organic carbon content (above 3%).

It is also observed in:

- poorly drained soils even if the soil pH is below 6.8
- soils heavily fertilized with phosphorus
- sub-soils exposed by land leveling operations or by wind and/or water erosion
- soils with high silicon content
- soils with high bicarbonate content
- soils with magnesium to calcium ratio in soil of >1
- acidic sandy soils low in total Zn.

Soils likely to be deficient in Zn include saline, soils derived from corals and limestone, peat, and soils derived from rocks consisting mainly of magnesium silicate.

Other factors that cause Zn deficiency

1. Continuous and intensive rice cropping.
2. Prolonged flooding of rice paddies.
3. Irrigation with alkaline water.
4. Continuous application of organic materials that are difficult to decompose such as rice straw.
5. Addition of lime to acidic soils, or presence of calcium carbonate ($CaCO_3$) can temporarily reduce Zn availability owing to tie-up of Zn with $CaCO_3$ particles.
6. Varietal differences in plant species Zn uptake and utilization.

Characteristics common to zinc-deficient lowland rice soils

1. Rice farm is situated at the lowest base slope in the landscape, usually near irrigation canals.
2. Presence of spring at the rice farm or nearby rice farms that causes year-long flooding of the area.
3. Presence of "rust" and "oil"-like compounds at the soil and surface water.
4. Rice plants at or near border rows of the ricefield exhibit better growth than those in the inner rows.
5. Weeds such as *barakbak* (*Cyperus* sp.) or *kiapo* (*Pista stratiotes* L.) grow in the area.

Importance of managing zinc deficiency

Zinc deficiency problem must be corrected to attain high yields. In Zn- deficient soils, nitrogen, phosphorus, and potassium (NPK) fertilizers alone cannot provide good yield unless Zn deficiency is corrected. For example, it was observed that in Agusan del Norte, where most rice fields are deficient in Zn, application of NPK fertilizers alone decreased lowland rice grain yield, whereas application of Zn as zinc oxide with NPK dramatically increased yield.

The following map shows the provinces where some soils have potential or had been diagnosed with Zn deficiency:

Luzon
Abra, Albay, Aurora, Bataan
Batangas, Bulacan, Cagayan
Camarines Norte/Sur
Cavite, Ilocos Sur, Isabela
La Union, Laguna, Marinduque
Mindoro (Oriental and Occidental)
Masbate, Nueva Ecija, Nueva Vizcaya
Palawan, Pampanga
Pangasinan, Quezon, Quirino
Tarlac, Zambales

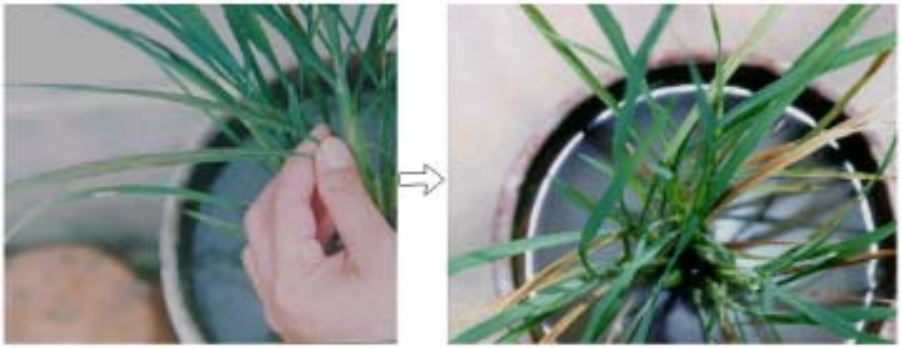
Visayas
Aklan, Antique, Bohol, Capiz
Cebu, Iloilo, Leyte (Eastern, Northern and Southern)
Negros (Occidental and Oriental)
Samar

Mindanao
Agusan del Norte/Sur, Bukidnon
Cotabato (South and North)
Davao (Oriental and Norte)
Misamis Oriental /Occidental
Sultan Kudarat, Sulu
Surigao del Sur, Zamboanga

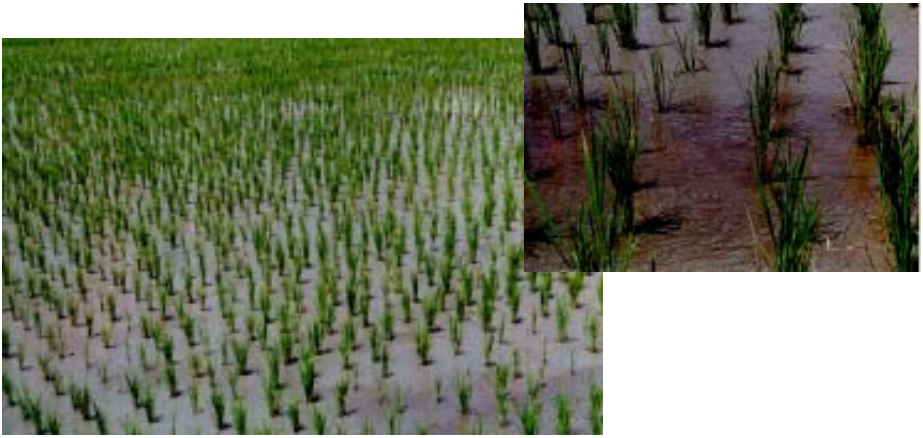
Symptoms of zinc deficiency

Symptoms of Zn deficiency vary with soil, rice variety, and growth stage of the rice plant. The following are the common symptoms:

- Midribs at the base of the youngest leaf becomes chlorotic or yellowish green, 2-4 weeks after sowing or transplanting.



- Brown spots appear on the older leaves. The brown spots eventually enlarge, blend, and give the leaves a brown color.



- Stunted growth and depressed tillering.

- Uneven growth of plants in one paddy and delayed maturity.

Note: If the deficiency is not severe, plants may recover after 6-8 weeks, but maturity is delayed and yields of susceptible varieties are reduced.

Degree of deficiency symptoms

1. **Very slight deficiency**. The growth and tillering is nearly normal but basal leaves are slightly discolored.

2. **Slight deficiency**. There is slight stunting in plant growth, decreased tillering, some lower leaves are brown or yellow, and some brown spots are observed from older leaves.

3. **Moderate deficiency**. The growth and tillering of the plant is severely retarded, 50% of all leaves become narrow, and appear rusty or yellowish.

4. **Severe deficiency**. Plant growth and tillering stops, most leaves become narrow, rusty, with brown spots, and yellowish. Leaf blades also become narrow.

5. **Very severe deficiency**. Almost all plants are dead or dying.

How to distinguish zinc deficiency from tungro

Farmers oftentimes mistakenly identify Zn deficiency symptoms as tungro disease. The following are the basic differences between the two:

Zinc deficiency	Tungro
	
1. First symptoms appear 2-4 weeks after transplanting. In moderate deficiency, the rice plants recover starting at 6 weeks after transplanting.	Symptoms occur at any stage of rice growth including seedling stage.
2. No presence of green leafhoppers or zigzag leafhoppers.	Presence of green leafhoppers and zigzag leafhoppers.
3. In each stage, **patches** of affected plants are found throughout the ricefield.	In early stages, **individual** infected plants are scattered throughout the rice seedbed or field.
4. Rusty brown discoloration on the old leaves and yellowing at the base of the younger leaves. Interveinal yellowing or stripping at the base of the emerging leaf.	Leaf color changes from green to light yellow to orange-yellow to brown yellow, starting from the tips of older leaves. Young leaves are often mottled or have pale green to white strips of different lengths running parallel to the veins.
5. When zinc deficiency is severe, NP fertilization significantly lower yields or even kills plants.	It has a positive response to NP fertilization.

Source: International Institute of Rural Reconstruction. 1990. Low External Input Rice Production (LIRP): A Technology Information Kit. Silang, Cavite, Philippines.

Factors that triggered the recent increase of zinc-deficient areas

1. Increase in nutrient uptake of more efficient high-yielding varieties.
2. The use of urea instead of ammonium sulfate which could slightly increase the soil pH over time.
3. Increased use of phosphate fertilizers.
4. Increased cropping intensity (2-3 times a year) because of availability of continuous irrigation water.

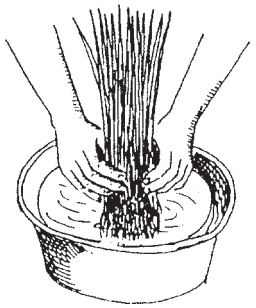
Management of zinc-deficient areas

1. **Crop diversification.** Planting of other crops such as legumes, vegetables, etc. between rice cropping will aerate the soil. Thorough soil aeration (drying) between cropping often alleviates slight to moderate zinc deficiency because it increases the availability of zinc in the soil.

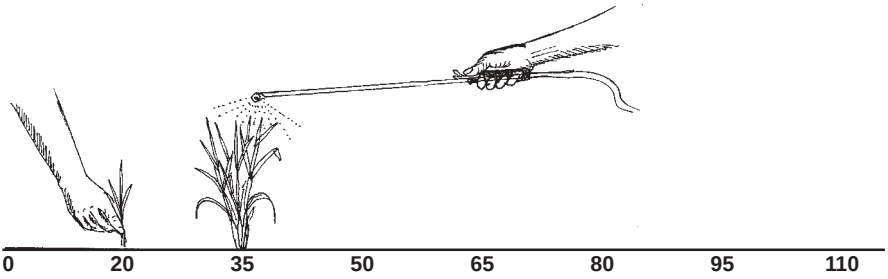
2. **Draining the field.** One of the reasons for Zn deficiency is continuous submergence of the soil. The first step to solving slight Zn deficiency is to drain the field during the crop's vegetative phase. Drain the flood-water and maintain the field up to saturated condition for 2 weeks when symptoms of Zn deficiency appear. Zinc deficiency can also be corrected by limiting the number of rice crop to only two per year and draining thoroughly the field between cropping.

3. **Apply Zn fertilizer using any of the following methods:**

   - Apply 25 g per m^2 at seedbed before sowing pre-germinated seeds. One hectare requires 400 m^2 seedbed with seeding density of 100 g per m^2.
   - Broadcast 10-25 kg $ZnSO_4$/ha, depending on the texture of the soil; the heavier the texture, the greater the dose. Broadcast $ZnSO_4$ to the soil not later than 10 days after transplanting or sowing. For very severe zinc deficiency, addition of up to 30-50 kg $ZnSO_4$/ha is recommended.
   - Dip the roots of the rice seedlings in 4% solution of $ZnSO_4$ (dissolve 2 kg $ZnSO_4$ in 50 mL water) after pulling and cleaning, which is usually a day before transplanting. If the zinc deficiency is severe, 8% solution of $ZnSO_4$ is recommended (dissolve 4 kg $ZnSO_4$ in 50 mL water). Detailed instructions on seedling dipping is shown in page 14.



- Foliar spray 2% solution of $ZnSO_4$ (dissolve 1 kg $ZnSO_4$ in 50 mL water) at 2-3 weeks after transplanting or sowing when deficiency symptoms are observed. Spray 200 liters of the solution per hectare.



4. **Use of tolerant varieties**. There is a wide differential response of rice varieties in a Zn-deficient lowland rice environment. Medium maturing varieties are generally more tolerant to Zn deficiency than early maturing varieties. PSB Rc18 and IR36 are examples of tolerant varieties. Screening of newly released varieties tolerant to Zn deficiency is ongoing at PhilRice Agusan.

5. **Use of organic manure containing fairly high content of Zn**. In addition to being a direct source of Zn, they also mobilize the native Zn through chelation. The order of effectiveness of organic manure as Zn sources that improves the tissue Zn concentration is as follows: poultry > cattle > pig.

NOTES:

- The method of Zn application to rice is important for efficient use of Zn fertilizer. On organic and calcareous soils (soils derived from corals and limestone), it is advisable to use a combination of planting Zn deficiency-tolerant varieties and element Zn amelioration. In calcareous soils, surface application of Zn can be more effective than soil incorporation.

- Several Zn sources such as $ZnSO_4$, ZnO, $ZnCO_3$, Zn frits (silicate), $Zn_3(PO_4)$, and Zn chelates have been used for ameliorating Zn deficiency in soils. The water soluble salts of Zn and its natural and synthetic chelates generally are more efficient than low solubility salts. The order of effectiveness of the various Zn carriers is as follows: Zn-DTPA > Zn-EDTA > Zn-fulvate > Zn-citrate > $ZnSO_4$ > ZnO > Zn frits.

- High phosphorus levels in rice soils induce Zn deficiency by immobilizing Zn in the roots. Avoid mixing phosphate fertilizer with Zn compounds in one application to rice.

- Crop response to Zn application is modified to a large extent by the environment. Zinc deficiency symptoms in rice can be acute in cold weather while mild or absent in warm weather. The response of rice to Zn application decreases with an increase in soil temperature.

- Though the rice plant requires only 300 grams of Zn to produce a ton of grain yield, a deficiency in zinc nutrition will result in low yield (<4 tons/hectare) no matter how much nitrogen, phosphorus, and potassium fertilizer is applied. Results of our field experiments in Zn-deficient soils have shown that an increase of 0.5 t/ha to more than 1.0 t/ha is obtained with application of $ZnSO_4$ or ZnO even without NPK fertilization. Combining $ZnSO_4$ fertilizer with NPK fertilizer will improve fertilizer use efficiency in Zn-deficient lowland soils.

Procedure for dipping the roots of seedlings

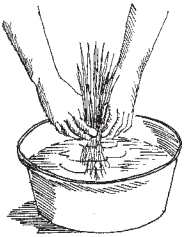
1.

Dissolve 1kg of ZnO or 2kg $ZnSO_4$ in 50 L of water to prepare a 2% ZnO suspension or 4% $ZnSO_4$ solution. Two and a half 19 L kerosene-cans of water can be sufficient to dip the seedlings needed for planting a hectare.

2.

Wash the roots of the uprooted seedlings until free of mud.
Drain the water completely.

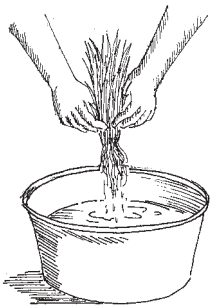
3.



Dip the washed seedlings in the ZnO suspension or $ZnSO_4$ solution and work up and down into the basin, stirring the suspension throughly.

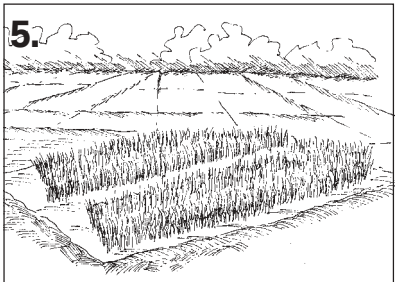
CAUTION: Before placing the seedlings in the basin, the bundle must be untied so the Zn suspension will reach all the roots. The roots must be drenched with ZnO suspension or $ZnSO_4$. A white deposit on the roots is an indication of proper dipping.

4.



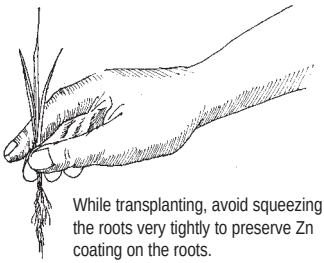
After dipping, drain the excess solution from the roots back into the basin.

5.



After dipping, put the seedlings on banana leaves or a plastic sheet or other containers to avoid removal of Zn coating. Do not place the Zn-coated seedlings directly on the paddy with water.

6.



While transplanting, avoid squeezing the roots very tightly to preserve Zn coating on the roots.

List of FPA-registered zinc fertilizers

Fully Registered

Product Name	Guaranteed Analysis	Company
Zinc sulfate	Zn=22.5%, S=11.95%	Agrikultura Pilipina Inc.
Rhizocote Micronutrient	Zn=4%, Cu=1.8%, **Fe=1.5%, B=0.2%,** Mn=4%	Biofield Industries Inc.
Wokozim	N=5.35%, Fe=0.10%, Cu=0.04%, Mn=0.17%, Zn=1.68%	Biostadt Mktg. Corp.
Maxigrain Liquid Fertilizer	N=5.35%, Zn=0.0105%, Cu=0.02%, Mn=0.013%, Fe=0.0402%	Biostadt Mktg. Corp.
Agro Planters Zinc Sulfate	Zn=20%	Everland Agriculture Corp.
Zinc Sulfate Heptahydrate	Zn=22%	FCX International Inc.
Zinc Sulfate Pentahydrate	Zn=18%	Ferchemx Corporation
Zinc Sulfate Heptahydrate	Zn=22%	Fercom Marketing
Zinc Sulfate Heptahydrate	Zn=22%	Fertiphil Corporation
Biozome Micronutrient Fertilizer	S=14.75%, Mg=3.45%, Mn=3.3%, ZN=4.5%, Cu=1%, B=0.5%, Fe=1%, Mo=0.05%, Co=0.03%	Manchem Industries Inc.
Harbest Foliar Fertilizer	N=0.17%, P_2O_5=0.2%, K_2O=0.18%, CaO=63.7%, MgO=0.72%, Zn=17.5 ppm, Cu=26 ppm, Mn=43.75 ppm	Maphris Enterprises
Zinc Sulfate Monohydrate	Zn=43.5%	McMai Cebu Trading Corp.
Zinc Sulfate Heptahydrate	20-22% $ZnSO_4.7H_2O$	McMai Cebu Trading Corp.
Noble Zinc Sulfate Heptahydrate	Zn=20%	Noble Mercantile & Devt. Corp.
Micromix Zinc Granular	Zn=15.5%	Sagrex
Liquid Chelate Zinc with Sulfur	Zn=10%, S=5%	Southern Agro Export Corp.
Micromate PV Mix	Cu=0.25%, B=0.2%, Ca=9%, Mg=6%, S=5.5%, Zn=3%, Fe=2%, Mn=1%	Stoller Phil. Inc.
Zinc Sulfate Heptahydrate	Zn=22%	Sytengco Enterprises
Complete Zinc Metallate	Zn=1.48%	Tillermate Enterprises
Nutraphos Super K	7-11-33 + Zn=0.12	Zagro Corporation (Zuellig Agrochem Corp)
Zobra Spray ZKP	0-16-9 + Zn=1%	Zagro Corporation (Zuellig Agrochem Corp)

Provisionally Registered

Product Name	Guaranteed Analysis	Company
Micnelf	Cu=1.5%, Zn=6%, Fe=4%, Mo= 0.1%, Mn=3.8%, B=2.4%	Sigma Trade Resources Phils. Inc.
Kiecite	Cu=0.5%, Zn=3.5%, Fe=2%, Mo=0.1%, Mn=2%, B=0.5%	Sigma Trade Resources Phils. Inc.
Boracol	Ca=3.5%, B=1.2%, Mg=4%, Mn=1.5%, Zn=3%, S=9.6%	Sigma Trade Resources Phils. Inc.
Liquid Chelate Calcium Zinc	Ca=5%, Zn=3%	Southern Agro Export Corporation
Growplus Micronutrient	S=14%, Zn=5.72%, Mn=2.14%, Fe=0.85%, Mo=0.14%, Mg=3%, Cu=1.75%, Co=0.07%, B=0.5%	Zyme Industries Inc.

Abbreviations

$CaCO_3$	-	calcium carbonate (calcitic lime)
DTPA	-	diethylenetriamine-pentaacetic acid
EDTA	-	ethylenediamine-tetraacetic acid
HCl	-	hydrochloric acid (muriatic acid)
N	-	nitrogen
P	-	phosphorus
K	-	potassium
L	-	liter
mL	-	milliliter
mg	-	milligram
g	-	gram
ha	-	hectare
t	-	ton
Zn	-	zinc
ZnO	-	zinc oxide
$ZnSO_4$	-	zinc sulfate
$ZnCO_3$	-	zinc carbonate
$Zn_3(PO_4)_2$	-	zinc phosphate

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DA-PhilRice

The Philippine Rice Research Institute (PhilRice) is a government corporation attached to the Department of Agriculture (DA). Executive Order 1061 approved on November 5, 1985 and amended by EO 60 dated Nov. 7, 1986, created PhilRice to help develop high-yielding technologies so that farmers can produce enough rice for all Filipinos. PhilRice accomplishes this mission through research, technology promotion, and policy advocacy, which are implemented through a network that includes 57 agencies and 108 seed centers strategically located nationwide.

Its interdisciplinary programs include the following: (1) direct-seeded and (2) transplanted irrigated lowland rice; (3) hybrid rice; (4) rice for adverse environments; (5) rice-based farming systems; (6) rice and rice-based products; (7) policy research and advocacy; and (8) technology promotion. With these programs, PhilRice aims to develop and promote technologies that are ecosystem-based, location- and problem-specific, and profitable to the Filipino farmers.

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