

Zinc fertilizer application

in rice crop: Why, when and how

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Zinc deficiency is an important disorder in lowland and aerobic rice. High soil pH drastically reduces zinc availability. Intensive cereal cropping over years also leads to zinc deficiency. The symptoms appear on the second or third leaf from top, at about 2 to 3 weeks after transplanting. Rice leaves develop brown blotches and streaks that may fuse to cover older leaves. Zinc deficiency for prolonged period reduces plant height, tillering and grain yield and in severe cases plants die. Regular consumption of low zinc rice induces stunted growth, improper development, low intelligence and diseases due to low immunity. Zinc deficiency in rice plant can be managed by fertilizer application, water management, soil amendment, crop diversification and organic matter application. Water soluble zinc sulphate can be sprayed on leaves, and zinc oxide can be administered as a root dip for seedlings. Due to its acid-forming properties and abundant sulphur, zinc sulphate is the best solution for sodic soil. To prevent initial loss, zinc fertilizer should be administered early. Foliar treatment throughout boot leaf to blooming is desired to obtain zinc-rich grain or seed.

Keywords: Foliar spray, Seedling root dip, Seed dressing, Soil application, Zinc fertilizers

RICE (*Oryza sativa* L.) is one of the most important cereal crops. About 3.5 billion people depend on rice for 20% of their calorie intake. Approximately 84% of total rice production is used as human food while 64% for wheat and mere 14% for maize. In high rainfall regions of Asia, rice crop account 90% of the food grain production and consumption. Rice is usually grown in areas with dense population. To produce more grain, application rates of nitrogen, phosphorous and potash has been increased led to decline in soil fertility and organic matter with an increase in secondary and micronutrient deficiency. Among the micronutrients, zinc deficiency in soil, plants, animals and human beings is important. The dependence of human beings on low zinc rice-based diet induces stunted growth, improper development, low intelligence, diseases due to low immunity and subsequently death. Globally, zinc deficiency

affects over 30% of the population. Some consider zinc deficiency as the second important factor after nitrogen. However, a survey by International Rice Research Institute revealed that nitrogen is the most important nutrient followed by phosphorus and potassium (joint second) and zinc and sulphur (joint third). Zinc deficiency is problematic in China, Japan, India, Pakistan, Bangladesh, Nepal, Sri Lanka, Philippines, United States of America and Colombia (under lowland) and in the Cerrado of Brazil (under upland).

Role of zinc in plant

Zinc is an essential component of various enzymes responsible for metabolic reactions in plants. Also, it has role in activation of several enzymes. Zinc is involved in auxin metabolism and this hormone is useful for adaptation to abiotic stresses through lateral root development. Indole acetic acid

belonging to auxin group helps in stem elongation. Zinc is involved in protein and carbohydrate metabolism. Also, it is involved in pollen formation and in maintaining the stability of biological membranes. Zinc has role in chlorophyll synthesis, so, in deficient soil, zinc application prolongs the period of plant greenness.

Symptoms of zinc deficiency

Zinc deficiency symptoms are pronounced at early growth stages. Commonly, these appears at about 2 to 3 weeks after transplanting. Zinc is partly immobile in plants. So, the deficiency symptoms appear on the second or third leaves from the top. For testing the deficiency, second or third leaf from the top is selected. Rice leaves develop brown blotches and streaks that may fuse to cover older leaves. Affected plants remain stunted and die in severe cases. This leads to few surviving plants in field. Sometimes, the native zinc



Foliar spray of zinc sulphate at 25 and 50 days after transplanting resulted in greener leaves (left side) as compared to basal soil application at planting (right side)

content in soil is available after the initial stress due to improved soil pH, redox potential and reduced concentration of antagonistic elements (Phosphorous, iron, manganese). In such situations, plants recover, but with reduction in plant height, tiller number and grain yield. Also, there is delay in maturity and increased chaff production. The extent of these adverse effects depends on the period for which the crop was subjected to deficiency. So, zinc fertilizer application should aim for early application so that the crop does not suffer much.



Brown blotches and streaks of zinc deficient rice leaves

Source: https://agritech.tnau.ac.in/agriculture/plant_nutri/rice_zin.html

Soil conditions favourable for zinc deficiency

Zinc deficiency is associated with a wide range of soil conditions, viz. high pH (>7.0), low available zinc, prolonged submergence and low redox potential, high organic

matter and bicarbonate content, high magnesium to calcium ratio, and high available phosphorous. High soil pH is the main factor for widespread zinc deficiency in the calcareous soils of the Indo-Gangetic plains. Availability reduces by 100-fold for each unit increase in pH. Perennial wetness is the major cause for zinc deficiency on peat soils and in coastal saline soils. Upland aerobic soils also attract zinc deficiency due to low solubility and transportation to roots. With the increased importance of water saving, dry direct seeded rice and aerobic rice are getting importance. In such situations, zinc management is important. Continuous cereal-cereal cropping system receiving high inorganic fertilizer promotes deficiency. Also, sandy soils are inherently low in zinc content whereas clayey soils are rich.

Strategies for mitigating zinc deficiency

Avoid cereal-cereal cropping system: Unfortunately, intensive cereal-cereal cropping systems such as rice-wheat, maize-wheat, millets-wheat, rice-rice and rice-maize are practiced to produce more food grains. Zinc deficiency is widespread in such systems due to huge uptake in straw besides grain. In rice-rice cropping system, the top 15–20 cm soil above the plough pan provide nutrients including zinc to crop. This top soil is exhausted of zinc after few years. Crop diversification involving

deep rooted crops help in nutrient recycling from deeper layers.

Avoid excessive reduced or oxidized soil condition: Highly reduced soil condition increases the concentrations of iron, manganese, aluminium and phosphorous. These nutrients in high concentration interfere in zinc uptake due to antagonistic relation. Similarly, under highly oxidized soil condition as in aerobic rice, zinc solubility and transportation is adversely affected. Zinc is basically immobile in soil. This property is further aggravated in deficit soil moisture condition. This leads to zinc deficiency in plants. Such plants have yellow leaves, short plant height, less tillers and low grain, and straw yield. Continuous growing of aerobic rice is highly prone to zinc deficiency and this can be managed by supplementing with zinc fertilizer and organic amendment.

Avoid removal of surface soil: Surface soil is sometimes removed to make field bunds and for other uses. Surface soils are rich in organic matter, macro and micronutrients. Macronutrients, especially nitrogen, phosphorus and potash are supplemented with high analysis chemical fertilizer application. Secondary and micronutrients are usually applied based on site specific soil testing. Such testing is not widely practiced and often zinc fertilizer application is ignored. So, when surface soil is removed zinc fertilizer supplementation along with organic matter is required in addition to macronutrients.

Land levelling: Land levelling is useful in easy water and weed management. This also helps in improving zinc availability in soil and plant nutrition. Easy weed management also helps in reducing zinc uptake by weeds.

Soil amelioration: In sodic soil, zinc is converted to insoluble zinc hydroxide and there by its uptake is greatly reduced. Soil amendment with gypsum improves the soil pH and there by zinc solubility and subsequent uptake by crop. Soil amelioration with organic wastes also improves the zinc availability in soil.

Table 1. Zinc content in crop residues vis-a-vis grain as compiled from different publications

Crop	Zn content in straw (mg/kg)	Zn content in grain (mg/kg)	Source
Rice	124.8	34.3	International Journal of Plant and Soil Science 18(1): 1–6
Wheat	22.2–31.8	20.9–27.5	International Journal of Current Microbiology and Applied Sciences 8(2): 1977–88
Maize	15.7–25.4	14.9–36.2	Plant and Soil 372: 81–92

Green manuring: Use of green manures such as sunhemp in upland rice and *Sesbania* in lowland rice supplements about 50 kg N, 10 kg P₂O₅ and 20 kg K₂O/ha. It is especially recommended in sodic and saline soils for improving soil pH. This enhances the availability of native zinc. Also, the green manure crops help to translocate subsoil zinc to surface soil through the deep root system. Moreover, the manures including green manures increase earthworm and beneficial microbe population. This promotes the plant availability of zinc.

Recycling of crop residues: Crop residues are generally rich in zinc content as compared to the grains (Table 1). Moreover, the crop residue biomass is higher by two to three times as compared to grain biomass. Thus, zinc uptake by residue is much higher than in the grain. Recycling of crop residues as vermicompost or compost is useful in supplementing macro and micronutrients.

Zinc fertilizer application

Soil application: It is the most common method for zinc fertilizer application through broadcasting or band placement. Broadcasting and then incorporating during the last ploughing is very common. The fertilizers with higher solubility



Seedling root dip in plastic tray
Source: Swati Sucharita, 2022.

(chelated Zn and zinc sulphate) usually help to transport greater amount to the roots as compared with the insoluble sources. However, chelated Zn fertilizers are cost prohibitive. So, zinc sulphate is commonly used (Table 2).

Foliar application: Foliar fertilization in rice is an effective strategy to overcome the deficiency when soil application is not feasible or when crop response is not positive due to soil constraints. The foliar application of zinc sulphate is very common due to cost effectiveness vis-a-vis chelated forms and good efficiency with little technical difficulty vis-a-vis nano zinc.

Seedling root dip: It's a cheaper solution to manage the deficiency. It is suitable for situations with temporary unavailability of native zinc due to antagonistic effect of high phosphorous from basal application and wet puddling of soil. Initial zinc requirement is met from root dip and the latter requirement from soil after the available phosphorous attains equilibrium with the soil particles. In our trial, roots of uprooted seedlings were dipped for 30 minutes in plastic trays.

Seed dressing: Seed dressing with ZnSO₄ or Zn EDTA is useful in alleviating zinc deficiency in direct seeded rice. The rate of seed dressing is about 2.8 g zinc per kg paddy seed.

Table 2. Important zinc fertilizer application methods in rice

Method and rate of zinc application	Amount of zinc fertilizer	Remarks
Soil application of Zinc 2.5 kg/ha	Zinc sulphate heptahydrate (ZnSO ₄ ·7H ₂ O) at 12.5 kg/ha	Suitable for zinc deficient soil with high pH such as sodic soil
Soil application of Zinc at 2.5 kg/ha + Foliar application with 0.1% zinc	Soil application as above + Foliar spray of 0.5% ZnSO ₄ ·7H ₂ O (2500 g in 500 litre water) at 25 DAT	In addition to soil application, foliar spray is useful for problematic soil in which zinc uptake is a constraint
Soil application of Zinc at 5 kg/ha	ZnSO ₄ ·7H ₂ O at 25 kg/ha	Suitable for highly zinc deficient soil with high pH. The method results in higher residual zinc
Soil application of Zinc at 5 kg/ha + Foliar application with 0.1% zinc	ZnSO ₄ ·7H ₂ O at 25 kg/ha + Foliar spray of 0.5% ZnSO ₄ ·7H ₂ O	For highly zinc deficient soil and problematic soils
One Foliar spray with 0.1% Zn at 25 DAT	Foliar spray of 0.5% ZnSO ₄ ·7H ₂ O	For soils with good amount of native zinc, but availability was suppressed temporarily due to high available phosphorous
Two Foliar spray with 0.1% Zn at 25 and 50 DAT	Foliar spray of 0.5% ZnSO ₄ ·7H ₂ O	For soils with the problem of zinc solubility and supply. The method is less expensive. However, each season application is required
Seedling root dip with 2% Zn	2.5% ZnO suspension (500 g ZnO in 20 litres water/ha) and seedling roots were dipped for 30 minutes	The method is less expensive. Useful to overcome zinc deficiency for initial 2 to 3 weeks
Seed dressing with Zinc	2.8 g zinc/kg paddy seed using zinc sulphate or chelated source	As above

Source: Swati Sucharita (2022).

It's a cheaper solution to manage Zn deficiency like seedling root dip.

SUMMARY

At present rice is largely grown in lowlands under transplanted condition with high input of primary nutrients and ponded water. Due to water shortage, aerobic rice is gaining momentum. Both the lowlands and uplands favour zinc deficiency, especially under continuous intensive rice based system. High soil pH aggravates the

problem. Even with hidden hunger, yield reduction up to 20% occurs besides reduction in zinc content in grain. Regular consumption of low zinc rice, in absence of zinc supplementation induces improper development in human beings, especially in children. Sustainable land management practices to mitigate the zinc deficiency includes avoidance of cereal-cereal system, land levelling, proper water management, residue recycling, green manuring and

zinc fertilizer application. This will help in increasing yield and zinc content of grain with a healthy soil-plant-animal-human continuum. Zinc sulphate is an ideal fertilizer considering the cost effectiveness and crop performance. Application of this fertilizer at 25 kg/ha during last ploughing improved B:C ratio and net return from ₹29811/ha to 41163/ha.

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