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THE IMPORTANCE OF ZINC IN PLANT GROWTH – A REVIEW

Komal Rudani, Vishal Patel and Kalavati Prajapati

Department of Microbiology,

HVHP Institute of Post Graduate Studies and research, Kadi

ABSTRACT

Zinc is plant micronutrient which is involved in many physiological functions its inadequate supply will reduce crop yields. Zinc deficiency is the most wide spread micronutrient deficiency problem, almost all crops and calcareous, sandy soils, peat soils, and soils with high phosphorus and silicon are expected to be deficient. The optimal rate of zinc foliar spray for achieving significant grain yield response was in the range from 1.0 to 1.5 kg Zn/ha. The potential damages that low-zinc bioavailability in soil can have for plants, humans, and animals. Zinc may also be incorporated as a component of proteins and other macromolecules. As a component of proteins, zinc acts as a functional, structural, or regulatory cofactor of a large number of enzymes.

Key words: Zinc, bioavailability, Zinc deficiency.

INTRODUCTION

Zinc is an important micronutrient for human beings, animals as well as crops. Zn is an important component of different enzyme catalyzing many metabolic reaction in plants .Zinc also plays a significant role in plant resistance against disease, photosynthesis, cell membrane integrity, protein synthesis, pollen formation and enhance the level of antioxidant enzymes and chlorophyll within plant tissues.(Azhar Hussain 2015) Zinc deficiency not only retards growth and yield of plants, but it also has effect on human beings more than 3 billion people world- wide are suffering Fe and Zn deficiencies, and this condition is particularly widespread in areas where population is heavily dependent on an unvaried diet of cereal based foods.(B.Hafeez 2013) Zn deficiency has become a serious problem affecting nearly half of the world's population. This is actually due to low Zn content of the crop grown in the Zn deficient soils. In India, about 50% of the soils are deficient in zinc and this remains the most important nutritional disorder affecting majority of the crop production. Zinc deficiency is expected to increase from 42% to63% by 2025 due to continuous depletion of soil fertility. (K.Sunitha kumari 2016) Exogenous application of Zn to counter its deficiency in plants in the form of zinc sulphate also gets transformed into unavailable forms like Zn (OH) and Zn (OH_2) depending on the pH of soil.(Beulah Jerlin 2017) Zinc is one of the essential micronutrients required for optimum plant growth and plays a vital role in metabolism. It is required in small but critical concentration for the functioning of several plants physiological functions like photosynthesis and sugar formation, fertility and seed production, growth regulation and disease resistance. (Manu Solanki 2016) As zinc is a limiting factor for crop production, this study on zinc solubilization by bacteria has an immense role in zinc nutrition to plants. Zinc plays an important role in basic cellular functions in all the group of living organisms and is also play important role in human immune system. (Vidyashree D.N 2016)

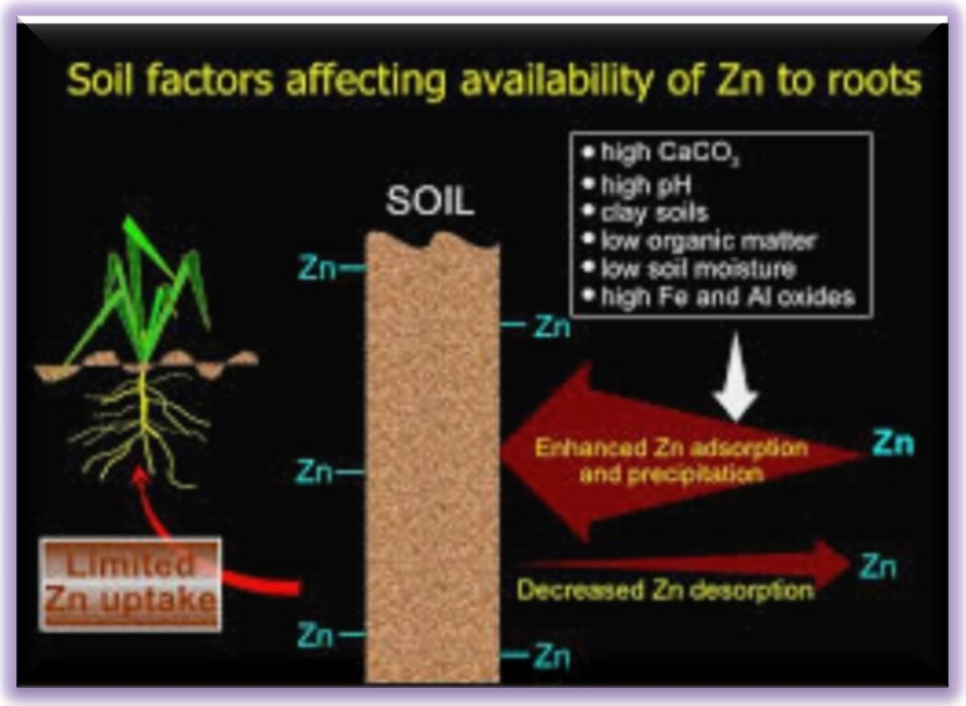
ZINC IN SOIL

Most Nebraska soils contain adequate zinc for crop production; however, areas within fields may not contain enough zinc for normal plant growth. Soil tests for zinc have been developed and should be used where the zinc status of a soil may be in doubt. Soils that have had topsoil removed, are low in organic matter, or contain excess lime are most likely to respond to

zinc fertilizers. Ideally, for healthy and productive soil the concentration of zinc should be 1-200 mg/kg. If the concentration of nickel in your soil is greater than 7400mg kg if would be a good idea to test the food grown in your soil and seek expert advice about whether you need to take special corrective action in the levels are high. Low-Zn soil may have low total Zn content (e.g. some leached acidic soil in tropics) or may have relatively large total Zn content, but a plant-available fraction is low because of soil chemistry favoring formation of sparingly soluble Zn complexes (Rengel, 2002a). Soils with low plant-available Zn (incorrectly called Zn-deficient soils because only living organisms can be Zn-deficient) are common in tropical and temperate climates, but are most widespread in regions with the Mediterranean type of climate (Sillanpää and Vlek, 1985).

The amount of zinc and its availability in soil can be affected by:

- **pH**: increased pH decreases zinc inhibits zinc availability.
- **Phosphorus:** high levels of phosphorus decrease zinc availability.
- **Organic matter**: organic matter adds zinc and can increase zinc availability.
- **Nitrogen:** low levels of nitrogen can reduce a plant's ability to zinc.
- **Moisture**: Excessively wet soils reduce the ability of plants to uptake zinc.
- **Copper**: zinc and copper appear to be taken up by plants via the same mechanism so when one is in excess, plants don't absorb enough.
- **Magnesium:** magnesium many assist with the uptake of zinc.
- **Arsenic:** high levels of arsenic can inhibit zinc uptake (K.M. Wade 2017)



Forms of Zinc in Soil:

- **Mineral form:** Zinc exists as Zinc sulphides, Zinc carbonates, and Zinc silicate. On weathering Zn ion released.

  Sphalarite- ZnS

  Smithsonite- $ZnCO_3$

  Willemite- $ZnSiO_4$

  Franklinite-Zn Fe_2O_2

- **Adsorbed form**: Zn is adsorbed on the surface of clays, oxide minerals, carbonate and organic matters.
- **Solution form**: In soil solution Zn exists as Zn ion and Zn (OH)+.
- **Organic complex form**: Zn form stable complex with organic colloids. This form is not readily available to plants.

FUNCTION OF ZINC:

Zinc is essential for much plant function. Some of them are

- Production of auxins, an essential growth hormone
- It activates enzymes in protein synthesis, plus is in the regulation and consumption of sugars.
- It is necessary for starch formation and proper development.
- Zinc influences the rate of seed and stalk mature.
- It is necessary for the formation of chlorophyll and carbohydrates.
- The presence of adequate amount in the tissue the plant to withstand lower air temperatures.
- Zinc is an essential component of the enzymes:
  1. Carbonic anhdrolase.
  2. Alcohol dehydrogenase.
  3. Superoxide dismutase.
  4. Carboxy peptidase.
  5. Aldolase.
  6. RNA polymerase.
- Important in the synthesis of IAA.
- Essential for water uptake.
- Play important role in stabilization of protein.

Physiological function of zinc:

- **Carbohydrate Metabolism:** Zinc exerts an effect on carbohydrate metabolism through its effects on photosynthesis and sugar transformations.

In general, zinc does not affect respiration in plants

(a)Photosynthesis:

A deficiency of zinc can cause a reduction in net photosynthesis by 50%-70% depending on the plant species and the severity of deficiency. This reduced efficiency of photosynthesis could be

due, at least in part, to a reduction in the activity of the enzyme carbonic anhydrase. Zinc is aconstituent of carbonic anhydrase, but the carbonic anhydrase in dicotyledons is a larger molecule and contains more zinc than carbonic anhydrase in monocotyledons (such as the cereals). In general, in C3 plants there is no direct relationship between carbonic anhydrase activity and photosynthetic carbon dioxide assimilation or growth of plants with different zinc nutritional status. Zinc is a constituent of other enzymes involved in photosynthesis, including ribulose 1, 5-biphosphate carboxylase (RuBPC) which has been found to catalyse the initial step of carbon dioxide fixation in photosynthesis and has been found in navy beans, barley, rice and pearl millet.

(b)Sucrose and Starch Formation:

Zinc may play a role in the metabolism of starch because the starch content, activity of the enzyme starch synthetase, and the number of starch grains are all depressed in zinc deficient plants. Zinc deficiency has been shown to increase the concentrations of sugars and starches in the leaves of cabbage, but in the roots of beans carbohydrate concentrations were decreased. The reason for this impaired sucrose transport is not fully understood, but could be due to the role of zinc in the integrity of biomembranes.

- **Protein Metabolism:**

In zinc-deficient bean leaves the concentration of free amino acids was 6.5 times greater than in control but these decreased and the protein content increased after administration of zinc for 48 or 72 hours. Zinc is necessary for the activity of the enzyme RNA polymerase and it protects the ribosomal RNA from attack by the enzyme ribonuclease. The importance of zinc in protein synthesis suggests that relatively high zinc concentrations are required by meristematic tissue where cell division as well as synthesis of nucleic acid and protein is actively taking place. The most fundamental effect of zinc on protein metabolism is through its involvement in the stability and function of genetic material.

- **Membrane Integrity:**

When zinc was resupplied to the plant for at least 12 hours, the leakage decreased. The role of zinc in maintaining the integrity of cellular membranes may involve the structural orientation of macromolecules and the maintenance of ion transport systems. The loss of membrane integrity is considered by some to be the earliest biochemical change caused by zinc deficiency. In addition

to zinc, are also required to maintain the integrity of cell membranes and these include: calcium, phosphorus, boron, and manganese. In experiments with culture solutions containing no zinc, phosphorus accumulated to toxic levels in the oldest.

- **Reproduction:**

  In subterranean clover it was shown that treatment of deficient plants with zinc had a greater- effect on the number of inflorescences and seed yield than on dry matter production or the size of seed. Zinc- deficient wheat has been reported to have developed small anthers and abnormal pollen grains.Showed that zinc deficiency in maize severely retarded the development of tassles, anthers and pollen grains. **(Zinc in Soils and Crop Nutrition** B. J. Alloway 2008)

➢ **Deficiency of Zinc:**

Zinc deficiency occurs when plant growth is limited because the plant cannot take up sufficient quantities of this essential micronutrient from its growing medium. Almost half of the world's cereal crops are grown on zinc deficient soils (Wikipedia zinc deficiency) the symptoms exhibited by plant suffering deficiencies of certain other essential nutrient elements are, in some cases, similar to those of zinc deficiency and may be confused with those of zinc or be seen together with the zinc deficiency symptoms where multiple micronutrient deficiencies occur.

Types of Deficiency Symptoms:

The various different types of symptom are:

a. **Chlorosis:** This is the change of leaf colour from the normal green chlorophyll colour to pale green and yellow, or even white. In many cases in zinc-deficient plants, the chlorosis appears between the ribs in monocotyledons (grains and grasses) and between the veins of dicotyledons (broad leaf) plants and this is referred to as interveinal chlorosis.
b. **Necrotic Spots on Leaves:** these can occur in areas of chlorosis due to the death of the leaf tissue in small concentrated areas
c. **Bronzing of Leaves:** chlorotic areas may turn bronze coloured.
d. **Rosetting of Leaves:** zinc-deficient dicotyledons often have shortend internodes, so leaves are clustered on the stem.

e. **Stunting of Plants:** small plants may occur as a result of reduced growth or because of reduced internode elongation
f. **Dwarf leaves (little leaf):** small leaves that often show chlorosis, necrotic spot or bronzing.
g. **Malformed leaves:** leaves are often narrower wavy margins.

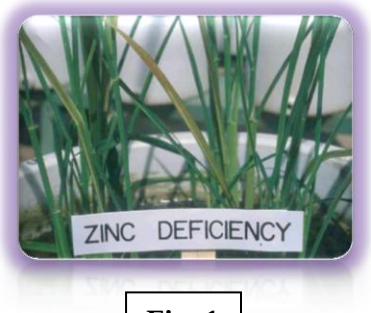


Fig: 1

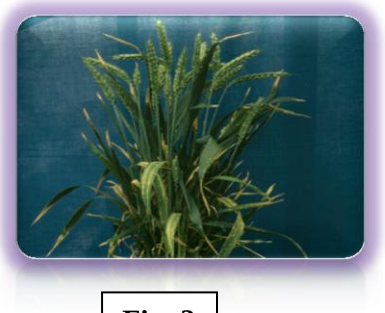


Fig: 2

Fig: 3

Visible symptoms of zinc deficiency in rice include, wilting due to loss of turgidity in the leaves, basal chlorosis of the leaves, delayed development of the plants, "bronzing" of the leaves and, in some ases, death of the rice seedlings (5). Neue *et al.*

Zinc deficiency in wheat reduces grain yield and nutritional quality. Symptoms appear first on young leaves as zinc is relatively immobile under conditions of deficiency. Light green to white chlorotic and necrotic streaks developed on either side of the leaf mid-rib are characteristic of mild deficiency in wheat.
Symptoms of zinc deficiency in maize appear as a yellow striping of the leaves.

Maize is highly susceptible to zinc deficiency. Areas of leaf near the stalk may develop a general white to yellow chlorosis (‘white bud’). In cases of severe deficiency, the plants are stunted due to shortened internodes and the lower leaves show a reddish or yellowish streak about one rhird of the way from the leaf margin.

Conclusion:

Zinc is extremely important in many ways to plant growth as well as productivity. It not only performs the important physiological functions as discussed in the review. Zinc may also be incorporated as a component of proteins and other macromolecules. Zinc plays a key role in stabilizing RNA and DNA structure, in maintaining. The activity of DNA synthesizing enzymes and controlling the activity of RNA degrading enzymes. Zinc deficiency is lead to iron (Fe) deficiency, due to prevent of transfer of Fe from root to shoot in zinc deficiency conditions. Zinc deficiency decreases plant growing by increasing the concentration of boron in the young leaves and tips of the branches. Zinc deficiency has been quite pronounced in various cereals like Wheat, Maize, and Rice as indicated by "bronzing" of the leaves.

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