Zinc

ESSENTIAL ELEMENTS

THE FERTILIZER INSTITUTE

Although Zinc (Zn) is a trace element and only required in very small amounts in the plant, Zn deficiency in crops is widespread around the world. Low Zn content in food crops contributes to Zn deficiency in approximately 30 percent of human diets. With the world population continuing to expand, it is critical that attention be paid to Zn nutrition in food crop production.

Zinc in Plants

Zinc is needed in very small amounts by plants. The normal concentration of Zn in most plants is between 20 to 100 ppm. Removal in the harvested portion of most crops is less than 0.5 lb Zn/A. However, this small amount of Zn plays a key role in plants as an enzyme co-factor and a structural component in proteins. Important biochemical pathways affected by Zn in plants include protein synthesis, hormone regulation and energy production.

Zinc in Soils

The total amount of Zn in soils averages about 50 ppm, ranging from 10 to 300 ppm depending on the geochemical composition and weathering of the parent material. Zinc, like all plant nutrients, must be dissolved in water before it can be taken up by roots. Soil solution Zn concentrations are very low, ranging from 2 to 70 ppb. Zinc exists in the soil solution as the divalent cation Zn^{2+}, and its availability for uptake depends on several factors, including the following:

Soil pH – Zn becomes less soluble as soil pH increases due to increased adsorptive capacity by clay minerals, aluminum (Al) and iron (Fe) oxides, and calcium carbonates. Zinc availability can also be reduced under low pH conditions, particularly in coarse-textured, highly weathered soils.

Soil organic matter – Rapidly decomposable organic matter such as manure can increase available Zn by forming soluble organic Zn complexes. Other organic materials found in peat and muck soils can form insoluble complexes resulting in lower Zn concentrations. Generally, low soil organic matter levels are indicative of low Zn availability. Cultural practices such as land leveling or tilling, as well as erosion, can also lead to lower Zn availability by exposing subsoils low in organic matter.

Climatic conditions – Diffusion is the primary mechanism for transporting Zn to plant roots, so any factor that inhibits root development will impair Zn uptake. Climatic factors resulting in reduced Zn uptake include cold, wet soils particularly early in the growing season. Plants may outgrow this early-season deficiency; however, some yield loss may have already occurred. Waterlogged soils can also have lower available Zn levels due to the reduced conditions and subsequent precipitation of insoluble Zn compounds.

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Zinc deficiency in corn.

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Zinc deficiency in barley.

Interaction with other nutrients – The antagonistic effect of other metal cations, especially copper (Cu^{2+}) and Fe^{2+}, can inhibit Zn uptake. High phosphorus (P) can also decrease concentration uptake of Zn. This interaction is most common in soils that are marginally deficient in Zn. The addition of fertilizer P to soils adequate in Zn will not induce a Zn deficiency. Plant physiological factors may also contribute to the onset of Zn deficiency associated with high P levels.

Fertilizing with Zinc

Considering the many soil factors that affect Zn availability to plants, soil testing is the best tool for predicting the need for additional Zn. Visual inspection and plant tissue analysis are also useful diagnostic tools to determine Zn fertilizer needs, but they often only are used after a deficiency has already occured.

Three basic types of compounds used as Zn fertilizers include inorganic mineral compounds, synthetic chelates and natural organic materials. Water solubility is the primary factor governing the performance of Zn fertilizers. Common sources of Zn fertilizers are listed in **Table 1**.

Zinc fertilizer rate recommendations vary regionally and by crop. In general, broadcast applications (typically of zinc sulfate) that raise soil Zn levels to adequate amounts are expected to be effective for 3 to 5 years. Some regions recommend a lower rate if the Zn is to be applied in a concentrated band in the soil. However, these reduced rates are usually anticipated to be added annually as part of a starter blend during planting.

This information was originally developed by the International Plant Nutrition Institute.

Table 1. Common zinc fertilizer sources.fertilizer.

Source	Zn Content, %
Zinc Sulfates (hydrated)	22-36
Zinc Sulfate (basic)	55
Zinc Oxide	50-80
Ammoniated Zinc Complexes	10
Zinc Chelates	6-14
Other Organics (polyflavonoids)	5-10

Foliar Zn applications of 0.5 to 1 lb Zn/A, typically in chelated forms, have been shown to be effective as an in-season fertilization strategy. However, this approach is best utilized as a rescue treatment or as a compliment to a sound soil-based fertility program.

Zinc Deficiency Symptoms

Zinc deficiencies occur in a wide variety of plants when the leaf level drops below 15 ppm. Zinc, like most micronutrients, is mostly immobile in the plant, and deficiency symptoms appear first in the newly emerging leaves.

Frequent symptoms associated with Zn deficiency include:

- Stunted plants
- Light green areas between the veins of new leaves
- Smaller leaves (little leaf)
- Shortened internodes (rosetting)
- Broad white bands on each side of the midrib in corn and grain sorghum (white bud)

Zinc deficiency symptoms are similar to those of manganese (Mn) and Fe in some crops, and a tissue test should be used to confirm the nutrient deficiency.

Crop Response to Zinc

Crops vary in their responsiveness to Zn (**Table 2**). When needed for production of a responsive crop, Zn fertilizer application can result in substantial increases in crop yield (**Tables 3 and 4**).

Table 2. Responsiveness of crops to zinc.

Most Reponse	Medium Response	Least Response
Beans	Barley	Asparagus
Corn	Potatoes	Carrots
Onions	Soybean	Grass
Sorghum	Sudangrass	Oats
Sweet Corn	Sugarbeets	Peas
Citrus	Table Beets	Rye
Rice	Tomatoes	Rye
Peaches	Alfalfa	Celery
Pecans	Clover	Lettuce
Flax	Cotton	Grapes

Table 2. Response of corn to application of zinc in a fertilizer band at planting[1].

Zn applied*, lb/A	Corn yield, bu/A
0	62
0.3	137
1.0	140
3.0	142

*Applied in an 8-20-0 suspension; DTPA-extractable Zn in the soil was 0.3 ppm.

References

1. Rehm, G. and M. Schmitt. 1997. Zinc for crop production. Univ. Minnesota Ext. Publ. FO-00720-GO.
2. Slaton, N.A. et al. Soil Sci. Soc. Am. J. 69:443-452.

Table 4. Response of rice to broadcast and incorporated Zn fertilizer applications[2].

	Site Year 1		Site Year 2		Site Year 3		Site Year 4	
	0 Zn	12 lb Zn/A	0 Zn	12 lb Zn/A	0 Zn	12 lb Zn/A	0 Zn	12 lb Zn/A
Grain yield, t/A	3.2	3.8	3.2	3.6	2.3	2.7	1.3	3.1
Dry matter, lb/A	248	419	693	920	178	527	329	782
Tissue Zn, ppm	15.1	21.0	15.6	23.5	13.9	21.5	12.4	17.9

Data are averaged over four Zn sources including a sulfate, ligosulfate, and two oxy-sulfates.

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