Zinc - Evaluating Needs of Soils and Crops in New Jersey

Fact Sheet FS721



Hickory exhibiting zinc deficiency.



Pecan exhibiting zinc deficiency.

Cooperative Extension

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Function of Zinc in Plants

Zinc functions as a structural component or co-factor for a wide range of enzyme systems that have catalytic or regulatory functions in plant metabolism. Synthesis of growth hormones, pollen formation, starch formation and seed maturation are processes promoted by zinc nutrition. Zinc also plays a role in protein synthesis and regulating gene expression through DNA and RNA metabolism.

Zinc is also an essential trace nutrient for animals and humans. The zinc content of food products is influenced by soil – plant relationships for zinc.

Zinc Deficiency Symptoms

Symptoms common to many crops include:

- light green, yellow, or white areas between the veins of leaves due to a reduced amount of chlorophyll.
- chlorotic striping between veins of leaves.
- shortening of the stem or stalk internodes.
- leaves smaller than normal (little leaf).
- Malformed leaves with wavy edges.
- resetting of terminal leaves.
- reduced fruit bud formation.
- early loss of foliage.
- dieback of twigs.

Plant Tissue Analysis

Tissue analysis is an effective tool to evaluate a plant's zinc nutritional status. Normal plant concentration range is 25 to 150 ppm of zinc in the dry matter. Zinc deficiencies are usually associated with concentrations of less than 20 ppm. Zinc toxicity has been associated with leaf levels exceeding 400 ppm in some plants.

Cultural practices can impact interpretation of leaf tissue analysis. The presence of zinc residues on plants from previous foliar fertilizer applications or from zinc containing pesticides can make leaf tissue analysis difficult or impossible. Leaf tissue phosphorus concentrations should be examined at the same time as zinc because phosphorus tends to reduce the physiological activity of zinc.

Soil Analysis

Soil analysis, when used in combination with plant tissue analysis, can be useful to diagnose zinc nutritional problems. The problems may be deficiency or toxicity.

Rutgers Soils Laboratory rates soils tested for zinc as *low, adequate or high*. Soils are considered to have adequate levels of zinc when the Mehlich-3 soil test level is between 1.0 to 50 ppm. Soils that test low (<1.0 ppm Zn) may be deficient but will not always to be responsive to zinc fertilization. Other important factors to consider with regards to the zinc soil test levels are soil pH and available phosphorus. The sensitivity of a particular crop to zinc deficiency is also a factor.

Zinc toxicity may be a concern when the soil test level is high (> 50 ppm Zn). *Toxicity has been reported for wheat, azaleas, and bentgrass golf greens when the soil test zinc level was greater than 50 ppm. Do not apply zinc fertilizer to soils rated high for zinc.*

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Factors Affecting Zinc Availability

Zinc nutrition is affected by many factors. The most important are soil pH, available phosphorus, organic matter, and climatic conditions.

Soil pH. Zinc availability decreases as soil pH increases. When soil pH is high, zinc forms insoluble compounds that reduce the available zinc in soils to low levels. Liming acid soils, especially ones low in zinc, will reduce plant uptake of zinc. Therefore, zinc deficiencies can occur at high pH levels of over-limed or calcareous soils. Most pH-induced zinc deficiencies occur within the range of 6.0 to 8.0.

Available Phosphorus. High levels of available soil phosphorus can induce zinc deficiency. This interaction occurs mainly when plants are grown without sufficient zinc. Increasing the phosphorus supply to zinc-deficient plants compounds the problem. The problem can be corrected by ensuring that zinc supplies are adequate and by avoiding the build up of excessive levels of available soil phosphorus. Yield decreases from phosphorus-induced zinc deficiency are most common in over-limed soils.

Soil Organic Matter. The effect of organic matter on zinc availability varies depending on the characteristics and amounts of the organic materials involved. The availability can be enhanced by formation of soluble chelated compounds of zinc. On the other hand, zinc is subject to immobilization by reaction with high-molecular-weight organic substances such as lignin. Zinc deficiencies are common in crops grown on low zinc content organic soils such as peats or muck.

Weather Conditions. Zinc deficiencies are generally most pronounced during cool, wet spring seasons. Visual symptoms may disappear following a period of warm sunny days. Low soil temperatures reduce the availability of zinc to crops. Benefits from zinc fertilization are usually greatest on cold soils.

Soil Texture. Zinc deficiencies are more prevalent in crops on sandy-textured soils than on silty and clay soils. On average, New Jersey coastal plain soils have lower levels of plant available zinc than finer textured soils of Northern New Jersey. A low zinc content in sandy-textured soils often leads to low zinc uptake by plants.

Interactions with Other Micronutrients. Other metal cations, including copper (CU^{+2}), iron (Fe^{+2}), and manganese (Mn^{+2}) can inhibit plant uptake of zinc (Zn^{+2}).

Mycorrhizae. Mycorrhizae can increase the uptake of zinc by many plants. Phosphorus fertilization often suppresses mycorrhizal colonization of plant roots and may result in decreased zinc uptake. Ectomycorrhizal fungi are common in undisturbed soils of native pecan groves. Tillage disturbs the resident fungi in these soils and may induce a zinc deficiency in pecan.

Nitrogen Fertilizer. Nitrogen fertilizers that are acid forming will increase the uptake of both native and applied zinc. Use of acid forming fertilizers may help to enhance zinc availability to young plants. Fertilizers that raise the soil pH depress zinc uptake.

Soil Erosion. Usually much of the available zinc is associated with organic matter and minerals in topsoil. Severe zinc deficiencies often occur in crops grown where surface soil was lost by erosion, land-leveling operations, or terracing.

Mobility and Leaching. Zinc is relatively immobile in most soils. Fertilizer zinc, therefore, should be worked thoroughly and deeply into the soil. Leaching does not result in significant losses of zinc from soil.

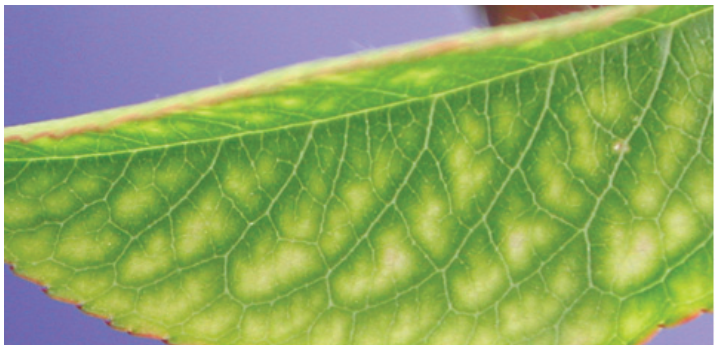
Sensitivity to Zinc Deficiency

Plants vary widely in their susceptibility to zinc deficiencies under conditions conducive to low zinc availability. Corn, for example, is very susceptible to low zinc soils but wheat has a low susceptibility. Fruit trees in general, and peach and pecan in particular, are very susceptible. Sensitivity of various crops to low levels of soil zinc is rated in Table 1.

In tree crops a critical period for zinc nutrition is between budbreak and fruit set. Zinc deficiencies at this stage stunt leaf and shoot growth and may result in abnormal development of pollen tubes and poor fruit set. Because zinc is relatively immobile in plants, a continuous supply of this nutrient is needed throughout the season to prevent reoccurrence of the deficiency. Later in the season, zinc deficiency may be exhibited as small fruit and/or poor color development.

Table 1. Sensitivity of Crops to Low Levels of Available Zinc in Soil

High Sensitivity	Medium Sensitivity	Low Sensitivity
Lima Beans	Alfalfa	Asparagus
Corn	Barley	Carrots
Fruit Trees	Clovers	Forage grasses
Pecan	Potatoes	Oats
Grapes	Sorghum	Peas
Onion	Tomatoes	Peppermint
Pine	Soybeans	Rye
Sudangrass		Wheat


Pecan exhibiting zinc deficiency.

Knowledge of plant sensitivities to zinc deficiency helps to predict the likelihood of the deficiency on a specific soil. In a rotation, for example, zinc deficiency may occur in corn but not in wheat.

Zinc Fertilizers

There are many zinc sources that make suitable fertilizer materials. Sources include inorganic salts, synthetic chelates and natural organic complexes (Table 2). Zinc sulfate, which contains 35.5% zinc, is the most commonly used zinc fertilizer. Zinc oxide is not a recommended fertilizer because the nutrient from this source is poorly available for plant uptake.

A new patented zinc fertilizer formula that has a trade name of NZN consists of zinc nitrate + ammonium nitrate + urea, and has a guaranteed analysis of 5% zinc and 15% nitrogen. This NZN product when used for foliar application claims to be superior for enhancing zinc absorption. Claims are also being made that NZN is less likely to cause foliar burn but without local and specific crop experience caution is warranted.

Micronutrient fertilizers are frequently derived from recycled industrial wastes and are sometimes contaminated with non-nutrient toxic substances. Contamination with heavy metals, lead and cadmium, is especially a concern with zinc fertilizers.

Table 2. Some Sources of Fertilizer Zinc

Source	Formula	% Zn (approx.)
Zinc sulfate monohydrate	$ZnSO_4H2O$	35
Zinc sulfate heptahydrate	$ZnSO_47H_2O$	23
Zinc oxide	ZnO	78
Zinc carbonate	$ZnCO_3$	52
Zinc sulfide	ZnS	67
Zinc phosphate	$Zn_3(PO_4)_2$	51
Zinc chelate	$Na_2ZnEDTA$	14
Zinc polyflavonoid		10
Zinc ligninsulfonate		5
NZN^{tm}		5

In the case of zinc sulfate, a good fertilizer product should contain at least 35.5% Zn and should appear white. Samples of questionable fertilizer products can be collected and tested by the New Jersey Department of Agriculture, P.O. Box 330, Trenton, NJ 08625. Phone: (609)984-2222.

In Washington State, all commercial fertilizer products must be tested and the results posted on the web: agr.wa.gov/PestFert/Fertilizers/default.aspx. Because many of the fertilizers listed are national brands, New Jersey growers can use this information for selecting products with low heavy metal content.

Method and Rate of Application

The methods of providing zinc fertilizers for control or prevention of deficiencies include soil and foliar application. The method and rate of zinc fertilization depend on crop, zinc source, and severity of deficiency. Soil application by broadcast or band placement predominates for field and vegetable crops. Broadcast applications are more effective than band placement for correcting severe zinc deficiencies. Broadcast zinc should be thoroughly mixed with the soil. Zinc can be band placed to increase or maintain soil zinc above a marginal level but may not be an effective treatment to prevent a deficiency on soils very low in zinc. Foliar application is used primarily for tree crops but is also used in emergency situations on other crops. Foliar application in the morning or evening helps to prevent leaf injury.

Broadcast rates for most field and vegetable crops usually range from 3 to 30 lb/A of elemental zinc when inorganic zinc salts are used, and from 1 to 3 lb/A when the zinc source is either a chelate or organic complex. Use lower rates on coarse textured soils and higher rates on fine textured soils. On sandy coastal plain soils, 3 to 10 lb/A elemental zinc is recommended, and

on piedmont soils 10 to 20 lb/A. Corn grown on zinc deficient soils with very high phosphorous levels and pH's near neutral or higher may require up to 30 lb/A of broadcast zinc. In most situations, applications of 10 lb/A of zinc from a soluble source should correct a deficiency for at least 3 to 5 years. Zinc can be applied in combination with other broadcast fertilizers. Zinc chelates are generally not economical for broadcast when high rates of zinc are required.

Zinc can be applied with the starter fertilizer for corn and other row crops at planting time. Apply 4 lb/A on coarse textured soils and 8 lb/A on fine textured soils. For zinc chelates, reduce the rate to 1 to 2 lb/A. The efficiency of banded zinc applications can often be improved by applying it in combination with an acid forming nitrogen fertilizer such as ammonium sulfate.

Zinc deficient soils should be corrected before planting long-term perennials such as vine and tree crops. On low testing soils, recommended rates of zinc for establishing grapes is 20 lb/A, and for tree fruits 100 lb/A. Broadcast zinc should be thoroughly worked into the soil for maximum effectiveness. Soil applications after establishment are only of limited value.

Foliar applications are effective for established tree fruits and grapes if applied at frequent intervals. Zinc can be supplied through sprays applied directly to the leaves, stems, and branches. Dormant orchards can be treated at the rate of 10 to 15 lb/A of elemental zinc applied as a spray of zinc sulfate in 100 gallons of water. Foliar applications of zinc sulfate should only be sprayed during dormancy or postharvest – application during the growing season may cause injury to fruit and foliage

For applications during the growing season, use chelated sources such as EDTA-zinc. (Exercise caution when spraying any formulation of zinc on peach and nectarine trees during the growing season. Zinc and other micronutrients have been implicated in the appearance of skin discoloration or "inking" of peaches.)The recommended rate is generally about 0.5 lb/A of elemental zinc per each application during the growing season, using zinc chelate as the source (follow manufacturer's label for specific rate). Use enough water to completely wet the plants to be treated. A critical spray time for stone fruits is the late dormant period; and for apples and pears, the dormant to silver tip stage. Refer to the *New Jersey Commercial Tree Fruit Production Guide* for more detailed information on zinc for tree crops.

Zinc added to soils accumulates in the surface soil where it is placed. Excessive applications can result in buildup to the extent that toxicity occurs. Therefore, as a precautionary measure, fertilization with zinc at rates much in excess of crop removal should be avoided, except where a deficiency is known to exist or is highly probable. Corn removes 0.18 lb of zinc per 150 bushels of grain and soybean removes only 0.06 lb per 40 bushels of grain.

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