12. ZINC - The Major Minor

It is the opinion of many that after nitrogen, zinc is the most limiting nutrient toward achieving maximum crop yields. More and more zinc deficiencies are being reported - many from areas where zinc deficiency has not previously been reported. New, higher yielding crop varieties and improved fertilization practices of other nutrients, particularly nitrogen, are the major reasons for the increased reports of zinc deficiency; a greater awareness of zinc deficiency on the part of farmers and fieldmen and gradual depletion of soil zinc over the years are other reasons.

On many crops, zinc deficiency is the rule rather than the exception. For example, in the southern San Joaquin valley of California, I have never seen a young, vigorously growing almond orchard that did not show zinc deficiency symptoms.

Crops vary in their sensitivity to zinc deficiency as shown by the following classification:

ZINC DEFICIENCY CLASSIFICATION

Very Sensitive	Somewhat Sensitive	Somewhat Tolerant
tree and vine crops, beans, onions, corn, garlic	cotton, sorghum, tomato	grain crops, lettuce, potato, sugar beets, carrots, safflower, alfalfa

The above classification will undergo modification as more knowledge is gained on zinc nutrition.

Factors Influencing Zinc Deficiency

A number of factors affect the probability of a particular crop developing zinc deficiency. Some of the more important factors are:

1 Soil pH

As soil pH rises above 6.0, zinc availability to plants decreases.

2. Lime content of soil

Lime ties up zinc. Magnesium carbonate is more detrimental than calcium carbonate in this respect.

3. Land leveling

Zinc content of soils decreases with soil depth. Cut areas of soil are very susceptible to zinc deficiency.

4. High amounts of phosphorus

Phosphorus ties up zinc. Heavy phosphorus fertilization can create a zinc deficiency.

5. Organic matter and manure

Zinc is less available in soils with a high organic matter con- tent. Heavy manure applications can create a zinc deficiency - chicken manure is particularly bad in this regard. Historically, some of the first reports of zinc deficiency were from old corral sites.

6. High levels of other metallic elements

Metallic elements compete with each other for entry into the plant. High levels of the other metallic nutrients (copper, iron, manganese) can induce zinc deficiency; a heavy application of iron material can induce a zinc deficiency (and vice versa).

7. Cool, wet soils

Like phosphorus, zinc is less available to plants at cool soil temperatures. Row crops can be zinc deficient early in the growing season, then grow out of it as the weather warms up.

8. Sunlight intensity

Plants are more susceptible to zinc deficiency in bright sunlight. This relationship is believed to be associated with auxin activity.

9. Crop rotation

The previous crop influences the availability of zinc to the present crop. Zinc deficiencies on cotton are common following sugar beets and rare following alfalfa.

Variations in the above factors account for differences in observed crop responses to zinc.

Diagnostic Aids

One or more of three methods given below can be used to diagnose zinc deficiency:

1. Soil Analysis

Soil test levels of zinc can give excellent information on the probability of a particular crop getting zinc deficiency. Soil tests will not precisely predict a crop response (or lack of response) but they are recommended pre-plant for row and field crops. Because soil temperatures influence zinc uptake, an interpretation of soil zinc might be valid at one temperature, but not at another; e.g., a soil zinc level that may be optimum for a warm soil may be too low for a cold soil.

2. Symptoms

Zinc deficient crops usually, but not always, exhibit characteristic deficiency symptoms. The most common symptoms are interveinal chlorosis or mottling of leaves, reduced terminal growth with small leaves and short internodes (reset- ting) and in severe cases, leaf necrosis and growing point dieback. Plants in the seedling stage can be suffering from zinc deficiency but show no other symptoms than a general stunting; when a whole field is generally stunted it is difficult to diagnose a deficiency. Poor early season growth of row crops due to zinc deficiency is often attributed to other causes. Plants can grow out of early season zinc deficiency as the soil warms up, but overall crop maturity will be delayed due to the poor early season start.

3. Plant Analysis

Plant analysis (usually leaf analysis) can provide supportive in- formation when diagnosing zinc deficiency. High zinc levels (over 30 ppm) or very low zinc levels (below 10 pm) can con- firm field observations on zinc status. Unfortunately most zinc levels of plant tissue fall in the gray area between deficient and sufficient (between 10 to 25 ppm) and no conclusions can be drawn. I have seen orchards that I have known were zinc deficient, that showed zinc deficiency symptoms and that responded to zinc application yet the leaf levels of zinc were well above 20 ppm.

Although the above 3 methods are useful in diagnosing zinc deficiencies, the only definitive method is to see if a crop response can be obtained by the addition of zinc.

Zinc Application

Zinc may be applied to the soil (the usual method for row crops) or as a foliar spray (the usual method for tree and vine crops). A variety of zinc materials are available. Material should be selected on the basis of performance and economy. Soil and foliar applications are discussed in the following:

Soil application of zinc

Application of approximately 50 Ibs of 36% dry zinc sulfate or 1 7 gallons of 10% liquid zinc sulfate is a common method of applying zinc to row crop soils in California. One soil application can last up to 5 years or more. Liquid zinc sulfate is probably superior to the dry since widely spaced dry zinc particles do not contact a maximum number of roots.

There are other materials available for soil application - chelates, organic complexes, zinc ammonium nitrate; with the exception of zinc sulfide, all are effective, however zinc sulfate has proven to be the most economical. All inorganic forms of zinc must be incorporated to be effective.

Zinc chelates are expensive, but can be both effective and economical if banded with other fertilizers; banded with phosphorus, chelates offset the depressing effect of phosphorus on zinc uptake. Zinc chelates applied in a small band around young trees can be used to supply zinc to small trees but this practice is not economical for large trees. Zinc chelate is being applied through drippers, apparently satisfactorily, although there is not yet enough solid evidence on this.

Although not usually tried, soil application of zinc sulfate may have merit for mature trees. Mature trees can have many roots in the top foot of soil that can pick up zinc. In a test on pecans on a calcareous soil, zinc sulfate, broadcast and incorporated to a depth of 6" was picked up by the trees; application of sulfur in conjunction with the zinc enhanced zinc uptake. In a walnut orchard, zinc applied in a trench around a tree and irrigated in was found to move 2 to 4 feet downward. The chemical makeup of the irrigation water undoubtedly influences the downward movement of zinc; more downward movement can be expected with a high calcium well water than with a low salt river water.

Foliar application of zinc

Foliar sprays of zinc materials, applied alone or in combination with insecticides, are widely used for both zinc deficiency correction and for zinc nutrition maintenance. A wide variety of zinc materials are used in foliar sprays including zinc oxide, basic zinc sulfate, zinc sulfate + lime (as a safening agent), organic zinc compounds including chelates and safened zinc proprietary materials.

Many of these materials have inherent disadvantages - zinc oxide is of low solubility and may not be as effective as other materials, basic zinc sulfate is not compatible with many insecticides and is relatively expensive, zinc sulfate + lime is not compatible with many insecticides because of the lime, organic zinc compounds and proprietary zinc materials are relatively expensive. Although relatively costly, the chelated zinc materials have given good results.

Straight zinc sulfate foliar sprays have not been widely used in the past because of the possibility of phytotoxicity (leaf and fruit burn). University of California recommendations for nutrient foliar sprays on citrus as recently as 1966 were to add lime or soda ash to all zinc sulfate sprays to safen the zinc. It was later found that a significant safening effect could be obtained without lime simply by cutting back on the amount of zinc sulfate used. It was found that low concentrations of straight zinc sulfate (36%) had the same active zinc concentration in solution as higher rates of zinc sulfate + lime. All the lime was doing was taking some of the zinc out of solution; the same thing could be accomplished by not using as much zinc to start with. Although it is not discussed widely today, the benefit of hindsight shows that the old lime-zinc recommendations were silly, and a waste of both lime and zinc.

There is currently much interest in the use of low concentration zinc sulfate sprays. Such sprays can have the advantage of being both effective and economical. These sprays offer growers two sizeable advantages:

1. lower per acre material cost
2. compatibility with most insecticides; straight zinc sulfate can **increase** the effectiveness of many insecticides by lowering the pH of the spray solution (this effect will also reduce or eliminate the need for buffers in the spray solution with many water sources).

So far, tests with these sprays are very promising. Current recommendations are ¼ lb of 36% zinc sulfate per 100 gals for stone fruits to 1 lb/100 gals for citrus, grapes, walnuts and row crops. Zinc sulfate sprays should not be applied on crops such as lettuce where foliage spotting is detrimental.

If a grower is aware of the potential hazards of leaf burn and fruit spotting, he should be able to use zinc sulfate sprays effectively. Where spotting of fruit is a major concern, the lower rates should be used or test plots only should be tried. Foliage spotting may be unsightly but plants will grow out of it.

The following points should be kept in mind when using zinc sulfate sprays:

1. Material should be accurately mixed to avoid overdosage.
2. Material should be thoroughly dissolved in spray tank. Use of zinc sulfate solution

usually solves this problem.

3. Urea increase the absorption of zinc by leaves. When urea is included in the spray mix, use the lower zinc rates.

4. Zinc sulfate is highly corrosive. Flush equipment thoroughly after use.

5. Spraying in cool or inclement weather or just before a rain increases the burn hazard.

Other inorganic zinc sources at low rates are also being marketed for use as zinc foliar sprays. A zinc nitrate material mixed with a nitrogen fertilizer (sold as N-Z-N) has shown to be superior to zinc sulfate on pecans but further testing is needed with this material; as with zinc sulfate, this material can also cause phytotoxicity.

For any foliar zinc application it is best if the spray wets the foliage thoroughly. Concentrate sprays (20 gals/acre) have been successfully used on citrus with no burn at the rate of 1.7 gals of 10% zinc sulfate or 5 Ibs of 36% zinc sulfate per 20 gals. Aerial spraying has been effective on many crops.

Because of the widespread need for zinc on many crops, growers and fieldmen should attempt to work zinc in with any pesticide sprays that go on during the growing season. If leery about phyto from zinc sulfate sprays, then zinc chelate sprays should be used.

Zinc Toxicity

High soil concentrations of zinc can be toxic to plants. Zinc toxicity is more of a concern on acid soils because of the higher solubility of zinc on acid soils. Soil buildup of zinc from foliar sprays over the years can be significant. Most almond growers put on a fall zinc spray containing roughly 30 Ibs of 36% zinc sulfate. Put this much zinc on every year for a period of 20 years and you are adding a considerable amount of zinc to the soil. On an acid, sandy soil, zinc toxicity on an older almond orchard should not come as a surprise. (Almond growers should pay closer attention to the actual need for zinc rather than apply it routinely as many do).

With the current heavy emphasis on zinc in agriculture care should be taken not to get over zealous with zinc applications. Determine if a need exists before applying zinc.

The antidote for zinc toxicity is the application of lime.

General References

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