Essential Plant Micronutrients

Zinc in Idaho

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Zinc (Zn)—like boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), and molybdenum (Mo)—is a micronutrient necessary for plant growth. Zinc is called a micronutrient because plants require it in lesser amounts than the macronutrients nitrogen (N), phosphorus (P), potassium (K), and sulfur (S).

Zinc has many important roles in plant growth, and a constant and continuous supply is necessary for optimum growth and maximum yields. A lack of zinc has been linked to reduced seed formation. Zinc is needed for a plant's enzyme formation and associated with hormone (indole acetic acid) formation.

Plants take up zinc in the Zn^{++} ionic form. Low levels of zinc in parts of southern Idaho have been found to limit plant growth in beans, corn, onions, and potatoes. In contrast, crops grown in northern Idaho do not often respond to zinc applications. However, as land continues to be intensively cultivated throughout the state, responses to zinc fertilizer are likely to increase.

Soil Deficiencies of Zinc in Idaho

Zinc deficiencies in Idaho are most often associated with soils where the organic matter is low. Consequently, zinc deficiencies in Idaho are most common on soils where the land was leveled for irrigation (Fig. 1). Land-leveling for irrigation scrapes off the surface of soils; thus, the removal of organic matter in the uppermost topsoil by land-leveling can result in zinc deficiencies. Since most irrigated soils on the Snake River Plain were at one time leveled for irrigation, zinc deficiencies are widespread in southern Idaho.

Severe soil erosion can also cause a loss of organic matter accentuating zinc deficiencies. This explains why zinc deficiencies are common on eroded hilltop soils in the Palouse region of northern Idaho; however, hilltops are low yield areas and usually constitute less than 20 percent of fields in the Palouse making fertilizer applications of zinc uneconomical (Fig. 1).

High pH (> 7.0) soils in the Kootenai River Valley of Boundary county also have a tendency to be low in zinc; however, fertilizer responses to zinc applications have not been widely observed.

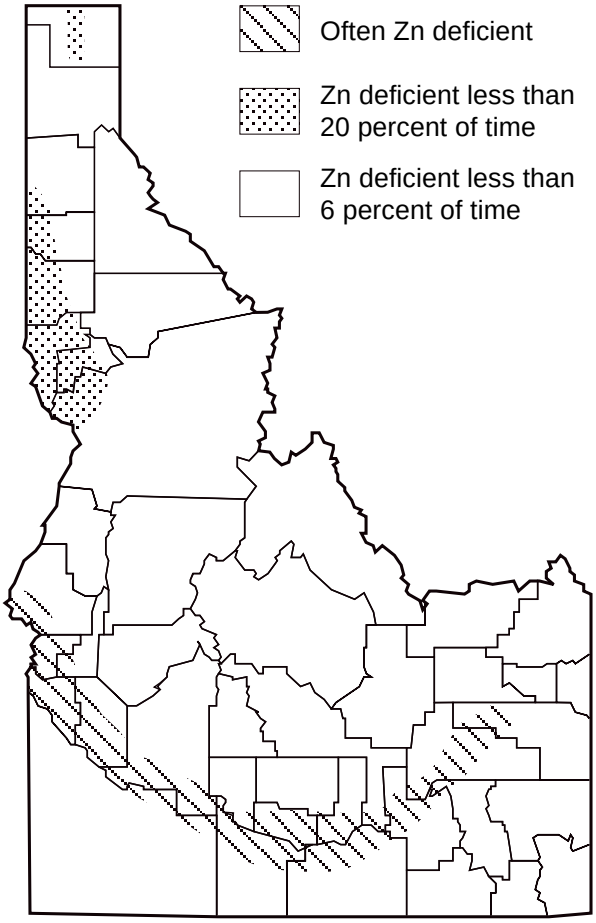

Fig. 1. Areas in Idaho where soils may be deficient in plant-available zinc.

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Crop Response

In soils, zinc availability is associated with the presence of organic matter. Consequently, soils that have not lost significant amounts of organic matter should have sufficient levels of zinc for adequate crop growth.

Conditions that tend to promote zinc deficiencies in plants include:

- loss of soil organic matter
- soils leveled for irrigation
- severe soil erosion
- high pH soils (> 7.5)
- excessive phosphorus fertilizer applications
- cool, wet weather

Zinc Deficiency Symptoms in Plants

When zinc deficiencies in plants can be diagnosed visually an economic loss has probably already occurred. Zinc deficiency in beans and corn usually delays crop maturity. An annual soil analysis can alert you to a potential deficiency of soil zinc before planting. Table 1 shows characteristic zinc deficiency symptoms for crops commonly grown in Idaho. In a plant, zinc deficiency symptoms first appear on the younger leaves. Deficiencies in these younger leaves are shown as chlorosis and bronzing of the plant tissue.

Table 1. Deficiency symptoms of some important Idaho crops.

Crop	Deficiency symptoms
Beans*	Mottling (yellowing) of the interveinal areas of younger leaves; the mottled areas may become gray and die; plants fail to develop to normal size
Corn*	Yellow interveinal striping in the leaves; production of light yellow to almost white bud leaves; early destruction and death of older leaves
Grains (wheat, barley)	Symptoms are indefinite; plant tissue analysis should be used instead of visual analysis
Legumes	In alfalfa and clovers, bronze-colored spots first appear around the margins of the upper leaves; eventually the bronze areas become white and necrotic (dead)
Potatoes** (Russet only)	Affected plants are stunted; young leaves are cupped, rolled inward, and appear smaller than the other leaves; internodes are short
Sugarbeets	General yellowing appears between the veins of younger leaves, progressing to necrotic spots having a silver color in interveinal areas and along leaf margins
Tree fruits	Conspicuous shortening of the internodes toward the tips of shoots and small narrow leaves; with severe cases, older leaves may drop off leaving "rosettes" of leaves at the tips of shoots

* Corn and beans tend to outgrow zinc deficiency symptoms in the Magic Valley beginning about July 20.

** Potatoes (Russets) usually die 2 weeks after symptoms appear.

Alfalfa and Clover—Zinc deficiencies are not common in alfalfa and clover in Idaho; however, a lack of zinc in these crops has been linked to reduced seed production. Zinc deficiencies first appear as bronze-colored specks around the margins of upper leaves. As the deficiency progresses, the bronze spots become white, and the leaves die. Under severe zinc deficiency conditions, the bronze spots will appear across the whole surface of the leaflets.

Beans—Zinc deficiencies are widespread in southern Idaho. Plants deficient in zinc do not develop to normal size. Symptoms usually first appear on the second set of trifoliate leaves or develop on primary leaves on some snap bean varieties. The older leaves may eventually turn gray or brown and die earlier than normal. From a distance, zinc deficient areas in bean fields appear yellowish-brown in color (Fig. 2). Lack of zinc will delay pod maturity and decrease yield, unless the season is long enough for maturity to be attained.

Corn—Zinc deficiency symptoms are easily recognized. In its mildest form, zinc deficiency appears as an interveinal striping in the younger plant leaves (Fig. 3). Mild and even severe deficiency symptoms may disappear as the weather warms up. With a severe deficiency,

Fig. 2. Zinc deficiency on dry beans.

Fig. 3. Zinc deficiency on corn appears as interveinal striping.

broad bands of bleached tissue will appear on the lower half of the plant leaves.

Potatoes—Plants lacking zinc appear to be stunted, with young leaves cupped and rolled inward (sometimes called "fern leaf") (Fig. 4). Grayish-brown irregularly shaped spots will often appear on the older leaves. In advanced cases, the plants may die within 2 weeks.

Tree Fruits—Deficiencies in fruit trees are commonly called "rosette." Symptoms are a distinct shortening of the internodes toward the tips of shoots and small narrow leaves (Fig. 5). The leaves are frequently bent upward.

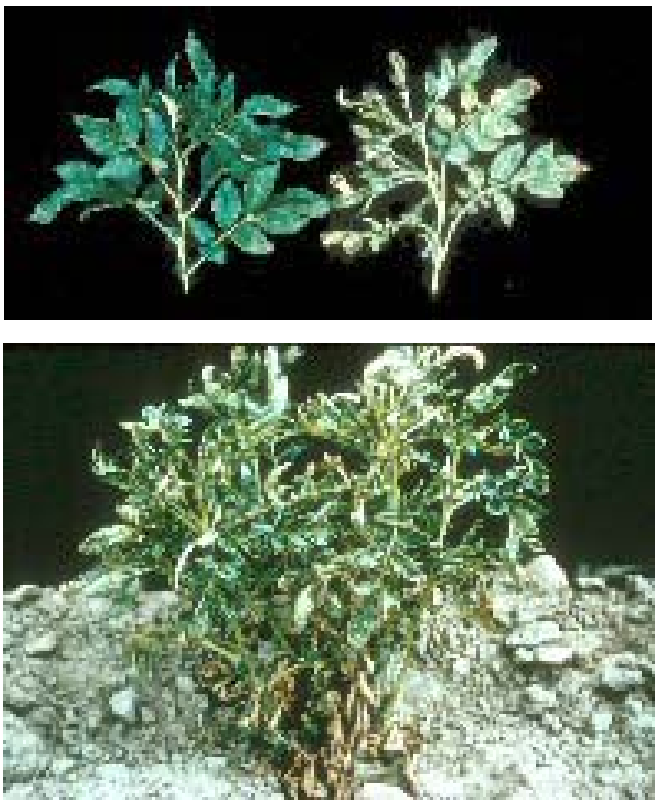

Fig. 4. Healthy potato leaves (top left) compared to zinc-deficient potato leaves (top right). Note how zinc deficiency causes cupped leaves in potato plants (bottom).

Fig. 5. Distinctly shorter internodes and small, narrow leaves are symptoms of zinc deficiency in tree fruits.

Other Crops—Although not common, zinc deficiencies have been observed on onions (Fig. 6) and sugarbeets (Fig. 7) in Idaho.

Correcting Zinc Deficiencies

If you live in an area where zinc deficiency is possible, you should have the soil tested for available zinc. When the soils test less than 0.6 ppm in the surface 12 inches of the soil, addition of fertilizer containing zinc is recommended, especially when growing a crop sensitive to zinc deficiency.

Zinc deficiencies are usually most pronounced on beans, corn, grapes, hops, potatoes, and fruit trees. Crops that seldom show zinc deficiencies include alfalfa, barley, wheat, sugarbeets, mint, peas, lentils, and berries. Most of the zinc fertilizer used in Idaho is applied to soils that have beans and/or corn in the rotation cycle.

Zinc Fertilizer

Several zinc fertilizer materials are commercially available (Table 2). Zinc sulfates and zinc chelates are probably the most common zinc fertilizer materials used in Idaho. The zinc materials can either be added to the soil (broadcast incorporated or banded) or used as a foliar spray.

Fig. 6. Zinc deficiency in onions (left) compared with healthy onion plants.

Fig. 7. Zinc deficiency on sugarbeets.

Table 2. Common zinc fertilizer materials available for use on Idaho crops.

Zinc materials	Chemical formula	% Zinc (Zn)	Rates of Zn per acre		
			3 lb Zn	5 lb Zn	10 lb Zn
			Amount of material to apply (lb/acre)		
Inorganics					
Basic zinc sulfate	$ZnSO_4$ $4Zn(OH)_2$	55	5.5	9.1	18.2
Zinc carbonate	$ZnCO_3$	52	5.8	9.6	19.2
Zinc oxide	ZnO	78	3.8	6.4	12.8
Zinc phosphate	$Zn_3(PO_4)_2$	51	5.9	9.8	19.6
Zinc sulfate heptahydrate	$ZnSO_4$ $7H_2O$	23	13.0	21.7	43.5
Zinc sulfate monohydrate	$ZnSO_4$ H_2O	35	8.6	14.3	28.6
Organics					
Zinc chelates	$Na_2ZnEDTA$	14	21.4	35.7	71.4
	NaZnNTA	13	23.0	38.5	76.9
	NaZnHEDTA	9	33.3	55.5	111.1
	ZnMPP	7-12			

*depends on % Zn

Zinc sulfate is probably the cheapest and most widely used source of zinc fertilizer. Zinc chelates are organic sources of zinc in which the zinc ions are protected by a claw-like chemical ring. This reduces the possibility of zinc being tied-up with phosphates and carbonates in the soils.

Chelated zinc remains mobile, allowing it to move freely in the soil solution for uptake by plant roots. The material is expensive relative to zinc sulfate, though. Zinc chelates can be either soil-incorporated or applied as a foliar spray.

Application Methods and Rates

The three traditional methods of correcting micronutrient deficiencies in the field are by (1) soil application at or before planting, (2) foliar application post-emergence, and (3) application of the micronutrient to the seed at the time of planting. Zinc deficiencies are most commonly corrected by application of the zinc fertilizer to the soil. While foliar applications of zinc are often beneficial, soil applications remain effective much longer. Seed applications of zinc, although successful on some plants, have not been shown to produce a yield response on crops under Idaho growing conditions.

Soil Applications—Soil application of zinc is the most common and generally the most successful method for Idaho crops. Zinc sulfates are the most commonly used inorganic fertilizer materials used in Idaho for soil application. Zinc chelates are the most widely used organic sources. Significant responses to soil-applied zinc (when initial soil test values are low) are often reported for beans and occasionally reported for corn, potatoes, onions, and hops.

Soil-applied zinc fertilizers may be either broadcast and then plowed into the soil (incorporated) or banded. Zinc must be worked into the soil. Banded applications of zinc are acceptable when the band is placed to the side of and below the seed. Banded Zn chelates have often been shown to be more effective than inorganic materials.

When using zinc fertilizer sources, a rate of 5 to 15 pounds of zinc per acre is recommended for crops with a high zinc requirement (beans, corn, onions, potatoes, and hops) while lower application rates of 2 to 5 pounds of zinc per acre may be required for grain crops in zinc deficient soils (Table 3). When using organic soil-applied zinc sources, application rates for high zinc demanding crops drop to 0.25 to 3.0 pounds of zinc per acre; however, these lower rates are adequate only if the fertilizer is perfectly distributed and well mixed into the root zone.

Foliar Treatments—Foliar applications of zinc are commonly used in tree fruits. Foliar-applied zinc can

Table 3. Recommended zinc application rates for crops to be grown in zinc-deficient soils.

Crop	If Idaho soil test reads below*	Amount of zinc to apply per acre
Irrigated alfalfa	0.6 ppm	5 to 10 lb
Dryland alfalfa	0.6 ppm	5 lb
Barley	Has not been shown to respond to zinc applications in Idaho unless land has been leveled	
Beans	0.6 ppm	10 lb
Corn, forage and sweet	0.6 ppm	10 lb
Onions	0.6 ppm	10 lb
Peas and lentils	0.4 ppm	2 to 5 lb
Potatoes	0.6 ppm	10 lb
Sugarbeets	0.6 ppm	10 lb
Dryland wheat	0.4 ppm	2 to 5 lb
Irrigated wheat	0.6 ppm on leveled land	2 to 5 lb
Mint (spearmint, peppermint)	0.6 ppm	10 lb
Fruit trees	0.6 ppm	10 to 15 lb in repeated foliar-applied applications
Hops	0.6 ppm	20 to 25 lb in new yards; 1 to 3 lb in established yards
Vineyards	0.6 ppm	20 to 25 lb before planting; 1 to 3 lb foliar-applied in established vineyards
Raspberries and strawberries	0.5 ppm	2 to 5 lb

*For soil samples collected from the surface 12 inches of the soil.

also be used to prevent zinc deficiencies in rapidly growing annual crops. Foliar applications in annual crops is a temporary remedy that should be used for emergencies only.

Success with foliar sprays to correct deficiencies is generally good with most Idaho crops. Exceptions to this are Russet Burbank potatoes that have not responded to foliar zinc. Since zinc is not very mobile in the plant, repeated spraying may be required for new growth. More than one foliar application of zinc during the growing season may be needed to achieve the same effect as 10 pounds of zinc broadcast or banded into the soil before planting. Many crops, though, including corn and beans, usually only require one application of foliar zinc because the plants tend to outgrow the zinc deficiency (warmer temperatures = faster organic matter decomposition = greater Zn soil release) as the season progresses.

Foliar spraying is important for perennial crops such as tree fruits. Foliar application rates of 0.25 to 1.0 pound of zinc per acre should be used. Foliar zinc must be applied before the appearance of deficiency symptoms in order to be completely effective. Lower concentrations are recommended for sensitive crops such as beans to prevent excessive burning or loss of leaves. Annual row crops generally require about 1 pound of foliar-applied zinc per acre. This 1 pound can be divided by the number of times zinc will be sprayed during the season to give the correct rate for each application.

Residual Effects—Recommended applications of 10 pounds per acre of soil-applied zinc last 3 to 5 years for all but very sandy soils low in organic matter. Little residual effect of zinc in the soil is left from foliar applications because of the low rates applied and most of the applied zinc is intercepted by the plant and does not reach the soil.

Soil Analysis and Plant Tissue Testing

Soils should be tested for available zinc three years after a soil application is made and when the fourth-year crop will be high in zinc demand. A soil test for zinc is recommended before every bean crop. If foliar applications with a zinc compound were necessary on a crop the previous year, a soil test is also recommended for zinc.

A good soil test for zinc is available. For sufficient zinc, the soil should test at 0.6 ppm (using DTPA as the soil test extractant) in the upper 12 inches for crops that are readily susceptible to zinc deficiencies.

The zinc status of plants can be monitored throughout the growing season with plant tissue testing. Monitoring zinc levels in high value cash crops can help to prevent severe zinc deficiency symptoms from developing in sensitive crops (Table 4). Be sure you sample the correct plant part at the correct stage of plant growth and get a sample representative of the field. Remember, a tissue or soil analysis can be no better than the quality of the sample taken.

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Table 4. Procedures for sampling Idaho crops for zinc tissue levels.

Crop	Stage of growth	Plant part to sample	# plants to sample	CNR* ppm Zn
Potatoes	Early tuber set, 50 to 60 days after planting	Petiole of most recently mature leaf 4th or 5th from top	20 to 30	10 to 20
Sugarbeets	Beets 2 to 3 inches in diameter; July 15 to 30	Petiole of most recently matured blade	30 to 40	8 to 12
Onions	Bulbs 1 inch in diameter; about July 1	Most recently matured leaves, 3rd or 4th from center	50 to 75	15 to 25
Dry beans	Mid-season bud stage	Youngest mature leaf or whole tops	20 to 30	20 to 25
Alfalfa	1/10 bloom	top 1/2 of shoots	40 to 50	10 to 14
Sweet corn	Silking	1st leaf below primary ear	30 to 50	10 to 15
Grain (wheat, barley, oats)	After heading	Leaves 2nd node below head	50 to 100	20 to 25
Hops	Early bloom	1st leaf sidearms	30 to 50	12 to 20
Mint	Early bloom	1st unbranched stem from top	25 to 60	20 to 25
Fruit trees: apples, cherries, peaches, pears, prunes	Early August	Mid-terminal leaves	50 to 100	15 to 20
Strawberries	August	Recently mature petiole	50 to 75	25 to 50

*CNR — critical nutrient ranges for zinc in plant tissue.

For Further Reading

You may order other publications about micronutrients in soils from the University of Idaho Cooperative Extension System office in your county or Ag Publications, P.O. Box 442240, University of Idaho, Moscow, Idaho 83844-2240, or phone 208/885-7982 or email: cking@uidaho.edu

These and other publications about soils may be seen on the University of Idaho *Resources for Idaho* web site: http://info.ag.uidaho.edu/

BUL 704, *Soil Sampling*, $2.00

CIS 617, *Essential Plant and Animal Micronutrients: Copper in Idaho*, 50¢

CIS 757, *Nitrogen and Phosphorus BMP: Fertilizer Placement*, 50¢

CIS 882, *Long-Term Effects of Lime on Soil pH in Some Acidic Soils in Northern Idaho*, 35¢

CIS 1085, *Essential Plant Micronutrients: Boron in Idaho*, $3.00

CIS 1087, *Essential Plant and Animal Micronutrients: Molybdenum in Idaho*, $1.00

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