University of Idaho
College of Agriculture

Cooperative Extension Service
Agricultural Experiment Station

Current Information Series No. 608

Essential Plant Micronutrients

Boron in Idaho

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Boron (B) — like chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn) — is a micronutrient necessary for plant growth. Micronutrients are so named because plants require them in lesser amounts than nitrogen (N), phosphorus (P), potassium (K) and sulfur (S). Nevertheless, too little or too much boron will reduce plant yield the same as a lack of nitrogen.

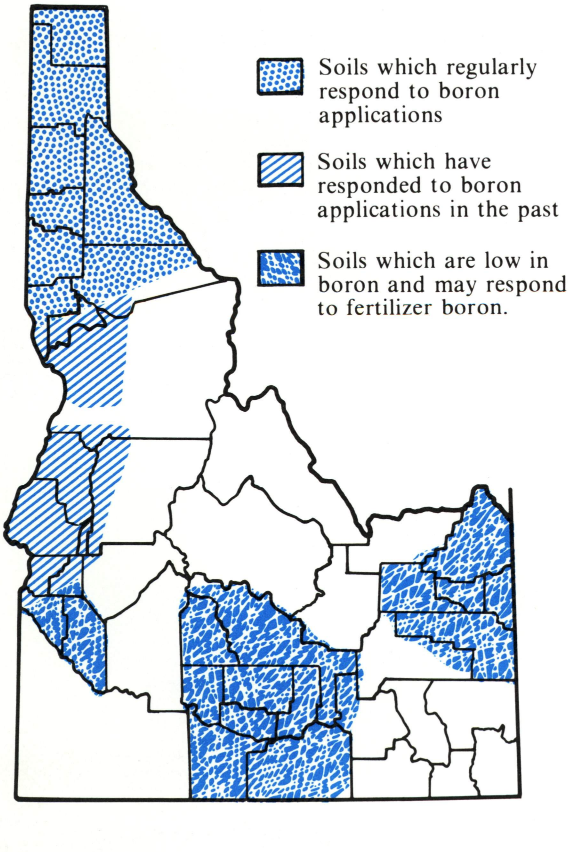

Fig. 1. Areas in Idaho with soils deficient in boron.

Boron regulates transport of sugars through membranes, cell division, cell development and auxin metabolism. Without adequate levels of boron, plants may continue to grow and add new leaves but fail to produce fruits, seeds or other structures that are the foods we eat. A continuous supply of boron is important for adequate plant growth and optimum yields.

Low soil levels of boron have been found to limit plant growth in many parts of Idaho (Fig. 1). Crops grown on northern Idaho soils have been shown to respond to boron fertilizer applications for more than 40 years. More recently several crops north of the Snake River in southern Idaho have also been shown responsive. As land continues to be intensively cultivated in other areas of southern Idaho, responses to boron fertilizer will increase.

Factors Affecting Crop Response

Coarse textured soils (sands, loamy sands, sandy loams) which are low in organic matter are often low in available boron. Boron deficiencies are especially pronounced in high rainfall areas (greater than 25 inches) where boron may have been leached from the soil profile. Overirrigation will cause the same results.

The availability of boron in the soil is pH dependent. Maximum boron availability occurs between soil pH 5 and 7. Most soils in northern Idaho fall into this range; however, many soils of southern Idaho have pHs above the optimum range for maximum boron availability. Soils in northern Idaho with optimum pHs are often low in available boron because of high crop usage of this element over the past several decades.

Soil moisture and organic matter content are also factors that affect crop response to available soil boron. Boron deficiencies are more prevalent under dry conditions (because of lack of organic matter decomposition) and in soils with less than 2 percent organic matter.

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Fig. 2. Boron deficiency in alfalfa evidenced by yellowed and stunted leaves on plants at right.

Fig. 3. Boron deficiency in sugarbeets seen in leaves of the crown and rotted growing point.

Boron Deficiency Symptoms

Boron deficiencies first appear at the growing point of plants. Growing tips may die, and plant growth fails when no boron is present. When fruits on trees or vegetables are growing rapidly or when tuberous roots of fleshy plants are expanding rapidly, the plants develop a larger amount of meristem tissue to provide for this growth. A lack of adequate boron to the meristem at this time may result in soft or necrotic (dead) spots in the fruit or tuber. Table 1 shows characteristic boron deficiency symptoms for Idaho crops.

Table 1. Boron deficiency symptoms for Idaho crops.

Crop	Symptoms
Alfalfa	Death of terminal bud, rosetting, yellow top, lack of flowering and poor seed set
Clover: crimson, red, white	Poor stands, poor growth and pale color, lack of flowering and poor seed set
Corn	Short, bent cobs, barren ears, blank stalks, poor kernel development
Sugarbeets	Yellowing or dying of leaves, cracking of leaf midrib, brown discoloration of internal (leaf, root, interveinal leaf) tissue, rotting of crown
Fruit crops	
Apples	Surface pitting of fruit, skin discolored, cracking of fruit, corking
Pears	Blossom blast, surface pitting of fruit, internal corking, bark cankers
Grapes	"Hen and Chick" symptoms, dead main shoots
Strawberries	Pale, chlorotic skin of fruit, cracking of fruit; die back
Vegetables	
Beets	External spotting, cracking and canker of roots
Carrots	Reddening of leaves, splitting of roots
Lettuce	Stunted growth, discoloration of leaves, brittle leaves
Turnips	Hollow center or brown heart, watery areas
Tomatoes	Thickened leaves, brittle leaves, fruit fails to set

Note: Boron deficiency symptoms are rarely observed in beans and/or cereals.

- **Alfalfa.** Boron deficiency in alfalfa in its mildest form goes unrecognized because it occurs as a reduction in flowering and seed set. Such mild deficiency reflects a decrease in seed yield but is seldom detectable in hay yields from any single cutting. However, reduced flowering may delay cutting and thus result in poorer quality hay.

Boron deficiencies in alfalfa are commonly mistaken for drought damage. Without sufficient boron, the youngest leaves of the plant become chlorotic. The upper portion of the plant becomes yellow or red in color (often called "alfalfa yellows" which should not be mistaken with the alfalfa virus disease) while the lower, older leaves remain green and healthy. As the deficiency progresses, the internodes of the young top growth become increasingly shorter until the plant assumes a rosette (circular cluster of leaves and other plant parts) appearance (Fig. 2). At this stage, the growing tip may become dormant or die.

- **Sugarbeets.** The first symptoms occur in the crown's young, center leaves. The young leaves will appear smaller and chlorotic, and the petioles tend to be brittle. Eventually, the petioles will become severely cracked, and the young leaves will die. The growing point of the crown may die and rot (Fig. 3).

- **Tree Fruits.** Variable boron deficiency symptoms occur on tree fruits. In apples, the fruit becomes corky, and the skin may die; wounds or greenish round spots occur on the fruit. Other types of fruit trees may show symptoms such as cracked fruit, blossom blast (failure of flowers to open, or failure of fruit or seeds to mature), chlorotic fruit skins and surface pitting of the fruit (Fig. 4).

Soil Analysis and Plant Tissue Sampling

Soils should be tested for available boron 3 years after a soil application of boron was made and when the 4th year crop will be alfalfa or a root crop. If an annual row crop was sprayed with boron the previous year, a boron soil test is needed for the next crop.

Deficiencies can be most easily avoided by frequently (every other year) having a soil analyzed for available

Photos courtesy o

boron. A good soil test for boron is available in Idaho. A soil test level of 0.5 ppm is sufficient for susceptible crops while a soil test level of 0.3 ppm is sufficient for low boron requiring crops.

The boron status of plants can be monitored throughout the growing season through the use of plant tissue testing. Monitoring boron levels in high-value cash crops can help to prevent severe boron nutrient deficiency symptoms from developing. Table 2 lists the plant parts and stages of plant growth to sample for boron tissue analysis for major Idaho crops. Care should be taken to sample the correct plant part at the correct stage of plant growth and to get a sample representative of the field.

Detection of Boron Problems

Boron deficiencies most often occur in northern Idaho, although some soils found north of the Snake River in southern Idaho are also often low in boron (Fig. 1). If you suspect a possible boron deficiency, have the soil tested for available boron. When soils test less than 0.5 ppm boron, addition of a fertilizer containing boron is recommended.

Plants belonging to the grass (cereals, corn) family generally need less boron than other crops. They usually require only about 25 percent as much boron for normal growth as do dicotyledons (beans, potatoes, tomatoes, sugarbeets). Boron deficiencies are usually most pronounced on alfalfa and on certain root and cruciferous crops (sugarbeets, cabbage, cauliflower, rutabagas and turnips). More boron fertilizer is used on alfalfa than any other crop in Idaho.

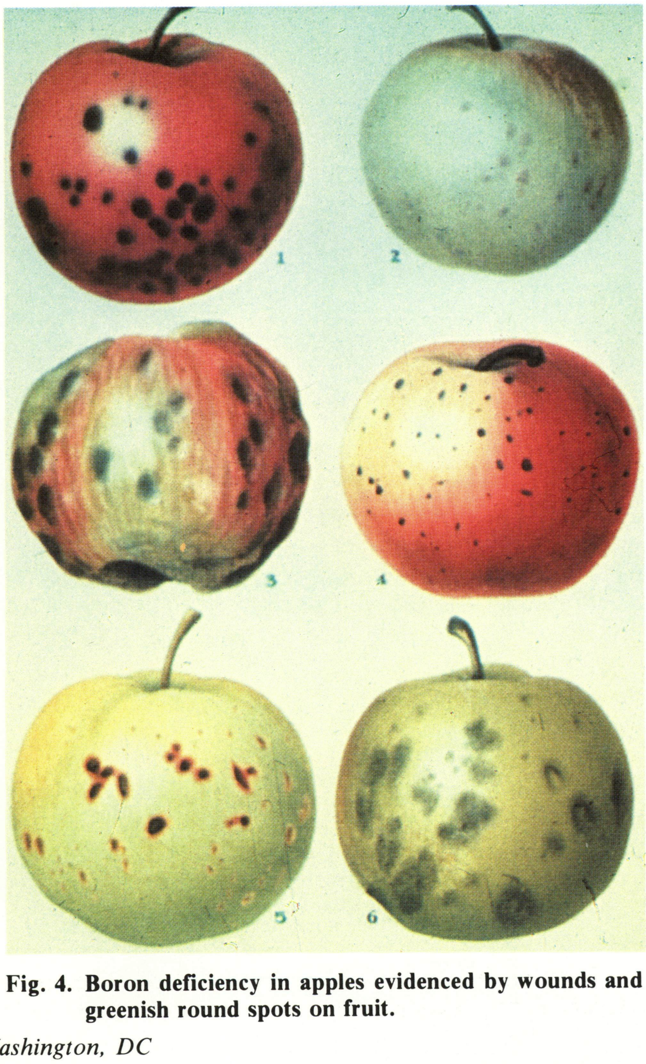

Fig. 4. Boron deficiency in apples evidenced by wounds and greenish round spots on fruit.

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Boron Fertilizer

Several fertilizer sources of boron are available for use in Idaho (Table 3). Borax and borated gypsum are probably the most commonly used boron fertilizers in Idaho. Both sources of boron are generally applied to the soil. Boric acid (H_3BO_3) is a versatile boron source that can be used either for soil or foliar application. Solubor is a common boron fertilizer applied as a foliar spray to plants to correct deficiencies as they occur during the season.

Methods and Application Rates

The three principal methods of correcting micronutrient deficiencies in the field are by (1) soil application, (2) foliar application of the micronutrient to the plant and (3) by application of the nutrient to the seed at the time of planting. Boron deficiencies are most commonly corrected by applying boron fertilizer to the soil. While foliar sprays of boron compounds are often beneficial, soil applications remain effective much longer. Most boron compounds used in foliar sprays can be mixed with other liquid fertilizers for applications to the soil. Seed applications of boron have not produced positive growth responses.

• **Soil Treatments.** A fertilizer rate of 2 to 4 pounds of boron per acre is needed for soil treatments on certain legumes and root crops. Lower rates (½ to 1½ lb per acre) are needed for other crops. Applying boron to the soil is the most efficient way of meeting the nutritional needs of most Idaho crops. Significant responses to soil-applied boron are usually reported for alfalfa. Boron fertilizer is usually broadcast as borated gypsum on the soil and plowed or disked in before seedbed preparation to prevent toxicity problems rather than banding.

• **Foliar Treatments.** Foliar boron applications are commonly used on perennial tree fruits. Foliar boron is compatible and can be mixed with many pesticide sprays. Foliar boron application rates of 0.3 to 0.9 pounds per acre are sufficient for most tree fruits. Foliar boron can also be used to prevent boron deficiencies in rapidly growing annual crops.

Foliar applications must be made several times during the growing season because boron is not mobile in the plant. As new growth appears, repeated spraying is required to get boron into the new growth. Five to seven foliar applications of boron over the growing season are required to get the same plant yield effects as 2 pounds of boron broadcast and incorporated into the soil before planting.

Because of the high cost of repeated applications, foliar spraying of row crops should be used only when boron is essential. Annual row crops generally require about 1 pound of boron per acre. The 1 pound can be divided by the number of times boron will be sprayed over the season to give the correct rate for each application.

• **Residual Effects.** Boron persistence in soils is largely determined by the soil type and the form of boron

Table 2. Procedures for sampling Idaho crops for boron tissue levels.

Crop	Stage of growth	Plant part to sample	No. of plants to sample	CNR*
Field crops				
Alfalfa	before or at 1/10 bloom stage	Upper 3 to 4 inches	40 to 50	20 to 30 ppm
Clover and other forage legumes	before bloom	mature leaf blades taken about 1/3 of the way down from top of the plant	40 to 50	20 to 30 ppm
Sugarbeets	early to mid-season	fully expanded and mature leaves midway between the younger center leaves and the oldest leaf whorl on the outside	30 to 40	20 to 40 ppm
Fruit crops				
Apples, apricots, peaches, pears, cherries	mid-season	leaves near base of current year's growth or from spurs	50 to 100	20 to 25 ppm
Strawberries	mid-season	youngest fully expanded mature leaves	50 to 75	20 to 30 ppm
Vegetable crops				
Root crops (carrots, onions, beets, etc.)	before root or bulb enlargement	center mature leaves	20 to 30	30 to 60 ppm
Sweet corn	1. before tasseling 2. at tasseling	the entire fully mature leaf below the whorl the entire leaf at the ear node	20 to 30	
Tomatoes	before or during fruit set	1. young plants: leaves adjacent to 2nd and 3rd clusters 2. older plants: leaves from 4th to 6th clusters	20 to 25	

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

Table 3. Boron fertilizer materials available for use on Idaho crops.

Boron material	Chemical formula	% Boron	Rates per acre 0.5 lb B	2 lb B	4 lb B
		(B)		(application of material) (lb)	
Borated gypsum	$CaSO_4\ 2H_2O{+}Na_2B_4O_7$	1	50	200	400
Borax	$Na_2B_4O_7\ 10H_2O$	11.4	4.4	17.6	35.2
Boric acid	H_3BO_3	17	2.9	11.8	23.5
Boron frits	variable	10-17		depends on % B	
Fertilizer Borate 48	$Na_2B_4O_7\ 5H_2O$	14.3	3.5	14	28
Fertilizer Borate 68	$Na_2B_4O_7$	20.2	2.5	9.9	19.8
Solubor	$Na_2B_4O_7\ 5H_2O{+}$ $Na_2B_{10}O_{16}\ 10H_2O$	20.5	2.4	9.8	19.5

applied. Boron will rapidly leach from sandy soils that are overirrigated or that have high rainfall but will persist for several years in soils high in silt and clay. Soil-applied boron will generally result in sufficient soil levels of boron for at least 3 years for all but very sandy soils. Foliar applications leave little soil residual boron since most of the applied boron is taken up by the plant and not the soil.

Boron Toxicity

Boron toxicity can result when plants have taken up too much boron; excessive levels of boron are toxic to plant growth. The best way to avoid boron toxicity problems is through proper management of fertilizer and a crop rotation program. Boron should be applied to the soil at low rates only after a demonstrated need has been established through plant tissue and/or soil testing.

A very narrow range exists between toxicity and deficiency. Plants differ in their sensitivity to excess boron. Beans and peas are extremely sensitive, while alfalfa is relatively tolerant to high boron levels. Amounts of boron commonly applied to alfalfa are toxic to beans. When required, boron should be applied uniformly to a field (broadcast, not banded) at rates not to exceed 4 pounds of boron per acre.

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