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BORON INJURY TO PLANTS

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BORON INJURY TO PLANTS

By L. V. Wilcox, *soil scientist, United States Salinity Laboratory, Soil and Water Conservation Research Division, Agricultural Research Service*

Boron is essential for normal growth of all plants, but the quantity required is extremely small. In some areas, especially where there is abundant rainfall, the soils are low in boron and characteristic boron-deficiency symptoms may develop on many plants. In other areas boron is excessive, and crop injury due to boron toxicity is not uncommon.

Boron has been found in toxic concentrations in the soils of many arid regions of the world. In the United States it is confined almost exclusively to the irrigated area of the West. The total area in which boron toxicity is a problem is not large, but the injury sometimes is very severe.

The purposes of this bulletin are (1) to discuss the nature and source of boron, (2) to describe boron-toxicity symptoms, and (3) to suggest remedies for boron toxicity.

What Is Boron?

Boron is the characteristic element of such well-known substances as boric acid and borax. It never occurs in nature in the free state but always in combination with other elements. In addition to boric acid and borax, many complex minerals contain small amounts of boron. These are the so-called borosilicate minerals. They are widely distributed and found in most soils. They are only sparingly soluble in water and as a result are not leached from the soil by rain. These minerals supply boron to plant roots and are, therefore, the principal source of boron for plants.

The compounds of boron that dissolve in water readily, such as boric acid and borax, are only moderately toxic to humans and animals but are extremely toxic to many plants.

Where Does Excess Boron Come From?

Boron has been found in toxic concentrations in some soils in the virgin state. Occasionally it accumulates in the soil as the result of water evaporating from the soil surface or from a shallow water table. However, the more common source is irrigation water. All natural waters contain boron, though usually in low concentration. Only a few surface streams are contaminated, but a large number of well waters are high in boron. They produce toxic concentrations of boron in the soil, especially under conditions of poor drainage.

One other source of boron toxicity is the accidental application of too much boron in treating boron deficiency. It should be kept in mind that the boron compounds used for this purpose can cause severe injury to crops if applied in excess.

How Does Boron Injure Plants?

Plant roots take up small quantities of boron from the soil solution. This boron is moved to the leaves, where the water is lost by transpiration. It remains in the leaf and tends to accumulate in the tip and margin. As the process continues the boron concentration becomes sufficiently high to be toxic to the leaf tissue. Yellowing or burning results, and finally the tip and margin die. This type of injury is found only on mature leaves, thus differing from boron-deficiency symptoms that appear only on the new growth. Other symptoms of boron toxicity include premature leaf drop, reduced growth, and reduced yield.

Several fruit trees do not show this type of leaf injury, although they are very sensitive to boron injury. They are the stone fruit trees, such as apricot, prune, peach, plum, cherry, and almond, and the pome fruit trees, including apple, pear, and quince. They show little or no discoloration or burning and do not accumulate boron in the leaves, as do other plants, but dieback of twigs and gumming on larger branches may develop in addition to reduced growth and yield.

How Can Boron Injury Be Recognized?

Very characteristic and easily recognized patterns develop on the leaves of many crops as a result of boron injury. They are as follows:

Tip Burn.—The injury starts with yellowing, followed by browning and death of the leaf tip. When the injury is very severe, some marginal burning and yellowing between the veins may occur. This type of injury is found on the leaves of lemon, orange, grapefruit, black walnut, eucalyptus, and other plants (see pl. 1, *A*, *B*, and *C*).

Tip and Marginal Burn.—The cereals and grasses show tip burn and marginal yellowing of the leaf blade back of the tip. These injuries affect such plants as oat, milo, corn, wheat, and barley (see pl. 1, *D*).

Marginal Burn.—Marginal burn occurs on the leaves of many broad-leaved plants. Growth at the margin slows or stops, depending on the

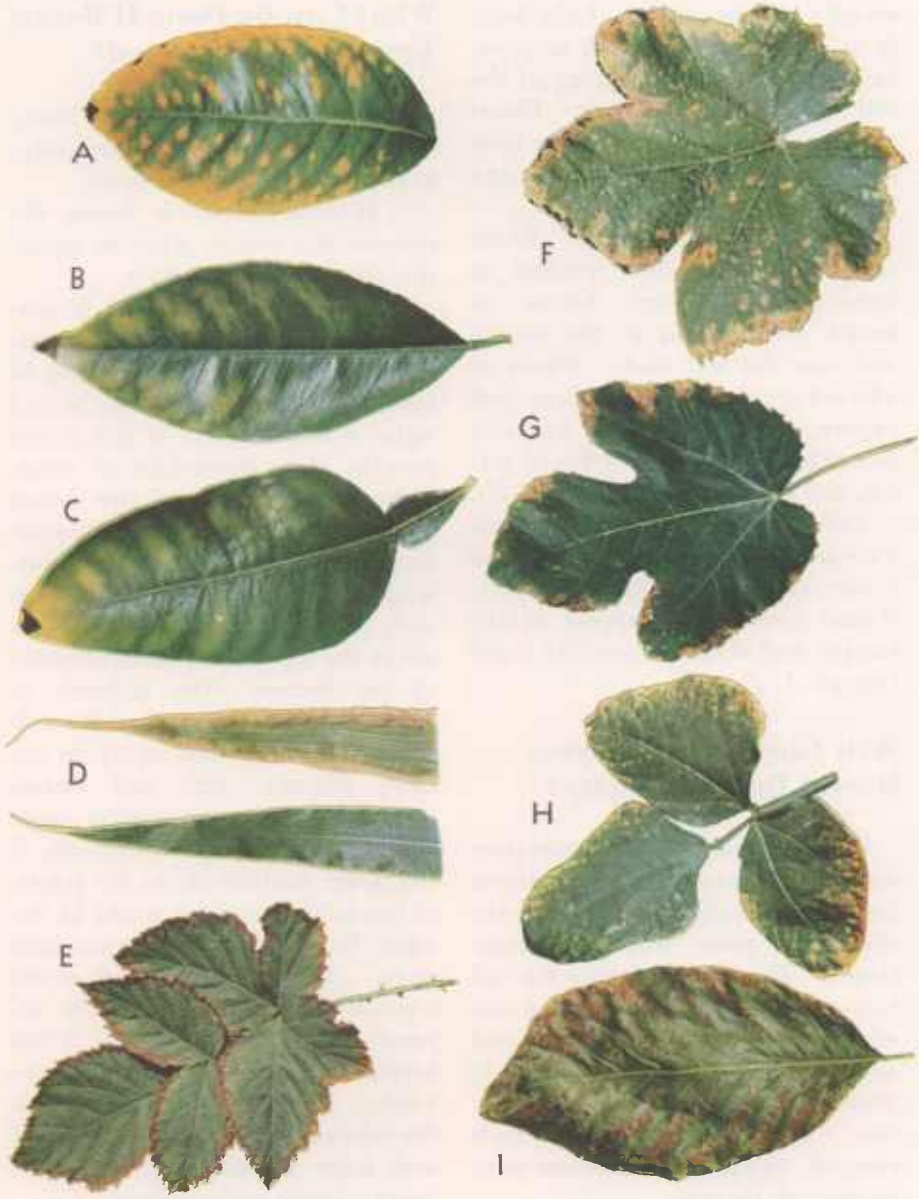

PLATE 1.—Leaves showing boron-injury symptoms. Tip burn: *A*, Lemon; *B*, Valencia orange; *C*, grapefruit. Tip and marginal burn: *D*, Corn. Marginal burn: *E*, Boysenberry. Irregular areas: *F*, Muscat grape; *G*, black fig; *H*, blackeye bean. Yellow or dead areas between veins: *I*, English walnut leaflet.

severity of the injury. Cells back from the margin continue to grow, causing a bulging or cupping of the leaf that is characteristic. Plants that show this type of injury are bush berries, alfalfa, cotton, rose, and violet (see pl. 1, *E*).

Irregular Areas.—Some leaves show no characteristic pattern of boron-toxicity injury. Yellow or brown areas appear at the margin and over the leaf blade. Plants so affected are elm, grape, fig, bean, bell pepper, tomato, potato, avocado, pumpkin, pea, radish, sunflower, turnip, and beet (see pl. 1, *F*, *G*, and *H*).

Yellow or Dead Areas Between Veins.—The English walnut develops a very characteristic type of injury. Round brown spots appear at the margin and then between the veins (see pl. 1, *I*).

Will Chemical Analyses Reveal Boron Toxicity?

Chemical analyses of representative samples of leaves will reveal boron toxicity in most plants, except the stone and pome fruit trees mentioned. The farm adviser or the Soil Conservation Service technician can advise regarding the collection and analysis of samples. The United States Salinity Laboratory, Riverside, Calif., does not analyze such samples, except in connection with its research projects.

With the exception of leaves from the stone and pome fruit trees, mature normal leaves contain from 40 to 100 parts per million of boron. Values below 20 parts are in the deficiency range and values above 250 parts are in the toxicity range.

What Can Be Done If Boron Toxicity Is Suspected?

1. Diagnose the problem. Study the leaf symptoms and, if necessary, have a chemical analysis made.

2. If boron toxicity is found, determine the source, whether irrigation water, soil, or fertilizer.

3. If the irrigation water is contaminated, mix it with another irrigation water of low boron content in such proportion that the mixed water is safe to use. If this is not possible, plant boron-tolerant crops. Table 1 shows the relative boron tolerance of several plants. They are divided into three groups—tolerant, semitolerant, and sensitive. Within each group the more tolerant plants are at the top and the more sensitive at the bottom. The quantity of boron shown at the top of the column may cause some injury to the more tolerant crops and serious injury to the more sensitive crops within that group. For example, if the water analysis shows 2.0 p.p.m. of boron, that amount would be too much for the crops in the sensitive group. The crops at the top of the semitolerant column would be injured slightly, whereas those at the bottom would be injured more severely. Probably all the crops in the tolerant group could be irrigated with water containing 2.0 p.p.m. of boron without serious injury.

4. If the soil is found to be contaminated with boron, reclamation will be necessary, entailing leaching with a large quantity of water. In general, a saline soil that is not contaminated with boron can be leached free from salts to a depth of 4 feet

TABLE 1.—*Limits of boron in irrigation water for crops of different degrees of boron tolerance*

Tolerant	Semitolerant	Sensitive
4.0 p.p.m. of boron	*2.0 p.p.m. of boron*	*1.0 p.p.m. of boron*
Athel (*Tamarix aphylla*)	Sunflower (native)	Pecan
Asparagus	Potato	Walnut (black and Persian, or English)
Palm (*Phoenix canariensis*)	Cotton (Acala and Pima)	Jerusalem-artichoke
Date palm (*P. dactylifera*)	Tomato	Navy bean
Sugar beet	Sweetpea	American elm
Mangel	Radish	Plum
Garden beet	Field pea	Pear
Alfalfa	Ragged-robin rose	Apple
Gladiolus	Olive	Grape (Sultanina and Malaga)
Broadbean	Barley	Kadota fig
Onion	Wheat	Persimmon
Turnip	Corn	Cherry
Cabbage	Milo	Peach
Lettuce	Oat	Apricot
Carrot	Zinnia	Thornless blackberry
	Pumpkin	Orange
	Bell pepper	Avocado
	Sweetpotato	Grapefruit
	Lima bean	Lemon
2.0 p.p.m. of boron	*1.0 p.p.m. of boron*	*0.3 p.p.m. of boron*

by passing a 4-foot depth of water through the soil. If the soil is badly contaminated with boron, an 8- to 12-foot depth of water may be required to remove the boron.

There is no economically feasible method for removing boron from irrigation water. Similarly, there is no chemical or soil amendment that can be added to the soil to render the boron nontoxic. However, under boron-toxicity conditions, crops will grow better and show somewhat less injury if adequately fertilized.

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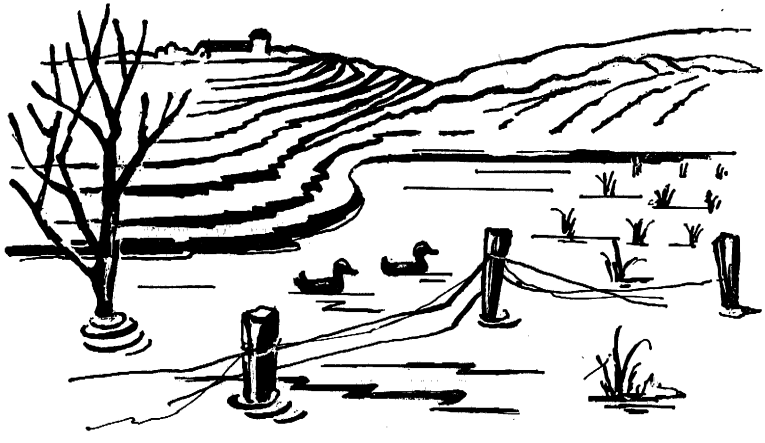

Conserve your soil and water

Develop a farm or ranch conservation plan.

Use each acre within its capability.

Contour, strip crop, or terrace sloping land.

Plant and manage trees as a crop.

Improve range; manage grazing.

Encourage wildlife as useful and profitable crops.

Plant grass on idle land.

Use ponds to impound water.

Improve irrigation or drainage systems.

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