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Boron Research Trial - Final Report

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INTRODUCTIONM

Boron is an essential element for plant growth. Plants without a source of boron will not grow or reproduce normally. The specific role of boron in plants is not clear despite years of study. It has been suggested that boron is required for nucleic acid synthesis, RNA synthesis, membrane function, cell wall formation, and pollen germination. Symptoms of boron deficiency, however, are similar in most plants. Boron deficient plants commonly have abnormal meristematic tissue (active growing points) including shoot tips, root tips and cambium, and abnormal pollen growth and fruit formation.

Boron is present in the soil in the form of insoluble boro-silicate minerals such as tourmaline and in a soluble form as boric acid. Generally less than one percent of the soil boron is in the soluble form. The soluble boron fraction can range from 0.1 to 5 ppm as measured by the hot water extraction method; typical Willamette Valley soils range from 0.1 to 2.0 ppm. In a 1985 survey of 1,600 Willamette Valley soil samples, 40% of the samples were less than 0.5 ppm soluble boron. Boron is often low in soils formed from igneous parent material, low pH soils, and soils in high rainfall areas. Willamette Valley soils are thus often low in available boron. Boron can be leached from the soil, which is an important consideration both in understanding why some soils are low in boron and also for determining an appropriate fertilization program.

BORON IN PLANTS

The method of boron uptake into plants is not well understood and there is evidence for both passive uptake (movement into the plant that follows the flow of water) and active uptake (an energy requiring uptake subject to plant regulation). Movement within the plant is primarily in the xylem stream, thus boron concentration can be related to transpiration rates. Phloem mobility of boron is limited, and as a result remobilization of boron from one area of a plant to another is usually of minor importance. However, a recent study did find significant movement of boron from sprayed leaves to adjacent woody tissue in fruit trees.

Boron deficiency of grapes is common in many of the grape growing areas of the world. Deficiency symptoms are most common in summer during a period of active shoot growth. Initial symptoms occur on the terminal leaves of primary shoots where leaves will become wrinkled or chlorotic. Leaves yellow between the veins and leaf margins may blacken and die (interveinal chlorosis). Leaf symptoms occur first on younger leaves at the shoot tip. Internodes may become shorter and the shoot tip may die. Deficient vines will not set a normal crop and may have straggly clusters with many small seedless berries.

Early-season boron deficiency can occur in grapes following a dry fall. Symptoms include poor bud break and new shoots that do not elongate. Internodes are very short and affected shoots may grow in a zig-zag pattern. These poorly growing shoots form compressed rosettes of leaves. Boron content of these shoots is very low (less than 10 ppm). Vines will usually resume growth later in the season, but lateral shoots, not primary shoots, will produce most of the vine growth. Affected shoots do not normally set a crop.

Boron toxicity is also common in grapevines. Toxicity symptoms on grapes have occurred at concentrations greater than 200 ppm in the affected tissue. Boron toxicity usually arises from excessive application of boron fertilizer or from a high boron content in irrigation water. The narrow window between deficiency and toxicity is the main reason boron nutrition needs to be carefully monitored. Generally, plant analysis labs recommend that growers keep boron concentrations in petioles below 70 ppm to avoid problems with boron toxicity.

EARLY-SEASON BORON DEFICIENCY IN 1988

In 1988, early-season boron deficiency was widespread in the Willamette Valley. Several cultural factors were associated with the occurrence of the disorder. Pinot noir was the most commonly affected variety. Cordon pruned vines were more affected than cane pruned vines. Vines pruned late (late February and March) were less affected than early pruned vines. The most seriously affected vineyards had been stressed for water the previous fall. Petiole boron levels in June (one of the standard methods of evaluating boron status in vines) was not related to the occurrence or severity of early-season boron deficiency symptoms. Yields were reduced in affected vineyards and in the most severe cases there was a complete crop loss.

OSU BORON RESEARCH

In 1988, Oregon State University began a research program to look at boron nutrition in grapevines in response to the widespread occurrence of early-season boron deficiency. The purpose of the study was to evaluate which factors influence boron content of new shoot growth in the spring. Two treatments were chosen for evaluation: late pruning and fall application of a foliar boron spray.

Late pruning was selected because of differences observed between early and late pruning on boron deficiency in 1988 and because of several examples in the literature of boron responses to pruning date. Fall foliar applications of boron were selected based on experiences at OSU with other crops. Fall applications were found to increase fruit set and boron concentrations of flowers in two studies on 'Italian' prune. There are other examples in the literature of the effectiveness of late summer or fall fertilizer applications on raising nutrient concentration of new growth in the spring. It is generally assumed that the initial growth of perennial plants is supported largely by stored nutrients in the plant, not nutrients taken up just prior to or during the first flush of growth.

The experimental design was a two by three factorial with two pruning dates (late December and mid-March) and three spray treatments (none, 1000 ppm actual boron pre-harvest, and 1000 ppm postharvest), for a total of six treatments. The spray rates were equivalent to 4 pounds of Solubor per 100 gal. This is twice the usual recommended rate for spring foliar sprays. These rates sometimes result in foliar burns, but we considered that an acceptable risk for a late season spray. Results from the spray and pruning treatments are summarized in Tables 1 and 2.

Table 1. The effect of boron spray treatments (fall 1988-89) on the boron content (ppm dry weight) of new Pinot noir shoots harvested at 3 cm length and petioles harvested at bloom.

	Control	Preharvest B Spray	Postharvest B Spray	Mean	Standard Error
Shoots 1989	13.3	16.0	22.3	17.2	0.82
Petioles 1989	27.0	26.9	26.9	26.9	0.67
Shoots 1990	36.8	34.8	35.4	35.7	2.14
Petioles 1990	27.6	27.2	28.1	27.6	0.47

Table 2. The effect of pruning date on the boron content (ppm dry weight) of new Pinot noir shoots harvested at 3 cm length and petioles harvested at bloom.

	Early Pruning	Late Pruning	Mean	Standard Error
Shoots 1989	14.8	19.6	17.2	0.67
Petioles 1989	26.6	27.2	26.9	0.55
Shoots 1990	32.8	38.5	35.7	1.75
Petioles 1990	27.9	27.4	27.6	0.43

RESULTS AND DISCUSSION

The study addressed the question "What are the factors that affect boron in new shoots?" Three main points emerged:

1. The main factor influencing the boron content of new shoots was seasonal variability. The non-sprayed control shoots had 13.3 ppm boron in 1989. In 1990 the shoot boron of the control was 36.8 ppm, an increase of 177% (Table 1). The main reason for this large change is most likely fall precipitation. Fall 1988 was quite dry with only 0.87 inches of rain during August, September, and October. Fall 1989 had a more normal precipitation pattern for Oregon with 4.13 inches of rain for the same period. Average precipitation for August, September, and October is 5.64 inches.

2. Fall boron sprays greatly increased boron content of new shoots in 1989 (a low boron year) but had no effect in 1990 (a high boron year) (Table 1). The post-harvest spray was more effective than the pre-harvest spray in 1989, but both the 1989 spray treatments were well below the boron level of the control in 1990.

3. Late pruning increased boron levels in new shoots in both 1989 and 1990 (Table 2). In both years, late pruning increased shoot boron levels about 5 ppm but the percent increase was greater in 1989, the low boron year.

Another point that became apparent in this study was that petiole boron content had little relationship to the boron content of new shoots in the spring. Neither year, spray treatment nor time of pruning had any affect on the boron content of petioles taken at bloom.

GROWER OPTIONS

The widespread occurrence of early-season boron efficiency in Oregon in 1988 had disastrous consequences for some Oregon grape growers and many growers lost tonnage in a generally low yield year.

Irrigation: The spring of 1988 followed one of the hottest, driest falls on record in Oregon. In 1987 there was less than a quarter inch of rain for a period of over 100 days stretching from mid-July to the end of October. September maximum temperatures were 9F warmer than average. Vines in many areas of the state were severely stressed for water and many were defoliating before harvest. This severe stress not only delayed ripening but also reduced wine quality in many cases. When the dry fall weather induced boron deficiency in the spring, there were significant crop losses as well.

Oregon experiences major variations in fall weather each year and this study has shown major variations in vine nutrient status as well. Although average rainfall values are adequate to supply a vine's water needs, low rainfall years must be considered. Vineyards on shallow soils or soils with reduced rooting depth would benefit from an irrigation system. Hillside vineyards often do not have access to enough water to irrigate, but some do, and growers evaluating prospective vineyard sites should favor sites with the potential to irrigate. In addition to the benefits to vine nutrition, an irrigated vineyard comes into production sooner and will have more consistent production.

Pruning time and fall sprays: Growers without irrigation must still deal with variation in boron. This research suggests two options. Late pruning increased boron in new shoots 33% over early pruned vines in 1989. The 1990 percent increase was less but still significant. Considering that Pinot noir was the variety most affected by early-season boron deficiency, growers should prune Pinot noir last, delaying pruning until February, or even early March, if possible. This is strongly recommended following a dry fall. Fall boron sprays are another option, but in light of these results they should only be considered in a dry fall. If a vineyard is dry enough to pull a sprayer through after harvest, then a boron spray should be considered.

Plant analysis: Do not assume that petiole boron values at bloom will represent the boron status of new shoot growth the following spring. Petiole boron values did not change in response to any of the treatment variables in this experiment. However, petiole analysis is still a good guide to the boron status of the vine later in the season. The lack of response of petiole boron to late pruning, fall sprays, or even fall drought indicates that none of these treatments will alter the boron status of the vine mid-season. Mid-season deficiencies and fruit set problems associated with boron are related to current season boron uptake and require a different approach. Current recommendations call for pre-bloom foliar sprays of Solubor (1 -2 lbs/100 gal) based on petiole analysis.

The information from these experiments will be incorporated in a fertilizer guide for grapes now being prepared by the Oregon State University Cooperative Extension Service.