Metalosate® Powered by Albion® Technology

Balchem® Plant Nutrition Research Paper

BORON NUTRITION AND METALOSATE® BORON

Boron in the Soil, Its Characteristics and Availability to Plants

Boron is one of 16 essential elements for plant growth and development. Plants must rely on available boron for their growth and developmental needs. Boron is found in the soil in concentrations ranging from 20-200 mg/kg dry weight. The vast majority of this boron is unavailable to plants because it is not contained in the soil solution. Boric acid makes up essentially all of the soluble boron in the soil solution. Boron differs from all the other essential plant nutrients found in the soil because at a pH range of 4-8 boron is undissociated. This means that there are no individual boron ions found in the solution. Instead, stable boric acid is the source of available boron. As a result, soluble, or available boron is very easily leached from the soil.

Soil pH has a significant impact upon the availability of boron to plants. Adsorption of boron to soil particles rises as soil pH increases from 5 to 9. Essentially this means that the higher the soil pH, the more tightly adsorbed the boron is to the soil particles; thus, boron becomes increasingly unavailable to the plants as the pH increases. For this reason, lime applications to soils decrease boron availability to plants. Boron is also tightly held by organic matter within the soils and consequently as organic matter levels increase in soil, boron availability decreases.

Boron in Plant Nutrition

"The role of boron in plant nutrition is still the least understood of all the mineral nutrients and what is known of boron requirement arises mainly from studies of what happens when boron is withheld or resupplied after deficiency."[1] This is unusual given the fact that on a molar basis plants require more boron than any other micronutrient. "There is a long list of postulated roles of boron: (a) sugar transport; (b) cell wall synthesis; (c) lignification; (d) cell wall structure; (e) carbohydrate metabolism; (f) RNA metabolism; (g) respiration; (h) indoleacetic acid (IAA) metabolism; (i) phenol metabolism; (j) membranes. This long list might indicate (a) that boron is involved in a number of metabolic pathways, or (b) a 'cascade effect' as is known for the phytohormones, for example. [i.e. The cascade effect can be described as being comparable to the domino effect.] There is increasing evidence for the latter alternative, and for a primary role of boron in the cell wall biosynthesis and structure, and for plasma membrane integrity."[2]

Roots have the ability to take up boron as undissociated boric acid from the soil solution. When boron is in this form, it is potentially absorbable into plant cells. There is still much discussion as to whether this process is an active or passive mechanism. There is evidence to support both theories. It has been suggested "that although the B uptake mechanism has not been fully elucidated, uptake can best be explained by a passive diffusion of free boric acid into the cell followed by a rapid formation of B complexes within the cytoplasm and cell walls. The decrease in concentration of boric acid within the cell associated with the formation of B complexes allows the further absorption of B from the external solution. Uptake is thus seen as a passive process acting in response to external boric acid concentration, membrane permeability, internal complex formation and transpiration rate."[3] In much of the older literature, boron is described as having only limited phloem mobility. More recently however, it has been discovered that phloem mobility is species dependent. In a study done to determine boron movement in apple and walnut trees, some interesting discoveries were made.[4] The walnut is an example of a species with very restricted boron mobility. Leaves were taken from species of similar age which were growing under identical management and environmental conditions. Within the leaf there was a much higher accumulation of B at the leaf tip and leaf margin as a result of transpirational flow of water through

Boron Deficiency in Broccoli

photo by D.C.Sanders, Horticultural Science, NC State University the leaf. Apple trees had a relatively even distribution of B throughout the entire leaf. This indicates that apples are able to move boron within the plant relatively easily. “The predominant movement of B in the transpiration stream with little phloem movement explains the occurrence of B deficiency symptoms in young growing tissue.”[5]

Boron, Cell Wall Synthesis, Membrane Function

Boron plays a very critical key role in cell wall synthesis. In boron deficient plants the cell walls are dramatically altered compared to cell walls of boron sufficient plants. Disorders such as ‘cracked stem’; ‘stem corkiness’; and ‘hollow stem disorder’ are all caused by low boron levels. Boron complexes strongly with cell wall constituents as well as helping to maintain structural integrity by forming weak borate-ester cross-links. These borate-ester cross-links are critical to the plant’s ability to elongate cell walls without destroying them. Since the cross-links are weak, they can break and then reform during cell wall elongation; furthermore, they provide negative charges for ionic interactions, with Ca^{++} for example. Boron is bound less strongly to the cell wall than is calcium. This same role of boron just described is also evident in pollen tube growth.

The important role of boron in cell walls is also suggested by the fact that one of the most rapid responses to boron deficiency has to do with root growth and development. Within a few hours of deficiency conditions, root growth and elongation are inhibited or cease alltogether. The roots take on a stubby and bushy appearance.

“From the published evidence as to the role of boron in cell wall biosynthesis, phenol metabolism, and plasma membrane integrity, it can be concluded that in higher plants boron exerts its primary influence in the cell wall and at the plasma membrane-cell wall interface….Changes in the cell wall and at this interface are considered as primary effects of boron deficiency leading to a cascade of secondary effects in metabolism, growth and plant composition. It should be remembered that the changes in plasma membrane potential acts as a signal for many changes in the cytoplasm, and also for a shift in excretion of cell wall material.

“This function of boron in cell wall synthesis can readily be seen in pollen tube growth. After germination, pollen tubes extend by tip growth, i.e. deposition of new cell wall material at the growing point rather than by overall cell extension. In growing pollen tubes removal of external boron leads to abnormal swelling or even bursting in the tip region within 2-3 min of removal”.[6]

Boron Deficiency

Boron deficiency is a very widespread nutritional disorder. There are many factors that can contribute to this problem, among them being: (a) boron is readily leached under high rainfall situations; (b) boron has limited mobility within many species of plants; (c) boron has decreased availability with increasing soil pH; and (d) availability of boron also decreases significantly under drought conditions.

A common feature in B deficiency is the disturbance in the development of meristematic tissues, whether these are root tips, tips of upper plant parts or tissues of the cambium. Deficiency symptoms are first noticeable at the apical growing points, terminal buds or youngest leaves. These may become discolored, misshapen, wrinkled and may die. Internodes are shorter, giving the plants a bushy or rosette appearance. Sometimes interveinal chlorosis may also be present. Leaves and stems become brittle with stems becoming enlarged due to the previously discussed disturbance in cell wall growth. This increase in stem diameter is common and may lead to symptoms such as ‘stem crack’ in celery, or ‘hollow stem disorder’ in broccoli. As the deficiency increases phenomena such as the dropping of buds, flowers and developing fruits are commonly observed. In the heads of vegetable crops, water soaked areas, tip burn, and brown- or blackheart occur. In fleshy fruits that are boron deficient, the growth rates are lower and fruits are smaller. Fruit quality can be severely affected by malformation (e.g. ‘internal cork’ in apple) or, by a decrease in the pulp/peel ratio in citrus.[7]

The demands on boron for reproductive growth are much greater than the demands for vegetative growth. This is directly tied to the need for boron in pollen tube growth. In some plant species poor growth of pollen tubes results in parthenogenesis (production of a fruit from an unfertilized egg). This is particularly true for grapes. Parthenocarpic fruits remain very small and are of very poor quality.

Boron Fertilization and Crop Requirement

The most commonly used boron fertilizer is borax applied to the ground. The problem with this is that it is very easily leached from sandy soils and, in the higher pH of calcareous soils, it is unavailable to the plants roots. For this reason, foliar application is often more efficient than broadcast application to correct boron deficiency. With a foliar application of

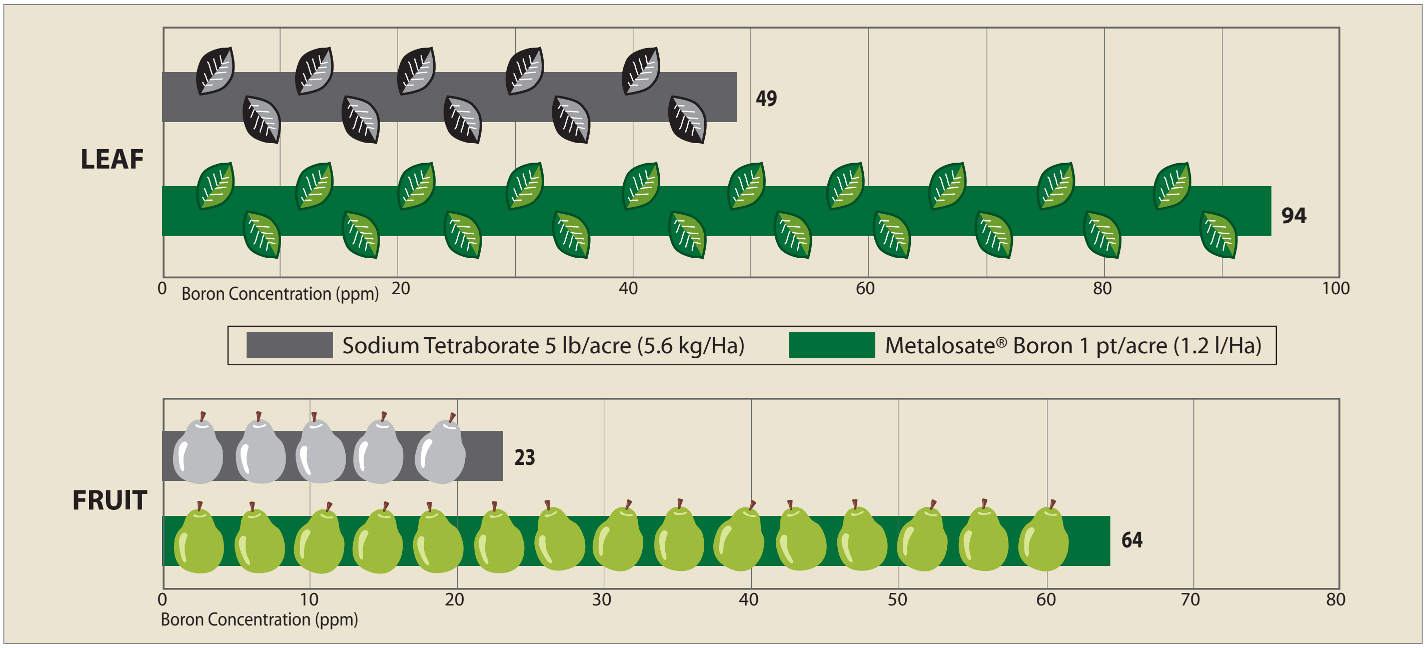

Figure 1. Leaf and fruit tissue levels of boron in pears as a result of foliar application of Metalosate® Boron compared to sodium tetraborate. The test orchard was located in North Washington.

Metalosate Boron, it is possible to provide boron to plants at times of critical need, such as for flowering and fertilization.

In Washington State Albion conducted a field trial on a block of pears. In the trial one application of Metalosate Boron at the rate of 1 pint per acre (1.2 L/Ha) was compared to one application of sodium tetraborate at the rate of 5 lbs per acre (5.6 kg/Ha). Leaf as well as pear flesh samples were collected and analyzed. The results are shown in Figure 1. It is obvious that Metalosate Boron significantly outperformed the other product.

Crops differ in their sensitivity to boron deficiency. Members of the Cruciferae family; i.e., cabbage, turnips, Brussels sprouts, cauliflower and the Chenopodiaceae family; i.e., sugar beets are highly sensitive to boron deficiency and respond very well to applications of boron. Boron deficiency of grapes is one of the most severe diseases in vine growing. "Fruit formation is impaired and yield depressions as high as 80% may occur compared with plants adequately supplied with B. This is a consequence of the high requirement of boron for pollen tube growth and viability."[8]

In summary, the need for boron in crop nutrition is obvious. There are many factors in the soil which affect boron availability to plants. Many of these cannot be overcome by soil treatments. This does not mean that because soil boron is unavailable that it is any less important or that the plant needs it any less. It simply means that boron needs to be applied as a foliar application of Metalosate Boron. Boron serves many functions within the plant. It is a key element in cell wall and membrane development, playing a critical role in pollen tube growth as well as being essential in meristematic growth areas. Boron deficiencies are widespread and, in many instances, ground applications of boron are ineffective at solving boron deficiencies. Foliar application of Metalosate® Boron is very beneficial in supplying plants with a useable form of boron when needs are the greatest.

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Liquid Foliar Products

- Boron
- Calcium
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- Iron
- Magnesium
- Manganese
- Potassium
- Zinc
- Crop-Up®
- NPK
- Multimineral™
- MZ™
- Tropical™
- Zinc Plus™

Organic Foliar Products

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- Calcium Boron
- Copper
- Iron
- Magnesium
- Manganese
- Zinc
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