EXPANDING THE BORON RESEARCH BASE

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Crops
Corn, Soybeans, Alfalfa, Clovers, Canola, Potato, Strawberry, Sunflower, Wheat, Rice, Apples and many other tree fruits, Pine Tree, Vegetables, Sugarbeet

Introduction;

Boron deficiency in crops is more widespread than the deficiency of any other micronutrient (Gupta, 1993a). Visual symptoms of B deficiency generally become evident in dicots, corn and wheat at tissue concentrations of less than 20-30, 10-20 and 10mg kg^{-1} dry wt., respectively (Anon., 1991: Gupta, 1993b). Nutritional disorders attributed to B deficiency are also prevalent among vegetables, fruit and nut trees

Boron is a unique micronutrient that has been actively researched for many generations. There are many myths as well as facts that revolve around this unique element. U.S. Borax has for many years been an active participant in expanding the knowledge base and dispelling the myths on boron in North America and worldwide.

In North America we consistently have funded between $100,000 and $200,000 worth of research each year, specifically on agricultural borate applications. This has involved approximately 20 different crops as well as forestry uses. U.S. Borax has also funded basic plant physiology research on how boron moves within diverse plants and soils. The development of alternative boron extraction methods that would replace the tedious and relatively costly standard hot-water procedure has been explored.

Highlights of Selected Boron Research projects

Alternatives to Hot-Water B (HWB) extraction;

HWB is the dominant soil-test analysis method for making boron fertilizer recommendations by soil testing labs in North America. This is not a lab friendly procedure and does not lend itself to rapid routine analysis and is also lacking in precision.

The HWB method (Berger and Troug, 1994) has many variables in the process; heating temperature, time of equilibrium, cooling time, all influence the quantity of boron extracted. Differences in these variables within a lab on a daily basis will vary the amount of boron extracted and thus affect the precision of this method. A study conducted in 1997 (R.O. Miller), as part of the Western States Proficiency Program indicated that the level of HWB precision within a lab ranged between 15-25%, quite variable!

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In the Eastern United States, multi-element (Mehlich 3) extractions, which include B, are used successfully, however this does not work well for *alkaline/calcareous* soils. Vaughan and Howe (Miller and Vaughan) showed that simple saccharides were effective as chelates of boron. They showed that sorbitol could be used with ammonium acetate. The addition of sorbitol to DTPA should be an effective means to extract Boron in addition to Zn, Cu, Mn, an Fe.

The results of the Vaughan and Howe study indicated that the sorbitol DTPA extraction method is both precise and lab friendly, in addition the DTPA-sorbitol was able to maintain greater precision at lower detection levels than the HWB (0.45 vs. 0.15mg kg^{-1}).

This will have an impact on the number of labs that will offer boron analysis and the "price" that they can subsequently charge. It should make it much easier for an individual soil-test lab to make Boron part of their basic package of analysis whenever micronutrients are requested!

Soybeans;

In the last ten years there has been several major projects in the soybean producing areas of the United States. Many of these have shown a significant yield increase to the addition of boron.

G. Gasho, University of Georgia and D. Blevins, University of Missouri, were instrumental in developing state recommendations for boron on soybeans in the mid-south. Wisconsin (E. Oplinger) was also a participant in a large regional project. Average yield increases of 3% were seen when 0.25lbs B/acre were applied as a foliar application at the R2-R3 growth stage.

Results from the southern states were significant and resulted in the adoption of foliar B as part of recommended production plans. In the northern states the results have not been as consistent. The trend indicates a yield increase when the boron is applied, but the variability of getting that increase was much greater than in the south.

Alfalfa;

Most of the boron applied in the Upper Mid-West is going onto this crop. The rate varies slightly from 1-3 pounds B/acre depending upon the state. There has been some revisitation of the yield response work that was done in the 1950's and 60's. Some of this is being done with the newest alfalfa genetics (R. Leep, MI State Univ.). To date this has not resulted in any major changes to the boron recommendations for alfalfa. However there are a couple of changes that have shown up.

First with the advent of nutrient management, many alfalfa fields that used to get an annual top-dress application of P& K with boron piggybacking along are no longer getting that application. This is due to high or excessively high soil-test levels of P and/or K. Without the "free ride" for boron, many of these fields are not getting any supplemental boron.

An alternative application method is to apply your boron when you are spraying for insects (alfalfa weevils, potato leafhopper, etc.). This works, but you are at the mercy of Mother Nature. Uptake of B in alfalfa is from the soil solution rather than through the leaves. If it stays dry after the B application, you may not see a response until it rains!

The second change that was noticed is how alfalfa is being soil-sampled. More fields going into alfalfa are now being grid-sampled, primarily for pH, however what is interesting to note is that the boron numbers in a grid-sampled field vary almost as much as does pH (B. Vaughan, MDS Harris Labs). This has helped generate some additional awareness of the need of boron in top production alfalfa!

Additional work is also being done on looking at the "Grazing type" alfalfa's and the response to applied boron (M. Collins, University of Kentucky). They seem to respond similarly to the hay types.

It has been known for some time that boron plays a significant role in the formation and subsequent development of cell walls. When boron is limiting in the plant, phenols normally complexed by boron accumulate. These phenols are associated with an increase in fiber development, which can then decrease digestibility of the forage.

Apples and other tree fruits:

In the past few years there has been some major boron work done with apples and some other tree fruits. In apples (Malus spp.) boron is essential for optimal yield and quality but may also impair fruit quality if present in excessive amounts (F.J Peryea, Tree Fruit Research Center, Washington State).

Boron toxicity is rare in apple production and is usually associated with over-applications of B. The more common problem is maintaining sufficient B in the tissues to assure both quality and quantity. The reduction in fruit cracking and bitter pit was significant when B concentration in the leaves was kept above 25ppm. This is especially important for storage of apples. Those with low boron have a much shorter shelf life than those produced with adequate B.

Peryea has also done a lot of work on timing and rates of boron application to apples; from the pre-pink stage using 0.5-1.0lbs B/acre, post-harvest- 0.2-0.6lbs B/acre, dormant application of 0.6-1.0lbs B/acre with dormant oil. His work has helped apple growers to harvest both more apples and apples higher in quality.

This work has translated nicely to the Great Lakes apple producing regions!

Plant Physiology;

Historically boron movement in plants has been related to movement in the zylem or apoplastic system with little to no phloem movement. Uptake of boron is a passive (non-metabolic) process. Once boron has been incorporated into tissues, it cannot be remobilized to supply the needs of other plant tissues!

Patrick Brown and H. Hu (Univ. CA, Davis) have helped to expand our knowledge on boron movement in plants. Some of their recent work has shown that there are vast differences in how boron will move in a plant. Their work refutes the current thought that boron is immobile in the plant. They have shown that there are species differences.

Brown has identified that in plant species that utilize polyols (simple sugars) as a primary photosynthetic metabolite, boron will move in the phloem. Knowing whether or not boron will move in the plant you are working with will tell you how to manage it for boron, what plant parts to sample and how rapidly a deficiency in the plant can be corrected.

Examples of species in which boron is immobile are; corn, wheat, alfalfa, tomato, strawberry and most vegetables. Identified mobile species are: apple, pear, apricot, celery, grape, and peach.

For most of you this means that most of the boron needs of the crops you are working with need to be supplied via the soil!

Other Crops and Projects;

US Borax has sponsored research in numerous other crops and uses of boron. Many of these crops are siqnificant in other parts of the world. The following is a brief list of some of those crops and the types of responses found with boron:

Blueberries

- Foliar application of 0.25-0.5lbs B/acre increase both size and number of berries.

Canola

- Several researchers are looking at this crop, both in North American and the rest of the world. Current status is that boron applied to the soil at planting will positively affect glucosinolate levels, which impact the quality of the oil produced after crushing.

Almonds & Prunes

- Not an important crop for us in the mid-west, however it is from work done on the almonds that the current research on boron mobility evolved.

Potato

- Not a minor crop. Long recognized that boron is important in its production, the companies that grow potatoes for the chipping business now consistently recommend the use of boron to assure the quality they need for their end product. Rates vary depending upon state/region but range from 1-4lbs B/acre.

Turf grasses/golf courses

- Small acreage's compared to corn/soybeans, but large profit potential.

Pine trees

- Applications of boron to pine plantations have significantly increased the rate of growth of several pinus species. North America and World Wide, most of these acres receive little or no fertilizer, currently the best researched nutrients in this arena are nitrogen and phosphorus use. An interesting untapped market!

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