Assessing the scale of the boron market

in North America

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Boron for agricultural use is a stable market in North America, but it has more growth potential than most people realize. Boron deficiency is a common problem, and more and more research is being carried out that validates the importance of boron to every crop.

In order to determine the potential size of the boron market in North America, it is important to note that there is a high correlation between acidic soils and boron deficiencies. Regions with acidic soils include central California, the Pacific Northwest, and the US east of the Mississippi. Boron content in soil varies according to soil type. Therefore, it is important to look at water soluble boron in the soil to determine how much is bioavailable because not all boron in the soil is available for plant uptake. Borosilicate in the soil contains 20-50 ppm of B but this form is not available for plant uptake. Adsorbed boron bonded to organic matter, clay, and Al/Fe oxides and hydroxides can range from 7-22 ppm, but this is also not available B for plant uptake. The only B available for plants is in the soil solution and is typically in the range of 0.1-2 ppm B. Less than 1 ppm of B in soil solution signals boron deficiency, and boron fertilizer must be applied.

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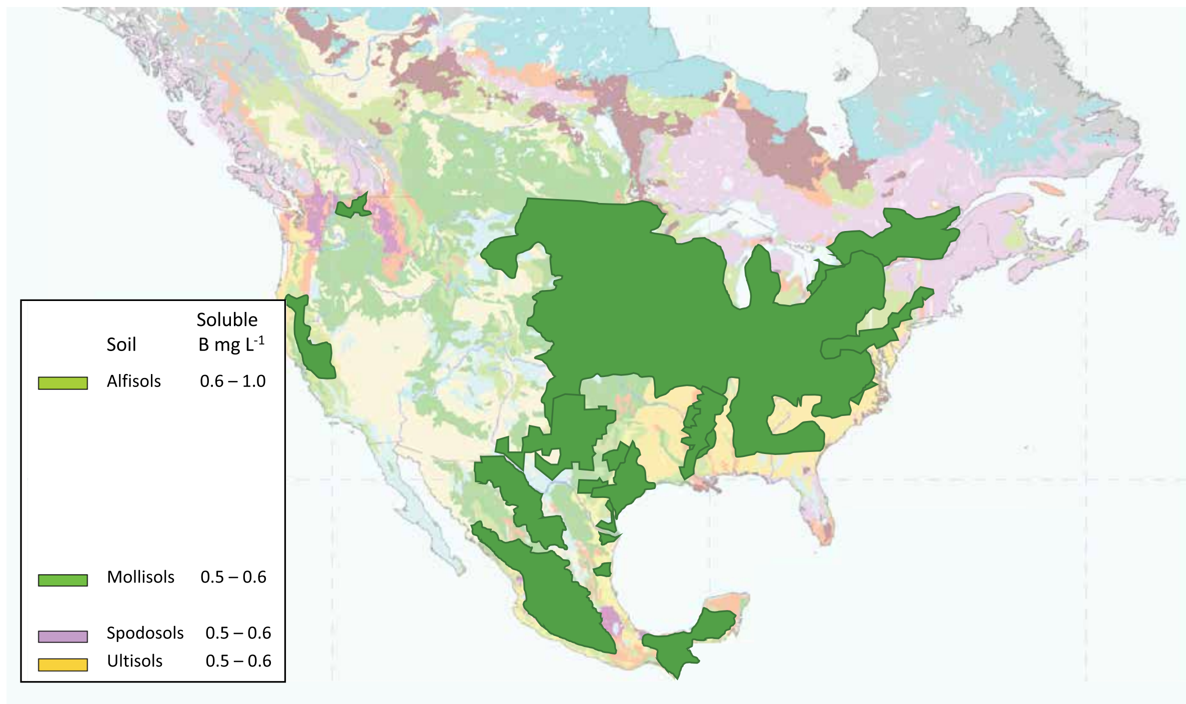
Worldwide, soluble boron content in the soil ranges from 0.5-2.0 mg/L. In the majority of North America, mollisol, spodosol, and ultisols only contain 0.5-0.6 mg/L and alfisols contain 0.6-1.0 mg/L, putting them squarely in the zone of boron deficiency.

In addition to existing boron soil content, one must consider the average yield of the main crops and average amount of boron required to produce that yield. Crops have varying susceptibility to boron deficiency and also have different required rates of application. For example, corn is moderately susceptible to boron deficiency and is often planted in the American Midwest where soils are already naturally deficient. This specific crop requires about 0.63 lbs. of elemental boron per acre to achieve ideal yield.

Incorporating our estimate of current fertilizer use intensity across these crops provides a theoretical maximum amount to boron demand in the North American fertilizer industry, assuming all growers applied recommended rates of boron to their crops. Currently, a wide mix of boron products are available on the market, including boron-only fertilizers, liquid boron products, compounded fertilizer products, and enhanced macro/micro formulations. Even though the North American fertilizer market is well-developed and farmers have a higher level of sophistication when compared with many parts of the world, the awareness and use of micronutrients including boron is still surprisingly low.

Based on internal sales data and our estimate of industry imports and sales, the current agricultural boron market

Image 1. Soluble boron content in North American soils



Sources: Map: USDA. 1999. Soil Taxonomy - A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Agriculture Handbook
Boron content: Shorrocks. 1997. The occurrence and correction of boron deficiency. Plant and Soil 193: 121-148.

in North America is only around 25% of the theoretical maximum amount required by soil condition and crop types.

Identifying the right blends and delivery mechanisms for specific crops and conditions

It is important to understand the function of boron in plant health in order to identify the right blends and delivery mechanisms for boron products. Boron is essential for cell wall development, cell membrane permeability, cell division, lignin and indole-acetic acid synthesis, root growth elongation, sugar transport, photosynthesis, pollen tube elongation for proper seed formation and nitrogen fixation in legumes, making it a catalyzer for most other plant nutrients (see table 1).

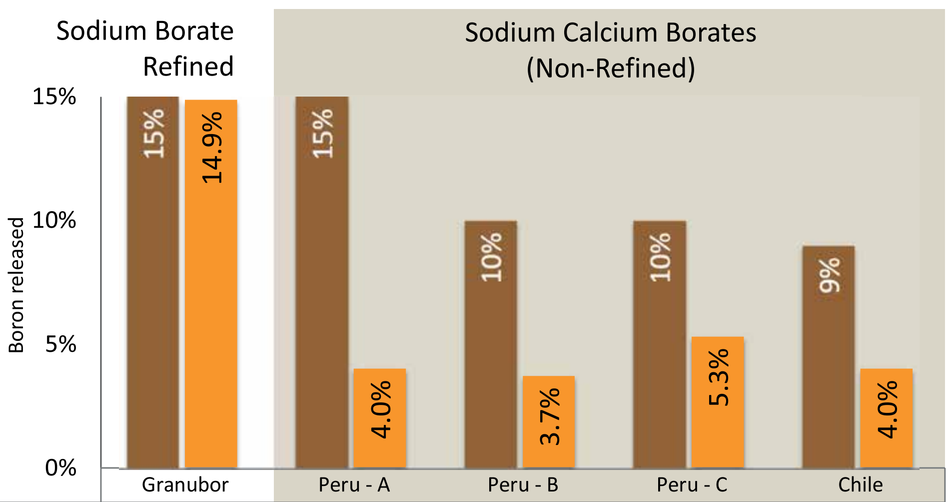
Too little boron will stunt plant growth and development, and too much boron will also affect the uptake of other nutrients and cause adverse effects. Synergistic and antagonistic effects must be taken into account. For example, low rates of B will diminish N,P,K, and Mg uptake, while low rates of P and Zn will stimulate B uptake. Boron must be properly applied in the correct amount along with the other macro and micronutrients for optimal growth.

In order to apply boron in the right amount, growers need to have an understanding of the different boron sources. Most dry boron products in the market, regardless of form, are composed of either refined sodium

Table 1. Nutrient interactions with boron

Nutrient	Interaction with Boron
N	Urease enzyme is inhibited by boric acid
P	B plays a role in transport of P through cell membrane
K	Absorption of K increases in presence of B and hardly occurs without it
Mg	B interacts with Mg, Ca, and P to enable photosynthesis
Ca	Ca and B play important role in cell wall metabolism and are required for auxin transport process
Zn	Zn and B together enable optimal functioning of ATPase and plasmatic membrane redox systems
Mn	B deficiency will reduce Mn uptake and limit root growth
Fe	B levels influence Fe absorption and translocation

Table 2. Release of boron in refined sodium borate versus non-refined mineral calcium borates using hot water extraction.



	Granubor	Peru - A	Peru - B	Peru - C	Chile
Boron extraction acid digestion (HNO3+3HCl)	15.0%	15.0%	10.0%	10.0%	9.0%
Boron extraction using hot water	14.9%	4.0%	3.7%	5.3%	4.0%

borates or sodium-calcium and calcium borate minerals. The most important factors for a grower to consider in their buying choice are the type of boron present in their product and the amount of that boron that is water soluble. Advertised boron levels are determined by an acid digestion process and reflect the amount of elemental boron contained in the product. However, acid digestion does not reflect true soil conditions.

All boron taken up by the plant is in the form of boric acid $B(OH)_3$. In soil, refined sodium borates dissociate into four molecules of boric acid, one molecule of water, and one molecule sodium hydroxide. All boron is released into soil solution and available for plant uptake. For unrefined borate minerals, the process is not as efficient. As an example, ulexite, a sodium calcium borate, dissociates into two molecules of boric acid, one molecule of water, one molecule of NaOH, and one molecule of calcium tetraborate. The chemical bond between calcium and the borate ion is very strong and will not break in typical soil conditions, which results in over half of the boron content being locked in a form that cannot be taken up by the plant and will not contribute to its nutrition. Therefore, one must look at the solubility of each product in hot water to determine how much of the boron will actually be bioavailable to the plant during the course of the growing season.

Table 2 shows that the amount of advertised boron is not always the amount that will be available for plant uptake. Many growers are applying what they believe to be enough boron, without taking water solubility into account. Considering the importance of the interaction of boron with other nutrients, these growers will have lower than optimal uptake of their N,P,K, and Mg fertilizer products.

Once the proper product is chosen, application methods are similar to other bulk fertilizers. Boron can be applied by itself or in blends with N,P,K and other fertilizer ingredients via band and row spreaders. Due to the relatively low rate of application (7-14 lbs per acre), when applied by itself, it can be economical to deliver boron by airplane and in the future, potentially drones.

Soil application of boron is the preferred application method, as the mechanism of action in the plant is to absorb boron via the root system. However, there are times where it necessary to treat crops via foliar application due to available equipment or a need to spot treat a crop later in the season. In this case, the two most common products are boric acid and Solubor (a refined sodium borate). Both can be used, but boric acid becomes saturated in water at 5% concentration while a Solubor solution becomes saturated at 15%. This saturation point also affects boron penetration into the leaves. Studies show that 48 hours after foliar application, elemental boron penetration is 10% for boric acid and 12% for Solubor. After 12 days, the difference is even higher. Elemental boron penetration is 41% for boric acid and 51% for Solubor.

Another common form of liquid boron is boric acid in a solution with monoethanolamine (MEA) and in this case the saturation level is 10%. Boric acid plus MEA is an effective product but is not suitable for organic applications due to the presence of MEA. A solution is only considered organic if it is a refined borate mixed with water.

Incorporating boron in an economical way for growers

Applying boron to crops should always be viewed as a worthy investment by growers. For a grower working with boron-deficient soil, the return on investment of proper boron application can be staggering. As an example, applying 3 lbs of boron per acre to a soybean crop can increase yield by 150 lbs per acre and generate additional sales of approximately USD30/acre. With a treatment cost of a little less than USD2/acre for boron, the return for each dollar invested is approximately USD15. This calculation is based on our historical library of field studies, though results may vary by soil condition, weather, and a host of other factors.

In addition to the increased yield generated by proper nutrition, it is important to factor outside costs like handling, manpower, and freight when choosing how to incorporate boron. Products with a higher soluble boron content have more efficient logistic costs when considered on a basis of cost per ton of soluble boron. Returning to the foliar product example, Solubor (21% boron) is a more expensive product than boric acid (17.5% boron). But, if a grower takes into account the cost of additional water needed due to the different saturation point, additional freight per unit of boron due to the lower boron content of boric acid, and additional manpower needed to handle and dissolve more product, it makes the Solubor more cost-efficient.

The agricultural boron market is robust and backed by the plant's requirements for additional boron beyond the level that can be obtained from the soil. Choosing the proper boron source is essential for growers to maximize the return on investment they generate with the use of boron. Overall, demand for boron fertilizers will continue to increase as the industry invests in new products containing boron, makes growers aware of the science, and most importantly, demonstrates the positive impact to their bottom line that can be realized with proper application of boron. ■

Note: Solubor® is a registered trademark of Rio Tinto Borates - US Borax
For the potential return on investment for various crops, Rio Tinto Borates - US Borax recommend visiting the US Borax online return on investment calculator at agriculture.borax.com