Boron in South America

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U.S. Borax
We were first to mine borates on a large scale.

Our history dates back to 1872.
Soil pH in Americas

Low pH soil is a good indication of boron (B) deficient soils

Red: Acid pH soils
Blue: Basic pH soils

Atlas of the Biosphere
University of Wisconsin-Madison
Micronutrient deficiencies in Brazil

Boron (B) is the most deficient micronutrient in Brazilian soils.
Zinc (Zn) is the second most deficient micronutrient in Brazilian soils.

13,416 soil samples from 21 Brazilian states were collected and analyzed by the laboratory of the Institute Agronomic of Campinas (IAC). Modified from Abreu et al, 2005.
Availability of boron in Brazilian soils

Cerrado region in Brazil (green)
Based on 518 soil analyzes (0-15 cm), 60% of soil analysis were very deficient in B (< 0.2 mg/dm³ of B).

State of Parana (PR), Brazil
High (H), medium (M) and low (L) availability of boron (B) in the soil
Solubility of borates by type

The solubility of borates depends on the source material and the interaction of boron with sodium (Na), calcium (Ca) and magnesium (Mg). The more Mg and Ca a borate has in its composition, the less soluble this mineral will be.

**Hydroboracite**

CaO · MgO · $3B_2O_3$ · $6H_2O$

Calcium and magnesium borate

Insoluble in water

**Colemanite**

$2CaO$ · $3B_2O_3$ · $5H_2O$

Calcium borate

Partially water soluble
Solubility of borates by type

**Ulexite**

\[ \text{Na}_2\text{O} \cdot 2\text{CaO} \cdot 5\text{B}_2\text{O}_3 \cdot 16\text{H}_2\text{O} \]

Calcium-sodium borate

Partially soluble in water

**Kernite**

\[ \text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O} \]

Sodium borate

Water soluble

**Tincal or Borax**

\[ \text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O} \]

Sodium borate

Water soluble
## Borates commonly used in agriculture

<table>
<thead>
<tr>
<th>Product/fertilizer</th>
<th>Chemical formulation</th>
<th>Solubility in water (g/L at 20°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrefined Borates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hidroboracite (10 - 15% B)</td>
<td>CaO·MgO·3B₂O₃·6H₂O</td>
<td>0.8 g/L</td>
</tr>
<tr>
<td>Colemanite (8 - 15% B)</td>
<td>2CaO·3B₂O₃·5H₂O</td>
<td>4.7 g/L</td>
</tr>
<tr>
<td>Ulexite (8 - 15% B)</td>
<td>Na₂O·2CaO·5B₂O₃·16H₂O</td>
<td>10.9 g/L</td>
</tr>
<tr>
<td>Refined Borates</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dehybor®</strong> (anhydrous borax, 21% B)</td>
<td>Na₂B₄O₇</td>
<td>19.0 g/L</td>
</tr>
<tr>
<td><strong>GRANUBOR®</strong> (borax pentahydrate, 15% B)</td>
<td>Na₂B₄O₇·5H₂O</td>
<td>26.5 g/L</td>
</tr>
<tr>
<td><strong>Optibor® TG</strong> (boric acid, 17.5% B)</td>
<td>H₃BO₃</td>
<td>47.2 g/L</td>
</tr>
<tr>
<td><strong>SOLUBOR®</strong> (DOT, 20.5% B)</td>
<td>Na₂B₈O₁₃·4H₂O</td>
<td>97 g/L</td>
</tr>
</tbody>
</table>

Solubility with different sources of borates

- Unrefined borates (ulexites) release between 28 - 43% of the total boron content
- Refined borates have greater solubility over 20 weeks, due to the absence of impurities and calcium in their composition

![Graph showing the solubility of different sources of borates over time.](image-url)

Boron release curves

Study conducted over 40 weeks in sandy soil (pH 4.7). Fundação ABC, Brazil.

Barth et al., 2017.
Boron release curves

Study conducted over 40 weeks in clay soil (pH 4.2). Fundação ABC, Brazil.

Boron release curves

Study conducted over 20 weeks in sandy soil, and acidity corrected with ag lime (pH 5.7). Fundação ABC, Brazil.

Boron release curves

Study conducted over 20 weeks in sandy soil and naturally acidic soil, without limestone correction (pH 4.8). Fundação ABC, Brazil.

Barth et al., 2020.
Response of corn to the application of B in increasing doses (1; 2; 3 and 4 kg/ha) using different sources available on the market

Average yield of 2019/20 and 2020/21 crops

Experiment conducted in Cruz Alta/RS, Brazil, in a soil with ≥ 42% clay

Shaich et al., 2021.
What technologies are being developed for more seamless applications of boron?

What solutions are readily available?

- Ulexite
- Colemanite
- Borax pentahydrate
- DOT
- Anhydrous borax
- Zinc borate
- Liquid fertilizers (mainly MEA+BA)

What is in the pipeline?

- New liquid formulations
- B + macro and/or micronutrients
- Slow release boron fertilizers, with better technology (B sources)
Thank you!

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