U.S. BORAX

Boron in soybean nutrition

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Boron uptake by soybean

Agronomists have investigated the patterns of nutrient uptake, partitioning, and remobilisation in soybean cultivation for many years. Recent studies have shown that the potential for nutrient uptake by soybean crops has increased significantly as productivity (yield) levels have risen. This has resulted in higher overall demand for nutrients – including for boron.

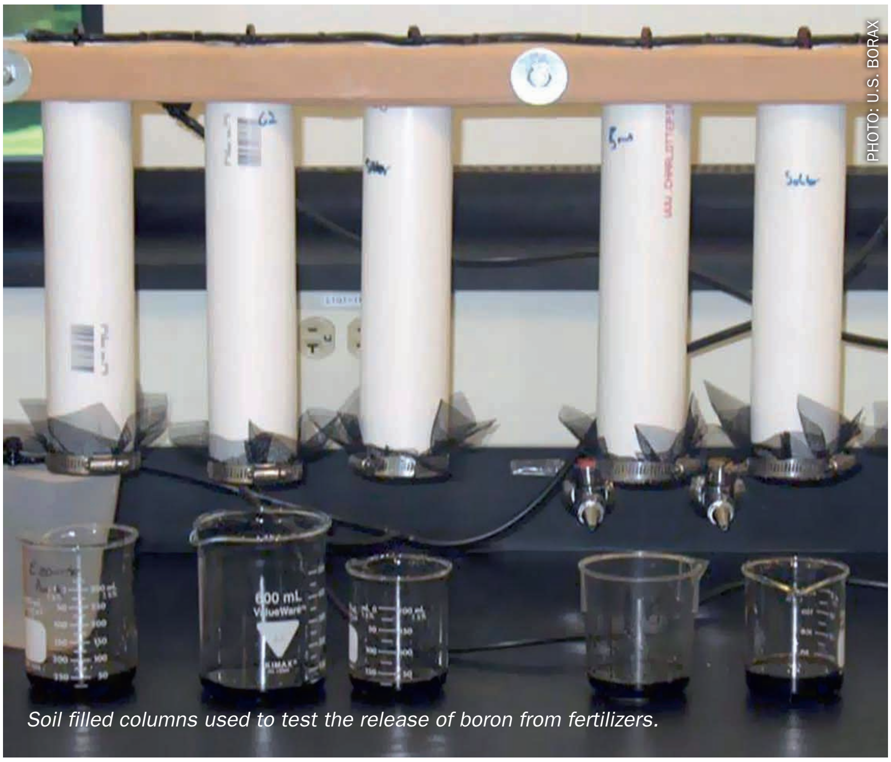
Crop research carried out by the Brazilian Agricultural Research Corporation (EMBRAPA), for example, shows that new soybean varieties (SYN 1039 and DM 6563) accumulate and export more boron compared to the variety (BRS 184) traditionally grown (Table 1). These data reinforce the fact that precise knowledge about nutrient uptake and demand, and how this varies for different soybean varieties planted in different regions, is essential when it comes to better crop nutrient management

Similarly, results obtained for total boron uptake by soybean plants and boron removal by soybean seeds from a U.S. study (Table 2) do differ from those observed in Brazil. Indeed, such variations in boron uptake are to be expected, as these reflect differences in the growing environment, climate conditions, soil type, and soybean cultivation techniques.

An important parameter provided by the U.S. study is the maximum boron accumulation rate, essentially a measure of peak boron demand. U.S. researchers found that the maximum soybean demand for boron occurs during the R4 reproductive period, with a peak accumulation value of 5.18 g/ha being observed (Table 2).

These results demonstrate the importance of using fertilizer sources – such as Granubor® (sodium tetraborate pentahydrate) – that release all their boron over the growing season and therefore guarantee gradual and consistent boron supply, this being particularly important during those soybean growth stages with the greatest boron demand.

The 2016 EMBRAPA study also determined boron accumulation curves for three soybean varieties. Results show that soybean demand for boron starts in the vegeta-



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Soil filled columns used to test the release of boron from fertilizers.

Table 1: **Boron uptake and removal for three different Brazilian soybean varieties**

Variety	Crop productivity (kg/ha)	Total B uptake (g/ha)	B removal with soybean seed (g/ha)	Harvest index[4] (%)
BRS 184[1]	3,230	183	80	43
SYN 1059[2]	4,000	375	125	33
DM 6563[3]	3,000	225	73	32

Notes:
1. Conventional, 2. RR, 3. RR2 Pro
4. Harvest index (HI) is the ratio of grain nutrient removal to total nutrient accumulation, and is therefore a relative indicator of nutrient partitioning to soybean seeds
Source: Oliveira Jr et al. (2016)

Table 2: **Boron uptake and removal during U.S. soybean cultivation[1]**

Total B uptake (g/ha)	B removal with soybean seed (g/ha)	Harvest index (HI)	Maximum accumulation rate (g/ha/d)	Maximum accumulation growth stage
325	111	34	5.18	R4

Notes:
1. Average soybean yield = 3.84 t/ha, as measured at measured at physiological maturity (R8 growth stage).
Source: after Bender et al. (2015)

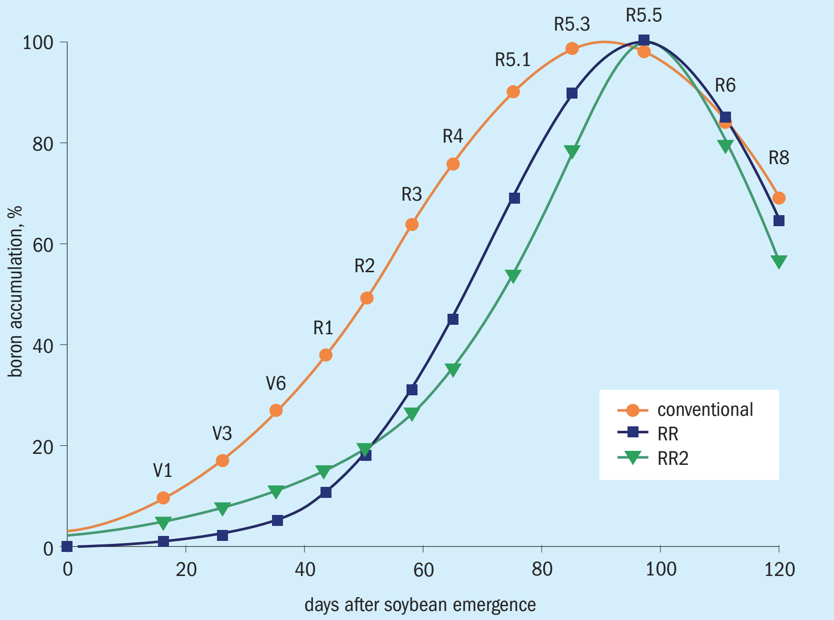
tive phases (V1-V6) and then progressively increases during the crop's reproductive period – particularly between periods R2 and R5 – reaching maximum accumulation between the R4 and R5 phases (Figure 1).

Soybean cultivation research studies commissioned by U.S. Borax, and carried out with different agronomic research institutions in Brazil, show that using Granubor® as a source of boron delivers an average incremental yield improvement of 277 kg/ha. Results were obtained using reliable experimental designs and determined from rigorous statistical analysis, such as ANOVA and mean tests. This provides a high level of confidence in the crop recommendations for Granubor® and the resulting yield improvements.

Granubor®: a high agronomic efficiency fertilizer

To evaluate boron release from different fertilizer sources, U.S. Borax carried out percolation experiments using columns filled with soil under controlled laboratory conditions (see main photo). Water was applied daily to the individual columns, each of

Fig. 1: **Boron accumulation curves during the growth stages (V1-R8) of three different soybean varieties cultivated in Brazil**



Notes:
Conventional: soybean variety BRS 184, yield = 3.25 t/ha
RR: soybean variety SYN 1059, yield = 4.00 t/ha
RR2; soybean variety DM 6563 (Intacta RR2 PROTM), yield = 3.00 t/ha

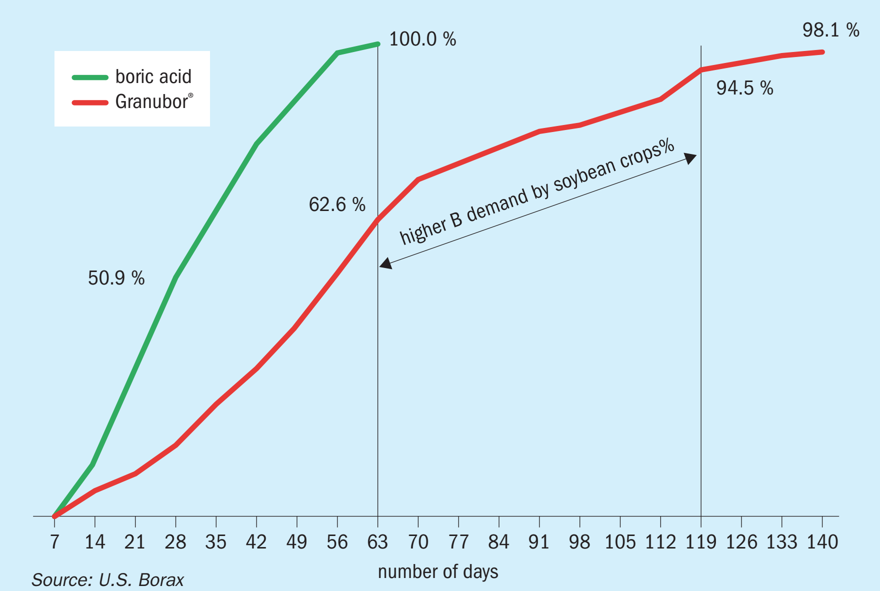
Source: after Oliverira Jr et al. (2016)

which contained a boron dose from different fertilizer sources. The boron sources tested were standard boric acid (17.5% B), Granubor® (15% B), and five types of ulexite from different regions. The results obtained for ulexite have been described previously (*Fertilizer International* 521, p26).

The volume of drained (percolated) water was collected each day and analysed for soluble boron content. Experimental conditions were as follows:

- 300 g of topsoil (clayey soil) around 10 inches deep (classified as well drained) was placed in 12'' x 2" PVC pipes
- Soil content: < 0.1 ppm of B
- 250 g of soil placed in a tube followed by 1 g of boron equivalent fertilizer, covered by 50 g of soil
- Watered 100 ml/day
- Boron concentration in percolated solution was measured by inductively coupled plasma (ICP) analysis.

Fig. 2: **Boron release curves over 140-day period, standard boric acid vs Granubor®**



Source: U.S. Borax

Results (Figure 2) show that 100% of the boron present in the boric acid percolated after 63 days (9 weeks), while 98.1% of the boron in Granubor® percolated after 140 days (20 weeks). These results confirm that boric acid percolates faster than Granubor® due to its more rapid solubilisation. Therefore, in practice and from a field application perspective, standard boric acid may not fully meet the boron demands of soybean throughout the growing season.

Whereas for Granubor®, in contrast, the pattern of boron release strongly matches the period of greatest boron demand from soybean plants (Figure 2). It can supply boron to the soybean crop when it's most needed, if applied at the correct time.

Soybean is a global crop and its nutrient needs in different regions will vary according to soil type, climate conditions and soybean variety etc. Nonetheless, U.S. and Brazilian soybean growers have observed significant corrections in boron deficiency symptoms on farms using Granubor®.

In our view, Granubor® provides the best solution for soybean growers requiring a soil-applied boron fertilizer, based on the rigorous analysis of extensive field data collected from numerous research studies (Figure 3).

References

Bender, R. et al., 2015. Nutrient Uptake, Partitioning, and Remobilization in Modern Soybean Varieties. *Agronomy Journal*, 107(2), 563-573.

Oliveira Jr, A. et al., 2016. *Estádios fenológicos e marcha de absorção de nutrientes da soja.* Londrina: Embrapa Soja.

About the authors

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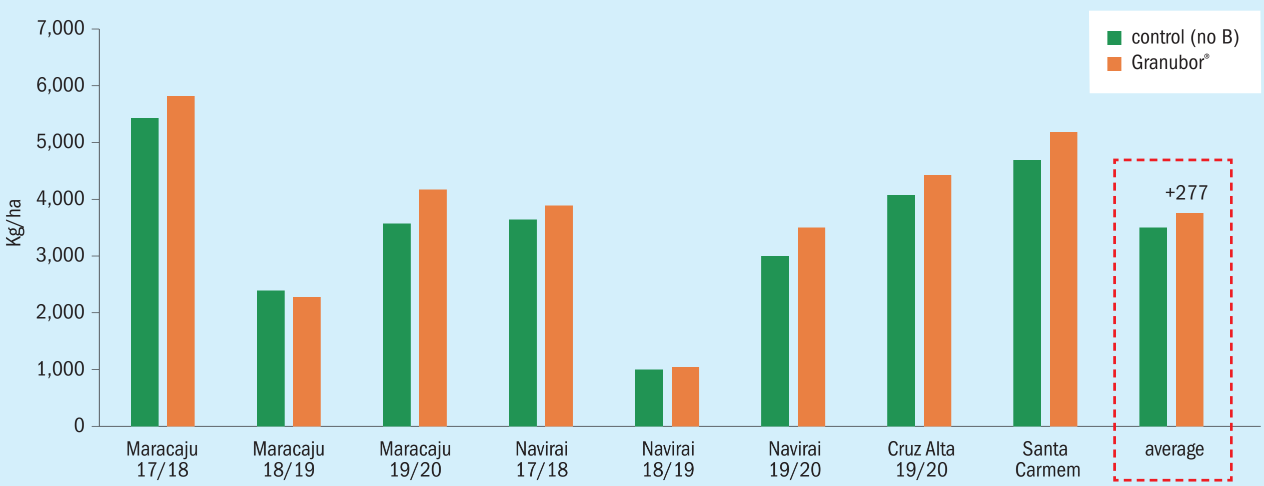
Fig. 3: **Boron yield response of Brazilian soybean crops to the use of soil-applied Granubor® – results for different locations, soil types and growing seasons.**



Source: U.S. Borax