

BORON UPTAKE BY CONTAINER-GROWN, ROOTSTOCK AVOCADO PLANTS FROM DIFFERENT BORON-CONTAINING MEDIA

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Abstract

Working with the influence of boron on fruit set in avocado, we were interested in boron uptake and the localisation of boron in different plant organs. 'Hass' avocado plants on clonal 'Duke 7' rootstocks were grown in containers filled either with washed sand or soil (+ or - humic acid), in a temperature controlled glasshouse. A 50% Hoagland's solution with varying boron levels was applied and leaves, roots and stems were analyzed at regular intervals for total dry mass and boron concentrations.

On average there was a linear increase in the boron content of all three organs (roots, stems and leaves), with increasing boron levels of the medium, reaching higher levels in the plants growing in the soil + humic acid, and lowest levels in sand. The dry mass of the plants growing in the sand was much higher than of those in the soil and on average, showed a linear decrease with increments in the boron concentration of the medium. The highest dry mass of all organs and best general growth was obtained in the sand culture with 0.5 mg/f boron. Severe toxicity symptoms appeared at higher boron concentrations. Boron concentrations of leaves from plants growing in the soil + humic acid, increased to more than 900 mg/kg. It seems very difficult to control boron concentrations in avocado leaves by applying boron through the roots.

1. Introduction

The importance of boron as an essential micro-element and in particular for pollen tube growth, has become a fact (Vasil 1963). For optimal pollen tube growth to occur in avocado pistils, a boron concentration of between 50 mg/kg and 100 mg/kg in the flowers is required (Robbertse & Coetzer 1988). Using boric acid enriched with the isotope ¹¹B, Coetzer et al. (1993) showed that during flowering, boron is translocated from the youngest mature avocado leaves to the inflorescences. To obtain a concentration of 100 mg/kg in the flowers, the boron concentration in the young, mature leaves should be above 70 mg/kg. Although we did manage to get close to these levels by spraying Solubor on the leaves (Robbertse & Coetzer 1990;

Robbertse et al. 1992), virtually nothing is known about boron uptake by avocado roots. This paper reports on the results of experiments on boron uptake by avocado roots from different boron-containing substrates and localisation in the roots, stems and leaves.

2. Materials and methods

2. 1. Sand culture

Avocado plants for this experiment were first grown in a water medium, but for some unknown reason the most of them died after a month (Coetzer et al. 1994) and we had to switch to the sand culture. Sixty young 'Hass' avocado trees (on average 1.0 m high), grafted on 'Duke 7' clonal rootstock were planted in 5 liter containers filled with washed sand. For the first 9 weeks the plants received a daily drench with a 50% Hoagland's solution without boron. After this period the plants were separated into five groups of 12 plants each. The twelve control plants continued to receive the zero boron and 50% Hoagland's, while for the other four groups, either 0.5 mg/l boric acid (BA), 1.0 mg/l BA, 2.5 mg/l BA or 5.0 mg/l BA was added to the Hoagland's. The plants were kept on a rotating table in a temperature controlled greenhouse (15°C/28°C). Four plants from each treatment were harvested four, eight and twelve weeks after the boron applications were started and the following parameters recorded: Plant height; diameter of stem; number of leaves; total dry mass of roots, leaves and stem; boron concentration of dry roots, stems and leaves.

2.2. Soil-medium

Sixty plants, as for the sand culture, were planted in a soil mixture (pH 5.8) of coarse sand, top soil and compost (25:50:25). All plants received a drench with distilled water and one soak with 50% Hoagland's without boron. The plants were grouped into five times 12 plants each. The 12 "control" plants did not receive boron while, based on previous experience, the other groups either received 0.25 g Solubor, 0.75 g Solubor, 1.50 g Solubor or 3.00 g Solubor per container. The Solubor was dissolved in 500 ml distilled water and applied as a drench, once only, four weeks after planting when the young trees had settled down. Six plants from each of the five treatments, in addition, received a single treatment with humic acid (3 g dry powder, mixed with the upper soil layer). The same parameters were recorded as for the sand culture.

All results were statistically analyzed using a Genstat 5 programme.

3. Results

The results are presented in figures 1 to 4. Figures are adjusted means, using plant height of the first harvest as co-variant. Highly significant differences were found between the plant heights of the different treatments. The two soil treatments gave very similar results and therefore figures of only the soil + humic acid treatment are presented. Parameters for the stems are also not presented, due to the small difference from those of the leaves.

The line graphs in figures 1 and 2 represent combined means for all three substrates and show a linear increase in the boron concentration from the lower to the higher boron concentrations in the medium. In general, root and leaf dry mass show a clear tendency towards a parabolic distribution with the optimum between the second and third treatments (figures 1 & 2). From the first to the third harvest, the optimum shifted from the higher towards the lower

boron concentrations in the substrate. In substrates containing more than 1 mg/1 B or 0.7 g Solubor/container, severe boron toxicity symptoms were observed on the leaves.

4. Discussion

Boron is taken up by the avocado roots against a steep gradient and accumulates in the above-ground organs of the plant. The linear increase in the boron concentration in the leaves and roots (figures 1 - 4) shows that the avocado does not seem to have a mechanism to stop the boron uptake once sufficient amounts have accumulated in the leaves or other organs. In the soil medium, which is a better buffered system compared to the sand, toxic boron levels were reached in a shorter period. In figure 4, the decline in the leaf boron concentration in the second soil treatment (0.25 g Solubor/pot), clearly shows that avocado plants 'pump' out the boron from the substrate. In the comparable sand medium, where there was a continuous supply of boron, an increase in leaf boron concentration occurred while toxic levels in the roots occurred at the time of the third harvest.

Results from this experiment clearly show that it is almost impossible to control boron levels in the vegetative parts of the avocado plant by applying boron to the substrate. Although optimal leaf and root dry masses were obtained in the lowest application, toxic boron levels occurred in the roots. In the single 0.25 Solubor soil application (figure 4), too much boron was absorbed by the roots during the first two months, while the leaf boron started to decline. Continuous or regular low dosages of boron, as was achieved in the sand culture, may solve the problem, but more information in this regard is required.

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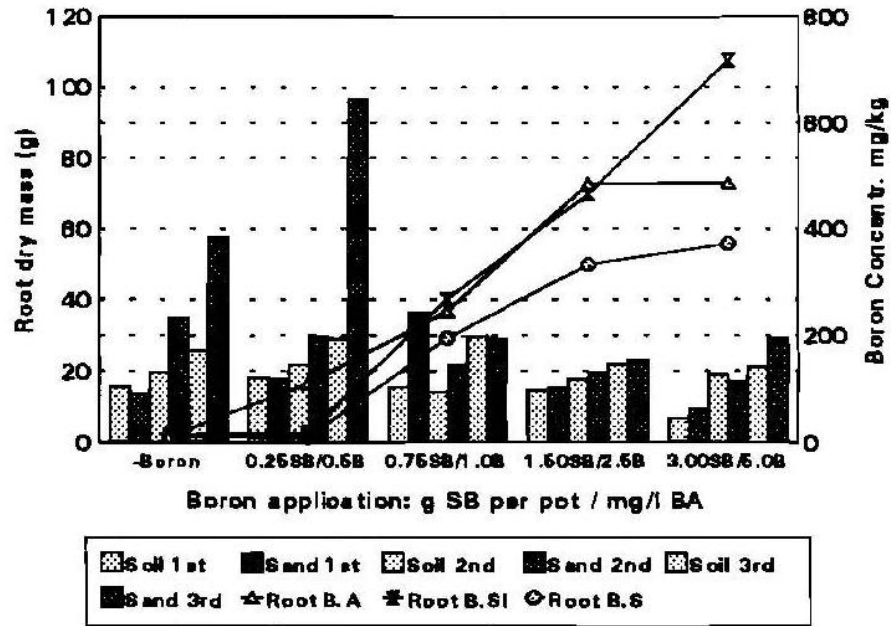


Fig.1 Root dry mass vs. Root B conc.

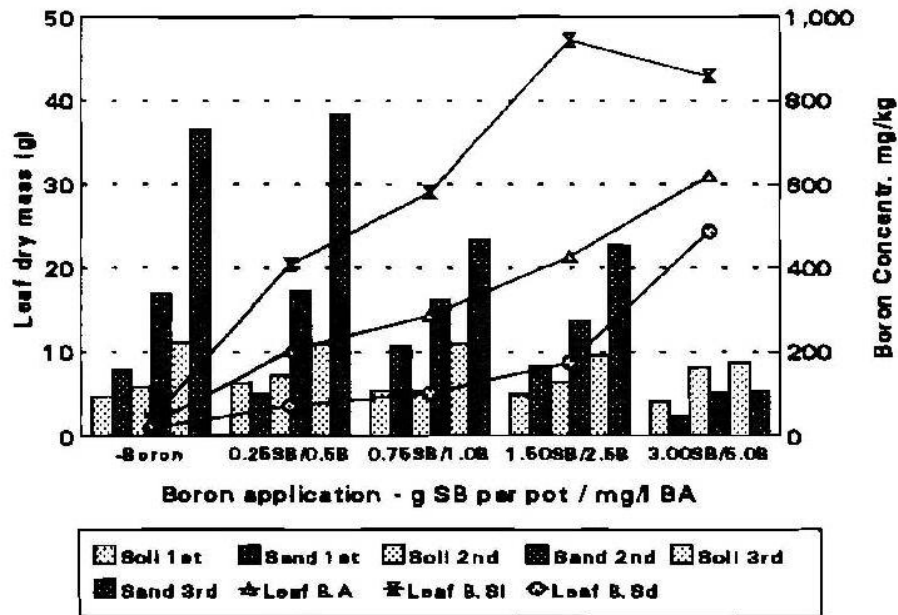


Fig.2 Leaf dry mass vs. Leaf B conc.

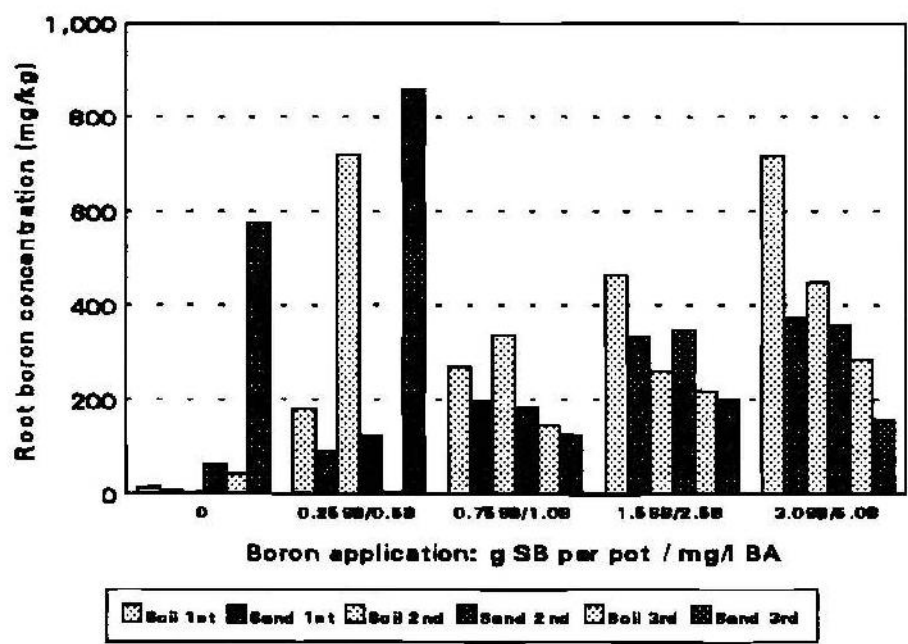


Fig.3 Root B conc. in diff. treatm.

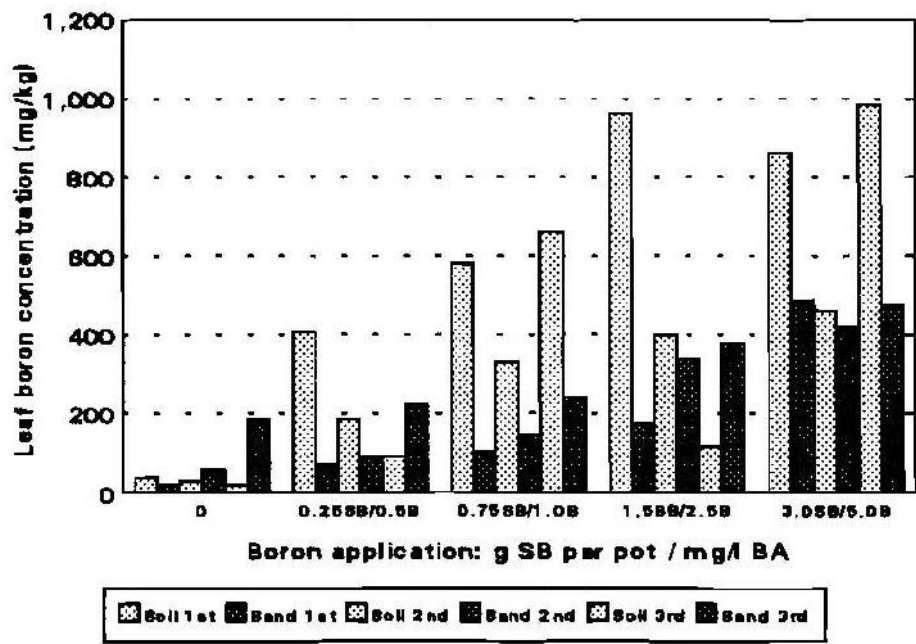


Fig.4 Leaf B conc. in diff. treatm.