

## UPTAKE AND TRANSPORT OF BORON IN AVOCADO SEEDLINGS

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### ABSTRACT

*The importance of boron on fruit set and fruit production in avocados is well documented in the literature. Most of this reported work on boron was on its influence on the flowering, fruit set, fruit production and to a lesser extent on leaf and shoot development. Since many commercial avocado growers have started applying boron as an agrotechnical procedure, many questions have been put to the researchers regarding applications, concentrations and toxic levels. No proper experimental work has been done on the toxic influence of boron on the roots and other vegetative parts. Therefore it has become very important to study the response of these parts to different boron concentrations and the translocation and distribution of boron in avocados. This paper deals with an experiment on the sensitivity to boron of different vegetative parts of young avocado trees and seedlings grown in soil and liquid nutrient medium.*

### UITTREKSEL

*Die belangrikheid van boor op vrugset en vrugopbrengs in avokado's is goed in die literatuur gedokumenteer. Die meeste van hierdie gerapporteerde boorwerk handel veral oor die invloed daarvan op blomming, vrugset en vrugopbrengs en in 'n minder mate op blaaren stingelontwikkeling. Sedertdien het talle kommersiële avokadoboere boor as 'n agrotegniese maatreël begin toedien en is talle vrae oor boortoedienings, konsentrasies en toksiese vlakke aan die navorsers gestel. Geen behoorlike eksperimentele werk oor die toksiese uitwerking van boor op die wortels en ander vegetatiewe dele is al uitgevoer nie. Daarom het dit dringend noodsaaklik geword om die reaksie van hierdie plantdele op verskillende boorkonsentrasies asook die vervoer en verspreiding in avokadoplante te ondersoek. Hierdie artikel handel oor 'n eksperiment waarin die sensitiwiteit van vegetatiewe dele van Jong avokadoboompies en saailinge op verskillende boorkonsentrasies in die grond en 'n vloeibare voedingsmedium, nagegaan is.*

### 1. INTRODUCTION

The main aim of most avocado growers is to increase the production of high quality exportable fruit, and to achieve this goal the grower must carefully nurse the trees helping them to get the correct nourishment for optimal fruit production and the best protection against diseases. Boron is one of the micro elements needed by the plants

and one of many the grower must take note of in achieving his ultimate goal.

The importance of boron on fruit set and fruit production in avocados is well documented in the literature (Coetzer *et al.*, 1993). However, most of the reported work on boron referring to avocados, is on its influence on flowering, fruit set and fruit production and to a lesser extent on leaf and shoot development (Robbertse & Coetzer, 1988 & 1990; Robbertse *et al.* 1989 & 1991). Since many commercial avocado growers have started applying boron as an agrotechnical procedure, no work has been reported on the toxic influence caused by the overdosing of boron on the roots or other vegetative parts of the avocado plants. Therefore it has become very important to find the boron levels avocados can tolerate and inform the growers.

From one of our previous experiments, reported by Robbertse *et al.* (1992), it came to our attention that avocados and mangoes seem to differ in their response to high boron levels. This is very important information for proper orchard management and should be available to growers.

The main objectives of the present study was to gain information on the influence of different boron levels on avocados under controlled conditions and to study the translocation and distribution of boron to different parts of the plants.

## **2. MATERIAL AND METHODS**

### **2.1 Material**

'Hass' seed was obtained from Westfalia and were germinated in a sandbed. Seventy five seedlings were transferred to 11 litre containers with a liquid medium. At the same time 75 young, grafted 'Hass' trees, ready for planting in an orchard, and obtained from Westfalia too, were transplanted into 10 litre plastic pots in a nursery mixture. The experiment was conducted in a semi-controlled glass house of the department of Plant Production and Soil Science, University of Pretoria.

### **2.2 Methods**

#### **2.2.1 Seedling in Water culture**

The seedlings were kept in 11 litre containers, lined with black plastic bags, in half strength (50%) Hoagland's solution minus boron. After two weeks in the solution, the following treatments were applied to 15 plants each:

- a. only the 50% Hoagland's medium minus boron comprising the control treatment;
- b. 50% Hoagland's with  $0.25 \text{ mg.kg}^{-1}$  boric acid (0.25 ppm)
- c. 50% Hoagland's with  $2.5 \text{ mg.kg}^{-1}$  boric acid (2.5 ppm);
- d. 50% Hoagland's with  $5.0 \text{ mg.kg}^{-1}$  boric acid (5.0 ppm);
- e. 50% Hoagland's with  $10.0 \text{ mg.kg}^{-1}$  boric acid (10 ppm).

The Hoagland's medium and boron were replaced every 3 4 weeks for almost 5 months.

#### **2.2.2 Potted trees**

The young trees have received 1.0 litre Hoagland's nutrient medium minus boron only once weekly for almost 5 months. Every second day each plant was given 1.0 litre distilled water. The following treatments were applied once only after the young trees have settled down in the pots (after approximately one month) and started to flush:

- a. 1.0 litre distilled water only - control treatment;
- b. 0.25g Solubor in 1 litre distilled water per pot;
- c. 0.75g Solubor in 1 litre distilled water per pot;
- d. 1.5g Solubor in 1 litre distilled water per pot; and
- e. 3.0g Solubor in 1 litre distilled water per pot.

Each treatment was applied to 15 trees. The experiments were laid out on turning tables which rotated all day during the daylight hours to equalize all external conditions.

### 2.3 Measurements

- a. The following parameters were measured and compared:
- b. plant size measured fortnightly;
- c. stem diameter measured monthly with vernier callipers at 10 cm above soil level;
- d. dry mass of the stems, leaves and roots after drying in a laboratory oven at 60°C;
- e. boron contents of the stems, leaves and roots, determined with an auto-analysier at the department of Plant Production and Soil Science according to Basson *et al.* (1969).

## 3. RESULTS AND DISCUSSION

The results given below and discussed here are not representative of all the aims set out for this experiment as explained in MATERIAL AND METHODS because all those parameters could not be measured. The experiment ran smoothly for about a month before most of the seedlings in the liquid medium started to die. The department of Plant Pathology,

University of Pretoria, suspected a *Phytophthora* infection of the roots. The rationale for this part of the experiment was based on the success of people over many years to germinate avo seed and keep the seedlings growing on a window sill in a glass jar with only water. This would have enabled us to follow and record the root development in the different treatments without having to uproot the seedlings. To compensate for this, and to compare it with soil conditions, the second part of the experiment (2.2.2) was conducted.

It was also observed that there was a huge variation in the vegetative growth of the avocado seedlings. This was mostly due to the genetic variation which, while planning the experiment, was not foreseen that it would have reached this magnitude. It was decided, however, to repeat the experiment using only clonal material of 'Duke 7' because this is the most popular rootstock in the avocado industry at the moment and the rootstock determines the performance of the plant during the treatments.

We continued the experiment only with the potted 'Hass' plants and the results are shown in Figs. 1, 2 and 3. The sizes of the plants, referring to their height, did not show any significant difference between the majority of the treatments and were left out. Most of the plants receiving the high boron treatments did not grow much and all of the 3g Solubor per pot treatment died in the end. We are sure, however, that over a longer period, one will be able to observe growth differences between the lower boron treatments. A comparison of the stem diameter between the treatments over a certain period (Fig. 1) shows the trend that is to be expected of the plant sizes. Three groups can be distinguished in this result viz. the first group where the stems increased in

diameter, the second group where the stem diameter remained almost constant during the time of the experiment, and the third group where the stem diameter decreased almost a third from its original size.

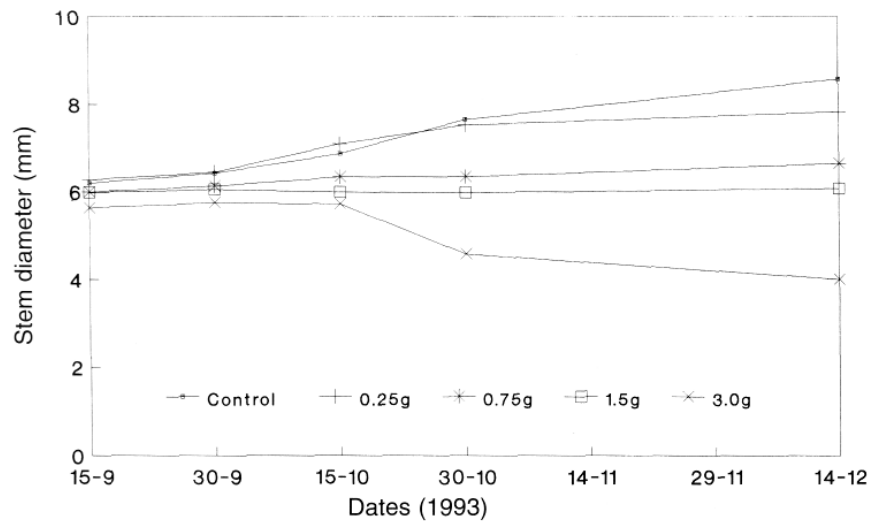


FIG 1. Stem diameter (in mm) of potted 'Hass' plants in relation to boron applied, measured at different intervals from middle of September to middle of December 1993. Legends indicate boron application per plant.

### Stem diameter

The following comments can be made on the results in Fig. 1:

- Although a 1.5g application per pot is very high, the influence on the plants was not much different from that of the 0.75g treatment and there seems to be a relatively high short term threshold value only above which the plants react clearly like in the 3.0g treatment.
- The control plants and those of the 0.25g treatment showed a similar increase in diameter with the control plants performing a little better in the end. A shortcoming of the experiment is that the boron concentration in the potting soil was not determined. However, it seems that even the 0.25g treatment had a slightly negative effect on the stem growth, but was close to the ideal concentration.
- It became evident that only a huge overdosing of boron will show effect in a relatively short time. Small overdosing will only show in the long run and it is therefore important to make very sure when determining the dosages to be applied commercially.

### Dry mass of vegetative parts

The results of the dry mass (Fig. 2) shows only small amounts of material being handled due to the small size of the trees used. The material was collected at three different dates and showed with only one exception that of the roots during the second collection, a general decrease in the average dry mass of the vegetative parts as the amount of boron in the treatments increased. With the exception again of the roots during the second collection, the highest average mass of all the material was from the control

treatment.

The differences in the average dry mass of the leaves, stems and roots were not very prominent at the first collection with about a 3g difference between the leaves (lowest) and the roots (highest) of the control treatment. At the end of the experiment this difference was very big with the average dry mass of the roots more than 30g per tree and that of the stems not even reaching 10g. However, with every collection the differences became more prominent where growth was not impaired (control and 0.25g treatments) in comparison with the treatments which received a large amount of boron. It is interesting to note that although initially there was a good match in mass between the above ground parts and the below ground parts, it ended up with a much higher rooting mass than the combined totals of the stems and the leaves. The biggest fluctuation in the mass occurred at the lower boron treatments. There was not much, if any, decrease in the mass from the 1.5g treatment to the 3.0g treatment. The growth impairment by the high boron treatments is the major cause for the low dry mass recorded in some treatments.

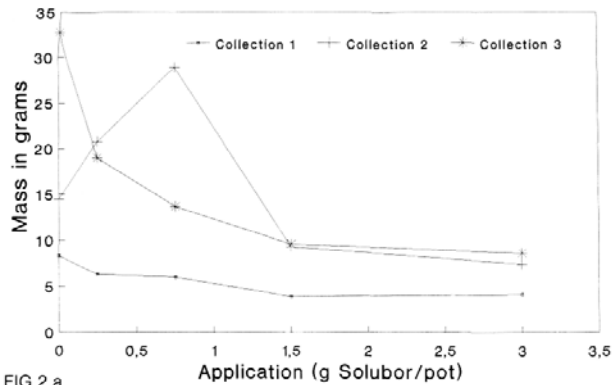


FIG 2 a

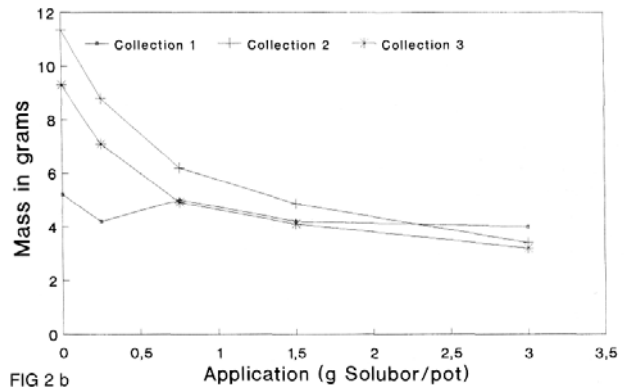


FIG 2 b

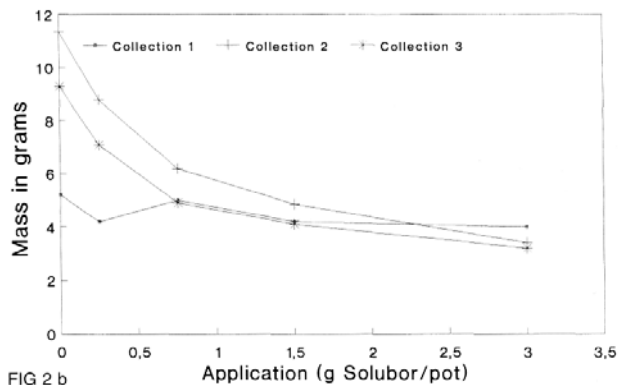


FIG 2 b

### Boron concentration of vegetative parts

The results are shown in Fig. 3. A striking feature in the results of the first collection is the huge difference in boron concentrations between roots, stems and leaves. There were no significant differences between them regarding the control and 0.25g treatments. Another peculiarity is the relatively low boron concentration in the leaves in spite of the higher applications in the other treatments. The impression is created of the

roots accumulating most of the boron and providing some to the stems but almost nothing reached the leaves.

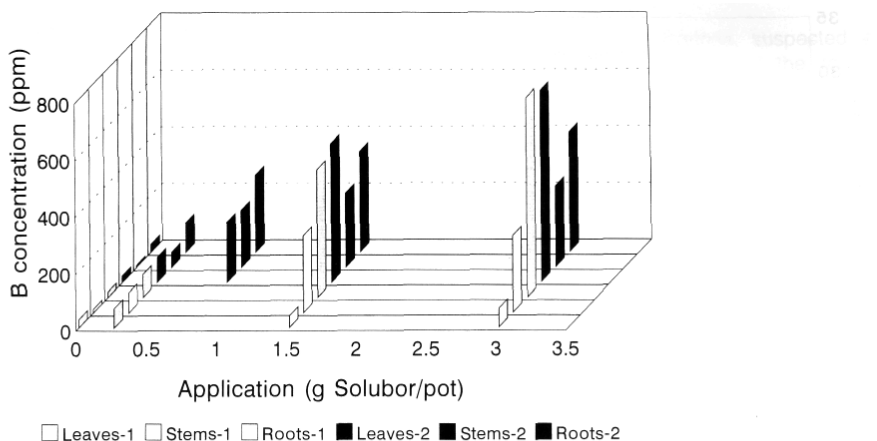


FIG 3. Average boron concentrations in different vegetative parts of potted 'Hass' plants following different boron applications to the soil. Leaves -1, Stems-2 and Roots-2 from the second collection.

The situation changed during the second collection where the leaves reached the highest boron concentrations in the 1.5g and 3.0g treatments. The stems (lowest) and roots retained their respective positions with regard to one another for all the treatments. Interestingly the concentrations in the stems remained almost the same as in the first collection, but the leaves and roots reversed their trends of the first collection.

## SUMMARY

Growers should be warned that avocado roots are very sensitive to a high boron concentration. The roots nevertheless do need boron for optimal growth and development. It seems, however, that avocado roots accumulate a large amount of the boron, more than they pass on to the stems and leaves, when subjected to a high concentration of boron in the growth medium. It is recommended that growers should be very cautious with applying boron to the soil and should seriously consider keeping to leaf applications. The answer to the question of the ideal boron concentration in the soil for optimal root growth is still evading us, but for a calculated guess we can come up with a figure of more or less 5 mg.kg<sup>-1</sup> warm water extractable boron.

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