

THE ROLE OF BORON IN AVOCADOS: THEORY, PRACTICE AND REALITY

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ABSTRACT

It has been found that Boron improves fruit set in various plant species, but very little information is available on the optimal Boron requirement for optimal fruit set. There is also very little information on the movement of boron in plants. By using boron enriched with the isotope ^{10}B , we have shown that the boron is indeed absorbed by the avocado leaves and then remobilised from the distally positioned mature leaves of the branch to the inflorescence. Therefore, the boron concentration of the leaves at the stem tip, directly below the axillary buds which are destined to produce the inflorescences, should be adjusted well in advance of the flowering period, to a level for optimal pollen tube growth during the flowering period. This level was determined to be between 60 mg.kg^{-1} and 80 mg.kg^{-1} .

It is important to distinguish between the free and the bound boron in leaves, as it is only the free boron which is available for remobilization to the inflorescences. The optimal level of the free boron is yet to be established.

Increasing the boron concentration in avocado leaves can best be achieved by repetitive foliar spraying. Relatively little boron is absorbed by the avocado roots themselves due to the absence of root hairs; most of the minerals are provided to the plants by mycorrhiza.. Fungi however, do not require boron and usually do not take up boron naturally. Care should therefore be taken about the amount of boron sprayed onto a tree, for when the excess spray drips down from the leaves, it can cause a build-up of boron in the soil which can damage the mycorrhiza.

INTRODUCTION

From the time in 1923 that Warington put the importance of boron for plants on a par with the necessity of vitamins for animals, boron was studied with new attention. Many different reports were published on aspects as diverse as the role of boron in cell growth (Gupta *et al.*, 1985), sugar biosynthesis (Reeve & Shive, 1944), fruitset (Dickinson, 1978; Hanson & Breen, 1985), the successful completion of a plant's life cycle (Pilbeam & Kirkby, 1983) and many more. Evidence from the literature shows that certain boron levels indeed improve fruit set/seed set in some crops. A boron treatment some time before flowering commences, was reported to have increased the yield of tomatoes, beans (Coetzer *et al.*, 1990), cherries (Hanson, 1991), macadamia nuts (Stephenson &

Gallagher, 1987) and hazel nuts (Shrestha *et al.*, 1987).

This paper is a synopsis of the experimental work that has been done over a period of four years. Most of the results have already been published in the Yearbook of SAAGA, but some new data has been included and is put into perspective with the previous work. For all the detail of the material and methods, the reader is referred to the previous editions of the Yearbook. All the work on commercial trees were done at Westfalia Estate and the greenhouse work at the Margaretha Mes Institute for Seed Research of the University of Pretoria.

OPTIMAL BORON REQUIREMENTS FOR POLLEN TUBE GROWTH

A positive relationship has been indicated between the boron concentration in avocado plants and pollen germination, pollen tube growth, fruit set and fruit production (Robbertse *et al.*, 1987; Robbertse & Coetzer, 1988; Robbertse *et al.*, 1989). This was related to a boron level of $\pm 70 \text{ mg.kg}^{-1}$ in the avocado flowers.

If we proceed on the assumption that the success of fruit set is based on effective fertilization, all efforts should be directed at increasing the fertilization to a tree's optimum potential. Because it is difficult to measure effective fertilization in an early stage, it can at best be deduced from, as far as the measurable influence of boron is concerned, the number of pollen tubes reaching the ovule as well as from the fruit set and fruit production. However, the crucial aspect which can never be over emphasized is maintaining high quality pollen tube growth in the styles and having good quality ovules and pollen.

To achieve this we suggested a boron concentration of $\pm 100 \text{ mg.kg}^{-1}$ in the mature leaves at the stem apex before the inflorescence starts to grow. In practice this has never been obtained for avocado and it seems too high. We therefore advise to aim for $\pm 70 \text{ mg.kg}^{-1}$ in the leaves and $\pm 50 \text{ mg.kg}^{-1}$ in the inflorescences.

BORON APPLICATION TO AVOCADO PLANTS

Boron is very soluble and leaches with ease from sandy soil during wet seasons. During dry seasons and in different soil types the situation will vary. It therefore has to be supplemented only when required. Two methods are currently used in applying boron to avocado trees videlicet by spraying the leaves and by means of a soil application.

Results of the last season in a commercial orchard (Robbertse *et al.*, 1992) showed that absorption of boron by the roots was very restricted and the highest increase in total boron concentration in the leaves was achieved by leaf spraying. It was also evident that, regardless of the soil treatment, it took the boron almost a month to reach the leaves near to the inflorescences in those trees.

From the spray treatments in the same commercial orchard, the boron concentration increased from a very low 15 mg.kg^{-1} to almost 50 mg.kg^{-1} while the soil applications reached a highest of only 28 mg.kg^{-1} . These results supported those of Robbertse *et al.*, (1989) and Robbertse & Coetzer (1990) that there is a limit to the amount of boron avocado plants can utilize from the soil. The problem seems to be with the roots or with

the avocado mycorrhiza.

Dugger (1983) has indicated that the mycorrhiza themselves do not utilize boron. If the boron concentration in the soil should rise above a certain level, it may become toxic for the roots. This may restrict the mycorrhizal activities and by doing so harm the plants indirectly or may cause them to die. This may explain the results of our experiment conducted in a greenhouse on potted avocado and mango trees. Each tree of the two groups were treated with 500 cm^{-3} of aSg.dm^{-3} Solubor solution. The young mango trees accumulated boron in their leaves up to 600 mg.kg^{-1} before the trees died. The avocado trees also died, but their leaf boron concentrations never exceeded 60 mg.kg^{-1} . The symptoms were similar to trees that had died because of a lack of water and nutrients. The 'toxic' boron concentration in the soil killed the roots and/or the mycorrhizal fungus. We do not know the toxic level of boron in the soil for avocados.

The amount of boron applied to an average avocado tree, is much higher than what is generally realized. With at least 2 leaf applications per season, each tree gets $\pm 40\text{g}$ of Solubor per year. Some of this remains on the tree, but some of the solution drips from the tree and can accumulate around the roots. After the second year the tree has had a total of $\pm 80\text{g}$ of Solubor; the majority on the leaves, but one part by means of an indirect "soil application". At the end of the third year the total can be as high as 120g of Solubor with a substantial percentage of this already accumulated in the soil. Add to this scenario a serious drought and heavy soils, and the matter can get out of hand. Therefore, the amount of boron to be sprayed annually must be determined very carefully.

THE RELATIONSHIP BETWEEN BORON ANALYSIS OF AVOCADO LEAVES AND AVAILABLE BORON FOR THE FLOWERS

In the beginning of this study we attached much importance to the boron concentration of the leaves as such. However, this showed the total boron concentration of the parts analyzed, and this total amount of boron was not available to the flowers. Later it became clear that we could not be sure which percentage, if any, of this total boron was destined for the flowers. Skok & McIlrath (1958) showed us how to distinguish between free boron and bound boron, with the free boron the only boron available for remobilization to any new growth.

Developing cells need boron. Some of it is bound into the cell walls and cell organelles (Tanada 1983) and some is used for certain processes like carbohydrate metabolism (Sisler *et al.*, 1956). Only when the boron requirements of a cell are satisfied, will it accumulate boron and keep it in solution inside the cell vacuole (Eaton, 1944). This is the bulk of the free boron and the only part that can be remobilized.

We suspected the remobilization of free boron when we found a decrease in the boron concentration of the mature leaves on a branch and a simultaneous increase of boron in the flowers on the same branch. The boron concentrations of the young leaves remained almost the same during the flowering period.

By using boron enriched with the isotope ^{10}B and applying it in a solution to the upper and lower surfaces of different avocado leaves, it was possible to confirm that boron is

remobilised only from the mature leaves to the inflorescences. By far the most of all this boron entered the leaves by their lower surfaces. All the enriched boron supplied to the young leaves, remained there and was probably bound by the developing cells. Although some boron can reach the flowers via the transpiration stream from the roots (Raven, 1980), it seems that this supply of free boron is supplemented with the free boron from the mature leaves.

To have more boron available for the flowers, it is therefore necessary to increase the boron concentration of the mature leaves close to the stem tip, well in advance of the flowering period.

SAMPLING FOR BORON ANALYSIS

Before any amount of boron can be applied to an orchard, one has to determine the mean boron concentration of the plants involved. The standard method is to collect leaf samples and have them analysed in a laboratory. Two very decisive factors involved in collecting the samples are the **time** of sampling and the **position** of the leaves on the plant to be sampled.

Much information has been published on sampling for leaf analysis (Agarwala *et al.*, 1988, Gupta, 1991 & Smith, 1992), but the last word has certainly not been spoken yet. According to results from our experiments with mangos, the correct time to sample seems to be shortly before the flowering flush starts. However, for corrective steps to be taken in time, leaves should be sampled earlier. We recommend that the sample be taken from the mature leaves close to the dormant stem apex because their boron concentration is a very good indicator of the tree's boron status at the stage when the youngest mature leaves developed and differentiated.

INFLUENCE OF BORON APPLICATION ON FRUIT PRODUCTION IN AVOCADOS

The ultimate goal of any avocado farmer is to increase the production of high quality exportable fruit. During the past few years we have shown in our experiments that there was always some improvement in fruit production by the trees treated with boron over the control trees (Robbertse *et al.*, 1989; Robbertse *et al.*, 1991 & Robbertse *et al.*, 1992) however, in some experiments we could show only a marginal improvement over the control plants.

SUMMARY

1. The aim in boron concentration should be for $\pm 70 \text{ mg.kg}^{-1}$ in the leaves and $\pm 50 \text{ mg.kg}^{-1}$ in the inflorescences.
2. Leaf application of boron is preferred to a soil application in avocado. Care should be taken not to induce a buildup of excess boron in the soil.
3. The amount of free boron in the mature leaves nearest to the inflorescence gives a better indication of the boron status of a tree.

4. The youngest mature leaves should be sampled for boron analysis the closer to the onset of the flowering period, the more accurate.
5. It is widely accepted that the optimum amount of boron improves fruit set and fruit production. This also applies to avocados if all the other factors involved are in optimum too.

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