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Only Spring Flush Leaves Should Be Sampled for a Reliable Assessment of Nutrients in the Avocado

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Abstract

Three types of leaves were sampled monthly from N-deficient avocado trees and healthy trees over the course of an entire year: previous year's leaves, leaves from spring flush, and leaves from the second flush (summer). In all three leaf types and throughout the year, N concentration was significantly lower in the N-deficient trees than in the fertilized ones. A significant difference was found also between the spring leaves and the summer leaves, sampled at the same time.

In order to ensure accurate interpretation of leaf analyses — the most important tool for determining the N-nutrient status of the plant — only leaves from the spring flush should be sampled. Leaves from the spring flush can be differentiated easily from those of later flushes, according to their calcium content.

Introduction

Leaf analysis is accepted as the most reliable method to determine the nutritional status of avocado trees. It is well known that leaf age, position on the twig, fruiting, cultivar, soil type, and cultural practices may all contribute to variations in the mineral concentration of avocado leaves. In order to obtain reliable results, it is most important to standardize sampling methods, so that the analysis will correlate with the nutritional status of the tree.

It is recommended to sample healthy, unimpaired mature leaves of the first growth of the current year; namely, leaves of the spring flush (5). However, it is very easy to err in determining the age of leaves, since leaves of the various flushes do not differ in shape or color.

In 1977, Koo and Young (3) compared the concentrations of nutrients in leaves from the early and late flushes of the avocado. They found that the level of N was high and that of Ca was lower in the summer flush leaves as compared with the spring flush. It was concluded that since it was virtually impossible to distinguish between the leaves of the two flushes, it was advisable to sample both.

The objective of the present report was to determine more accurately the differences between spring and summer flush leaves, with regard to N application, since N is considered to have a great influence on the growth and fruiting of avocado trees.

Materials and Methods

The experiment was conducted in an 8-year-old avocado plantation, on a low-lime grumusol soil with 60% clay. The plantation was irrigated by the drip method, with 12 drippers per tree each discharging 4 l/h.

Nitrogen was injected as liquid NH_4NO_3 at a constant concentration of 40 ppm into the drip irrigation system. The results presented refer to two treatments: one constantly supplied with N during the 4 years (1981-1984) and the other, because of a technical failure, not given any N during 1982 and 1983 (Table 1).

The trees deprived of N showed typical N-deficiency symptoms (Fig. 1), expressed by restricted growth, pale, small leaves, and early leaf shedding. In addition, fruit number and size were significantly reduced and the trees were more susceptible to frost damage (6).

The experiment was conducted in six replications, each comprising 12 Hass and 12 Fuerte trees. During one year, starting in April 1984, leaves were sampled monthly from the fertilized and non-fertilized trees for nutritional assessment.

Three types of leaves were sampled: (i) those remaining from the previous year (1983), as long as they were on the trees; (ii) leaves of the spring flush; and (iii) leaves of the summer flush. Each sample comprised three leaves from each tree, with a total of 36 leaves in each replication. After being washed and ground, the samples were wet-ashed and analyzed for 11 elements; only nitrogen and calcium will be discussed here. A more detailed report will be published elsewhere (4).

Table 1 Amount of nitrogen (kg/ha) supplied during 4 years.

Treatment year	+N	-N
1981	190	161
1982	248	0
1983	254	0
1984	189	157

Fig. 1 *Extreme N deficiency (left) with restricted growth and early leaf shedding. On the right, healthy tree.*

Results

Nitrogen concentration in leaves increased in spring, the first period of leaf growth. Later on, the level decreased gradually and stabilized in autumn and winter (Fig. 2). In the following spring, the N-level decreased until the leaves were shed. The highest N-concentration was found in leaves of the summer flush, and the lowest in leaves of the previous year. It was clear that nitrogenous fertilization influenced the N content significantly in all three leaf types. At the accepted sampling time (autumn), a highly significant difference was found in N content of the spring- and summer-flush leaves.

It should be emphasized that in spite of the normal fertilization regime in summer 1984, noticeable differences in the leaves' N content were still observed. The previously unfertilized Fuerte trees contained 1.62% N *vs.* 1.78% in the fertilized trees; the respective levels in the Hass leaves were 1.52% and 1.73%.

Calcium concentration in the avocado leaf increased gradually from leaf emergence to shedding (Fig. 3). Only the spring-flush leaves showed some stabilization in Ca content in autumn. There were marked differences in Ca content — the converse of those revealed by the N content — in the various leaves: the highest concentration was in the previous year's leaves and the lowest in summer-flush leaves. Nitrogenous fertilization had almost no effect on the Ca concentration in the leaves.

Discussion

The variation in the level of N and Ca was more affected by leaf age than by any other factor, even more than by the nitrogenous nutrition. With leaf aging, N level decreased while the level of Ca increased as had been previously reported (2, 3, 5).

Additional confirmation was obtained of the suitability of the autumn sampling season for the avocado. The concentrations of most nutrients including N and Ca in leaves of the spring flush are almost constant in autumn. This season is therefore reaffirmed as the best one for sampling avocado leaves. Since the previous year's leaves had already been shed at that time, only the spring *vs.* summer flushes will be discussed here.

Fig. 2. *The effect of leaf age, fertilization regime, and sampling date on nitrogen content of avocado leaves.*

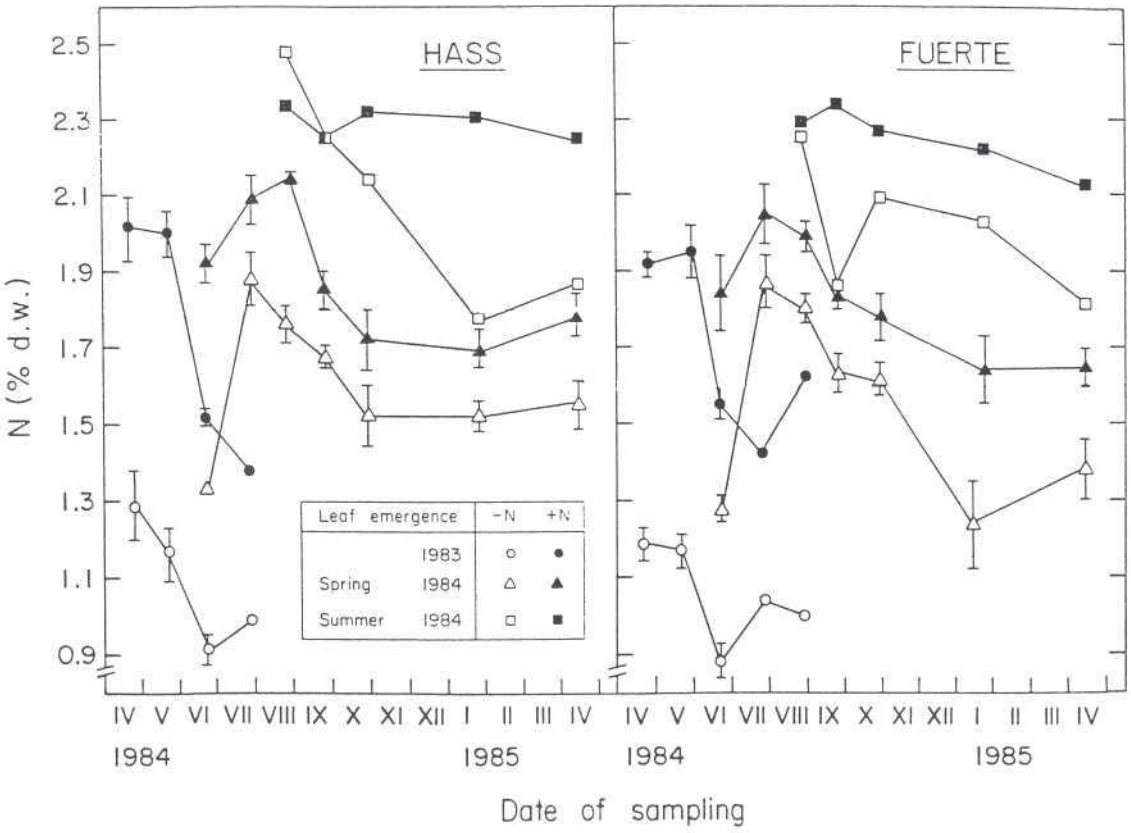
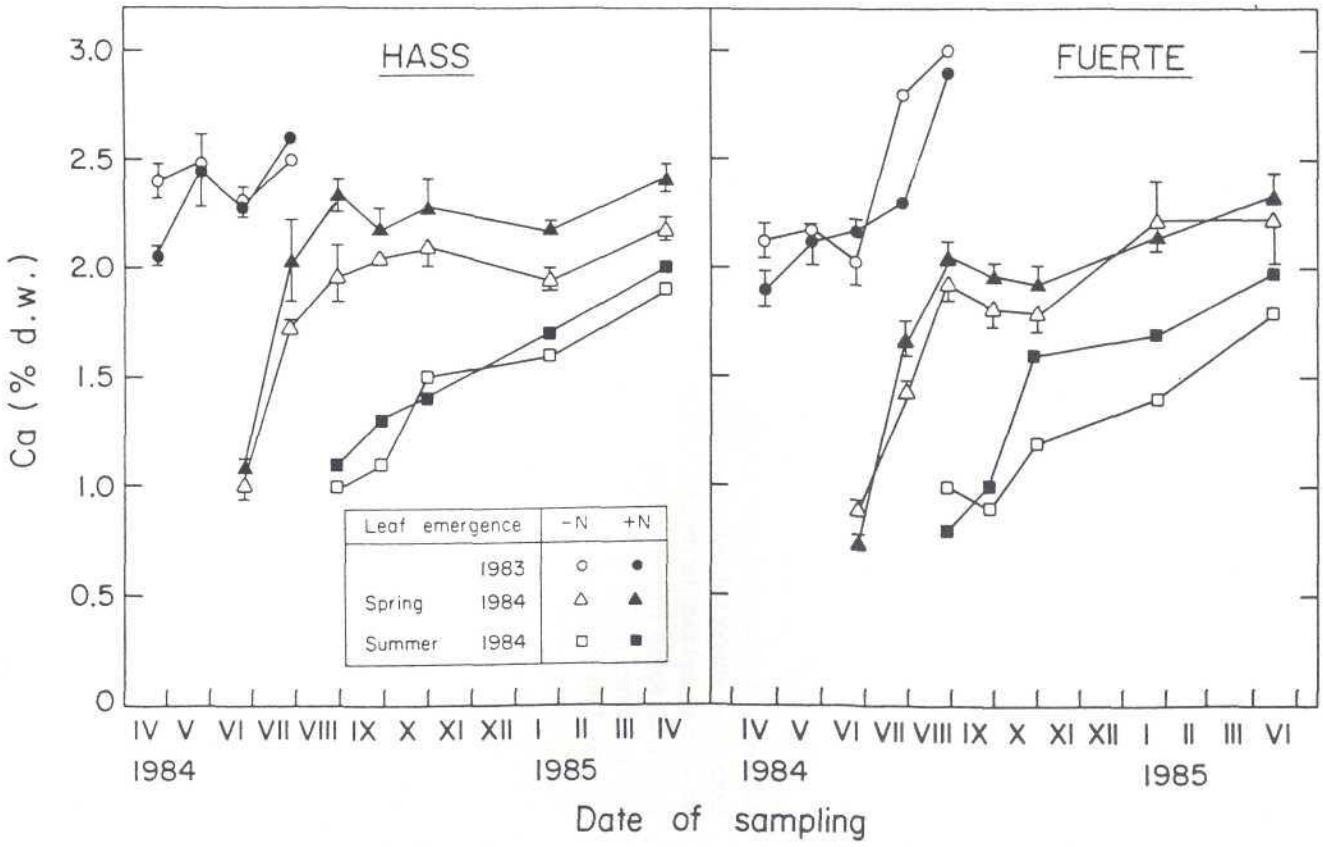


Fig. 3. *The effect of leaf age, fertilization regime, and sampling date on calcium content of avocado leaves.*



Since significant differences in N content were generally found in all leaf types, the leaf can be considered a good organ for determining the nitrogenous nutritional status of avocado trees. When comparing the critical N levels (1.6% in Fuerte and 1.8% in Hass), it is noted that N was always above the critical level in fertilized trees, as compared with a deficiency in unfertilized trees. This was found only in the spring-flush leaves. The N-level in the summer-flush leaves was always above the critical level, both in fertilized trees and in those suffering from a severe N-deficiency. It is therefore concluded that leaves of the summer flush are not suitable for sampling, as long as the critical level of N for avocado is not increased. In addition, in the autumn, the N level had not yet stabilized in the summer-flush leaves. This fact may lead to wrong interpretation of the leaf analyses and hence to wrong fertilization recommendations.

Despite the fact that N is highly mobile both in soil and trees, even in autumn 1984 (one season after N fertilization was resumed) significant differences in N content were observed between the fertilized and unfertilized trees. It is suspected that a severe N deficiency cannot be corrected in a short time, and that the process takes more than one year. This slow response to N may result from the large N reservoir present in the avocado trunk and branches (1, 7), which has to be filled before the leaves receive their supply. This N reservoir is estimated at 250g N per (7-year-old) avocado tree. Contrary to the long time (2 years) required for correcting N deficiency, it was seen that the effect of deficiency on avocado leaf content is almost immediate. Low N levels were found in

the autumn-sampled leaves already by the end of the first season with N application (1982).

It is recommended in California to sample fully mature leaves, the last leaves to complete their development (2). Since some of these leaves are not from the spring flush, their analysis will produce unreliable results. Koo and Young (3), who sampled both spring- and summer-flush leaves, found the same differences as we did. However, their conclusion was that, since it was virtually impossible to distinguish between leaves of the two flushes, a mixture of the two flushes should be sampled and analyzed. We believe that, because of the large and significant difference in the nutrient content, one should differentiate between spring- and summer-flush leaves and only spring-flush leaves should be sampled. It is relatively easy to identify the spring-flush leaves. They can be found immediately above the ring of the dormant buds formed between the last year and the present year's growth (Fig. 4).

The results obtained show that there is no basis to change the critical level of N in avocado leaves. In autumn sampling, the Fuerte unfertilized trees contained less than the critical level of 1.6% N; the fertilized trees contained more than that. In cv. Hass, the fertilized as well as the unfertilized trees contained less than the critical level of 1.8% N. It seems that in this case the trees were not fertilized sufficiently and, as is well known, cv. Hass requires more nitrogen than Fuerte (5).

The significant differences in Ca content between spring and summer leaves enabled us to differentiate between them. In the recommended sampling season, the Ca level in the summer-flush leaves never exceeded 1.6%. while that of the spring-flush leaves was always above 1.8% and often above 2%. Therefore, one can easily distinguish between spring- and summer-flush leaves by determining their Ca level.

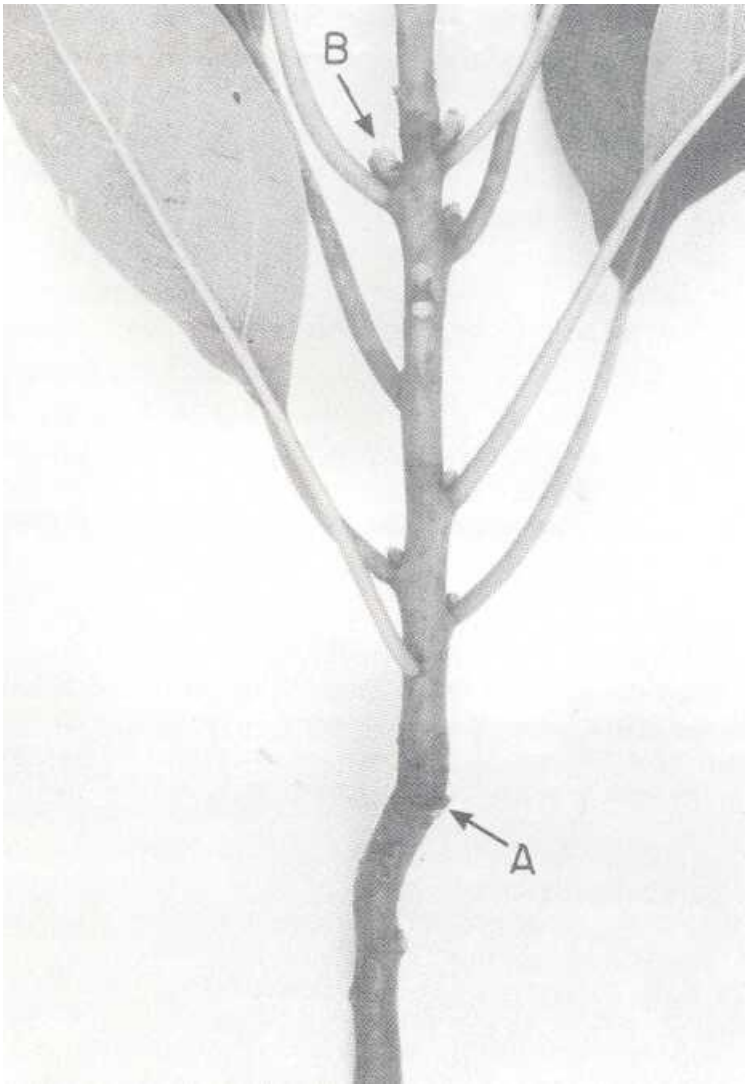


Fig. 4. *Location of the spring flush leaves (between A and B) recommended for sampling. A - ring of buds between the previous and present-year's growth; B - buds separating the spring and summer flush.*

In order to ensure accurate interpretation of leaf analyses — the most important tool for determining the N nutrient status of the tree — only leaves of the spring flush should be sampled. They can be identified easily according to the ring of buds marking the end of the previous year's growth. After sampling, the leaves of the spring and summer flushes can be identified according to their Ca content.

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