South African Avocado Growers' Association Yearbook 2000. 23:56-62

Macro nutrient accumulation and requirement of Hass avocado trees

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ABSTRACT

Various questions concerning the correct nutrition of avocado trees are asked by avocado producers. Questions regarding the correct use of nitrogen, the importance of potassium and calcium in fruit quality, as well as the timing and ratios of these macro elements for maximising fruit quality and for increasing yields are regularly asked. These questions have arisen from a greater awareness of the effect of tree health and the importance of fruit quality. With this awareness and willingness to upgrade general orchard management, producers hope to eliminate alternate bearing of avocado orchards, as well as fruit quality problems (internal as well as external).

The ARC-ITSC, in its effort to find answers to these problems, initiated research projects some years ago to study the physiology of the avocado. These studies include the starch metabolism of avocados, nutrient uptake and distribution, as well as the effect of various manipulation actions on the basic physiology of the avocado tree.

The current study concentrated on the accumulation and distribution of starch and macro elements within the Hass avocado tree at harvest. With the results of this study it is now possible to give scientifically founded guidelines with regard to the macronutrient requirement of Hass avocado trees. The authors provide some provisional guidelines of the fertilizer needs of avocados. This approach does not, however, eliminate the need and usefulness of leaf and soil analysis in determining fertilizer requirements.

INTRODUCTION

Stassen *et al.* (1997) provide information on the seasonal pattern of N, P, K, Ca and Mg content in the fruit, leaves, shoots, wood, bark and roots of six-year-old avocado trees. The authors indicate how the data may be used to estimate the annual nutrient demand according to yield and/or stem circumference. Taking into account fruit removal, nutrient fixation in certain plant parts and requirement by all plant parts, nutrient guidelines for mangoes have been presented (Stassen *et al.* 1999). The authors describe in detail how the annual nutrient demand is determined and how it must be applied during the year in order to satisfy the crop requirements timeously.

The advantage of these guidelines is that they are directly coupled to crop performance and development. In this way plant age, planting distance, cultivation practices and pruning are already part of the equation. The guidelines must, however, still be refined to suit the particular soil type based on soil structure divisions as discussed by Stassen *et al.* (1999). Soil and leaf analysis, as well as visual observations, or plant measurements regarding vigour of growth, and fruit development must at all times be used in the refining process. In this article more information is provided on the nutrient requirement and the distribution of nutrient elements in the different parts of Hass avocado trees. Guidelines are presented that can be adapted and refined for specific circumstances.

MATERIALS AND METHODS

Three trees were selected from each group of three-, four-, six and 11-year-old Hass avocado trees excavated at harvest. The trees were divided into the different plant parts, weighed and sampled for analysis. Sixty trees were selected from each group of three-, four-, six and 11-year-old Hass avocado trees. They were measured and yields recorded.

RESULTS AND DISCUSSION

Relationships and norms

As indicated for the mango by Stassen *et al.* (1999) there also exists for the avocado significant relationships between dry mass (tree development) and the stem diameter measured about 8 cm above the graft union (Figure 1a).



There are also relationships between stem circumference and yield (Figure 1b).



From Figure 1b it appears that the yield for unpruned Hass avocado trees reaches a peak at about nine years with a stem circumference of about 85 cm and a yield of 80 kg/tree (22t/ha if trees are planted at 278/ha). Before trees are nine years old, a management programme must already be in place for production to be maintained. From the above figures it can be seen that the stem circumference (between 30 and 90 cm) can be used to estimate the potential yield. It can therefore also be used to estimate the nutrient requirement as this is determined by the dry mass accumulation and yield potential.

In Table 1 the "optimum" leaf norms for avocados is given as determined in experimental orchards.

Table 1	Optimum leaf norms for avocado trees maintained in experi- mental orchards				
Ν	Pinkerton	2,3%			
	Hass	2,0%			
	Fuerte	1,7%			
Р		0.15%			
К		1,0%			
Са		1,2%			
Mg		0,5%			
S		0,3%			
Zn		30 mg/kg			
Cu		9 mg/kg			
Fe		80 mg/kg			
В		40 mg/kg			
Мо		0,5 mg/kg			

A great deal of research needs to be done to obtain optimum leaf norms especially as regards the relationship between leaf norms and quality aspects.

In the case of nitrogen, attention must be given to excessive growth and in particular to strong watershoot development. Nitrogen application at the wrong phenological stage (summer) must be applied with circumspection and avoided if vigorous growth is already present and leaf norms are already above the optimum level. In addition guideline quantities must be adjusted, upwards or downwards, if the norms in Table 1 are respectively too low or too high.

• Distribution of macro elements in avocado frees

Figure 2 gives the actual cumulative quantities of the different elements as determined in avocado trees of various ages just prior to harvest.



Potassium occurs in greatest quantity, followed by nitrogen, magnesium and phosphorus. The quantities for each element accumulate as the trees get older and dry mass increases.

Figures 3a, b, c, d and e show the total amount respectively of N, P, K, Ca and Mg in different parts of three to 11 -year-old Hass trees.

Figure 3a shows that a large quantity of nitrogen is fixed into the leaves. Large quantities are also fixed in the permanent parts (roots, bark and wood). The fruit and seed contain the rest, and this is removed from the tree at harvest.



Figure 3b indicates that P is relatively evenly spread throughout most of the plant parts but the bark and seed contains the least.



Figure 3c shows that the fruit contains a substantial quantity of K that is removed at harvest. In other plant parts K is mainly fixed in the wood. The new shoots and leaves contain about the same amounts.



Figure 3d gives a good indication of the small amount of Ca found in the fruit. Most of the Ca goes to the leaves. Trees with excessive watershoot growth will use the Ca even more in the leaves and shoots to the detriment of the fruit which are the weaker competitors.



Figure 3e shows that Mg occurs mainly in the leaves. This is followed by the new shoots and wood. The quantity removed by the fruit is relatively small.



Annual macro element demand

From the results it is easy to determine the annual fixation, removal and requirement of elements. The information can then be translated into the amount of the element needed by the plant in order to produce one kilogram of fruit. Another approach can be to determine the amount of each element required to produce a certain quantity of dry mass (plant tissue and fruit). Such calculations are summarised in Table 2.

Table 2 Guidelines for macro or g per cm trunk c replenished	o elemen ircumfere	ts as kg ence wi	l elemer hich mu	nt per to st annu	on yield ally be
	Kg element/each ton yield				
	N	Ρ	К	Ca	Mg
Sandy soils (0-12% clay)	7,1	1,2	10,2	3,3	2,3
Medium potential soils (13-24% clay)	5,7	1,0	8,2	2,6	1,8
High potential soils (>24% clay)*	4,5	0,8	6,5	2,1	1,5
* On old banana soils (higher than 24% clay). Le necessary. Do an organic N soil analysis to determ soil.	af and soil and nine the exped	alysis would iency of plar	determine w nting avocad	hether any c o directly int	application is o this kind of
	g element/cm trunk circumference				
and the second second	Ν	Ρ	К	Ca	Mg
Sandy	5,3	0,9	7,6	2,5	1,7
Medium	4,2	0,7	6,1	2,0	1,4
High	3,4	0,6	4,9	1,6	1,1
See "old banana soils" above					

Along with this information the soil potential (leaching and fixation) is taken into account. This applies especially to nitrogen but the same principle also applies to other elements. Meyer *et al.* (1986) divides soils into four categories for the application of nitrogen to sugar cane and Saayman and Lambrechts (1998) give recommendations for table grapes based on three soil structures.

• How is the annual nutrient demand determined for the avocado tree or orchard?

The figures differ from those of Stassen *et al.* (1997) which were higher. Current research has, however, shown that taking leaf loss into account overestimates the requirements. In addition the current study is based on 3-, 4-, 6- and 11-year-old Hass trees.

The annual requirement can therefore be calculated on the basis of fruit yield. On high potential soils 90 kg N/ha/year is needed for a yield of 20t/ha (4,5 x 20 according to Table 2). That is, 321 kg LAN/ha/year or 802 g LAN/tree/year if there are 400 trees/ha.

Similarly a tree with a stem circumference of 75 cm needs 255 g N/tree/year or 910 g LAN/tree/year in high potential soil.

The guidelines will still be an overestimation that will have to be adapted according to leaf and soil analyses as well as tree vigour. Excessive watershoot development is an indication that too much N is available for the tree and/or that a too high proportion has been applied at the wrong time. In areas where thunderstorms occur in the summer months a reduction of up to 20% of the annual N requirement can be made. Adaptations must be made for each farm and will be accurately determined within a year or two.

• How must the annual requirement be applied?

Stassen *et al.* (1999) describe the basis by which the nutrient element proportions that are applied during certain phenological periods of the mango tree are determined. The same principles can be applied to the avocado tree. Conventional applications will be more or less scheduled as follows with account being taken of specific cultivars as far as N is concerned:

- 1. 20% directly after harvest (±May/June).
- 2. 20% one to two months later (±July/August).
- 3. 15% during budding/flowering (±September).
- 4. 15% during early fruit development (October/November).
- 5. 5% in the summer (± December/January).
- 6. 15% when trees flush (±February).
- 7. 10% during later fruit development (±March).

Applications 1 and 2 can mainly be applied together directly after harvest. Application 4 can be left out if leaf analysis values (norms) are 0,2% higher than the optimum listed in Table 2. Adaptations also need to be made if analysis values (norms) are too low.

Application 5 will in most cases, where trees are growing well, be left out. Applications 6 and 7 can sometimes be combined.

If no yield was attained (off year) no application will be made after harvest as sufficient reserves are available to support growth. If necessary only 10% can be applied at application 2, based on the anticipated yield. From application 3 onward, applications can be based on this anticipated yield. More complete and specific recommendations will be determined for fertigation and for open hydroponic systems as described by Stassen *et al.* (1999) for mangoes. For example it will be necessary to concentrate the Ca application so that it is available during the first six to eight weeks of fruit development (Stassen *et al.* 1997). It is possible to get the required effect with good management and where good root contact can be achieved, as good as with a hydroponic system, otherwise additional Ca sprays and post-harvest dipping must be considered.

Conventionally a one-off application of P can be made in the post harvest/ winter period. K can, however, be applied to soils with more than 12% clay, twice (post harvest and again in November). In soils with less than 12% clay more frequent applications must be made.

Ca can be applied in the post harvest winter period (just before fruit development) and followed up in the summer period (three to six weeks before harvest).

It is of course always necessary to keep the ratios of Ca, Mg and K in the soil in mind as well as the pH (H_2O) optimum of 6,2. It is also important to remember that too much N, especially at the wrong phenological time, will increase Ca uptake in the new growth to the detriment of the fruit.

SUMMARY

Annual element requirements can be obtained from the plant itself by determining the annual removal, fixation and utilization of elements by the different plant parts. By dividing this quantity by the yield figure (kg fruit) or the stem circumference (in cm), the demand can be expressed in terms of yield or stem circumference.

The value of this method lies in the fact that tree age, planting distance, production potential, etc., are all taken into account. A computer programme can be developed whereby the nutrient requirement of different orchards can be very accurately determined and refined with the optimum leaf and soil norms and which takes into account, not only yield, but also fruit quality. It is important to realise that a crop requires different elements in certain proportions. The elements in the soil also have to be present in specific proportions to avoid competition among the elements for uptake by the plant. In addition incorrect N management causes important elements to be channeled to vegetative parts of the plant to the detriment of fruit development. More refining of the nutrient application management programme is essential for determining the needs of the crop during the various phenological stages. The balance between growth and yield as well as between yield and quality is becoming more important where fruit has to be stored for prolonged periods.

LITERATURE CITED

- MEYER, J.H., WOOD, R.A. & LEIBRANDT, N.B., 1980. Recent advances in determining the N requirements of sugarcane in the South African sugar industry. *Proceedings of the South African Sugar Technologists' Association*, 205-211.
- SAAYMAN, D. & LAMBRECHTS, J.J.N., 1998. Guidelines for the judicious application of irrigation and fertiliser for Barlinka table grapes on sandy soil. *Decid. Fruit* Grow. : 22-30.
- STASSEN, P.J.C., JANSE VAN VUUREN, B.P.H. & DAVIE, S.J., 1997. Preliminary studies on macro-element utilization by Hass avocado trees. *South African Avocado Growers' Association Yearbook* 20: 68-73.
- STASSEN, P.J.C., MOSTERT, P.G. & SMITH, B.L., 1999. Mango tree nutrition. A crop perspective. *Scientiae* 303: 41-51.