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Production potential of Fuerte on seedling rootstocks

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ABSTRACT

All Fuerte trees on Westfalia were rated on a scale of A to E in terms of fruit density, A being a top producer and E being a poor producer. Fifty trees with a consistent A rating over a four-year-period and 50 E trees were then used in a trial in an attempt to identify a causal factor of these consistent ratings. Considerable yield differences were shown between A and E trees. Leaf and fruit inorganic nutrient data were discussed, with significant differences occurring between magnesium, boron and aluminium levels in the leaves and calcium, zinc and boron levels in the fruit. Phenological stages were then dealt with. Trees were also tested for ASBV, with 72% of the E trees testing positive. The implications of this and a plan for future work in this field were then discussed

INTRODUCTION

As is known, avocados do not come true from seed and therefore every seedling is in effect a different variety, although some of the progeny may resemble the parent in leaf and fruit characteristics and growth habit (Halma, 1954). In general, avocado yields on a tree to tree basis are extremely variable (Lincoln & Harkness, 1951; Jones, Embleton & Cree, 1957; Ben-Ya'acov,1972; Durand, 1986 and Jones *et al,* 1957) have shown the variability of avocado yields to be several times greater than that of a number of other tree crops.

All Fuerte on Westfalia are on seedling rootstocks and, as a result, tend to show tremendous variation between trees in terms of tree size and yield. Growers on Westfalia began to notice trees that per-formed consistently well, and trees that per-formed consistently poorly. These observations led to the implementation of an annual individual tree rating.

This rating was implemented in 1988, where trees were rated in mid-February according to fruit density, using a scale of A to E. A was a tree with a very high fruit density and E a tree with a very low fruit density. Studying of this individual tree data identified trees that had a consistently high fruit density (A trees) as well as trees that performed consistently poorly (E trees).The question was raised as to why these differences in productivity were being observed.

There are a number of obvious reasons for trees bearing consistently poorly, such as *Phytophthora cinnamomi* infection (Zentmyer, 1980), sunblotch viroid (Da Graca,1985), *Eucalyptus* plantations (Köhne & Kremling, 1988), soil conditions and cultural practices. However, the occurrence of some E trees could not always be explained using the above factors. The implications of being able to identify a causal factor of A and E trees to both present and future yield increases was obvious, and a trial was therefore initiated to attempt to do just that.

MATERIALS AND METHODS

Fifty consistent A and fifty consistent E trees of the cultivar Fuerte were selected. The E trees were those for which no obvious causal factor could be identified. Trees underwent all normal cultural practices under taken by Westfalia management.

Trees were harvested individually in two rounds (April and May), and fruit quality for each round evaluated after four weeks of cold storage at 5,5°C, using 28 fruits per round (weight range 266-305 g). There after, the temperature was increased to 18°C to induce ripening. Soft-ripe fruit were cut open and inspected externally for cold damage and internally for the physiological disorders pulp spot, grey pulp and vascular browning. Leaf, fruit and soil samples were taken from each tree for nutrient analysis. Phenological stages of trees were monitored and trees tested for avocado sun-blotch viroid (ASBV).

RESULTS AND DISCUSSION

Table 1 shows data from five A and five E trees used in this trial, and quantifies what is meant by the terms "A" and "E" tree in terms of production. The important parameter to look at however, especially in selection of superior trees, is the yield per unit area of tree as described by Köhne (1985). This is also shown in Table 1. Expressing the data as such immediately shows which trees have the greatest production potential.

The yields for 10 A trees were converted to $t.ha^{-1}$ (Table 2). Similar values were obtained by Durand (1986), who used the top five producers in a 27-year-old Fuerte orchard and calculated yields of 60,4 $t.ha^{-1}$.A monetary value was then attached to the increase in production above the industry mean (taken as 12 $t.ha^{-1}$). Using these few A trees, return per hectare could theoretically be increased by R70 $000.ha^{-1}$ (based on a return of R1 $500.t^{-1}$). Even if only 50% of this is obtained in reality, the positive implication of being able to reproducethese top producers is obvious.

Quality data are shown in Table 3. Externally, cold damage was greater on fruit from E trees in both picking rounds. Similar observations were made by Cutting and Vorster (1991). Looking at the individual internal disorders, there was no significant difference in the first round. However, when these disorders were considered as a total per fruit, the quality of fruit from A trees was significantly better ($P \leq 0,01$)

TABLE 1 1991 yield (kg/tree^{-1} and m^{-2} canopy) of selected A and E trees

	Yield (kg)	Yield (kg/m^{-2})
A Trees		
E2123	934,53	7,52
E2639	487,6	6,94
E3650	479,99	8,93
B35A50	467,96	9,44
B35A6	464,68	9,04
E Trees		
W9B139	2,05	,05
W33A19	6,85	,10
W9B6	8,45	,21
W9B129	9,51	,18
W9B149	11,35	,27

TABLE 2 Yield of 10 selected A trees in t.ha^{-1}, shown as an increase above the industry mean (taken to be 12 t.ha^{-1}) and then expressed as a monetary value based on a return of R1 500.t^{-1}

t.ha^{-1}	Increase above 12 t.ha^{-1}	Monetary value R1 500.t^{-1}
57	45	67 500
66,5	54	81 675
59,57	47,6	71 353
49,39	37,39	56 085
71,83	59,8	89 744
66,75	54,75	82 122
66,97	54,96	82 451
48,77	36,77	55 155
49,94	37,94	56 908
48,17	36,17	54 254

TABLE 3 External (cold damage) and internal (pulp spot, vascular discolouration, grey pulp and total of the above internal disorders) fruit quality of A and E trees over two picking rounds (April and May 1991)

	Round 1		Round 2	
	A Tree	E Tree	A Tree	E Tree
External				
Cold damage	95,1a*	86,4b	93,4a	82,1b
Internal				
Pulp spot	94,2a	96,2a	93,6a	94,5a
Vasc disc	94,2a	92,3a	80,5a	67,1b
Grey pulp	99,2a	98,5a	96,6a	82,9b
Total	82,2a	69,2b	67,3a	42,5b

Figures show the percentage fruit clean of the disorder listed.
*Mean separation in rows per round by Duncans' multiple range test at the 5% level.

TABLE 4 Leaf analysis of A and E trees, including the normal range for avocado used in South Africa

Element	Norm	A Tree	E Tree	Sig[1]
Nitrogen (%)	1,7–2,0	2,01	1,96	NS
Phosphorous (%)	,08–,15	0,1080	0,1076	NS
Potassium (%)	,75–1,25	0,896	0,966	NS
Calcium (%)	1,0–2,0	1,599	1,483	NS
Magnesium (%)	,4–,8	0,769	0,702	*
Manganese ($mg.kg^{-1}$)	50–250	265,18	229,29	NS
Zinc ($mg.kg^{-1}$)	25–100	65,82	67,63	NS
Aluminium ($mg.kg^{-1}$)	–	8,2	9,76	**
Boron ($mg.kg^{-1}$)	50–80	44,54	58,45	***

[1]statistical significance
*P ≤ 0,05 **P ≤ 0,01 ***P ≤ 0,001

TABLE 5 Fruit inorganic nutrient analysis of A and E trees in $mg.kg^{-1}$

Element	A Tree	E Tree	Signifance
Potassium	15 876	15 574,36	NS
Calcium	890	682,05	**
Zinc	52,54	47,92	*
Magnesium	1 144	774,36	NS
Boron	63,62	95,08	***

*P ≤ 0,05 **P ≤ 0,01 ***P ≤ 0,001

Than that from E trees. This difference in total quality was also true for the second round (P ≤ 0,0001), with a significant differ-ence in favour of A trees in terms of vascular discolouration (P <0,01) and grey pulp (P < 0,0001). It is interesting to note that pulp spot was on average lower in E trees than A trees, although not significantly so.

In terms of leaf analysis (Table 4), all Etrees fall within the normal range for avocados, as stipulated by Köhne *et al* (1990).Significant differences that did occur, were greater magnesium levels in A trees thanE trees (P < 0,01), and greater aluminium(P <0,01) and boron (P < 0,001) levels in the leaves of E trees. Magnesium is involved in a long list of enzyme reactions and a magnesium deficiency results in impaired assimilate partitioning (Marschner, 1986).Further work on the importance of higher magnesium levels therefore needs to be looked into. Although aluminium levels were higher in E trees, levels observed were only in the region of 10 $mg.kg^{-1}$. Ac-cording to Mengel and Kirkby (1982),higher plants usually contain in the order of 200 $mg.kg^{-1}$ aluminium in the dry matter. It was therefore felt that the low levels observed here would not have a toxic effect. The significant difference in boron levels observed was attributed to crop load.

Another difference (although non-significant) was that of manganese levels, with A trees having greater levels of manganese. Bezuidenhout and Vorster (1991) stated that in avocado a statistically significant correlation between leaf manganese content and production (kg/ha'[1]) was found on Westfalia. As manganese is involved in photo synthetic oxygen evolution (the Hill reaction), and increased levels of manganese would therefore lead to an increased rate of photosynthesis (Marschner, 1986), the possible relationship between manganese and production needs to be looked at further.

Fruit analysis data are shown in Table 5.Calcium ($P \leq 0,01$) and zinc ($P \leq 0,05$) levels were significantly higher in the fruit of A trees, which can be related back to fruit quality. Postharvest physiological disorders have for some time been coupled to the calcium content of fruit (Bangerth, 1979; Millaway & Wiersholm, 1979) and Vorster and Bezuidenhout (1988) reported on the relationship between high calcium and zinc levels and fruit without pulp spot. Boron levels were significantly greater ($P < 0,001$) in the fruit of E trees, and it was felt that this could be once again related to crop load. Analysis of soil below each tree did not show any consistent trends.

Monitoring of phenological stages showed that E trees flowered about one month earlier than A trees. Furthermore, A trees flowered (stage 9 on Davenports' scale of in-florescence development, 1986) over a two week "period (August/September), yet flowering was still observed on some Etrees until mid-November! Initially the set on E trees looked good, but as fruitlets enlarged one realised the majority were parthenocarpic fruit. This tendency for the majority of fruits to be parthenocarpic was true for most E trees.

All E trees were then tested for avocado sunblotch viroid (ASBV), with the result that 72% of the trees were positive. Of those that were negative, the majority had a reasonable yield. Such trees could be those responding positively to improved *Phytophthora cinnamomi* control, better cultural practices, etc. Seventy six percent of the A trees have been tested for ASBV to date, and all are negative. Therefore the majority of E trees used in this trial are" symptomless" carriers of ASBV. Wallace (1958) and Bergh (1974) stated that symptomless carriers of ASBV are poor bearers, and Da Graca (1985) confirmed this when the found an 82% reduction in yield on Edranol and a significant reduction in yield on Fuerte, due to ASBV.

CONCLUSIONS

With the help of an individual tree rating system, it has been possible to identify good and poor producers (both on a single tree and orchard basis) and -thereby identify problem areas and ultimately yield potential. In trees which have a history of consistently poor yields (E trees), and where no obvious causal factor can be identified, it appears that ASBV is a factor. A factor that has perhaps been underestimated thus far. Furthermore, the potential of A trees has been realised and these trees identified. The question now remains as to where this work will go to from here.

- Firstly, continued testing from a yield and quality point of view, specifically on A trees, to confirm data obtained in the previous season, for ultimate selection.

- Application of nutrient data obtained to date will also be undertaken on a trial basis, especially the possible relationship between magnesium and manganese and yield.

- Further testing from a physiological point of view will be undertaken in the continuing quest to isolate a manipulable factor, specifically on A trees.

- This work should now also move into D trees. ASBV can be transmitted by seed, grafting (including natural fusion between tree roots) and pollen (Desjardins, Drake & Swiecki, 1980) and the danger of further transmission and infection is therefore very real. Are D trees there-fore in a state of gradual decline due to a slightly lower infection of ASBV? These are areas that need to be considered.

In conjunction with continued testing, one must pursue the genetic option. That is, is the tree a top producer due to a rootstock, scion or rootstock/scion combination and therefore can this tree be reproduced to per-form similarly to the mother tree? Ben-Ya'Acov (1972; 1973; 1976) has done extensive work in this field and has achieved ex-act duplicates of outstanding trees (Ben-Ya'Acov, 1987). In terms of rootstock/scion productivity, Ben-Ya'Acov (1987) made the following points:

(a) There are large differences in productivity between different sources of scion of the Fuerte cultivar.

(b) Rootstock type influenced productivity and size with some of the better root-stocks increasing productivity by 120% (Gillespie [1954] stated that the variability in the yield of trees made up from the same scion source, grafted on to seedling rootstocks [Mexican], could only be attributed to the variability in the genetic make-up of the seedling).

(c) Rootstock/scion combination is important a certain combination may be totally unproductive, while that same rootstock or scion in combination with other material is productive and productivity as influenced by rootstock, scion or the rootstock/scion combination, is very consistent over the years.

Theoretically, therefore, the possibility exists of reproducing top-producing trees with favourable influences on future production .There is no doubt that such single tree data have far-reaching implications to both present and future production.

However, our industry is moving towards a Hass type fruit and this work should be more concentrated in that field. Single tree measurements for Hass are available on Westfalia, and this cultivar will be included in the programme.

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