Production variability among Hass avocado trees grafted onto Mexican rootstocks

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ABSTRACT

Avocado orchards are highly heterogeneous with regards to productivity. Most likely, they are the most variable of all fruit orchards. The main reason for this situation is the variability in the rootstocks used, propagated by seed and with a high level of heterozygosis. A common production practice in Chile is to establish orchards using seedling rootstocks of the Mexican race, obtaining seeds from mother plants without proper isolation. In order to select outstanding trees for clonal propagation, we studied the production variability among avocado cv. Hass trees, within a 14 ha orchard using annual production records for individual trees. The following production parameters were studied: cumulative yield over a 10-year period (kg/tree); tree production efficiency (kg/trunk cross sectional area); annual distribution of the average yield (intensity of yield fluctuations); and nutrient levels in fruit and leaves. The results indicate that the variability within the orchard is very high, thus justifying the need to select outstanding individuals for cloning and further evaluation.

Keywords: rootstocks, avocado, variability, yield.

INTRODUCTION

The variability within avocado orchards established using seedling rootstocks was originally described by Guillespie in 1952, indicating that cv. Fuerte trees grown under very uniform conditions showed an annual yield ranging from 12 to 500 kg (Ben- Ya'acov and Michelson, 1995).

From 1985, Ben- Ya'acov conducted experiments in Israel using seedling rootstocks, following their productivity over a 10-year period. He discovered a high variability in production, with outstanding individuals of the Hass and Fuerte cultivars that yielded 100% more than the average tree.

Smith and Köhne (1992) and Smith, Köhne and Schutte (1993) studied the variability in cv. Fuerte trees grafted onto seedling rootstocks, classifying the trees according to their production level. They showed that certain trees have a consistently good yield, while others are quite poor. Research done by Durand (1986) demonstrates that the average yield in a given orchard was largely sustained by the trees that yield more than the average. Should an orchard be established solely with outstanding trees, the yield could change from 13 to 30 ton/ha.

More than 70% of the Chilean avocado industry is based on the Hass cultivar, and most of the trees are grafted onto seedling rootstocks of the Mexican race. The average yield of a well-managed orchard peaks at 10 ton/ha. While a number of management practices are being implemented in order to increase yield, little has been done with regard to the use of selected rootstocks that could improve the current production level.

This investigation had the following goals: a) to determine the variability in cv. Hass productivity when grafted onto seedling rootstocks; and b) to define the vegetative growth, production and physiological parameters that could help to explain this variability.

MATERIALS AND METHODS

The study was conducted within a commercial avocado orchard that belongs to Mr. Helmut Krausharr Scheuch, located in Hijuelas, Province of Quillota, Valparaiso Region, Chile (32º 49.981´ S and 71º 07.079´ W).

The area has a mild Mediterranean climate with rainfall concentrated in the winter (473 mm/year), June being the wettest month. Average summer temperatures range from 18°C to 23ºC, with an average maximum temperature in the warmest month (January) of 27ºC. The four seasons are clearly distinguishable. The site is within a narrow valley flanked by the Andes and the coastal mountains. The area under study consists of 1 ha, in which 199 trees were established 12 years ago, using cv. Hass grafted onto a Mexican seedling rootstock. The trees were planted 6 x 6 m apart, and were irrigated with microsprinklers. Soil characteristics were uniform within the area of study, as were the management practices over the last 10 years.

Yield data was obtained from May 1992, recording the yield of each individual tree. Harvest was done at the same time every year; the data was recorded in a card attached to each tree. Yield data were collected on site and entered into a spreadsheet, and the cumulative yield over the 10-year period was calculated.

In March 2003, the trees were classified according to their production level, assigning them to one of the 4 classes (A, B, C, D) described in Table 1. Once sorted, the groups were compared using statistical analyses, in order to determine if there were statistically significant differences among the classes for the following traits: cumulative yield, yield fluctuations, and production efficiency. The first step in the analysis was to determine the homogeneity in the variance among classes using Bartlet's test; then, the results were analyzed using Tukey's test.

Table 1. Classes of trees according to cumulative yield during a 10-year period.

Class	Range in cumulative yield over 10 years (kg/tree)
A	751-1000
B	501-750
C	251-500
D	0-250

Table 2. Performance of outstanding trees.

Cumulative yield over 10 years for cv. Hass grafted onto Mexican seedling rootstocks (kg/tree)	
Average	459
Average of outstanding trees	804
Additional harvest from outstanding trees	75%

Table 3. Trunk cross-sectional area and production efficiency for each tree category.

Category	Trunk cross- sectional area (cm^2)	Production efficiency (kg/cm^2)
A	1081.0 a*	0.8 a
B	1198.3 a	0.5 ab
C	497.5 b	0.8 a
D	369.3 b	0.3 b

* Numbers followed by the same letter are not statistically different, using Tukey's Test (p=0.05).

Table 4. Mineral nutrient content in fruit and leaf tissue.

Element	A trees		B trees		C trees		D trees	
	fruit	leaf	fruit	leaf	fruit	leaf	fruit	leaf
Nitrogen (%)	0.79	1.4	0.70	1.4	0.89	1.3	0.83	1.4
Phosphorous (%)	0.05	0.1	0.11	0.1	0.1	0.1	0.15	0.1
Potassium (%)	0.96	0.4	1.46	0.6	1.07	0.5	1.73	0.6
Calcium (%)	0.04	2.9	0.05	2.7	0.04	2.6	0.07	3.0
Magnesium (%)	0.04	0.6	0.06	0.6	0.05	0.5	0.06	0.6
Zinc (ppm)	2.00	21.7	3.50	16.2	4.00	19.0	4.75	24.3
Manganese (ppm)	2.00	100.8	2.00	96.5	2.50	122.8	3.00	148.6
Boron (ppm)	58.84	16.4	52.99	14.1	64.98	19.8	30.41	20.3

Once the trees were sorted according to their production level, the classes were compared using statistical analysis for the following parameters: tree efficiency (kg/trunk cross sectional area), annual distribution of average yield (intensity of yield fluctuations), and nutrient levels in leaves and fruit.

RESULTS AND DISCUSSION

When analysing the proportion of trees in each of the four productivity classes (Fig. 1), it is possible to observe that most trees fall into the classes C and B, with the least number of trees in the most extreme classes (A and D).

According to this distribution, the average annual yield for this orchard was 10 ton/ha.

As seen in Table 2, the average cumulative yield in the class A trees was 75% higher than the average for the orchard. Should this orchard be planted exclusively with class A trees, the average yield would be 20 ton/ha.

Fig. 2 shows the production trend in the 10-year period for the 4 tree classes. It can be seen that the yield fluctuations are consistent among the classes, thus yield fluctuation does not seem to depend on the production level of the tree. When evaluating the statistical significance for production efficiency, expressed as kg of fruit per cm^2 of trunk cross sectional area, we found that it was higher in the class A trees compared to class D trees, with a 3-fold difference in area between the two classes (Table 3).

Chemical analyses performed on leaf and fruit tissue indicated that the tree classes do not differ significantly in these parameters (Table 4).

CONCLUSIONS

There is a high variability in production levels in the Hass cultivar grafted onto Mexican seedling rootstocks with up to +75% between the average and outstanding trees' yield

Rootstocks may be the principal cause of the variability that exists in avocado orchards (planted under identical soil and climatic conditions), although it remains to be determined whether it is the specific combination of rootstock and variety or only the rootstocks themselves that are responsible.

Given these results, it will be necessary to clonally propagate more trees from the outstan-

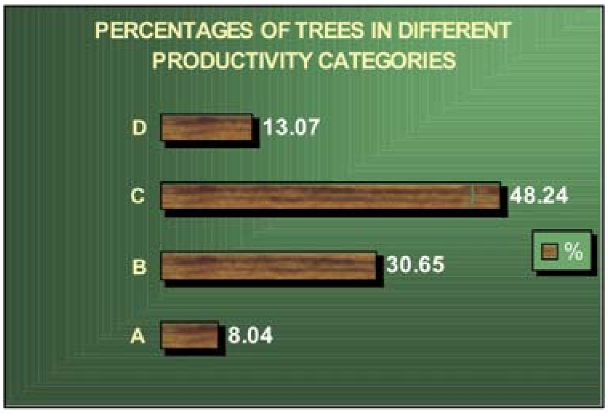

Figure 1. Percentage distribution of the trees in the four productivity classes in cv. Hass trees grafted onto Mexican seedling rootstocks.

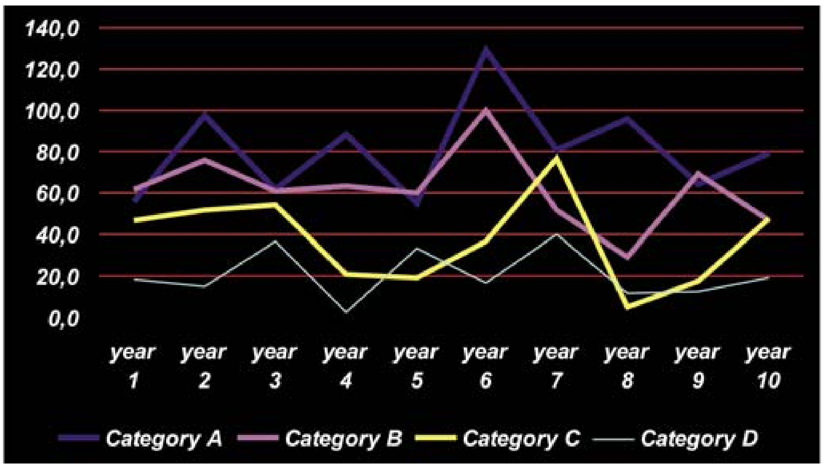

Figure 2. Annual yield distribution for each category of trees (kg/tree).

ding individuals in order to evaluate their ability to maintain high production.

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LITERATURE CITED

BEN YA´ACOV, A. and MICHELSON, E. 1995. Avocado rootstocks. *Horticultural Reviews* 17: 381-429.

DURAND, B.J. 1986. Avocado roostock/scion relationships: A limited survey of the situation in South Africa. *South African Avocado Growers' Association Yearbook* 7: 83-85.

SMITH, D.G. and KÖHNE, J.S. 1992. Production potential of Fuerte on seedling rootstocks. *South African Avocado Growers' Association Yearbook* 15: 83-85.

SMITH, D.G., KOHNE, J.S. and SCHUTTE, J.M. 1993. Progress with the single tree management concept. *South African Avocado Growers' Association Yearbook* 16: 80-81.