

## Avocado rootstock-scion relationships

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### SYNOPSIS

*Selection of avocado rootstocks was found to be the main way of adaptation of this sensitive tree for soil stress factors. Both selection of rootstocks and of sources of scion could significantly improve the productivity of this shy bearer. Rootstock-scion relationships exist when rootstocks behave differently under different cultivars or different sources of scion, and when cultivar response changed according to the rootstock.*

*A complete change in the propagation material of avocado in Israel occurred during the last 20 years, as a result of this research. Recently, clonal rootstocks have been taking the place of seeded ones, and as a result of vegetative propagation of both rootstock and scion - a complete duplication of outstanding trees was achieved.*

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### INTRODUCTION

The avocado (*Persea americana* Mill) is a relatively new fruit crop in commercial orchards. Until the present century it was planted mainly in home gardens and, if in orchards, only as seedling trees. When a selection from Mexico called Fuerte was introduced into the USA in 1911, the avocado became a commercial crop. Since then avocado has been shown to be especially sensitive to both edaphic and climatic factors. Among the soil factors, salinity, alkalinity, lime, and high soil temperature are found in the more arid countries (3,4,6,8) while acidity, soil diseases and some toxicities occur in tropical, wet ones. Poor soil aeration is an important stress factor in all growing regions. Originating in the tropics, the avocado is very sensitive to climatic factors prevailing in the subtropics, and especially to extreme temperatures that never exist in the tropics. Extreme temperatures result in low productivity, and sometimes even in severe damage to the tree canopy (5).

As is well known from other fruit trees, the best method for adaptation of a given tree for different soil conditions, is by selection of rootstocks. Selection of avocado rootstocks should be the main solution for the above-mentioned soil problems. The selection should not be aimed at solving one problem, which never exists alone, but to establish a variety of rootstocks, adapted to different combinations of soil conditions. An additional rootstock characteristic which should be investigated during the selection is its influence on the grafted tree's productivity (2,10).

Another factor that could affect the productivity of grafted avocado trees is the source of the scion; although all avocado cultivars have been propagated clonally for many years,

differences in productivity between different sources of scion of a given variety have been reported (2).

The behaviour and productivity of trees grafted on a given rootstock could be changed when grafted with different cultivars or different sources of scion of the same cultivar, and *vice versa*. The general evaluation of each rootstock-scion combination depends greatly on the rootstock-scion relationship.

Clonal avocado rootstocks have been propagated worldwide for a decade. They are going to be the best and the only avocado rootstocks in the future. They are more uniform than others, and could conserve excellence both in resistance and in productivity. The rules mentioned earlier for rootstock selection, scion selection and rootstock-scion relationships, prevail also for clonal rootstocks (4).

Around the world, very little research has been done on avocado rootstocks and sources of budwood. No field experiment with propagation material has been completed, to the best of our knowledge. Most of the work has been done in California (6,7), and in regard to the root-rot disease. Selection of resistant rootstocks resulted in some new rootstocks, but the field experiments with them commenced just recently, and their general characteristics are unknown.

In Israel, Oppenheimer (10) conducted a rootstock trial with Mexican and Guatemalan stocks in light soil. Better yields were obtained on the Guatemalan stocks, with the four varieties that were included in the experiment.

The project reported on here commenced in 1968 and is based on longterm, large-scale field experiments, planted according to the experimental design in commercial avocado orchards. The aim was to find the best rootstocks, scions, and rootstock-scion combinations for each set of climatic and soil conditions, and for each commercial variety.

## **MATERIALS AND METHODS**

The materials and methods were described in detail in an earlier publication (1), and are presented here briefly, along with the pertinent data.

The study was based on many field experiments, planted in randomised blocks. The propagation material had been chosen from commercial sources. A comparison of rootstocks was possible by grafting different rootstocks with the same source of scion; and a comparison of sources of the scion by grafting them onto the same rootstock. This was achieved through the cooperation of the commercial nurseries.

The experimental plots were planted within the commercial orchards, with the cooperation of the avocado growers. Each experiment included a certain number of rootstock-scion combinations, for comparison purposes. The number of blocks in each experiment, and the number of trees representing each stionic combination per block, varied from experiment to experiment. The data collected were yield (kg/year/tree, as

reported by the growers); area occupied by the tree (in m<sup>2</sup>, as calculated from aerial photography); leaf burn (caused by salinity) and chlorosis (determined by a survey).

From these data calculations were made a cumulative yield for the whole period (kg/tree); and cumulative yield per square metre (kg/m<sup>2</sup>/tree). Analysis of variance was done for each experiment. The entire project with seeded avocado rootstocks included about 350 experiments, in 70 settlements, incorporating 100 000 trees. About 400 different rootstocks and 400 different sources of scion were included.

For clonal rootstocks, a new system of experiments was established, in 1979, and the experiments are still in progress; they are not summarised in this paper.

## RESULTS

Data on tree performance are presented in Table 1.

In Table 1, the results of one survey in one orchard demonstrate the differences that have been found between rootstocks in many surveys. In this case, trees of the Hass cultivar grafted onto two rootstocks were significantly more chlorotic than those on two other rootstocks. These four rootstocks all belong to the West Indian race. The same two rootstocks were found to be more sensitive than the three others to leaf burn caused by salinity.

Differences were found also in the total area covered by the tree, as measured on an aerial photograph.

Data on damage caused by poor aeration in another experiment are presented in Table 2.

The percentage of trees of cv Hass which suffered severely was 69 per cent on one rootstock and only 19 per cent on another one.

In regard to yield, two tables are presented: Table 3 demonstrates the difference between rootstocks, with a common scion source, and Table 4 shows the difference between some sources of scion (plot 1), and an example of the rootstock-scion relationship (plot 2).

TABLE 1 Some data collected in autumn 1975 from Hass avocado trees planted at Kibbutz Urim in autumn 1969 (z,y,x).

Rootstock	Number of trees	Chlorosis <sup>w</sup> rating	Leaf burn rating <sup>v</sup>	Average tree area (m <sup>2</sup> ) <sup>u</sup>
Degania 59	23	0.61 ab	1.61 b	21.3 c
Degania 112	20	0.50 b	1.10 b	21.7 bc
Degania 113	47	0.42 b	1.60 b	23.3 abc
Degania 1	44	1.02 a	2.56 a	23.5 ab
Peker 2	33	0.98 a	2.59 a	24.2 a

(z) Randomised blocks experiment, in which the 24 blocks include one or two representatives of each stionic combination, per block.

(w) 0 = green tree, to 3 = severe chlorosis.

(v) 0 = green tree, to 4 = very severe burns.

(u) Projected area of each tree was measured on an aerial photograph (9).

(y) Values followed by different letters are significantly different at P = 0.05.

(x) Total lime (CaCO<sub>3</sub>) in the soil was about 20 per cent.

TABLE 2 Results of a survey of Ometz Orchard, March 1972.

Variety	Scion	Rootstock	Number of trees compared	Average degree of damage <sup>z</sup>	% of Trees with Grade 4-5 Damage
Fuerte	Netzer 5	Gvar Am 18	26	2,43	42
	Netzer 10	Gvar Am 18	27	2,21	37
	Netzer 20	Gvar Am 18	27	1,95	30
	Barkai 19	Anaronowitz 1	24	3,21	58
Hass	Barkai 6	Shmit	16	1,50	19
	Zrifin 1	Zofit 6	15	2,06	33
	Barkai 30	Gvar Am 6	14	1,50	22
	Barkai 13	Wagschal 5	15	3,38	69

(z) On a scale of 0-5 from 0 = no damage to 5 = death of the tree

TABLE 3 Cumulative yield of cv Fuerte avocado trees in Ofir orchard, planted in 1969<sup>z</sup>.

Rootstock	Number of trees	Total yield until 1978 (kg/tree) <sup>y</sup>
Caliente	22	253.9 a
Slonim 4	24	272.9 a
Slonim 6	17	239.9 a
Northrop	20	152.2 b

<sup>z</sup> Randomised blocks experiment, in which the 13 blocks included two representatives of each stionic combination per block at the time of planting.

<sup>y</sup> Values followed by different letters differ significantly at P = 0,05.

TABLE 4 Cumulative yield of cv Fuerte avocado trees in Taibe orchard, planted in 1963.

Plot no	Scion	Stock	Total yield (kg/tree) <sup>z</sup>	
			4 years	5 years
1	Naeh 1	Glickson 8		201 a
	Naeh 5	Glickson 8		110 b
2	Naeh 21	Glickson 8	33 b	
	Naeh 9	Glickson 8	155 a	
	Naeh 21	Glickson 5	155 a	

<sup>z</sup> Values followed by different letters differ significantly at P = 0,05.

## DISCUSSION AND CONCLUSIONS

### Resistance for soil-stress factors

#### Lime-induced chlorosis

There is a very wide range of resistance to lime-induced chlorosis, which is the result of iron deficiency. Guatemalan rootstocks are the most sensitive, and for them the soil

should be non-calcareous. Most Guatemalan x West Indian hybrids, like the Floridian cultivars Hall, Colinson, Booth 8, etc, were also found to be very sensitive, and should not be planted in soils with more than eight per cent lime. The most resistant rootstocks were from a 'pure' West Indian source, while most of the Mexican rootstocks were of intermediate tolerance. In Table 1 the difference between the 'pure' West Indians and the hybrids can be seen.

### **Salinity**

In this research as in some prior studies, a very large range of resistance to salinity was found. The most resistant trees were again the 'pure' West Indians, while the most sensitive were the Mexicans. Guatemalan, and hybrids were of intermediate resistance. Some rootstocks can withstand irrigation water with chlorine content of more than 600 ppm, while trees grafted on some of the Mexican rootstocks exhibit damage even when irrigated with 100 ppm Cl and less.

### **Poor soil aeration**

Good soil aeration is essential for avocado, but we could not find any data in the literature about the behaviour of rootstocks under poor aeration conditions.

In our experiments it was proven that the West Indian rootstocks as a group were more sensitive to poor aeration than the Mexicans. In addition, differences were found within the races, as seen in Table 2 for the Mexicans.

### **Resistance to low temperature**

There are large differences in the sensitivity of the three horticultural races to low temperatures. The West Indians are known as the most sensitive, due to their origin, but when used as rootstocks the different types do not influence the sensitivity of the grafted tree, and its response to frost depends on the characteristics of the variety alone.

### **Productivity**

- (a) Big differences in productivity were found between different sources of scion of the Fuerte cultivar (Table 4, plot 1).
- (b) Rootstock type affect productivity in the Ettinger and Fuerte cultivars. A better rootstock could increase productivity of Fuerte trees by 120 per cent (Table 3).
- (c) Rootstock-scion combination is important in itself, and in some cases a certain combination is non-productive, while the rootstock or scion of this combination is productive with another complementary partner (Table 4, plot 2).
- (d) In each horticultural race of the avocado, productive and nonproductive rootstock types can be found.
- (e) The productivity as influenced by rootstock, scion, or the rootstock scion combination, is very consistent over the years.
- (f) Rootstock affect tree size to a large extent, and thereby can also affect the productivity per unit area.

#### Application of the research results

Changes in the rootstocks in use: The number of rootstock types in use in Israel was reduced from 600 in 1970 to 40 in 1985. Mother plantations have been established to supply seeds from the best types, and only this material is permitted for use at the present time. Clonal rootstocks selection had been started when outstanding trees were discovered among the investigated tree populations.

Changes in the sources of scion: The use of non-productive sources of scion has been eliminated. Only the best sources of scion are in use now.

The outstanding clonal rootstocks were regrafted with the best sources of scion, and an exact duplication of the outstanding trees was accomplished.

The centre for co-ordination of new plantings chooses the best of the selected material for the growers, according to the local conditions.

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