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CLONAL AVOCADO (*Persea americana* Mill.) ROOTSTOCKS IN ISRAEL

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SUMMARY

Clonal avocado rootstocks were developed in Israel on a small scale between the years 1962–1977, and on a large scale in the years following. During the entire period about 220 different rootstocks have been developed in an attempt to solve soil problems caused by stress factors such as salinity, lime, poor aeration and root–rot, and various combinations of these factors, while simultaneously improving productivity. Uniformity among trees and dwarfness were also taken into account as part of the search for better rootstocks. The development process included field evaluation on a very large scale, in which 350 experiments and 65000 trees took part.

KEY WORDS: clonal propagation, rootstocks, salinity, productivity.

INTRODUCTION

Clonal rootstocks are propagated by vegetative propagation means and hence conserve and express the mother tree′s traits. They are most common in some other fruit trees such as apples and grapes, after a long process of selection for growth and productivity has taken.

The avocado became an industrial crop in the beginning of the century, when nurseries started to propagate the crop by grafting its new cultivars on to seedling rootstocks. This method replaced the older one, in which avocado orchards were planted by using seedling, non–grafted trees, producing non– uniform fruits. Once cultivars were grafted, the fruit produced by each cultivar was uniform, and its positive traits were conserved. Today, most avocado orchards in the world include grafted trees of known cultivars on seedling rootstocks.

In Israel, a large–scale, long–term seedling rootstocks selection project took place (Ben–Ya′acov, 1972; Ben–Ya′acov, 1985), in order to adapt rootstocks to marginal soil conditions and to improve productivity. The planting of most avocado orchards during the establishment of the industry and until recent days was based on the results of this research. For all intents and purposes, there has not been any other research of this kind. Propagation of rootstocks by seedlings, could not conserve the positive characteristics of special rootstocks, in regard to their tolerance to soil conditions or to their impact on the grafted tree′s growth and productivity.

Moreover avocado orchards grafted on seedling rootstocks, are known to be extremely un–uniform. This non-uniformity is expressed by tree′s size and development, productivity and response to soil factors. In the Fuerte cultivar, Ben–Ya′acov in Israel (Ben–Ya′acov, 1989) and Gillespie in California (1954) found productivity range of 10-20 folds. We found significant variability between trees of other cultivars as well.

Such marked differences among different avocado trees, even if the propagation material is taken from one source of graftwood and one source of seeds, is not known in other fruit crops. Hence, it was very logical to develop new avocado rootstocks, from very tolerant and productive trees, and to propagate them clonally in order to preserve their unique positive traits (Ben–Ya′acov *et al*., 1992; Ben–Ya′acov, 1986). Prior to the research described here, selection of clonal avocado rootstocks was done mainly in order to solve the avocado root–rot problem, and the Californian investigators, under the leadership of Zentmyer (1980) were responsible to this effort.

In Israel, the water salinity is on the rise, and the avocado, as the most sensitive fruit tree to this factor, is in an endangered situation. West Indian avocado rootstocks were found to be much more tolerant to salinity (Oppenheimer, 1947) but their productivity under saline conditions is not satisfactory. Moreover, salinity in many cases is combined with alkalinity, lime, non–aerated soil, and recently – also with root–rot. Seedling rootstocks can never solve problems caused by combined situations like these. Clonal rootstock, when selected under special growth conditions, and taken from a very productive tree – theoretically could be the best for such conditions. This hope can be justified only after evaluation process of the new rootstock has taken place (Ben–Ya′acov and Michelson, 1995).

MATERIALS AND METHODS

The selection of clonal avocado rootstocks was highly dependent on the availability of clonal propagation method. During the first period (1962–1977), selection was done mainly under saline conditions, and from randomized seedling trees that did not show typical leaf burns. In that period, propagation of the selected rootstocks was done by cuttings, under mist spray conditions. This method resulted in poor root systems, and poor plants in general which needed a long hardening process . For West Indian rootstocks it was not effective at all.
Since 1978, when Brokaw variation of Frolich propagation method (Brokaw, 1987; Frolich and Platt, 1972) became available, and was adopted by Israeli nurseries, the selection was accelerated.

Methods for clonal rootstocks selection

Information earlier collected from trees included in the huge seedling rootstocks experimental system (Ben–Ya′acov, 1985) enabled the singling out of the best outstanding trees from each experiment, according to their scionic combination and the local growing conditions. This means that the rootstocks that were selected for to their unique impact on the grafted tree, should be recorded. The recovering process will be later described.

Criteria for the selection of productive rootstocks included:

1. Productivity of the grafted tree. In each seedling rootstock – scion experiment, out of 350 such experiments, the best productive trees were identified. This was based on 6 productive years, at least, and usually until 10 years of age. The best productive trees belonged mostly to the most productive stionic combination in the related experiment. Very productive trees were selected also in orchards′ trees population not belonging to the experimental system, where yield data were recorded for practical aims.

Two other productivity factors were taken in account:
a. Tree efficiency, calculated by long term productivity divided by the area occupied by the tree (which was calculated from aerial photographs).
b. Alternate bearing rate.

2. Tree size and conditions: This title includes fierce criteria such as the area occupied by the tree, leaf burns caused by salinity, lime induced chlorosis, etc. These criteria were used for the outstanding productive trees as well as for trees selected for their tolerance to the different soil stress factors, when productivity information data of the grafted tree was limited.

Methods for producing trees from the rootstocks candidates

The first step after choosing the candidates for rootstocks is to achieve and conserve their vegetative material. Material of the very productive grafted scion trees was conserved by grafting it in a mother orchard. It is more complicated to achieve rootstock material. In several cases, offshoots of the rootstock supplied the material, but mostly it was necessary to cut back the whole tree, expecting the rootstock new growth to appear.

Once the rootstock vegetative material was obtained, it was also grafted in the mother orchard, and simultaneously checked for Sun–Blotch presence.

Methods for re-evaluation of the clonal rootstocks

Once a new rootstock is available as vegetative material, it should be re–evaluated as clonal rootstock. The propagation itself is done by specialized nurseries, and according to the experimental plan. Each designed experiment includes stionic combinations of one cultivar in which the different compared rootstocks are known to be adapted for the local conditions. To compare different stionic combinations of one cultivar originating from outstanding trees – duplicates of the same trees are included in the re–evaluation experiments; to compare rootstocks themselves – they were grafted with one source of scion; to compare sources of scion – they were grafted on one common rootstock. Altogether, 350 re–evaluation experiments were established, in which 65.000 trees were included.

The experimental methods for this re–evaluation was earlier described (Ben–Ya′acov, 1996). The whole project was previously described, as preliminary report (Ben–Ya′acov *et al*., 1992).

RESULTS AND DISCUSSION

This report deals with the whole project of clonal rootstock development in Israel. As such, the whole resulted inventory will be discussed according to its components. None of the re–evaluation experiments and their results will be presented and discussed here.

The total number of clonal avocado rootstocks in the Israeli stock today is 228, out of which 224 were developed here, and 4 were introduced. The data is not presented as a detailed list, but as groups of rootstocks according to their purpose of development: rootstocks developed for superior productivity, from outstanding productive trees or – with no pre–selection, as is the situation with material that was rooted from the Israeli germplasm. Other groups of rootstocks were selected and now presented according to their tolerance to salinity, lime, non–aerated soil or root–rot. Four rootstocks are simply rooted cultivars.

Each one of the clonal rootstocks received a number while it was developed, called VC number. The VC symbolized the ″Vegetative Clone″, to which it belongs, and the fact that it was developed during research project managed in ″Volcani Center″. VC numbers 1–200 were devoted to rootstocks developed in Israel, numbers 201–300 to rootstocks rooted from the germplasm bank, and 801–831 to rootstocks especially selected to stand root–rot infection.

Table 1. Clonal avocado rootstocks in Israel.[z]

Persea americana subspecies rootstock group[y]	West Indian	Mexican	Total	Total for rootstock group
1. Reproduced from productive trees				
Cultivar:				
Fuerte	26	33	59	
Ettinger	15	19	34	
Hass	7	4	11	
Horshim	6	1	7	
Wurtz		1	1	
Nabal	2	1	3	115
2. Salinity and lime tolerant	18	12	30	
3. Root rot tolerant	25	4	29	59
4. Rooted cultivars[x]			4	
5. Germplasm origin[x]			50	54
Sum-up			**228**	**228**

[z]Taken, corrected and updated from Ben–Ya′acov *et al*. (1992).

[y]Groups 4 and 5 were not recognized according to race.

[x]The identification of the rootstock for race (sub–species) is hypothetic; hybrids between races could be found.

In the detailed list of rootstocks, data is presented in regard to each rootstock origin, history and botanical type. In the sum–up (Table 1) the rootstocks are grouped according to the botanical race and the cultivar under which they were investigated.

In Table 1, 115 rootstocks are selections of either Mexican (59 rootstocks) or West Indian (56 rootstocks) originated from outstanding productive trees. They were recovered under ‘Fuerte’ trees (59 rootstocks), ‘Ettinger’ (34), ‘Hass’ (11) and other cultivars (11).

The rootstock group that showed tolerance to salinity and lime includes 30 rootstocks, out of which 18 are West Indian types and 12 Mexican. Several of them showed tolerance to one of the stress factors and others – to both. Their effect on the grafted tree′s growth, size and productivity was not known prior to the selection step.

The root–rot tolerant rootstock group includes 29 items, out of which 4 were introduced from U.S.A., and the rest were selected under productive grafted trees in one orchard (Zilberstaine *et al*., 1992). The same orchard served also for re–evaluation of the locally selected rootstocks, different rootstocks from productive rootstocks, and about 50 items from the Israeli germplasm bank.

CONCLUSION

In this report, the development of clonal avocado rootstocks in Israel has been described and the resultant inventory was presented. Several avocado industries in the world have already adopted clonal rootstocks which have become the majority in new orchard planting, mainly because of the root–rot problem. Avocado specialists around the world believe (Wolstenholme, 1988) that the clonal rootstocks are the future rootstocks of the avocado the world over, and that they are the only way to ensure sustainable avocado industries. In Israel, the situation is more complicated, because different stress factors are present and it has already been proven (Ben–Ya′acov and Michelson, 1995) that rootstocks should be chosen according to their possibility to maintain high productivity under increasing salinity conditions.

It was necessary to work on very large scale, in order to achieve solutions for wide diversity of local conditions and for different cultivars.
One hundred and seventy rootstocks were selected, excluding the germplasm items, the rooted cultivars and four introduced rootstocks; they became the subject for further evaluation but only about half have passed this process as of now. Although experiments for re–evaluation of the Israeli rootstocks are not included in this report, our duty is to give the avocado growers around the world some knowledge about the conclusions, and the present recommendations.

For planting of Fuerte cultivar we recommend the Mexican rootstocks VC 31, 39, 40, 42, and the West Indian rootstocks VC 6, 7, 45, 46, 55, 65, 68, 98.

For ‘Ettinger’ – the Mexican clones 24, 40, 57, and the West Indian ones VC 6, 26, 27, 28, 44, 51, 65, 75.

For ‘Hass’ – the Mexican dwarfing clone VC 15, and the West Indian VC 26, 27, 28, 51, 66.

For ‘Horshim’ – the dwarfing West Indian types VC 65, 68.

For ‘Pinkerton’ – the West Indian type VC 66 was most successful.

For root–rot conditions we selected some of the Israeli productive rootstocks – VC 49 (Mexican), 55, 66, 69.

Other rootstocks were selected for root–rot resistance among the germplasm accessions and among the local selections in Kibbutz Givat–Haim. (Zilberstaine *et al*., 1992).

Pointing out very tolerant trees with high productivity in order to achieve more rootstocks – is a process that should be continued as well as the enlargement of the re–evaluation step. This effort will give the avocado industries around the world a good chance to survive.

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