PLANTING TREES ON CLONAL ROOTSTOCKS

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With good returns for Hass on domestic markets, the California avocado industry is in a tree planting boom, and many growers are experiencing long waiting periods for tree delivery. As a result, some are accepting delivery of whatever Hass trees they are able to procure regardless of rootstock choice, perhaps without fully realizing the impact this may have on production in the future. This article is an attempt to answer the many questions received by the CAC Production Research Program not only on rootstocks in general, but also specifically as rootstocks are known to influence Hass production.

To simplify this article, it is useful to consider what constitutes a viable nursery tree. Fundamentally the tree needs to have functional shoots and roots. In horticultural terms, the shoot system is the scion variety and the root system the rootstock variety. In avocados there are three simple options for a viable tree: The scion could be growing on its own roots as a rooted shoot cutting; the scion could be grafted onto a germinated seed (called a seedling rootstock); or the tree could be grafted onto a clonal rootstock (a genetic selection duplicated over and over in the nursery).

Why do we use rootstocks at all?

Why not grow avocados on their own roots? For example, why do we not have Hass trees rooted on Hass roots? Perhaps one of the most basic reasons that we use rootstocks in avocado cultivation is that it is notoriously difficult to get roots to develop on avocado shoot cuttings. Many well known researchers have tried in the past, including Schroeder, Gustafson, Frolich, Platt, Kadman, Ben-Y'acov, and Salazar-Garcia. Cuttings, air layering and tissue culture have all been attempted to propagate avocado varieties on their own roots, but few successes have been reported. While a contributing factor, the difficulty encountered in propagating trees on their own roots is not the only reason rootstocks are used in avocado cultivation.

Imagine a tree growing in a grove in California. The root system and the shoot system exist in very different environments, each with its own set of environmental constraints. For example, the shoots, flowers and fruits may be exposed to extremes in temperature, desiccating Santa Ana winds, and a burgeoning range of pests. While simultaneously the roots may be challenged by shallow soils, Phytophthora root rot, wet and cold conditions or other constraints. We have selected scion varieties (shoots) and rootstock varieties (roots) to meet some of these challenges. Each part (rootstock and scion) contributes different attributes to the tree as a whole, and the combination determines the overall productivity of the tree. Using conventional breeding techniques, it would take a very long time to develop an avocado tree with the genetic makeup that results in both an ideal root and shoot system on the same un-grafted tree. While genetic engineering may offer this promise in the future, this science has a long way to go before delivering the ideal avocado tree in a single package. By grafting, we can select the best combination of root system and shoot system for specific orchard environments, resulting in productive trees with good quality fruit.

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Why use a clonal rootstock?

We have established that we need to graft avocado scion varieties onto viable rootstock roots in order to propagate orchard trees, but why not just use avocado seedlings as rootstocks?

Firstly, avocado seedlings have a very high degree of variability. This is because the avocado is relatively new as a cultivated crop, evolved across a relatively wide geographic range, and has tremendous genetic diversity. Interestingly, it has been suggested that the genetic variability between seedlings from a single variety, (say seedling trees grown from germinated 'Zutano' seeds), exhibit more genetic diversity (differences) than that observed between the common commercial varieties of avocado. That is because we have selected commercial varieties based on a few specific attributes like fruit weight, oil content, skin color, seed size, etc. Seedling populations go back to the broad genetic base of the avocado.

While this may be challenging for breeders, the huge genetic variation in avocado is good, because it gives us a tremendous opportunity to improve the crop in the future.

While we may successfully propagate trees on seedling rootstocks, we normally see a measurable degree of variability in the field, resulting in wide differences in productivity between trees. In tree planting booms, such as that currently experienced, many growers may plant trees on seedling rootstocks because of availability and lower cost. However, some degree of variation may be experienced in such blocks, and the advantages of using clonal rootstocks will be completely missed.

Secondly, we need clonal propagation to multiply identical avocado rootstock plants and to maintain material with specific attributes. For example, rootstocks may provide specific pest or disease resistance, influence the size or growth habit of the tree, allow the tree to adapt to various soil conditions, or confer specific attributes to the fruit. These are very broad topics and will constitute the remaining discussion in this paper.

The first clonal propagation work on avocado rootstocks was done to develop a method to produce material rapidly and economically, so that when desirable avocado plant material was identified, it could be passed along to the grower community. Work by E. F. Frolich in the early 1950's identified etiolation (growing shoots in darkness, without chlorophyll) as a precursor to reliable root development in avocado shoots, and opened the door to clonal rootstock propagation as we know it today. Pioneering nurseryman, H. Brokaw, was the first to commercialize this method.

The process of clonal rootstock propagation is fairly complicated and has been described by others in detail, and so will not be discussed further in this paper. Suffice to say that innovative nurserymen continue to adapt Frolich's method to increase the efficiency of nursery operations and decrease the cost of avocado rootstock production. (For more detailed information, see: *Propagating Avocados: Principles and Techniques of Nursery and Field Grafting*. Publication # 21461. Available from: Division of Agriculture and Natural Resources, University of California, 6701 San Pablo Avenue, Oakland, CA 94608-1239, (510) 642-2431 or visit: http://www.avocadosource.com/links.htm #GENERAL to read an article by Reuben Hofshi on the subject.)

Specific attributes of avocado clonal rootstocks

The first real need for clonal rootstocks arose out of the devastation caused by Phytophthora root rot early in the history of the avocado industry in California. Researchers realized that resistant rootstocks were likely to be the best long-term solution to the problem. Still today, the primary selection criterion for clonal rootstocks is resistance to Phytophthora root rot.

A great deal of research has been conducted developing root rot resistant rootstocks world-wide – particularly in California, South Africa and Israel. Clonal rootstocks such as Duke 7, Thomas, Barr Duke, Toro Canyon, and Merensky II, generally exhibit greater tolerance/resistance to root rot compared to seedling rootstocks. These rootstocks vary in their tolerance/resistance to root rot and are more expensive to produce than trees on seedling rootstocks, but they may confer a degree of insurance against devastation by the disease.

Research conducted by Dr. John Menge in California, showed that the first generation of clonal rootstocks including Duke 7, Toro Canyon and Thomas, had some tolerance to root rot. We know now that when combined with other disease mitigation measures, these rootstocks can support highly productive trees in root rot infested soils (see Phytophthora Root Rot insert in March 2002 AvoResearch, Vol. 2, Issue 1).

The next generation of clonal rootstocks is currently being field tested and is showing good root rot resistance. In trials being conducted by John Menge in root rot infested soils industry-wide, Uzi, Merensky II, Merensky III, and Zentmyer are all showing good early performance. These trees are not only root rot resistant, but are yielding well too. Zentmyer, a rootstock from John Menge's breeding program, appears to be sensitive to salt, and this downfall

has held back its release to the California industry. Merensky II (formerly Dusa, a South African selection), has been released to the industry and the first trees should be available in the spring of 2003. This latter rootstock has performed very well under 10 years of testing in California with high yields and a high degree of root rot resistance.

A long-term trial testing 10 individual clonal rootstocks conducted by Dr. Mary Lu Arpaia in a non-root rot infested soil showed that Hass grafted onto either Duke 7 or Borchard were the top yielding trees after 11 years. Disappointingly, Borchard, has now been shown to have no root rot resistance. This rootstock could be considered in new plantings with no root rot and where future disease pressure would be predictably low. In the same trial, Toro Canyon, D9 and clonal Topa Topa (planted as a 'control') fell into a second lower-yielding group, but still gave adequate production. When canopy volumes were measured it was found that Borchard trees grew to the largest size, with Toro Canyon and D9 being the most compact. Duke 7 trees were intermediate in size.

It is worth noting here that, while other fruit industries including apple, pear and citrus have been able to find true dwarfing rootstocks, the avocado industry continues to search for rootstocks with this feature. In Mexico, a rootstock variety called Colin V-33 was thought to be dwarfing but research has failed to confirm this. The breeding programs conducted in California by John Menge and Mary Lu Arpaia continue to include dwarfing as a selection criterion.

The relatively good performance of Duke 7 as a clonal rootstock in research trials is important because Duke 7 has become (and remains) the most popular clonal rootstock in California, and also world-wide where clonals are used. The California Avocado Commission Production Research Program is following several other research questions involving clonal rootstocks including: Are there salinity tolerant clonal rootstocks? Do clonal rootstocks confer pest resistance to the scion? Can fruit quality be improved through the use of clonal rootstocks? Judging from results obtained in other fruit crops, the answers are likely to be positive to all of these questions. While these benefits of clonal rootstocks may take years to realize, growers can immediately reap the benefits of the currently available clonal rootstocks by selecting high yielding, root rot tolerant trees.

Remember, it is always a good idea to get the opinion of your local University of California Farm Advisor before planting or replanting an orchard. They will be able to give you the latest recommendations.

Further Reading:

Arpaia, M.L. 1997. Avocado clonal rootstock production trial. In: Proc. California Avocado Research Symposium, Riverside, lose insert, 3pp.

Bijzet, Z. and Sippel, A.D. 2001. Rootstocks. In: The Cultivation of Avocado (ed. E.A.de Villiers). Institute for Tropical and Subtropical Crops, Nelspruit, South Africa, pp. 85-90.

Menge, J.A. 2001. Screening and evaluation of new rootstocks with resistance to *Phytophthora cinnamomi*. In: Proc. California Avocado Research Symposium, Riverside, CA. pp. 49-53.

Menge, J.A. and Marais, L. J.2000. Soil Environmental Factors and their Relationship to Avocado Root Rot. Subtropical Fruit News 8(1-2):11-14.

Interesting Web sites with rootstock information:

http://ucavo.ucr.edu/Rootstocks/Rootstocks.html

http://www.avocadosource.com/

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