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SHOULD THE CALIFORNIA AVOCADO INDUSTRY CONSIDER "SNAP" HARVESTING?

Reuben Hofshi
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Increasing competition from abroad requires a serious look at all aspects of the California avocado farming enterprise. Offshore growers spend as little as one cent per lb. to harvest their avocados, while the average California harvesting cost is greater than 10 cents per lb. and rising. The number of workers available to harvest California avocados is shrinking. Additionally, inexperienced newcomers are replacing the aging guard of experienced pickers. This article will discuss how "snap" harvesting of avocados can help improve ripe fruit quality and reduce harvesting costs to help California growers remain competitive (Figure 1).

Fruit quality issues

"Snap" harvesting is not a new concept and has already been adopted by other producing countries (Figure 1). The Israeli avocado industry, which exports most of its avocado production to

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From The Editor

Guy Witney
California Avocado Commission, Production Research Program Manager

The CAC Production Research Program's mission is to "provide California avocado growers a means to achieve optimum profitability, now and in the future, through focused research, global collaboration, and effective communication of results." I believe that the articles in this issue of *AvoResearch* encapsulate this mission.

In the cover article, Reuben Hofshi, Chairman of the Production Research Committee, summarizes what we have learned from research about "snap" harvesting fruit in California, and he compares this to the experiences and scientific data collected from other avocado industries. While our industry is a long way from adopting "snap" harvesting as a routine practice, CAC Board Chairman, Jerome Stehly, recently suggested that our industry carefully review "snap" harvesting as a means to reduce grower costs and increase worker safety in the future. We hope that this article stimulates debate on the subject.

In keeping with previous issues, we continue our review of other world avocado industries with a short article on South Africa, the world's largest exporter (by volume) of avocados.

In light of the planting boom currently underway, a brief review of rootstocks is also provided to help growers understand the long-term advantages of investing in clonal rootstock varieties. Finally, Mark Hoddle has provided us with an insert on persea mite. This article summarizes what we know about this serious pest after six years of intensive research.

RESEARCH UPDATE

Work done last winter by Joe Smilanick, Dennis Margosan and Mary Lu Arpaia with fruit harvested after rainfall, shows that substantial reductions in stem end rots were obtained by storing the fruit at cool temperatures (41 to 50 °F) for several days before ripening.

Preliminary data from research being conducted by Pascal Oevering, Ben Faber and Phil Phillips on naturally occurring populations of glassy winged sharpshooters (GWSS) in Valencia orange trees and adjacent avocado trees in Pauma Valley and Fillmore, shows significant movement of adult sharpshooters to avocados from infested citrus, some egg laying on avocado leaves, but very few developing nymphs. They are monitoring the effects of adult GWSS feeding on the trees and developing fruit.

Watch for meeting notices in the AvoGreensheet or log onto www.avocado.org/growers for more information.

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"SNAP" HARVESTING

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Europe, has been marketing several varieties of "snapped" avocados successfully for many years. Other countries are switching to "snap" harvesting as well. Visits to the Asian markets over the last two years reveal "snapped" Hass from Australia (Figure 2). Avocado growers in Spain are also "snap" harvesting. The driving force behind the Spanish effort is to improve quality by "snap" harvesting their late season Hass targeted for the French market. Various studies conducted in Spain demonstrated that late season Spanish Hass avocados have high levels of stem end rots, which could be significantly reduced by "snap" harvesting. A recent e-mail (April 2002) from Dr. José Maria Farré, a researcher in Malaga, Spain, summarizes the situation in Spain:

> "Since January (2002) we have been marketing snapped and clipped fruit (from different growers) without any problem. After further studies this year, it does not appear that dew markedly increases stem end rot under our conditions. Spanish workers do not like to pick on wet trees anyway so I think that the snapped-clipped discussion is over. Practically all our postharvest studies this season have been done with snapped fruit."

The California avocado industry recognizes that fruit quality plays an increasingly important role in the competitive avocado marketplace and therefore requires critical attention. Growers and marketers have always associated "snapped" fruit with the inferior quality of stem-out fruit resulting from over maturity, stress and windfalls. This is an unfounded perception resulting from years of habitual clip harvesting of avocados and lack of knowledge. In fact, several researchers have demonstrated that "snapped" Hass fruit quality is comparable to that of "clipped" fruit. Dr. M. L. Arpaia conducted a two-year study, funded by CAC, with fruit from three groves in Ventura County harvested every six weeks, from January through August. She found that overall the "snapped" fruit ripened slightly faster and had slightly greater weight loss as compared to the "clipped" fruit. More importantly she noted that late season, beginning in June, "clipped" Hass had a significantly higher incidence of stem end rot as compared to the "snapped" fruit, similar to the Spanish observations. Working with Dennis Margosan and Dr. Joe Smilanick of USDA-ARS, she was able to demonstrate that the type and infection level of pathogens causing stem end rot in the "clipped" fruit were more severe than with the "snapped" fruit. In short, the collaborative research by Arpaia, Margosan and Smilanick found no evidence to indicate that Hass avocados should not be "snap" harvested under the less humid conditions in California. It is likely that the California Hass avocado can be successfully "snap" harvested. Similar research in New Zealand by Dr. Allan Woolf and Anne White of HortResearch, concluded that when environmental conditions were "dry" that "snap" harvested Hass were of higher quality than their "clipped" counterparts. This is primarily due to a reduced incidence in decay.

Figure 1. An example of "snapped" and "clipped" Hass avocados. (Photo, M.L. Arpaia)

An interesting side outcome of the California research was the demonstration that the number of decayed fruit increased immediately after a rain regardless of picking method; although in this case the percentage of decayed fruit was greater in the "snapped" fruit. The lesson learned is that avocados should not be harvested by either method during or immediately after rain and before the trees have adequate time to dry out. The effect of rain on incidence of rots is corroborated by the research conducted by Woolf and White in New Zealand. If you are interested in learning more about California "snap" experimental results, visit the links at the end of this article.

Picking method comparison

A comparison between the two picking methods illustrates that "snap" harvesting could result in considerable labor savings. The number of moves required to harvest a single avocado and place it in a picking bag is used here as a means to calculate the rate of harvest by a

Figure 2. "Snapped" Hass avocado fruit from Australia in the Hong Kong Wholesale Market (August 2001). (Photo, A. Woolf)

picker. Two complementary methods are commonly employed depending on tree height and if a picking pole is needed. One technique, termed "3+ moves", is used to clip the fruit that is reachable by hand. The picker holds the avocado in one hand, clips the stem with the clippers held in the other hand and places the fruit in the picking bag. Often the picker clips the stem at a short distance away from the stem-end and re-clips it a second time before placing the fruit in the bag. The same method is used when placing a ladder against the tree and picking what is reachable by hand. The second technique, termed "4 moves", is employed when using a picking pole. The fruit is first clipped by the clippers at the tip of the pole; the fruit is brought out of the pole bag, re-clipped and placed in the picking bag. The "3+ moves" and the "4 moves" methods described above are practiced by the majority of California pickers. There are some experienced pickers who manage to clip the avocado and place it in the picking bag with one hand in one sweeping move. However, there is a tendency to clip a portion of the skin near the stem-end with this method, which can result in fruit injury.

To illustrate the potential for labor savings using the "snap" harvesting method, a comparison of the number of moves required to commercially strip harvest a 15-20 ft. tree with 100 lbs. of fruit averaging 7 oz., which is a total yield of 227 fruit. The fruit distribution on the tree is such that 40 lbs. are harvested from the ground by hand; 20 lbs. are harvested by hand off a ladder; and the remaining 40 lbs. are picked with the aid of a picking pole either from the ground or off the ladder. Therefore 60 lbs. or 136 fruit are picked by hand, and the remaining 40 lbs. or 91 fruit are picked with the aid of a picking pole. The picker who clips the fruit with the "3+ moves" method requires 408 moves to pick the 136 avocados harvestable by hand. The remaining 91 fruit are picked by the "4 moves" method and require an additional 364 moves. The total moves required to harvest 100 lbs. in the "clip" method is 772. The same fruit picked by "snap" harvest require a maximum of 1 move (snap and place in the picking bag in one move) to harvest the fruit reachable by hand from the ground or the ladder (the word maximum is used because often both hands are "snapping" 2 individual fruit simultaneously and thus reducing the number of moves even more). Therefore the 136 fruit reachable by hand require 136 moves. The remaining 91 fruit to be harvested with a picking pole require 3 moves each, (the stem is snapped while the fruit is being removed from the pole bag and placed in the picking bag) for an additional 273 moves. A total of 409

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"SNAP" HARVESTING

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moves are required to "snap" harvest the same number and distribution of avocados. This equates to 47% fewer moves than in clipping.

Cost analysis comparison

The current average picking cost using the clip method is about 10-14 cents per lb. with early size picking costs ranging much higher. So a 30% reduction in the rate associated with picking becomes meaningful. For example: In a 385 million pound Hass crop year, the industry's cost to harvest the crop at an average rate of 10-14 cents per pound, will total $38.5 - $54 million. Therefore with a 30% savings, growers could potentially save $11.5 - $16.2 million if "snap" harvesting is adopted. In other words, a grower with 10,000 lbs. per acre currently pays $1,000 - $1,400 per acre to strip harvest the trees. "Snap" harvesting can potentially reduce the cost to $700 - $980 per acre. Obviously not all trees are 15 to 20 ft. tall, and the numbers presented above are only an illustration of potential savings and are by no means absolute. Pickers' experience, terrain, fruit load, tree fruit distribution, tree height and overall accessibility will all influence real savings. In Israel where harvesting is done from cherry pickers, increased productivity/cost savings by "snap" harvesting is reported to be approximately 50%.

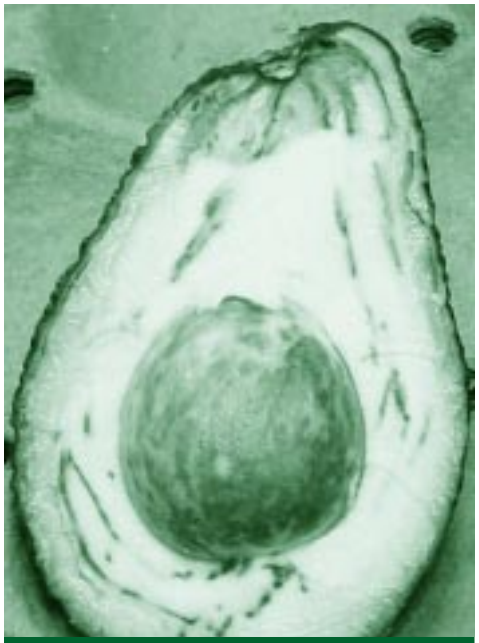

Figure 3. Stem end rot is caused by a number of postharvest fungal diseases and is manifested in discoloration of the fruit stem end. The vascular bundles of the fruit may also darken. (Photo, M. L. Arpaia)

Manpower

The availability of farm labor, in general, and experienced avocado pickers in particular, is becoming scarcer each year. Avocado harvesting, especially size picking, is an art perfected over years of experience. Even a relatively inexperienced "snap" picker can outperform his "clipping" counterpart by significant margins. A given picker will potentially be 30% more productive if he "snaps" the fruit instead of "clipping" it. If the "clip" workforce harvests through the season an average of 1,500 lbs. of Hass avocados per day per picker, a 385 million lb. crop will require approximately 257,000 man-days to harvest. "Snap" picking can reduce the demand for labor through higher productivity of the individual picker, i.e., one picker harvests more avocados per day, and thus the crop is picked with a smaller number of pickers. The reduction in man-days demand will be proportional to the increased efficiency of the pickers "snapping" rather than "clipping" the avocados. Thus a 30% increase in picking efficiency will translate to a potential industry savings of 77,100 man-days.

Worker safety

Clippers are sharp and cumbersome and pickers on ladders or with picking poles need to be mindful of the clippers strung on their finger especially in case of an emergency or a fall. The industry needs to be aware of newly contemplated OSHA rules which may limit or disallow the use of clippers altogether because of the high incidence of carpal tunnel syndrome caused by repetitive motion of clipping.

Worker's compensation considerations

The availability of sufficient pickers during the entire season and peak demand periods, the basic per pound or per hour pay, the profit margin of the farm labor contractor and the overhead associated with equipment, housing, transportation, taxes and worker's compensation, all contribute to the cost of harvest. The increase in the minimum wage rate at the beginning of 2002 explains the recent increase in the basic cost per pound. Additionally, in the last year, the worker's compensation rate for orchard work increased to 20.5%. Discounts for existing policyholders associated with credits plus experience modification bring the rate, in real terms, to an average of 15% of gross payroll.

On February 15, 2002, Governor Davis signed into law AB 749. This law will increase benefits for temporarily and permanently injured workers from $490 to $602 weekly starting on January 1, 2003. Benefits will continue to rise until 2005, when the maximum will reach $840 a week. Starting in 2006, benefits will be adjusted annually based on increases in the state's average weekly wage. Workers with partial but permanent injuries will see an increase ranging from $130 to $270 a week. The current benefits range from $70 to $230 a week. In addition, the current maximum death benefit will double to $320,000. Some business interests estimate the cost increase to the state's employers at $3.5 billion. These increases will particularly impact farmers and will significantly influence the harvesting costs of avocados in California and may place harvesting costs at equal or even ahead of water costs!

In conclusion, the California avocado industry will be well served if it seriously considers adopting "snap" harvesting as the method of choice for harvesting Hass avocados throughout

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AN OVERVIEW OF THE SOUTH AFRICAN AVOCADO INDUSTRY

Guy Witney, California Avocado Commission, Production Research Program Manager

HISTORY

Avocados were likely introduced into South Africa by settlers coming from the West Indies and other Dutch colonies between 1652 and 1700. Supporting this theory are references to early specimens suggesting that they were all seedlings of the West Indian race. Interestingly, in some parts of the country large, low-oil fruit from West Indian seedling trees are still preferred over higher quality avocado varieties introduced from California.

Between 1932 and 1938 the first experimental avocado cultivar evaluation block was planted for the Department of Agriculture near Nelspruit (see Figure 1). Large-scale plantings of avocado commenced in the same region in 1938, once it was shown that the imported California varieties performed well in the region. These plantings were mainly made in the mountainous areas of the Lowveld – (Figures 2 and 3) a region characterized by grasslands, thorn tree scrub and abundant wildlife.

Figure 1. Most avocados are produced in the eastern part of South Africa, a subtropical region with summer rainfall.

THE INDUSTRY

Climactically, the industry is mostly located in warm to cool subtropical areas with a predominantly summer rainfall of approximately 30 – 45 inches. Most soils are of granitic or doleritic origin, are highly leached, acid to very acid, and are infertile. They are mostly oxisols (red clay loams to loamy clays), and are basically well drained in spite of clay contents from 20 to over 50%.

The avocado industry currently consists of around 3 million trees planted on approximately 36,000 acres. Total production varies between 125 to 250 million pounds. The most important production areas are Tzaneen with 38% of the trees, followed by the Nelspruit area at 33%, Levubu at 21% and the Natal Midlands at 8% (Figure 1).

While Fuerte still dominates South African acreage at around 40% of the total, Hass now accounts for approximately 35% of acreage and is the only variety seeing significant expansion. Ryan, Pinkerton and Edranol are also grown, and there is a keen interest in Lamb Hass, Harvest and Gem.

In 2001, South Africa was the largest exporter of avocados worldwide. About 60% of the total avocado crop is exported annually with 97% of this destined for the EU. The export volumes are around 50/50 Hass/Fuerte with a small amount of Pinkerton. The largest EU markets for South African avocados are Germany, France and the UK. South Africa's main competitors on EU markets are Kenya, Spain, Mexico, Chile, Israel, Peru and the U.S.

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"In spite of enormous transit distances, South Africa regards the U.S. domestic market as an important future destination for their fruit. This is because they could deliver Hass fruit to the U.S. domestic market from June through September, the period we currently have to ourselves."

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The South African avocado industry is under the leadership of the South African Avocado Growers Association (SAAGA) which is funded by voluntary levies from all members. Its mission is to improve the economic viability of the production, packaging and marketing of avocados.

SAAGA encourages coordinated fruit exports, funds limited field and postharvest research, and organizes grower meetings. Two field representatives and one technical officer serve as the "extension team" working with the approximately 500 individual growers. Under SAAGA's leadership, the industry is very tight-knit, with most growers participating in monthly "study group" meetings held in each region. These meetings generally include a field tour and barbecue, and serve as both educational and social functions. Growers are quick to embrace new technologies and are progressive by world standards. SAAGA produces an annual yearbook containing the results of their research, a monthly newsletter called AvoInfo, and they also run a web site at: http://www.avocado.co.za/

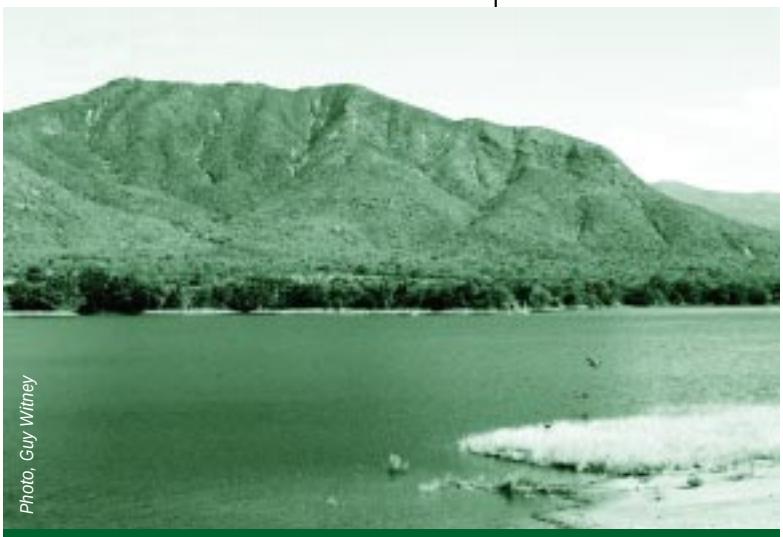

Figure 2. Early avocado plantings were mainly made in the mountainous areas of the Lowveld — a region characterized by grasslands, thorn tree scrub and abundant wildlife.

Avocado consumption in South Africa has been increasing due to efforts by SAAGA to develop the domestic market. Their marketing tools emulate those used by CAC and include radio campaigns, celebrity chef recipe features, recipe competitions and print advertisements. Current domestic consumption is between 2.5 and 3.0 lbs. per capita, with a long-range target of 5 lbs.

PLANTING AND ORCHARD SYSTEMS

There are six registered avocado nurseries in South Africa producing certified disease free trees. Most new trees are on clonal rootstocks with Duke 7 the predominant choice. The Merensky series of clonal rootstocks developed by Merensky Technological Services, Tzaneen, is showing promise in local trials and the first trees will be available to South African growers in 2003.

Most orchards are now trained to hedgerows with trees spaced approximately 12–15 feet in the row. Rows are spaced 18–20 feet apart. A combination of mechanical hedgerow cutting and plant growth regulators (triazoles) are used to control vegetative growth (Figure 4).

While in many growing areas summer rainfall is abundant, winters are very dry and irrigation is required to maintain production and optimal tree condition. Systems generally are similar to those in California with Israeli designed mini-sprinkler systems dominating the industry. Leaf and soil analysis are performed routinely and tree nutrition is

Photo, Guy Witney

Figure 4. A mature Hass orchard with trees spaced approximately 15 feet apart in the row, with rows 20 feet apart. A combination of mechanical hedgerow cutting and plant growth regulators (triazoles) are used to control vegetative growth. Velvet beans are planted in the row middles to provide organic matter, a refuge for beneficial insects and improve the soil.

based on norms that have been adapted from those established in California. Nitrogen is the key element manipulated to balance vegetative growth and fruiting. Growing conditions and soils are diverse, so specific nutrition recommendations are made for each grower based on leaf analysis. Because of their highly acidic soil profiles (pH 4 – 4.5), deep lime incorporation into new orchard soils with heavy equipment is a common practice.

Since the South African avocado industry is export oriented, fruit quality is of paramount importance. Growers recognize that good shipping quality is generally associated with adequate calcium nutrition and suitable ratios between calcium, magnesium and potassium. In spite of boron sprays during flowering and fruit set, growers continue to battle boron deficiency in orchards because of low soil levels and poor root uptake.

PESTS AND DISEASES

The entire South African avocado crop is produced in areas with rainy and humid summer weather, resulting in several fruit fungal problems. The most serious of these is Cercospora spot which largely affects the Fuerte crop and has traditionally been treated with copper. Anthracnose can also be a serious problem in wet areas on all varieties. Recently, Colletotrichum spot has been a problem on Pinkerton fruit.

Phytophthora root rot decimated the industry in the 1960's and 70's. Much of the early work on phosphorus acid for Phytophthora control was conducted in South Africa and today treatments with commercial phosphite products are routine. While many growers still use injection techniques to apply the product, there is a move toward foliar sprays to mitigate tree damage. For a detailed description of the techniques currently used for Phytophthora control in South Africa, see the inset on root rot in the previous issue of AvoResearch (Vol. 2, Issue 1).

At least four species of sucking bugs (*Hemiptera* spp.) can cause serious damage to the avocado crop if not treated. Currently these insects are controlled with broad spectrum pyrethroid insecticides resulting in few options for integrated pest management. Local research is underway to test insecticides that are more target specific. Several worm species and false coddling moth can both be serious pests if allowed to build up in orchards. Fruit flies are monitored and controlled with insecticide baiting.

INTERNATIONAL FOOD SAFETY REQUIREMENTS

With an emphasis on export markets, the South African industry is moving rapidly to adopt several food safety requirements of the international community. The European Union, and particularly the United Kingdom have become particularly sensitive to food safety issues. SAAGA is currently working with a consultant to deliver a EUREP-GAP (Euro Retailer Produce Working Group – Good Agricultural Practices) document for growers to achieve compliance within the EU.

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Photo, Guy Witney

Figure 5. Merensky Technological Services researchers (left to right) Riaan Duvenhage, Stefan Köhne, and Sylvie Kreme-Köhne standing in a Phytophthora rootstock development plot with SAAGA Technical Manager, Derek Donkin.

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This will be followed by similar documents for the packing industry which will include a GMP (Good Manufacturing Practices) manual and a HACCP (Hazard Analysis Critical Control Point) manual. Both of these manuals will allow for rapid identification and rectification of food safety and quality problems in the handling chain. *(Note: CAC recently received a $150,000 grant from the CDFA Buy California Initiative to produce similar documentation.)*

If this is not enough, some of the EU's retail giants are doing third-party audits of local groves, picking operations, and packing facilities and have raised the bar of food safety standards above international norms.

RESEARCH

Research projects on avocados are mainly conducted by three entities. Two of these are public institutions, the University of Natal, Pietermaritzburg, and the Agricultural Research Council's Institute for Tropical and Subtropical Crops, Nelspruit. The private Merensky Technological Services near Tzaneen receives very limited public funding, but is a very prolific avocado research institution (Figure 5). The new Merensky series of rootstocks originate from the latter organization.

Research projects currently underway in South Africa include cultivar breeding and evaluation, tree nutrition and physiology, manipulation of growth and fruiting, pest and disease management, and postharvest physiology. Research results are presented annually in summer (February) at the SAAGA Research Symposium. For a copy of their latest research abstracts, visit the SAAGA web site at: http://www.avocado.co.za/

THE FUTURE: STRATEGIC POSITIONING FOR THE U.S. MARKET

In spite of enormous transit distances, South Africa regards the U.S. domestic market as an important future destination for their fruit. This is because they believe they could deliver Hass fruit to the U.S. domestic market from June through September, the period we currently have to ourselves. Also, their production costs are low (skilled farm labor is paid around $0.50 to $1.10 per hour resulting in harvest costs of 0.5 to 1 cent per pound of fruit), and foreign exchange rates from an undervalued currency drive exports.

Photo, Guy Witney

Figure 3. Mature Hass orchards in the Tzaneen area of Southern Africa. Yields are typically between 10,000 and 20,000 lbs. per acre with fruit maturing in June through September.

However, meeting the phytosanitary requirements for market access to the U.S. will be difficult. South African orchards have several pests not present in California, including fruit flies and false codling moth.

SAAGA will focus on the U.S. market over the next few years, with access as a long term goal. Their research program is looking at irradiation, fumigation and holding temperatures (coupled with CO_2 and 1-MCP) as a means to eradicate target pests. They realize that recent pest introductions and quarantines in the U.S. have raised the standards of pest risk analysis and mitigation procedures, making it more difficult for foreign fruit to enter domestic markets. They are very closely monitoring the work currently underway by Mexico to expand market access in the U.S.

While South Africa poses no competitive threat to the California industry at this time, we should be cognizant that this industry is progressive, export driven and could enter the market in the future if phytosanitary requirements are met.

PLANTING TREES ON CLONAL ROOTSTOCKS

Guy Witney
California Avocado Commission,
Production Research Program Manager

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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CLONAL ROOTSTOCKS

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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/

"A great deal of research has been conducted developing root rot resistant rootstocks worldwide, particularly in California, South Africa and Israel."

"SNAP" HARVESTING

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the season. Although studies are still needed to demonstrate the acceptability of "snapped" avocados in the trade and marketplace, the research we funded makes a good case in favor of removing the stem and a good starting point for discussion with the buyers. The potential cost savings that "snapped" avocados represent to our industry is substantial. Our goal must be to improve the quality of our avocados, as well as to reduce our costs. In this pursuit, hiding behind traditional customs and perceptions is a habit we cannot afford.

Links to papers discussing fruit quality of "snapped" avocados:

Arpaia, M.L. and Hofshi, R. 1998. The feasibility of "snap" harvesting of Hass avocados.
http://www.avocadosource.com/

Margosan, D.A., Smilanick, J. L., Arpaia, M.L. and Sievert, J. R. 1999. Fungi isolated from avocados with stem-end rot after "snap" or "clip" harvest. In: M.L. Arpaia and R. Hofshi (eds.), Proceedings of Avocado Brainstorming '99:150-151.
http://www.avocado.org

Margosan, D.A. and Smilanick, J. L. 2000. Fungi isolated after harvest from decayed California avocado fruit. California Avocado Research Symposium, October 14, 2000:101-103.
http://www.avocado.org

Smilanick, J.L. and Margosan, D.A. 2001. Management of postharvest decay of avocado fruit. California Avocado Research Symposium, October 20, 2001:115-119.
http://www.avocado.org

Woolf, A., White, A., Sievert, J. and Arpaia, M.L. 1999. Summary of New Zealand and Californian experience with "snap" picking. In: M.L. Arpaia and R. Hofshi (eds.), Proceedings of Avocado Brainstorming '99:161.
http://www.avocado.org

These articles can also be found through links available at Reuben Hofshi's web page:
http://www.avocadosource.com/

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