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Nota Científica

IMPROVING AVOCADO PRODUCTIVITY

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INTRODUCTION

In considering the ultimate productivity of an orchard, it is important to think of the orchard as a system that has a beginning, middle and end - from the conception and layout of the orchard, to the middle when cultural practices are affecting tree growth and fruit production, and to the end when fruit is harvested and packed. It is very difficult to improve yields in the mature avocado grove when basic problems such as planting density, rootstock, soil pH or pipe sizing become the major limitations in yield. Far too often growers (and researchers) tend to concentrate on one aspect of yield improvement (such as better fertilizer application timing) rather than looking at the grove as a whole system from the very beginning. For instance, a change in a fertilizer practice may not do much to improve yields if the over-riding problem in the grove is soil pH, a problem that is much easier to correct by adding soil amendments and turning them into the soil during orchard preparation rather than correcting the problem when the trees are older. Taking the proper steps early on can reduce productivity problems in the future. This article will review some of the establishment and cultural considerations necessary to obtain optimum productivity. Hopefully, this proceeding will contain other insights in optimizing productivity.

DISCUSSION

Site selection

This discussion presumes that the orchard site has all the necessary prerequisites: a warm climate, reasonably good soil and sufficient water of adequate quality for irrigation. If frost is a problem in the area, it is important to have some history of the site and avoid those portions of the terrain that have consistent freeze tendencies. It is also wise to avoid areas that have periodic strong winds which will eventually cause problems with dropped fruit and limbs denuded of leaves.

Cultivar Selection

The next step is selecting a cultivar early enough to ensure delivery from the nursery so that the trees can be successfully planted in the spring. If the desire is to increase yields in the early years, the selection should be for an upright stature in order to reduce future pruning requirements and to allow for higher planting density. The cultivar should be high-yielding and low alternate bearing. The fruit should have good market acceptability and ship well. Cultivars with resistance to pest or disease should be sought out; for example 'Lamb Hass' has resistance to *Scirtothrips perseae*, a thrips pest currently a problem in California. The fruit also has a thicker peduncle which should make the fruit less prone to drop in windy areas. There are several cultivars in the University of California breeding program that have traits which should be considered in selecting the appropriate cultivar.

Despite our desire to improve yields and cultural qualities by selecting a cultivar that might make farming easier, it is important to remember that if we change cultivars there must be a sound marketing plan for this fruit to enter and be successful in a 'Hass'-dominated market.

Rootstock Selection

Rootstock selection is as critical as varietal choice. In a seven-year old rootstock trial in Southern California in "clean" soil (no *Phytophthora cinnamomi*) Duke 7 and Borchard rootstocks each produced 20% more fruit weight ('Hass') than the next grouping of rootstocks (Toro Canyon, Topa Topa and D9), and approximately 100% more fruit weight than Martin Grande (G755) (Arpaia *et al.*, 1993). In soils that are infested with *P. cinnamomi*, or have the potential to be infested, starting out the grove with clonal Thomas rootstock might be the wise choice since Thomas (from an escape tree of Mexican origin found in Escondido, CA) has consistently performed better when rated for tree health than other rootstocks in University of California replant trials (Menge *et al.*, 1999; Menge *et al.*, 1992). Barr Duke and D9 have also performed well when rated for tree health. Unfortunately, Thomas is one of the more susceptible rootstocks to trunk cankers caused by *P. citricola* and *Dothierella* fungi. New rootstocks with even better tolerance to *P. cinnamomi* will become available in the near future from the program at the University of California, Riverside.

There have been many selections made of West Indian rootstocks made by Dr. Avraham Ben Ya'acov in Israel. Many of them have salinity and root rot tolerance. Some of the selections appear to grow with no ill effect with irrigation water containing 300-400 mg·liter⁻¹ chloride, twice of that tolerated by Mexican rootstocks. In warmer areas these rootstocks should definitely be considered. In cooler environments, seedling West Indian rootstocks have, in the past, not performed satisfactorily due to poor root growth and lateness in leaf development in the spring. Questions have been raised, however, as to whether these rootstocks have been studied adequately in Southern California. As Hofshi notes, "It is true that the West Indian race as a group is more cold sensitive than the Mexican or Guatemalan races, but not to the point of

wholesale rejection of all West Indian types. Israel experiences cold temperatures and freezes and yet continues to plant on West Indian rootstocks” (Hofshi, 1996).

Other rootstock characteristics are important. At this point there is no truly dwarfing rootstock available commercially, but there are hopes for one in the future. ‘Borchard’ rootstock (also a Mexican selection from southern California) is a clonal that shows better resistance to calcareous soils and their tendency to cause iron chlorosis. Thomas, D9 and G6 rootstocks imparted considerably more frost tolerance to the ‘Hass’ scion than other Mexican rootstocks when rated after the freeze in January 1991 (Bender *et al.*, 1999).

Planting

Whatever combination of scion and rootstock chosen, it can not be emphasized enough that good quality trees should be used in the planting. These should be vigorous with a good root system. If the trees have become root-bound in their containers, it is best not to accept them. Some nurseries in California in the 1970’s and 1980’s had problems with *Phytophthora cinnamomi* infection in their young trees. When these trees were placed into mature groves root rot was initiated and, in many cases, caused the entire grove to eventually fail. Although most nurseries are now very careful about cleanliness and produce good quality healthy trees, the grower should double check the roots of the replant trees before they are placed in the ground.

Prior to planting, land preparation to clear vegetation and install roads for removing fruit should be kept to a minimum to avoid soil compaction. If planting on steep slopes, terracing should be minimized to avoid loss of rooting volume in shallow soil. On flatter soils, where hard pan or stratified layers are found, ripping the soil will help with tree growth. If soil pH is high or low, it can be most easily corrected at this time with sulfur (for high pH soils) or lime applications (for low pH soils). If the soils are heavy or there are problems with drainage, mounds or berms should be built on which to plant the trees for improved aeration. Drainage channels should also be built to ensure that high rainfall does not cause root asphyxiation.

The irrigation system should be installed prior to planting trees. It should be of an adequate size to meet the needs of the mature orchard during peak water demand. There should be pressure compensating emitters and/or pressure regulators in the lateral lines, filtration and enough irrigation blocks to meet any microclimate differences, such as can be found with differences in aspect, slope and elevation.

Depending on the cultivar, tree spacing will vary with the site. In windy areas where wind pruning keeps trees small, higher densities are possible. Shallow soils tend to restrict rooting, which may result in smaller trees. These soils can be planted at higher densities. The initial tree training (if trees are pruned to a single leader) will also permit closer spacing, but will increase the initial cost for the trees at planting time. Higher densities allow for earlier returns from the orchard, but a plan must be followed to deal with crowding. Tree removal, pruning, replanting or a combination of techniques is

required. In countries that allow the use of growth retardants, such as paclobutrazol, the crowding issue is not as acute as in California, but all avocado groves eventually must address the problem.

Proper planting techniques are often overlooked in a rush to get the trees into the ground. Planting should be done early in the spring after any frost threat is over. Holes should be dug to the same depth as the container or slightly more shallow. A common problem found in planting into a deeper hole or mixing large amounts of organic amendment in the hole, is that settling occurs and soil eventually covers the trunk, and in the worst case, can actually cover the bud union. Covering the trunk can lead to various diseases and physiological problems.

The new trees should be protected from rodents and sunburn by using trunk wraps. Loosely staking the tree will help to prevent wind damage, yet allow for a larger trunk caliper and the development of a more balanced tree structure.

Using mulch around trees can serve two purposes: it reduces the amount of water lost due to evaporation and if the mulch is at least 7 cm deep, it prevents weed seed germination (Downer and Faber, 1999). In areas with root rot, woody mulch acts to reduce the impact of the disease and should be used along with a source of calcium-lime in acid soils and gypsum in higher pH soils.

Pollinizers

Consideration needs to be made of the need for cross-pollination. 'Hass' trees often set more fruit when close to B flower pollen donor trees, but this effect is not always consistently noted. In the inland area of Temecula, CA it was shown that percent out-crossing to a B flower cultivar and yield were positively correlated, but it was not clear whether percent out-crossing was related to yield in the more coastal environment of Santa Barbara and Ventura, CA (Kobayashi *et al.*, 1996). In some countries, the value of introducing pollinizers has not caused many problems because of the marketability of pollinizer fruits. In California there has been reluctance to plant non-'Hass' cultivars because of the differential paid for greenskins. Space occupied by the pollinizer was space that otherwise would be occupied by a 'Hass' tree. Some growers have turned to using pollinizers only as a source of pollen, and pruned the pollinizer as a pole so that it would impact the more valued cultivar in the least competitive way. With several of the new cultivars from the UC breeding program, there are now B flower pollinizers that have a strong similarity in appearance to 'Hass' fruit. When one or more of these cultivars are released to the industry for planting, the decision to plant pollinizers should be easier for the growers.

Pollination

There are many problems associated with pollination of avocado. When pollen is shed in a given flower, under the normal dry California conditions the stigma is no longer receptive and functional. This is a result of avocado's unique dichogamous flower in which the receptive female stage opens, then closes and opens later in the male stage.

Therefore, at least in California, we believe that pollen must be transferred by an insect from a male flower to a female flower to complete the pollination event. The insect most commonly found visiting avocado flowers, and carrying the most pollen on their bodies, is the honeybee (Visscher and Sherman, 1999). Davenport has noticed in Florida (a more humid climate) that the reliance on an insect pollinator may be overstated; he has observed wind-borne avocado pollen that may be responsible for pollination within a given flower from the anthers in the male phase of the flower to a still receptive stigma left over from the female phase (Davenport 1999).

Despite the possibility that wind-borne pollen may play a role, we continue to see low fruit set in California when bees are lacking. When avocados are caged with bees, especially when there is another cultivar with a different flower type nearby, fruit set in 'Hass' has been shown to increase from 0 fruit per tree to almost 300 fruit per tree (Peterson, 1955).

How do we increase bee visitation to avocado flowers? There seems to be few options except to just bring more bees into the grove and to reduce the number of nearby crops (especially citrus) which successfully compete for bee visitation. Farm advisors from the University of California have traditionally recommended 1 strong hive per acre be placed in the grove, but some local growers appear to be achieving more success (bee visitation and fruit set) with 3 to 4 hives per acre.

Bee attractants containing sugar, honey and various types of pheromones are often sold to avocado growers with the promise that fruit set will be increase. We have not yet seen any research from a University which can verify this claim. Theoretically bee attractants could be useful if sprayed at daybreak before scout bees choose the plant type to be worked that day, but we doubt they are useful when sprayed later in the day, and because of the volatile nature of the attractants, the effect would probably last only one day. Clearly, this is an area in need of more research.

Irrigation

Once trees have been planted, the major activity in many avocado-growing areas is irrigation. It has been recognized in Southern California that frequent moisture stress is probably one to the main factors contributing to low yields. This activity is often set on a fixed schedule without taking into account the change in water requirement by the trees due to rapid changes in temperature, humidity and/or wind. In addition, a large percentage of groves are managed by professional grove managers that have difficulty changing work schedules of their laborers to meet changing irrigation schedules. To compound these problems, many groves are planted on soils with low moisture holding capacity (hillside decomposed granite), but some are planted on heavy clays that store more moisture. Some technique that can guide the irrigator needs to be developed, whether it is some expensive soil moisture device or a shovel. Tensiometers have worked very well to help schedule irrigations, if they are properly maintained. The use of evapotranspiration data from weather stations has also been useful to help growers recognize changes in irrigation requirements in their groves.

The irrigation system should be maintained so that optimum water distribution is obtained. This means fixing breaks, clogs and keeping the system at optimum pressure for emitter performance. Pre-set pressure regulators on the lateral lines, and pressure compensating emitters are very useful to maintain proper flow to each tree. Water should be kept away from the trunks to reduce the incidence of trunk canker diseases. In conjunction with irrigation, drainage channels need to be maintained to avoid puddles and reduce erosion.

Fertilization

Trees should be fertilized with the goal of maintaining optimum concentrations of nutrients in the leaf tissue. Consideration of the fruit load in the tree is also important. All too often, growers do not adjust their fertility practices to account for the amount of fruit on the tree. Applying the same level of nutrients when a tree has no fruit, only leads to a bigger tree that will need to be pruned more heavily. Unfortunately, with the advent of fertigation, it is difficult to adjust the fertilizer application to meet the differential needs of the individual trees in the grove.

Recent research by Lovatt in California indicates that timing of nitrogen fertilizer applications may be more important than once thought, and may be related to tree phenology (Lovatt, 1999). She conducted a four-year trial in which 150 lbs per acre of nitrogen as ammonium nitrate was applied in five equal dosages during the months of November, January, April, July and August (the control). The treatments consisted of the control treatment plus an extra 25 lbs per acre applied in either of the five months, for a total of five treatments. At the conclusion the treatment with the extra nitrogen in November (formation and differentiation of buds) produced an average of 39% more fruit yield (by weight) than the control. The extra nitrogen in April (middle of bloom) produced an extra 30% fruit yield. The extra nitrogen applied in January, February or June did not result in a significant difference in yield compared to the control.

Canopy management

Tree crowding is inevitable in avocado production and the resultant loss of canopy due to shading, reduced light interception and photosynthesis, and reduction in yield is evident in almost all avocado growing areas. Guidelines on how to deal with this problem are lacking, but many growers are trying various methods, including removal of every other tree, stumping and stag-horning at various heights, removal of one or two branches each year, pruning to a single leader or pruning to a vase shape, and combinations of the above methods. Research is now underway in California that will eventually give scientific and economic guides to canopy management, but we are years away from being able to provide good research-based information to growers.

Harvesting

In the end, comes harvesting. Harvesting exposed fruit so that it will not sunburn seems like an easy decision which is often overlooked. Size picking for larger fruit in order to take advantage of the higher price is normally done, but may not be worth the effort if

there are relatively few fruit and harvesting costs are too high. If possible, trees should be strip picked before trees set fruit again. This may not always be possible, depending on the market and price, but reducing the amount of fruit load will help the tree and reduce alternate bearing. A technique that is commonly used in Israel and South Africa is snapping fruit rather than clipping it. This is a speedier style and may soon be common in California. Finally, once the fruit is picked, it is important that the fruit is kept out of the sun and heat until it can be taken to the packinghouse. Fruit should be kept in the shade or cooled with leafy branches or misters to avoid overheating and reducing storage life.

CONCLUSIONS

Avocado is a tree crop that has historically exhibited low yields. This review considers some of the items that need attention if avocado yields are to be improved. Some are in the category of “good farming practices”; items such as irrigation scheduling and maintaining proper pressure and flow in the irrigation system may seem mundane, but are important. If good farming practices aren’t followed, we can gain little by spending a lot of money on research for new rootstocks and cultivars.

Some items are unique to avocado and better understanding of avocado phenology is required before improvements can be made. Fruit set alone is influenced by temperature, humidity, light, water status, cropping history, nitrogen fertilization, boron status, adjacent cultivars, and honeybee behavior. Several of these factors may be influenced by the style of canopy management. It is very difficult for researchers to sort out optimum conditions for fruit set when there are so many interweaving factors involved in the process. Yet, it is important that we expand our knowledge base as rapidly as possible and use this base of knowledge to help growers increase their production and remain a commercial success.

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