Fig. 2, left. A South African grapefruit grove planted with a windbreak of Australian pine, Casuarina cunninghamiana, for wind scar protection.

New production technologies for Florida citriculture

By Bill Castle

Professional travel is almost always a wonderful experience because it opens new worlds and stimulates new thinking. I enjoyed two such episodes recently. Each one opened a door to new technologies that will be important to the future of our industry.

My plant improvement colleagues, Fred Gmitter and Jude Grosser, and I traveled with four representatives of the Florida citrus industry to South Africa for a two-week tour in early May. Our main host was Graham Barry.

We studied certain aspects of their scion variety introduction and management system along with commercial production techniques. Why South Africa? Because while ranking number 13 in production, South Africa ranks second in export of fresh fruit. Therefore, the real answer is that their fruit industries, including citrus, are very competitive in the world marketplace. To maintain that position with fresh fruit, citrus growers are ever vigilant to discover modern technologies and adapt them quickly to their best advantage.

South African growers produce oranges, lemons, Clementines among other mandarins, and some grapefruit. These are shipped mostly to Europe, but also to other parts of the northern hemisphere. Premiums are placed on many fruit characteristics including quantity and size, but it is equally, if not more important, that the right varieties are grown to service their traditional and new markets.

THE OPEN HYDROPONIC SYSTEM

To achieve some of their goals, some growers are using the Open Hydroponic System (OHS), a cultural technique that involves frequent fertigation and other horticultural procedures. The principal objective of the OHS, like all production systems, is to make money. In this instance, the OHS is designed to accelerate the production of consistently good crops of the right sized fruit.

The OHS was developed by Professor Raphael Martinez in Spain. Since then, the general concept has been brought to South Africa, Australia, California and elsewhere, and has been subjected to a variety of local modifications. The name of the system can be confusing because a hydroponic system is generally envisaged as something that involves the careful application of nutrient solutions in a soilless system. In this instance, the word "open" is used to indicate that nutrient solutions are not reused or recirculated as they would be in a conventional "closed" system.

The normal advantages of a true hydroponic system would be a stress-free environment leading to rapid plant development, the ease of applying nutrients and changing the composition of the nutrient solution to match plant needs, and essentially reducing or eliminating any adverse influences of soil factors. Some of these advantages are actually part of the OHS concept. So how does it work?

***Fig. 1.** Inside an Open Hydroponic System control facility in South Africa showing the piping, controller, pumps (above) and the fertilizer tanks (below).*

As practiced in South Africa, for a new grove, you would take your site that consists of a soil with about 80 percent sand and 20 percent clay and silt and form the soil into small single-row ridges 18 inches to 30 inches high and 3 feet to 5 feet wide.

Install a drip irrigation system with a single line of drippers spaced about 32 inches apart and delivering 0.4 gal/hour. Connect the grove irrigation system to a central facility where water is pumped to the field and where the filtration and nutrient injection systems are located along with various tanks of fertilizer materials and a controller that is radio-linked to soil water sensors (Fig. 1.)

Plant navel orange, round orange, lemon, or mandarin trees budded at 18 inches to 20 inches on a conventional rootstock such as Carrizo citrange. Space the trees at 5 feet x 16 feet (540 trees/acre). Most groves also had windbreaks planted on all sides to reduce wind scar (Fig. 2).

Fig. 3. *A 5-year-old South African lemon orchard of trees on rough lemon rootstock spaced 5 feet x 16 feet and managed with the Open Hydroponic System using a single drip line. The trees are producing about 600 boxes/acre.*

Fig. 4. *"Turkey"' sweet orange trees on Swingle citrumelo rootstock being grown in South Africa on the Open Hydroponic System with a single line of drippers. The trees were planted in 2002 at 5 feet x 16 feet and most recently produced about 500 boxes/acre.*

The common species was *Casuarina cunninghamiana*.

Once the grove is established, you would fertigate the trees daily throughout the year with 30-minute pulses every hour from 6 a.m. to 6 p.m. Determine the nutrients to be applied by dividing the growth of the tree into two seasons: active and relatively inactive. The application of nitrogen to support shoot and canopy development would be emphasized during the active growth period and phosphorus to support root and root system growth during the period when shoot growth isn't occurring.

When the trees are about 2 years old, girdle them to induce flowering and fruiting. Every year, beginning when the trees crop for the first time, clip out any vigorous upright branches and other branches to keep height growth under control and to keep the canopy open for light penetration.

RESULTS

The outcomes? 500 boxes/acre of lemons on trees in their third season

Fig. 5. *"W Murcott"' trees on Carrizo citrange in a South African fresh fruit orchard. The trees were planted 5 x 16 feet on small ridges in 2003. They most recently have yielded about 300 boxes/acre. The trees are being grown on the Open Hydroponic System with drip irrigation. Fruiting was induced by girdling.*

(Fig. 3), 580 boxes/acre of "Turkey" orange on Swingle citrumelo rootstock at age 3 years (Fig. 4), and 345 boxes/acre of "W. Murcott" on Carrizo citrange rootstock in their second year (Fig. 5).

The same system can be installed in a mature grove. The main difference is that the water and nutritional requirements of the young trees will need to be adjusted for the older trees with particular attention paid to the composition of the nutrient solution. The annual cycle of a mature tree is divided into four parts that coincide with normal growth and development of the tree and fruit:

- Spring (essentially Stage 1 of fruit growth when cell division is the main activity),
- Summer (essentially Stage 2 of fruit growth when cell enlargement is the main event),
- Fall (Stage 3 when fruit maturity is occurring prior to harvest), and
- Winter when the fruit has been removed and the tree is "resting."

Particular nutrient elements are emphasized at each stage; for example, N for shoot growth and fruit set in Stage 1 and P in winter to aid root development.

INTENSIVE MANAGEMENT OF IRRIGATION AND NUTRITION

The preceding description illustrates many of the components used in the OHS. The concept is fundamentally focused on managing tree growth and cropping by intensive management of irrigation and nutrition. The normal role of soil is diminished and relegated mostly to providing support for the tree.

Control of the root system is necessary and this is accomplished by developing a managed root zone under each dripper where a non-stressful environment is maintained by irrigation pulsing with nutrients supplied according to the grower's objectives and the plants' needs.

One of the primary goals of the OHS is to manipulate the tree and crop to favorable ends. That means for newly planted trees, growing them vigorously to establish canopy volume, and then redirecting the tree from vegetative to reproductive growth, i.e., flowering and fruiting. The switch to cropping can be induced by girdling and maintained by managed water and nutrient applications and possibly additional girdling.

One management approach we observed in South Africa consisted of setting up individual rows in a block that received either a 1/2 x, x, or 2x OHS treatment. Those three rows served as a kind of in-field calibration used routinely to adjust the treatment applied to the remainder of the block. Some of the benefits appear to be limiting tree growth while maintaining good cropping, more consistent cropping, i.e., reducing alternate bearing. There was also the suggestion that branch angles might be increased leading to less vigorous, upright canopy growth.

OHS IN FLORIDA?

Will the OHS work in Florida? The heart of the concept is to neutralize the soil, create limited root zones, and then manipulate the tree and crop by intensive management of those root zones. One could argue that we are already OHS practitioners in Florida given our sandy soils and constant applications of water and fertilizer.

The statewide average Florida "Valencia" yield over the past 5 years was 2.5 boxes/tree or about 375 boxes/acre. Many growers have higher yields, but even if your regular yield is 500 boxes/acre, what if it was boosted to 600 to 700 boxes/acre? The potential for the OHS in combination with cultural factors like rootstock, site, and other horticultural practices is simply

too considerable to be ignored. Imagine the flexibility that reliable high yield provides for economic returns and managing diseases. Furthermore, the OHS may directly benefit our plant improvement team because we can speed up the development and evaluation of new varieties and, thereby, deliver them more quickly to our growers.

There are many unknowns. Florida has high rainfall that encourages root proliferation. Can restricted root zones be developed or can we restrict our management to only a portion of the typical root system? Our climate results in high levels of evapotranspiration. Citrus trees need relatively large amounts of water supplied on a daily basis to meet that demand. Can that demand be supplied by a drip system? With nutritional BPMs in place, can growers intensively manage fertilizer without environmental contamination? The common irrigation system in Florida is microsprinklers. The system serves the dual purpose of irrigation and cold protection. Can microsprinklers be used for the OHS in order to not give up the cold protection function? If the goal in Florida is to have 2-year-old Valencia trees on Swingle citrumelo that are 6 feet tall and produce 1 box/tree, is that possible?

WASHINGTON STATE FRUIT TREE INDUSTRY

My second trip was to Washington in the first week of July. I have always wanted to see one of the world's premier tree fruit industries that is located east of the Cascade Mountains largely alongside the Columbia River and its major tributaries from the southern border with Oregon to British Columbia on the north.

There are 250,000 acres primarily of apples (65 percent), cherries (15 percent), and pears (20 percent).

The purposes of this trip were to see the industry and to study their production technologies. Right now, cherries are the hot item and have been the most profitable in recent years. Fortunately, it was the sweet cherry harvest season. It took serious restraint not to race into an orchard and eat cherries until I was sick! The trip was very rewarding and provided much more than I expected.

My guide was Jim McFerson, manager of the Washington Tree Fruit Research Commission. The commission receives the statutory tax levy of $1.00/ton of fruit for apples and pears (equivalent to $0.045/box of Florida oranges) and $4/ton for cherries and other stone fruits. These levies generate about $3.5-4 million annually that are distributed for research every year.

In 1999, "Red Delicious" was king of the Washington apple industry, but its future was uncertain. Their tree fruit industry was in a situation similar to our current one for some of the same reasons and for some different ones.

Industry leadership developed a technology roadmap to provide a pathway to solve their problems. The road map has a strong connection to federal farm bill legislation that defines "specialty crops" and includes citrus. According to McFerson, "our Technology Roadmap started as a Washington apple effort, but grew into a national deciduous tree fruit initiative as we recognized we are all players in a global marketplace and that all deciduous tree fruit producers need to improve production efficiencies while simultaneously and continuously improving product quality (fresh or processed). Similarly, as we approach precision agriculture, automation, sensors, and diagnostics, we see nothing but similarities with our fellow perennial specialty crops (citrus, grapes and wine, berries) — thus our effort to develop a real Specialty Crops Research Team."

The Tree Fruit Commission held a retreat in 2000 to address such issues as a coherent research philosophy and discuss industry concerns that might have research answers. I left Washington quite excited about their plan and progress and, of course, any possible applications of a similar approach in our industry. Most important, the learning opportunity from a visit to Washington by Florida citrus industry leaders including commissioners, trade group executives, and public employees makes such a visit imperative.

If you travel to Washington, the horticultural scenes will be like the beautiful one in Figure 6. Over several days of touring, it was clear that many growers have made considerable progress toward new production technologies that primarily embody the concept of a fruiting wall combined with high density planting.

Labor is a major issue in Washington as well, so mechanical harvesting is also on their minds. Apple growers are the most advanced in trying new production systems because of the availability of size-controlling rootstocks. Apple trees are typically planted close in the row on a trellis and close between rows (Fig. 7). Sometimes each tree in a single row is divided into two branches that are trained up a trellis system that results in the tree taking on a "Y" shape or alternate trees are trained up one side or the other on a trellis to form a "V" shape (Fig. 8).

Pears and cherries lack proven

Fig. 6. *A vista looking up the Columbia River near the town of Brewster which is north of Wenatchee. Fruit tree orchards are visible everywhere along both sides of the river.*

Fig. 7. *A modern high density trellised apple orchard in the Yakima fruit growing region of Washington.*

Fig. 8. *Washington State apple trees being grown on a 'V' system.*

size-controlling rootstocks. Nevertheless, excellent progress has been achieved in evaluating trellis systems for these crops that are similar to those in use commercially for apples (Fig. 9). The objective with the new production systems is to improve yield, but fruit quality is recognized as very important as well. In fact, high quality fruit is deemed essential for the future of tree fruit industries.

CITRUS ON A TRELLIS?

Can citrus trees be grown on a trellis? The answer may be yes depending on the variety as our group observed in South Africa (Fig. 10).

I departed Washington with Will

Fig. 9. *Washington State sweet cherry trees under evaluation on a "V" trellis system.*

Rogers' words ringing in my ears: "Even if you are on the right track, you can get run over if you're sitting still."

Fig. 10. *"W. Murcott" trees on x639 rootstock in South Africa. The trees were planted in 2003 at 6.5 feet x 15 feet and are being trained to form a fruiting wall on a 4-wire trellis.*

That quote seems to sum up the progressive thinking of the Washington tree fruit business.