Advanced citrus production systems — grove designs for higher efficiencies

By Arnold Schumann, Kevin Hostler and Laura Waldo

In the August edition of *Citrus Industry,* we discussed the impacts of huanglongbing (HLB) disease, and production forecasts of the Hamlin orange advanced production system (APS) research trial near Auburndale. HLB-affected trees will remain smaller, with lower yields per tree — conditions which are better dealt with and compensated for with high planting densities and APS than with traditional low densities and conventional citriculture. A higher planting density was identified as one of the key ingredients of a successful APS, and in this follow-up article, we explore some of the possible grove designs which could be used for more efficient citrus production with higher planting densities.

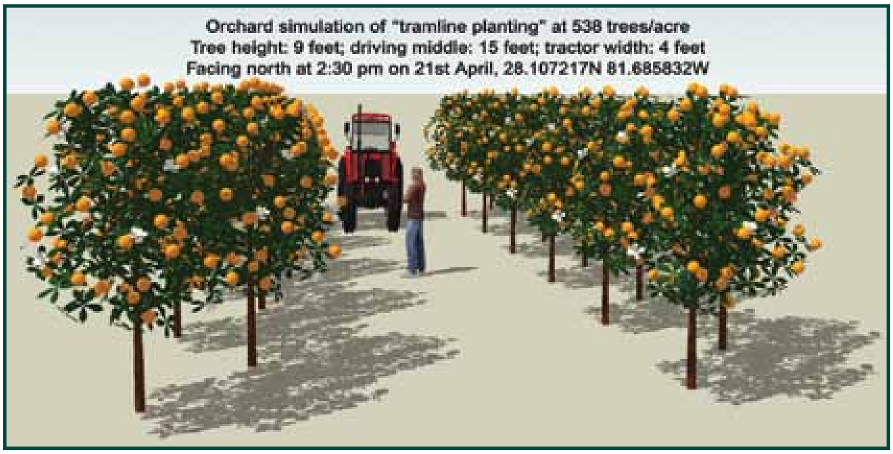

Figure 1. *Three-dimensional simulation model of a citrus grove planted with a high-density tramline system in the Lake Alfred, Fla. geographic region*

Research on planting densities of most cultivated row crops has shown that for a given cultivar and environment combination, an optimum planting density exists for maximizing yields. Biological and physiological/structural factors affecting maximum yields include maximizing sunlight interception and utilization by the crop canopy, and minimizing harmful above- and below-ground competitive effects between neighboring plants. Important practical management factors affecting the optimum planting density include the need for reserving space in a grove for the necessary production and harvesting machinery. In long-lived crops like citrus, the optimum planting density must also be designed for early high fruit production as well as sustainable long-term production. In this regard, rootstock vigor and precocity are important determinants of the optimum planting density or "sweet spot" for citrus APSs.

NEW EXPERIMENTAL GROVE DESIGNS

In the new UF/IFAS APS experiments, we are beginning to evaluate different grove designs using alternating double-row configurations, dubbed "tramlines," to achieve higher grove space utilization efficiencies and earlier fruit production. In a tramline grove design, the rows of trees are planted in pairs separated by a small interrow spacing which is much less than the traditional interrows or middles required for grove equipment (Figure 1). In the simulated and actual groves, the separation of the parallel tramline rows is only 3 feet. Additionally the trees are offset in a triangular fashion to maximize the utilization of space by the canopies, and to avoid blocking of herbicide sprays from two directions by adjacent tree trunks. Weed control in the tramline will rely on the herbicide boom's end nozzle achieving at least a 1.5- to 2.0-foot offset spray coverage. Trees will also require pruning to remove skirt branches at an early age. In our test configuration, the shortest distance between tree trunks is 5.4 feet diagonally, thus ensuring an early hedgerow formation and shading of weeds, but permitting additional expansion of the canopies with time into the spaces left by the triangular offset pattern (Figure 2). A video clip of the simulated grove can be viewed at http://128.227.177.113/ACPS/

In the first tramline APS experiment of Valencia orange being planted this summer, we are comparing a high density (538 trees/acre) tramline planting with a single-row, high-density (484 trees/acre) planting configuration. Because the row spacing in this experimental block will be only 15 feet, a 5-foot driving middle will be reserved for a 4-foot wide tractor. In standard Florida grove designs, an 8-foot driving middle is usually reserved for a 7-foot wide tractor. Fortunately the modern narrow tractors have similar PTO power, 4-wheel-drive and air-conditioned cabs as offered by the full-sized tractors. Harvesting fruit from the smaller trees grown in high densities will be particularly well adapted for manual methods, but fruit extraction equipment will need to be revised and modified in this ongoing research project.

The main purpose of tramline plantings will be to achieve higher planting densities for earlier economic production, and to grow larger fruit-bearing canopies at maturity than would be possible with single rows. For example, in the Valencia tramline experiment, a 20 percent longer "row length" is possible due to the zigzag planting pattern, and a 30 percent larger canopy can be achieved at maturity, probably in years 7 to 10, by the tree canopies growing into the "corrugations" or gaps formed by the triangular planting pattern (Figure 2). At slightly lower densities suited for the use of conventional grove equipment (e.g. 20-foot interrows, 8-foot middles, 396 trees/acre), calculations show a 25 percent larger canopy may be possible at maturity with tramline planting than with straight, single-row planting. Using tramlines, actual bearing canopy volume per acre increases

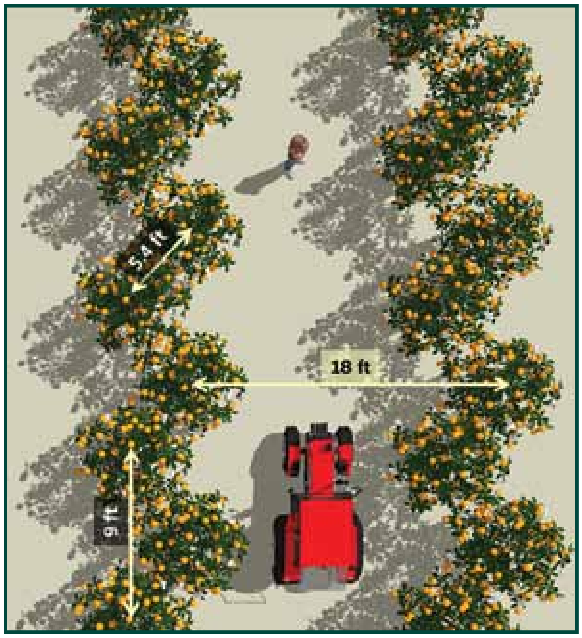

Figure 2. Aerial view of the simulated grove model in economic production at 3 to 4 years, showing the offset tree planting and spacing measurements

are calculated to be at least 10 percent. Adequate weed control in the 3-foot wide tramline will be one of the key prerequisites to research and develop in the new experiments.

Other advantages of high-density tramline planting may accrue from:

• Better interception of sunlight from multiple directions

• During hedging, one side of each tree will be aggressively hedged, and the other side will be less aggressively hedged. This technique may help maintain more consistent fruit-bearing behavior of the canopy.

• Potentially less fuel will be needed per acre by grove equipment due to a lower proportion of the grove space being reserved for grove vehicle traffic only, and not for growing fruit.

In all the experimental high-density plantings, light, frequent hedging will be used to control excessive vegetative canopy growth after year 4. A sickle-bar hedger similar to those used for light hedging of small bearing trees in Brazil will be tested in the APS experiments (Figure 3, page 9).

TRAMLINE PLANTING DESIGNS FOR BEDDED GROVES

Two separate grapefruit APS experiments are being prepared for planting on the Florida east coast in 2013. In these groves, the higher density tramline system will be tested as a retrofit method for increasing the efficiencies of existing 50-foot double-row beds. For example, a conventional higher density approach would be to plant two rows per bed at 5.41 x 25 foot = 322 trees per acre. By adding two tramline pairs per bed with the same 5.41 foot in-row spacing, we will achieve 387 trees per acre, which is 20 percent more canopy and potential yield per acre than the single-row system. The perpendicular trunk-to-trunk interrow spacing is 22 feet, although the net available inter-row distance reduces to 19 feet due to the offset planting; this should still be adequately wide for the use of conventional grove equipment.

In all higher density plantings, particular attention should be given to select a rootstock which is precocious, but less vigorous than one suited for lower density conventional plantings. In a future article, we hope to cover the topic of rootstock choices for APS in more detail.

***Figure 3.** Tractor-mounted, sickle-bar hedging machine used for light trimming of citrus canopies in Brazil*

SUMMARY

Existing APS research experiments have demonstrated the higher efficiencies which can be achieved with advanced fertigation, resulting in greater canopy growth and fruit yields for less water and fertilizer inputs, and in less time than with conventional production systems. Existing experiments also showed the merits of higher density plantings in achieving higher economic yields, especially in the presence of HLB. New grove designs such as the tramline system are being evaluated to hopefully further boost grove efficiencies in order to maximize fruit yield per acre, minimize the use of all production inputs per acre and reduce the environmental impacts of growing citrus. Ultimately the efficiency and profitability of a modern APS grove should be measured by the amount of fruit produced per unit of input material (e.g. fertilizer, pesticide, fuel) rather than per acre. Components of an APS to achieve these goals are early canopy development, early and high fruit production and return on investment, spare trees and compensatory growth in high-density plantings to offset tree losses, optimum nutrition, enhanced tree fitness, and maximum fertilizer and water-use efficiency.

We thank the CRDF, SWFWMD, CREF and the UF/IFAS Research Dean's office for funding this research, and for the excellent in-kind support from our grower cooperator, Gapway Grove Corp. Details of the APS, including information for a second field day in December, can be obtained from our CREC website at www.crec.ifas.ufl.edu>Research>Advanced Citrus Production or by contacting Arnold Schumann at schumaw@ufl.edu

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