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EQUIPMENT AND METHODS

EQUIPMENT AND METHODS FOR PRODUCING AND HARVESTING CITRUS IN HIGHER DENSITY PLANTINGS[1,2]

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Abstract. **High density plantings as discussed in this paper are those in which the in-row and between-row tree spacings are less than 20 ft (6.1 m) and 25 ft (7.6 m), respectively. Reducing in-row tree spacings allows continued use of most conventional production equipment, whereas substantially reducing between-row tree spacings requires a change in most equipment and methods. Tree height must generally be decreased with reductions in between-row tree spacings to avoid shading and reduced yield on lower limbs. Smaller trees should require smaller equipment such as sprayers, hedgers, and toppers. Problems with weed control in the tree row should generally be reduced because of the increased percentage of ground area which is shaded. The efficiency of continuous, down-the-row operations and of chemical and supplemental water utilization should be increased when the continuity of fruit-bearing space and root-bearing soil is increased, especially during the early years of the close-spaced planting.**

Harvesting in high-density plantings will require some new approaches. Hand harvesting has been a problem in existing plantings where trees have lost their individual identity as a unit by growing together in the row, thus eliminating space to place fruit containers and denying pickers the ability to move ladders around the tree in their traditional manner. Harvesting methods and fruit-handling vehicles and/or containers must be changed to accommodate this reduced space.

If high fruit production per hectare can be achieved using small trees for a reasonable number of years, the feasibility of developing essential equipment and methods to manage these trees appears to be very favorable. If such trees were maintained at a height of 10 ft (3 m) or less in a hedgerow planting, there is good potential for over-the-row equipment for production and harvesting.

The increasing tax rates and cost of land behooves the citrus grower to realize an early net return on his investment and to maintain an average annual net return at a high level. Obviously, these "returns" can be realized by maximizing yields while minimizing production and harvesting costs. High-density plantings (in-row and between-row spacings less than 20 ft (6.1 m) and 25 ft (7.6 m) respectively) offer early fruit yields of economic value and could conceivably result in lower production and harvesting costs than those for conventional plantings. One of the main drawbacks of high-density plantings is that when individual tree canopies start competing for space, high fruit yields are difficult to maintain while controlling tree size and shape for adequate equipment access (3).

Studies of production characteristics of high-density citrus plantings have been made in various parts of the world, (1, 6, 9, 10, 11, 13, 14) however, little has been reported concerning the specific equipment needs of producing and harvesting these plantings. This paper will discuss the equipment and methods visualized for the production and harvesting of high-density citrus plantings in Florida.

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Visualized Equipment and Methods

High-density plantings tend to encourage continuous in-row or hedgerow operations because the close in-row tree spacings increase the difficulty of across-the-row operation of equipment as tree size increases. Tree row widths of less than 25 ft (7.6 m) will require that the tree height be maintained at less than 20 ft (6.1 m) to avoid excessive shading and nonbearing zones on the lower portion of the trees.

If a tree has a given height in which it can effectively produce fruit (because of its light interception ability) in a high-density planting, where should this fruit-bearing zone be located? From an equipment standpoint, it should be as near to ground level as practical. Why? The height and size of equipment needed to produce and harvest the crop would be minimized. The potential for high-quality fruit would be greatest because the uniformity of pesticide deposition would be increased and fruit harvesting and handling from small trees should minimize mechanical damage to the fruit. Without dwarfing rootstocks, a regular program of hedging and topping would be required, but, again, the height and size of this equipment would be minimized because the quantity and size of wood for any one pruning should be relatively small.

In the following discussion of individual equipment operations it was assumed that tree height would be maintained at 16.5 ft (5 m) or less and that tree height would generally have to be reduced in some relation to the reduction in the between-row dimension.

Weed and Grass Control

Methods and equipment for the control of weeds and grasses would not change appreciably except that operations across-the-row would generally not be feasible, and the size (width) of equipment would be reduced. Because of the inaccessibility of equipment to across-the-row operations and limited operating space, effective herbicides and herbicide application equipment will be needed to replace conventional tillage tools (disks, choppers, and tree hoes). If mechanical cultivation is practiced throughout the life of the planting, smaller tillage tools will be essential. The need for across-the-row operations for weed and grass control should diminish in importance because of increased shading between trees in-the-row. With the advent of smaller tillage equipment, power requirements would probably not exceed 40 hp. If no mechanical cultivation is required, then power requirements would be even less. It appears that a minimum tillage system would include herbiciding under the canopy width in the tree row and mowing a leguminous cover crop in the row middle.

Pest Control

Compared to conventional plantings, control of tree size and shape in high-density plantings would increase the feasibility of using small sprayers thereby reducing power requirements, and would allow greater deposition efficiency of chemicals. An increase in deposition efficiency could be expected for at least two reasons. First, reduced sprayer-to-target distance would provide improved uniformity of deposits at any given rate of liquid output (8, 15). Second, decreased in-row tree spacing would provide increased continuity of down-the-row tree foliage to intercept applied chemicals, especially during the early years of the planting. Decreased tree height and uniformly shaped trees would increase the feasibility of using sprayers whose discharge would cover the entire tree height, and thus greatly increase the possibility of acceptable deposition efficiencies at increased chemical concentrations and decreased liquid volumes and equipment costs. An increased deposition efficiency would allow the use of less chemical and decrease the deposition and residues on nontarget areas.

Smaller trees would make aerial application of chemicals more attractive from the standpoint of achieving satisfactory coverage on tree foliage. However, if residues on nontarget areas are a significant problem, the broadcasting nature of aerial application may be a disadvantage if ground sprayers can confine chemical deposition to the target or tree foliage.

Nutrition and Irrigation

The equipment and methods for providing nutrition to a high-density planting will probably depend heavily on developments in the irrigation area. Satisfactory development of under-tree liquid distribution equipment could allow the application of both water and fertilizer with the same equipment (4). The development and use of such equipment would be encouraged because (a) across-the-row operations that might damage this type of equipment would be minimized or nonexistent in close in-row spacings and (b) conventional overhead sprinklers would have to be removed if the trees were topped on a regular basis. The placement of nozzles or emitters for a distribution system should coincide with the trunk line to prevent interference with operations parallel to the row. The successful development of under-tree distribution systems would allow more efficient placement of water and nutrients in relation to the tree root zone, especially during the early years of a planting when the root zones of adjacent trees have not begun to compete.

Conventional equipment and methods for water and nutrient distribution, such as overhead sprinklers and broadcast fertilizer spreaders, could, with few changes also be used in close-spaced plantings.

Control of Tree Size and Shape

This section contains a discussion of tree size and shape control, mainly by mechanical pruning, as opposed to dwarfing rootstocks or other means of stunting. How such control is accomplished is one of the most important management decisions when higher-density plantings are considered. The mechanical pruning program undertaken will greatly influence the average yield of the planting over its life. First of all, one should decide the final size and shape that the planting hedge should assume. Most of the pruning work on citrus has indicated that the amount of wood and foliage removed in year 1 can be correlated fairly well with the fruit yield loss in year 2. It follows that severe cuts should be avoided if at all possible. Pruning of trees should commence well before any of the foliage approaches the final width and height limits determined for the plantings. If this is done, no severe cuts will be necessary, and pruning can be initiated and repeated on small wood as required. Even though this type of pruning may be required annually in some instances, the size and power requirement of the pruning equipment could make tractor-mounting feasible (2, 7). The equipment should be smaller than some of the conventional hedging and topping equipment. Also, it is possible that with frequent pruning of small amounts of small wood, disposal of the prunings may not require a separate operation. If a separate operation is not required, the pruning equipment should be relatively simple and inexpensive to operate. Although the hedging and topping program should be directed mainly toward the production of high fruit yields, it should also be used to maintain the

fruit bearing zone of the tree as near to the ground as practical for the type of harvesting methods in use.

Cold Protection and Tree Removal and Replacement

Cold protection equipment and methods for high-density plantings would change little from those used in conventional plantings. Minimal ground cover during the winter months plus the capability to thoroughly irrigate the planting before a freeze should provide the ground with more heat and a greater ability to release the heat during critical freezing periods than conventional plantings.

Equipment and methods for tree removal and replacement would require few changes. Smaller tree sizes would allow the use of smaller tree removal equipment in comparison to present equipment.

Harvesting

Harvesting and handling of fruit from high-density plantings with conventional equipment and methods has been one of the main problems encountered by growers. After trees are 10 to 15 years of age and their canopies have grown together, between-row and in-row spacings of trees with low skirts do not allow adequate space for the conventional 10-box container and high-lift truck handling system. Along the row middle, sufficient space is needed to set the 10-box container beside the truck. Another problem is that many hand pickers and hand picking crews prefer to move across rows during harvesting and be assigned individual trees as picking units. Research is in progress in making multiple tree picking units by cross hedging or removal of every 3rd, 5th, or 7th tree to allow a picker to move his ladder around the tree unit and to provide a place to set the picking container.

Other changes might be in order if fruit in high-density plantings is to be harvested and handled satisfactorily. First, some system of handling the fruit in small spaces must be developed. If the 10-box container or a container of equivalent volume is used, then some vehicle to handle these containers is needed. One approach that has been investigated is the use of a vehicle than can straddle containers on the ground while picking up or distributing other containers. This would allow the movement of fruit from a middle 7 to 8 ft (2.1 - 2.4 m) in width. If the middles are bounded on both sides by continuous walls of foliage, space might not be adequate in a middle[3] for vehicle traffic and picker activities with a ladder to occur simultaneously. If space is inadequate, the scheduling of these activities would be essential. After the trees have grown together in a row, across-the-row movement of pickers and containers would not be feasible and pickers would have to be assigned to work in a middle rather than around each tree as is conventionally done. Empty or partially filled containers, instead of being moved across a row to the next middle, would be picked up when full by the straddle vehicle after pickers have moved from the middle where they have been working. The full containers would then be moved outside the grove, emptied, and distributed, before the arrival of pickers, in the middle beside the next row of trees to be picked.

Other options may be to reduce or change the container size and shape so that a smaller vehicle with its containers could be used much in the same way as the conventional systems. Still another option to be considered would be to operate the container handling vehicle and the containers in adjacent middles. A mechanism on the vehicle would be required to reach over the tree to handle the containers.

[3]In Florida the space between tree rows is referred to as a "middle". Ed.

Results of research on man-positioners for picking citrus fruit have shown that the economics of machine cost and maintenance vs. picker productivity do not justify the use of this equipment (5, 12). However, high-density, "treewall-type" plantings lend themselves best to multi-man, platform-type equipment from which pickers can reach 3 ft (0.9 m) into a tree from each side of the row and get all of the fruit. The use of multi-man platforms requires that the output of individual pickers be pooled. That requirement will necessitate a change in attitude from that with present piecework methods. When picking is done from a multiman platform that deposits full containers of fruit on the ground as the machine progresses, containers can be handled with standard lift equipment. However, special handling equipment is required when serving individual pickers because partially filled containers must be moved as well as full ones, and each container must be accounted for separately.

One of the main harvesting advantages of higher density plantings is that pickers would not be required to work above a 16.5 ft (5 m) height. Compared to taller conventional plantings, a larger percentage of the fruit could be harvested from ground level without a ladder, thus making picking easier, faster, and attractive to a broader spectrum of laborers.

Mechanical harvesting could very well become a more viable option on high-density plantings than on conventional plantings. The main reasons for this are related to smaller tree size and better tree uniformity than in conventional plantings. Removal of fruit by shaking should require less energy input for small trees than for large trees and better control over the shaking energy input should be possible. Collection of the fruit on catch frames should require smaller size units for small trees than for large trees. Reduction in tree height should reduce the mechanical damage to fruit as it falls through the trees or onto the ground. Further, the deposition of abscission chemicals should be more uniform with smaller trees.

Over-The-Row System

The previous discussion dealt with equipment and methods in high density plantings where all mobile equipment operated in the middle between adjacent rows. If the trees in high-density plantings are maintained at a height of 10 ft (3 m) or less, over-the-row equipment could be considered as it has been for other crops (16). From an equipment standpoint, an over-the-row system is attractive because of the possibility of using one prime mover to accomplish many production and harvesting jobs. It is conceivable that the same prime mover might be used for spraying, pruning, and harvesting, as well as for other operations. The particulars of potential equipment and methods for the over-the-row systems will not be discussed in this paper.

Summary

Potential savings from higher density citrus plantings justify a new look at production and harvesting equipment and methods. Low, narrow hedgerows mean smaller sprayers and less power to drive them than are required for tall, wide tree units. Hedging and topping machinery can be smaller than that used for tall trees, but would be used more often. Harvesting systems must be changed to move along the tree row and equipment must be designed to handle fruit in close spaces.

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