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COLLECTING AND HANDLING MECHANICALLY HARVESTED ORANGES IN SOUTH FLORIDA (LABELLE)[1]

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Abstract. **An experimental harvesting system was evaluated, in cooperation with Congen Properties, Inc., to determine the feasibility of operating in a bedded citrus grove. 'Hamlin' oranges that were sprayed with abscission chemical and mechanically dropped to the ground with an air shaker were raked with a tractor-drawn citrus windrow rake and picked up with an offset pickup machine.**

Down-the-row travel speed of the rake and pickup machine was 0.5 to 1 mph, and fruit-recovery efficiency was 98%. Fruit pickup and loading of the roadside trailer were limited by the round-trip travel time of the single, high-lift truck. That limitation reduced the field efficiency of the pickup machine to 60%.

The cost of collecting and loading fruit under these conditions was 40 cents per box of oranges.

Equipment and methods for collecting, handling, and cleaning mechanically harvested citrus in the grove have been developed over the past decade (5). However, most of the efforts have been directed toward handling fruit harvested from trees 20- to 80-years-old on loose sand, with relatively clean cultivation, in the "Ridge" area of Florida.

Approximately 16%, or 106,000 acres, of Florida oranges are produced on bedded plantings (1). The beds vary from one to eight rows between ditches and have some ground cover between tree rows. Trees are usually small and have dense foliage. Almost 30% of the early and midseason oranges in bedded groves are grown on four- to eight-row beds, slightly crowned, with adequate room between the outer row and the ditch bank for vehicle operation. This study was conducted 1) to evaluate an experimental harvesting system (abscission chemical, air shaker, windrow rake, and pickup machine) to determine whether this system could be operated in bedded groves with little or no modification and 2) to determine the performance data of the system components for an economic analysis.

Materials and Methods

Fruit were sprayed with an abscission chemical and harvested at weekly intervals from Jan. 23 to Feb. 27, 1979 from an eight-row bed of 'Hamlin' orange trees comprising 11.5 acres approximately 6 miles west of LaBelle in cooperation with Congen Properties, Inc. The grove area had a uniform ground cover and few surface irregularities. The rows were 0.5 mile-long and 25 ft apart. The trees were spaced 15 ft apart in the rows and tree height was maintained at 13 ft. Estimated fruit yield was 3.5 boxes of oranges per tree. A 14 ft-wide strip of ground down the center of each tree row was treated with herbicide.

The ground cover, consisting of bahia grass, torpedo grass, and various woody-type weeds 2 to 3 ft high, was mowed approximately 2 weeks prior to harvest. Several methods for removing the large amount of grass material were tried, including single and double windrowing the mass of cut grass away from the row being harvested. The grass, hedge cuttings, small rocks, and vines were preraked in all eight tree rows.

After the fruit had been removed from the trees with an air shaker (6), they were windrowed to the drip-line of the trees near the edge of the strip of ground treated with herbicide. The windrow rake used in these trials was a tractor-pulled unit developed by the U.S. Department of Agriculture (USDA) for this purpose (Fig. 1). A 50-hp tractor powered the rake, and one operator was required. Windrowed fruit was picked up with an offset pickup machine with a double-belt trash eliminator and locations for two people to do manual fruit-sorting (Fig. 2). This equipment was developed by the USDA and the Florida Department of Citrus (FDOC) and has been operated successfully in the "Ridge" area of Florida. A 60-hp, low-speed tractor pulled the pickup machine and the accompanying high-lift truck that received the cleaned and sorted fruit at the discharge conveyor. One tractor driver and two fruit sorters

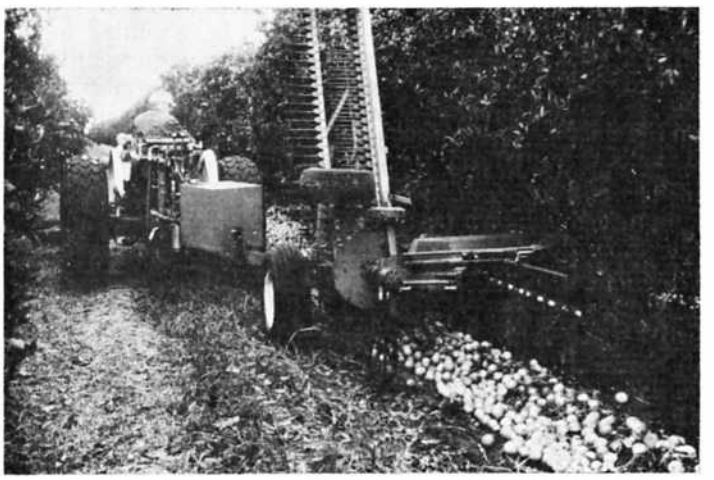

Fig. 1. Tractor-pulled windrow rake. This rake can be adjusted to form a center row or drip-line windrow of fruit.

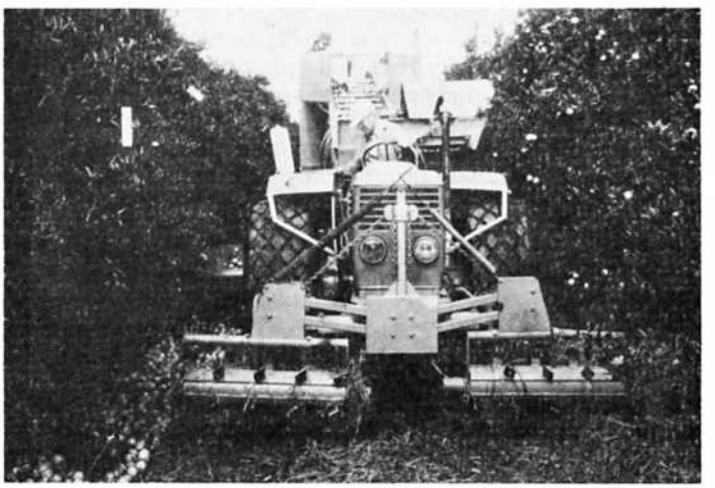

Fig. 2. Offset pickup machine, with stations for manual fruit-sorting. Machine loads fruit directly into high-lift truck pulled behind machine.

[1]Cooperative research by the U. S. Department of Agriculture (USDA); University of Florida, AREC, Lake Alfred; and State of Florida, Department of Citrus (FDOC).

made up the crew of the fruit-pickup operation. One of the two sorters also operated the conveyors of the pickup machine and the speed and discharge height of the loading conveyor. The other sorter was also the operator of the 80-box-capacity high-lift truck that transported the fruit from the pickup machine to the roadside semitrailer.

Fruit recovery was determined by randomly selecting 20 trees in each row (170 trees) and counting the fruit left on these trees and on the ground after harvest. The fruit left on the tree was attributed to the fruit removal method and was not included in the efficiency of raking or picking operations. Overall fruit production was determined by dividing the weight of fruit harvested from each tree row (170 trees) by 90 lb per box and multiplying by 250 fruit per box. Fruit losses from twenty trees were counted in an adjoining bed that was handpicked by a commercial harvesting crew for comparison with the mechanically harvested treatment.

Results and Discussion

The mass of cut grass and weeds left after mowing posed a problem that was never completely solved. Preraking the herbicide-treated area under the trees was helpful by removing vines, small stones, dead limbs, and other ground trash from the fruit-drop area, but large stones had to be removed manually to prevent equipment damage. Also, vines became entwined in the rake bearings and had to be cut out. Vine strippers were attached to the rake drive shafts, and they greatly reduced the vine problem.

The rake section that covered the middle, sodded portion of the drive row during preraking gathered torpedo grass runners in long sections and rolled the mass into a tight windrow that was unmanageable at times. A rotary mower would not cut this windrow of grass, and when the mass of grass was left in place during the air-shaker operation, some fruit became entangled in the mass and were lost over the trash removal belt during the pickup operation.

Another method of preharvest trash removal used was double windrowing to move the material as close to the adjoining row of trees as possible so it would not be encountered when the fruit was later harvested. This method worked well, but was time consuming, and the windrowed trash had to be raked back in the other direction before fruit from the second row of trees were harvested. Mowing more frequently and closer to the ground in the future would keep the weed material in shorter pieces and less likely to entangle the fruit as they are picked up.

The windrow rake was operated at 0.5 to 1 mph with a field efficiency of approximately 80%. The remaining 20% of the time, the rake was idle while dead limbs, rocks, and other trash were being removed from the raking path and vines and grass runners entwined in the rake bars and bearings were being removed. Fruit recovery averaged 99%; a few fruit were lost around tree trunks, due to tree sprouts and in an occasional ground burrow that entrapped the fruit.

Overall, the rake was dependable, and few repairs were required. However, replacement of rake tines that bent or broke when they struck rocks and exposed roots was a continuing repair item.

The pickup machine operated at 0.5 to 1 mph, depending on the amount of trash in the windrow. Field efficiency of the pickup operation was only 60%. A large percentage of time was spent in waiting on the high-lift truck to be emptied and returned. Fruit recovery was excellent (98%); however, some fruit were lost when trash was dense. Dry trash material was easily eliminated through the pickup chain or separated by the trash belts.

Fruit pickup in the rain on two occasions caused serious problems in that operation of the machine was difficult in wet grass, weeds, and trash. Wet grass built up at the transfer point between the pickup chain and cross conveyor chain, causing it to wrap around the head shaft and pull fruit between the two conveyors. This dense trash had to be removed from the machine before the pickup operation could continue. Total fruit recovery from the eight rows harvested ranged from 95% to 99%. Fruit recovery was lowest on rainy days.

The life expectancy of the pickup chain under the sand and rock conditions in the LaBelle area would be adequate to handle only about 15,000 boxes of fruit. The machine had excellent grove maneuverability in the tree rows and in turning at the row ends near drainage ditches.

Three loading areas were used during the course of these harvest trials, and the high-lift truck had to travel up to 2 miles roundtrip in moving the fruit from the pickup machine to the roadside trailer. This travel distance was due mainly to the lack of tree "skips" or turn rows in the 0.5-mile-long tree rows. Because of this problem, the high-lift truck had to move forward or backward considerable distances to service the pickup machine. An average of 8 loads of 75 boxes each were moved from each row. Travel time to the roadside trailer ranged from 5 to 15 minutes roundtrip, depending on 1) whether a tree "skip" was available for turnaround, 2) distance from the loading area, and 3) whether "topping-off" the trailer was required.

Table 1 presents a summary of estimated costs for the windrow, pickup, and hauling operations under the grove conditions of these tests. The costs are based on operating 50 days a season with only one machine of a type. The daily output is based on harvesting three 0.5-mile rows, or 1800 boxes of oranges, in 8 hours. At this rate, 90,000 boxes of oranges would be harvested per season. The cost of windrowing the oranges, picking them up, and loading them into a semitrailer would be 40 cents per box of oranges under the above conditions (2). The analysis used to arrive at the cost figures given in Table 1 was based on an economic analysis by Roetheli (4).

Improving the fruit-hauling operation by using a larger capacity high-lift truck or by providing turn spaces along the tree rows would increase the field efficiency of the pickup machine. If the pickup machine could operate 80% of the time, the daily production of the system would be

Table 1. Estimated operating costs for windrowing and picking up fruit.

Item	Rake	Rake tractor	Pickup	Pickup tractor	High-lift truck	Total
Machine cost, dollars	20,000	12,000	35,000	18,000	18,000	103,000
Total fixed cost, dollars/day	98.44	18.73	172.27	28.10	35.04	352.58
Variable costs, dollars/day	24.00	26.40	42.00	36.00	21.60	150.00
Labor cost, dollars/day	32.00	48.00	32.00	48.00	48.00	208.00
Total cost, dollars/box[z]	0.086	0.052	0.137	0.063	0.058	.396

[z]Based on a harvest rate of 1800 boxes of oranges per day.

increased from 1800 to 2400 boxes of oranges. This increase would mean a potential cost saving of about 16 cents per box.

Fruit counts from the mechanically harvested sample trees averaged 16 fruit left on each tree and 9.5 fruit left on the ground after harvesting was completed. Average fruit production was 859 fruit per tree. Since the rake and pickup operations were only involved with fruit on the ground, the overall rake and pickup machine efficiency was 99%. The handpicked sample trees had an average yield 849 fruit per tree and 8 fruit were left on the tree and 7 fruit left on the ground. Counting only the ground fruit, for comparison purposes, the handpicked fruit recovery was 99%.

Conclusions

The windrowing rake and pickup machines performed satisfactorily in these bedded grove conditions. Fruit recovery efficiency was equivalent to a hand harvesting operation in the same bedded grove area. However, before recommending full-scale operation of the handling system, further improvements should be made. The mass of grass and weeds encountered in preraking and picking up must be reduced to prevent fruit damage and loss, especially during wet operation. Frequent mowing prior to harvest appears to be the best solution. The field efficiency of the pickup machine should be improved by reducing the idle time generated by long hauls with the high-lift truck.

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