Citrus Rollout Harvest System

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ABSTRACT

A citrus rollout harvest system was designed for minimum investment cost and operational risk. It consisted of a tractor-mounted limb shaker, abscission chemical, and a rollout fruit collector. A harvest capacity of 21.25 t/day (8-h) was obtained at a cost of 46.36 dollars/t. A mode of operation change was indicated that would increase the capacity to 35.39 t and decrease the cost to 33.91 dollars/t.

INTRODUCTION

High volume mechanical harvesting system for citrus that drop the fruit on the ground have not been accepted by the Florida citrus industry (Hedden et al., 1983). The economic conditions of the past few years and the low efficiency of the systems have not been conducive to acceptance at a time when adequate hand labor has been readily available (Coppock, 1982a).

The investment cost of these systems is high and their performance is heavily dependent on uniformly loosening the fruit with an abscission chemical applied 3 to 5 days before harvest. For the desired fruit loosening, a high rate of abscission chemical is needed, thus injuring the fruit and reducing the time between harvesting and processing. Also, the effectiveness of the abscission chemicals is weather related, which exposes the whole harvest operation to considerable risk of large fruit losses and limited operational time during adverse weather conditions.

The problems encountered with industry acceptance of the high volume systems prompted interest in a system with lower investment cost and less operational risk even at the disadvantage of being more labor intensive. A rollout harvest system seemed to have good possibilities of meeting the desired requirements. This paper covers the design of a rollout system and the evaluation of labor requirements, operational mode and harvest cost.

HARVEST SYSTEM

The harvest system consisted of four elements: (a) apply an abscission chemical at a low rate 3 to 5 days before harvest with a conventional sprayer to loosen the fruit, (b) spot field containers (408 kg capacity) along the tree rows using a conventional high-lift loader truck, (c) roll out fruit collector canvas under the tree to collect and convey the fruit into field containers and shake the fruit on the canvas with a tractor-mounted limb shaker, (d) pick up field containers, empty into a conventional high-lift loader truck, and transport and load the fruit into a roadside semi-trailer truck.

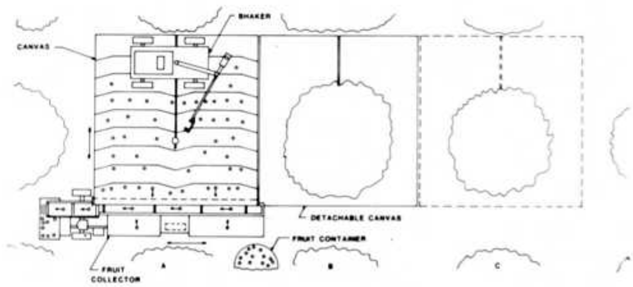

Fig. 1—Diagram of rollout harvest system showing mode of operation.

The rollout fruit collector and the limb shaker were operated together in one element of the system (Fig. 1). In operation the canvas was rolled out under a tree by two minimum skilled laborers; then the shaker was driven on to the canvas and the fruit was shaken to the canvas. Fruit that spilled over the sides of the canvas or were left on the lower limbs were gleaned and thrown on the canvas by the two laborers. The loaded canvas was then mechanically rolled up on the fruit collector emptying the fruit onto a cross conveyor. To keep fruit from rolling off the canvas as it was rolled up, the two laborers held the outer end of the canvas. The fruit was stored in a bin on the collector and emptied into field containers previously spotted along the tree row.

The rollout fruit collector (Figs. 1 and 2) consisted of a 3-wheel, hydrostatic driven propelling unit, a rollout canvas and a cross fruit conveyor. The canvas surface had soft cleats of a 4.8 cm square cross section spaced 1 m apart and across the width of the canvas. The cleats were cupped at the edge of the canvas to contain the fruit as the canvas was rolled up. The collector operator controlled the transport unit, cross conveyor and rollout canvas. A tractor-mounted limb shaker developed by Sumner and Hedden (1982) was used in the system.

Fig. 2—Rollout fruit collector with canvas extended under the tree and loaded with oranges.

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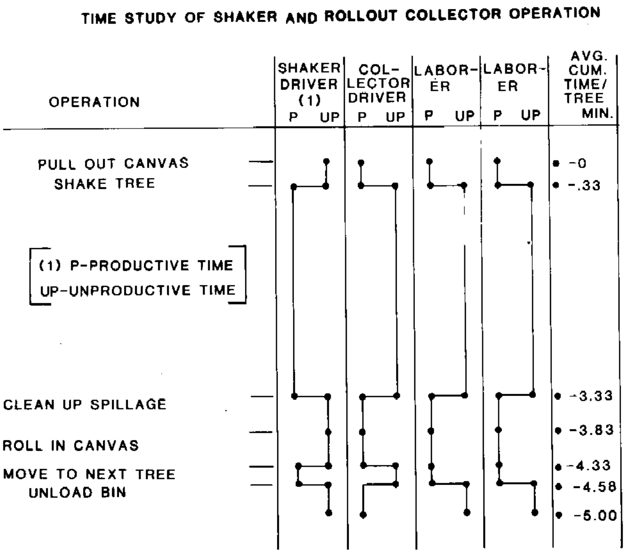

Fig. 3—Time study of each worker, the shaker and rollout collector operation.

Conventional equipment was used in the other system elements. The spray equipment was considered to be available for other spraying operations so only one-fourth of its use was accounted to the harvesting operation. The high-lift loader truck was considered to be operating one-half of the system operating time so only one-half of its use was accounted to the harvesting operation.

PERFORMANCE

The harvest system was operated under simulated commercial conditions in an old midseason orange planting with trees spaced 9.1 x 9.1 m (30 x 30 ft) and yielding an average of 272 kg (6.67 ninety-lb Florida fruit boxes) of fruit per tree. The field efficiency (% of available time the system was operating) was 84%. The average harvest rate (continuous running) was 12 trees per hour at a fruit removal efficiency of 97%. An average daily (8-h/day) system harvest capacity of 21.23 t (520 boxes) was maintained under good harvesting conditions.

To perform the shaker-fruit collector element one shaker driver, one fruit collector driver and two laborers are required. A time study of each worker was made (Fig. 3). Three of the four workers were unproductive when the trees were being shaken and 60% of the total time was spent in shaking mode of the operation. In turn, the shaker operator was unproductive 40% of the time when the fruit was being collected.

Economic Analysis

A budget was made for the system using methods developed by Roetheli and Zepp (1974). The total investment was about $100,000 which is one-half of the investment cost of the high volume systems (Coppock, 1982b). Based on 21.23 t/day harvest capacity, 97% fruit removal efficiency and an estimated 60 day (8-h/day) annual use, the cost per day of individual items in the system was calculated (Table 1). The system daily cost was $42.64/t of fruit. The limb shaker and rollout fruit collector were the largest cost items, representing over 50% of the daily cost.

Since it was not economical to glean the 3% of the fruit left on the trees, its value ($0.12/kg) was charged to the harvesting cost. This cost was $3.72/t of harvested fruit and when added to the system cost gave a total harvesting cost of $46.36/t.

TABLE 1. THE DAILY COST* FOR OPERATING THE ROLLOUT HARVEST SYSTEM

Items	Total $/day	21.23 t cap. $/t
Tank truck	21.86	1.03
Sprayer	83.53	3.94
Sprayer tractor	23.22	1.09
Rollout collector	284.77	13.41
High-lift truck	122.34	5.76
Field container	11.97	0.56
Limb shaker	357.53	16.84
Total	905.22	42.64

* Based on 60 day (8-hr day) annual use.

DISCUSSION

The system performance indicated improvements were possible in the daily capacity of the harvest system. The capacity of the spraying and fruit handling elements of the system was considered to be adaptable to the capacity of the fruit removal and collection element at a fixed unit cost. The capacity of the fruit removal and collection element could be increased by 40% by changing the mode of operation so that the limb shaker could operate at full capacity and be independent of the fruit collector. This increase in capacity might be accomplished by making the canvas on the fruit collector detachable and by placing separate canvases under the trees ahead of the shaker. The new mode of operation in shown in B and C of Fig. 1. The fruit collector would shuttle past the tree being shaken to position canvases ahead of the limb shaker. Provisions would have to be made to keep the fruit collector from running over the fruit that may be on the edge of the canvas opposite the limb shaker. Where it took 5 min per tree before, under the new mode of operation it would taken only 3 min, thus increasing the system capacity from 21.23 to 35.59 t/day provided no extra laborers were needed. This would lower the total harvesting cost from $46.36 to $33.91/t of fruit.

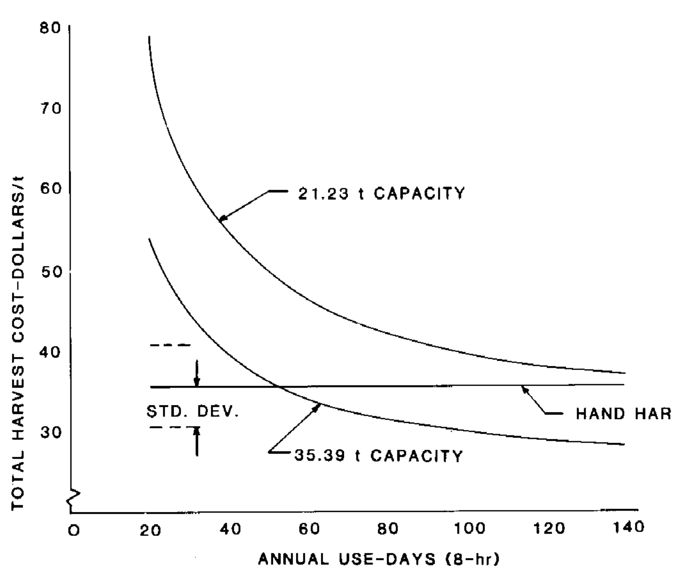

Fig. 4—The relationship of the annual use and total harvesting cost at 21.23 t and 35.29 t daily capacity of the rollout harvest systems and the average hand harvest cost.

In the cost analysis, the annual use of the system was considered to be 60 (8-h) days. The harvesting cost could be further reduced by increasing the hours per day or number of working days per season (Fig. 4). At a capacity of 35.39 t, the system harvesting cost would break even with the industry average hand harvesting cost (Hooks and Kilmer, 1981) at 46 (8-h) days of annual use. At a capacity of 21.23 t, the break even point was above 140 (8-h) days of annual use.

It must be recognized that there may be problems in operating the system under commercial conditions. Finding suitable labor willing to operate the system for the short harvest period could be a problem that would hinder industry acceptance. To evaluate this factor, the system will have to be operated over an extended period of time. Some tree pruning may be necessary to assure an efficient operation.

CONCLUSIONS

The study indicates the rollout harvest system could be a viable system for a segment of the Florida citrus industry if it was operated in such a way that the limb shaker could operate full time. The cost of harvesting would break even with the industry average hand harvesting cost at 46 days of annual use with a system capacity of 35.39 t/day.

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