Reprinted from Volume 78 of the Proceedings of the
FLORIDA STATE HORTICULTURAL SOCIETY
Miami, November 2-5, 1965

A TREE SHAKER HARVEST SYSTEM FOR CITRUS

S. L. HEDDEN[1]
G. E. COPPOCK[2]

Florida Agricultural Experiment Stations Journal Series No. 2251.

[1]Agricultural Engineer, USDA-ARS-AERD, University of Florida Citrus Experiment Station, Lake Alfred.
[2]Associate Agricultural Engineer, Florida Citrus Commission, University of Florida Citrus Experiment Station, Lake Alfred.

Cooperative research by the Florida Citrus Experiment Station, Florida Citrus Commission and U. S. Department of Agriculture.

ABSTRACT

A complete harvest system for citrus was built and tested in grapefruit and 3 varieties of oranges. The system consists of 2 catching frames each equipped with an inertia type tree shaker.

Fruit removal ranged from 90 to 98 percent in 'Marsh' grapefruit and 80 to 92 percent in

oranges. The equipment harvested 12 trees per hour with a 4-man crew. At this rate, 4 men on the machine can do the work of 10 hand pickers. Fruit damage occurred, limiting the fruit utilization to cannery purposes. 'Valencia' oranges do not lend themselves to this system because of the presence of the new crop and the succulent bark condition during the 'Valencia' harvest period.

Introduction

A tree shaker concept for harvesting citrus has been under development in Florida for the past 7 years. Coppock, Jutras, and Hedden (1, 2, 3, 4) have reported on the progress of this work on several occasions, and the need for a mass-removal type harvest system has not diminished.

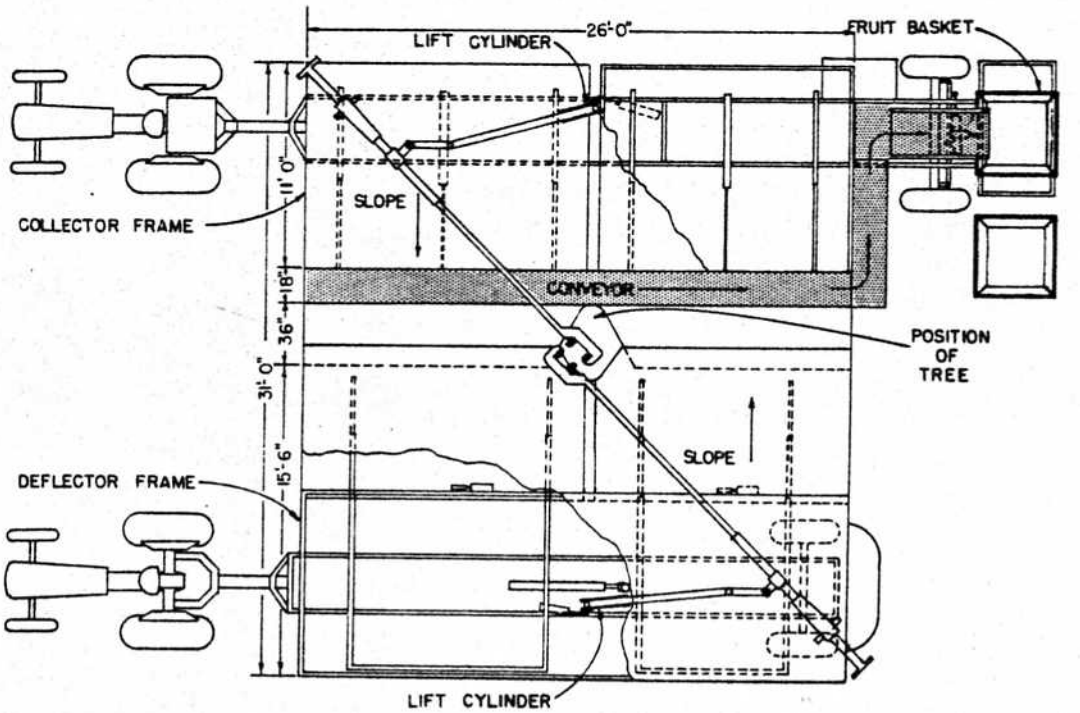
The "state-of-the-art" of tree shaking has progressed considerably in the past 3 years. The present inertia-type tree shaker is more powerful, heavier, and imparts a longer stroke to the tree limb than earlier models. A tree clamp developed by FMC Corp., San Jose, California, is currently being used because it has helped minimize bark damage.

A workable harvest system for early and mid-season oranges and grapefruit for cannery outlets has been developed and tested using the tree shaker and catching frame concept.

Experimental Harvest System

The harvest system has 2 tractor-drawn fruit catching units, each equipped with an inertia-type tree shaker, Figure 1. One unit has conveying equipment for moving the harvested fruit from under the tree as it drains off the sloping catching surface. The fruit is elevated into wire baskets (10 box equivalent) on a platform at the rear of the conveyor unit. The padded catching surfaces are sloped 20 degrees toward the tree and the removal conveyor.

In operation, the 2 units are pulled into position on opposite sides of a tree and the



PLAN VIEW OF C.E.S. SHAKE AND CATCH HARVEST SYSTEM

Figure 1.

catching surfaces extended until they meet and form a seal around the tree trunk, Figure 2. The 2 tree shakers are attached to the tree on opposite sides and operated simultaneously. Four men are required to operate the system—a tractor driver-shaker operator and a basket tender on the conveyor unit; a tractor driver and a shaker operator on the opposite unit. The full baskets are rolled off the platform and deposited at the side of the drive aisle between 2 trees where they can be picked up by a lift-boom type loader and dumped into a grove truck.

The catching surface of each unit can be folded or retracted to keep the machine within a 10-ft width for road travel between groves. Rear wheel steering of each unit allows close turns at the end of the tree row and on the road. The tractor-pulled units can attain speeds of 15 mph for inter-grove travel.

Harvest System Performance

The experimental harvest system was used throughout the 1964-65 fruit season in 'Hamlin,' 'Pineapple,' and 'Valencia' oranges and 'Marsh' grapefruit.

Trials were made at various harvest dates in the different fruit types to determine the effect of fruit maturity on removal, Figure 3. Fruit removal in 'Hamlin' and 'Pineapple' oranges and 'Marsh' grapefruit increased with fruit maturity (Brix/acid ratio); however, this trend did not hold true for 'Valencia' oranges, where maturity did not appear to affect removal. The lowest fruit removal obtained was 77 percent at the early part of the 'Pinapple' orange season, and the highest removal was 99 percent at the end of the 'Marsh' grapefruit season.

Some problems were encountered in the

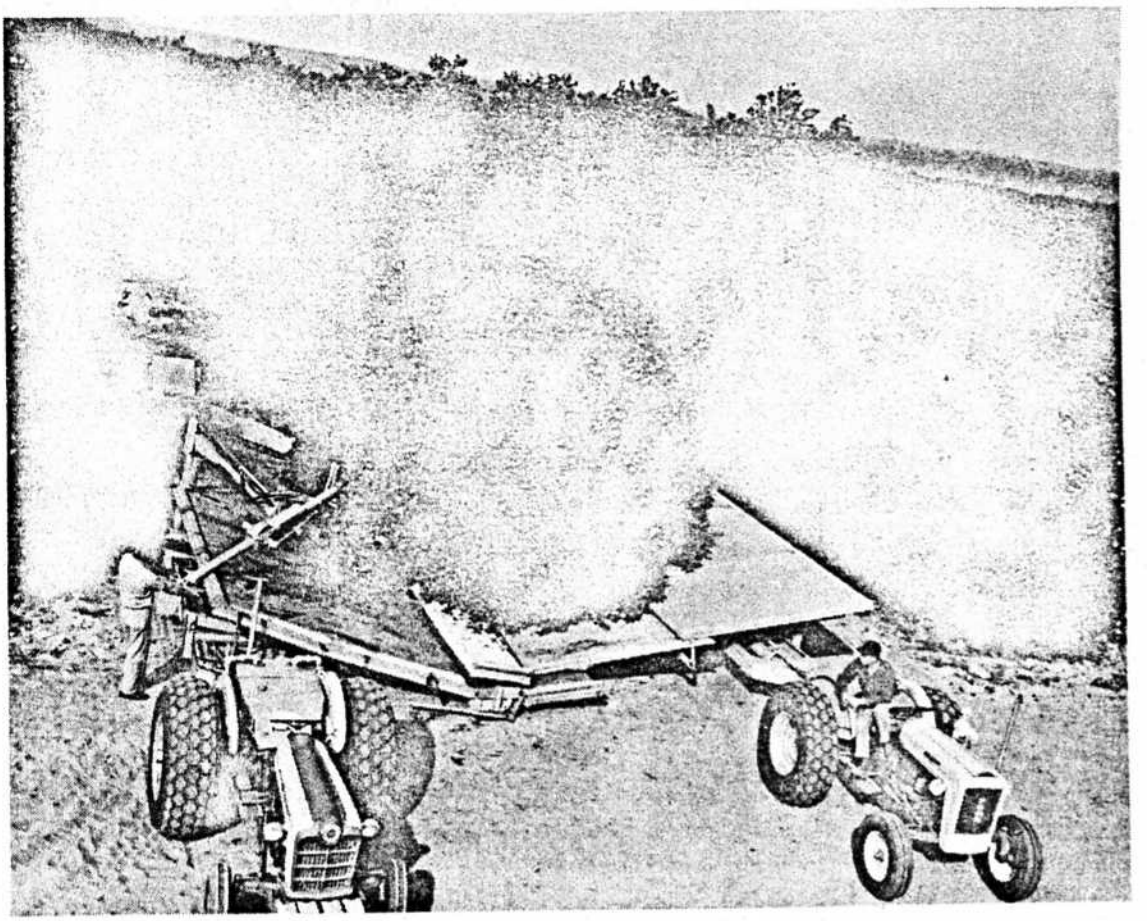


Figure 2.—The shaker-catch frame harvest system in position to harvest a tree.

trials. The fruit size was small in 'Hamlin' oranges, and considerable fruit splitting was encountered (3 to 5 percent) with this thin-skinned variety as it landed on the catching surface. Since 'Valencia' orange trees have the next season's crop (in the form of immature fruit) on the tree at harvest time, a large amount of this immature fruit was removed along with the mature fruit. Efforts to distinguish between these fruits with the tree shaker were not successful. Considerable bark damage was encountered because 'Valencia' oranges are harvested in the spring of the year when the tree bark is quite active and very succulent. These problems may seriously hamper the adaptation of the tree shaker harvest method for 'Valencia' oranges. All the fruit harvested in these trials were accepted for cannery use after the split fruit was picked out.

The rate of harvest with the shaker-catch frame system was essentially the same in oranges and grapefruit. An average of 12 trees per hour were harvested, regardless of fruit yield, using a 4-man crew. At this rate, 4 men on the machine can do the work of 10 pickers by hand. The 12 tree/hr rate of harvest included discharging full baskets and loading empty baskets onto the rear platform. An average of 3.86 minutes were required per tree for shaking and 1.17 minutes to move from tree to tree.

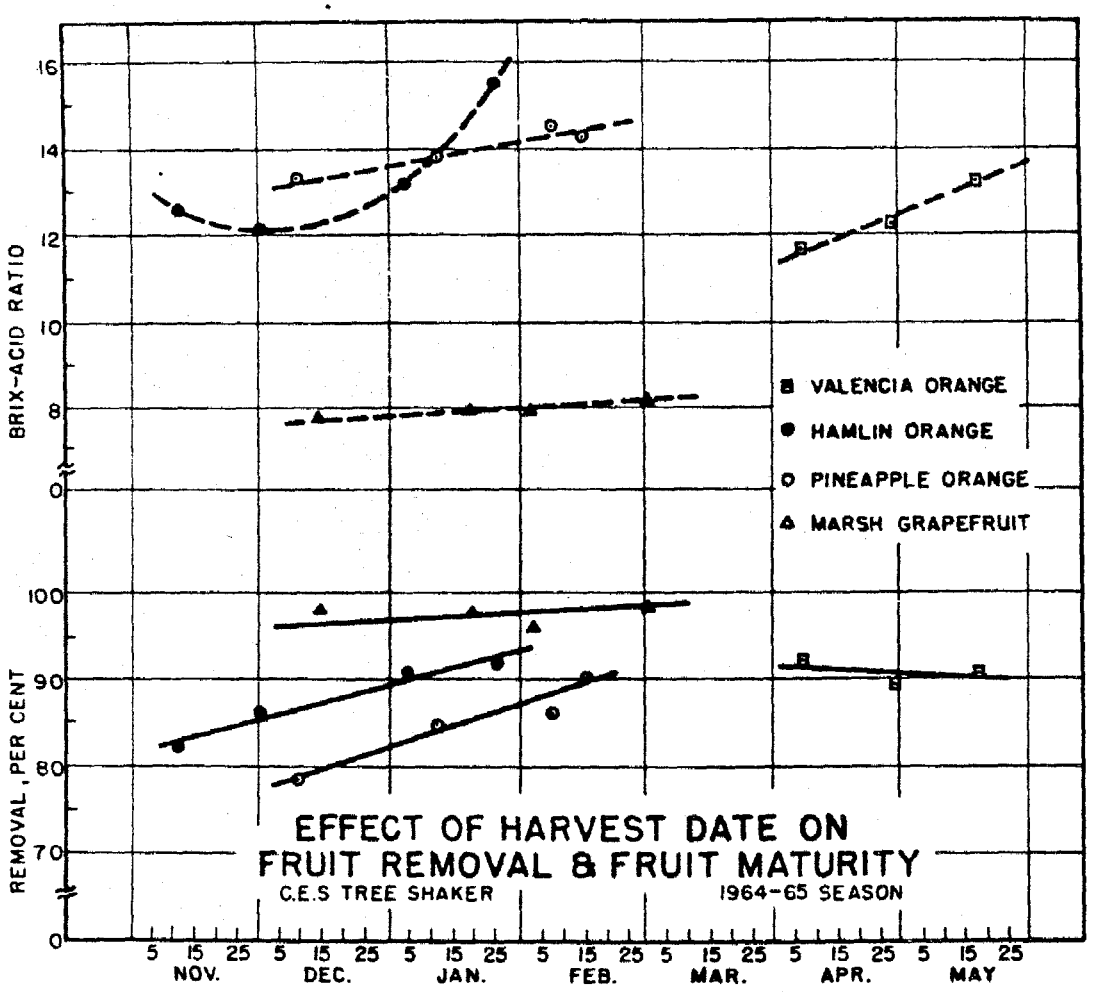


Figure 3.

Cost estimates were made of initial cost, operation, depreciation, interest, taxes, repairs, etc., and a harvest cost of 2.17 per tree was determined. This per tree cost is independent of fruit yield, and the cost per box will vary in proportion to the fruit yield per tree, Fig. ure 4. At a harvest cost of $2.17 per tree, orange trees yielding 8 boxes per tree would cost about 33 cents per box and grapefruit yielding 20 boxes per tree would cost 11.5 cents per box to harvest including gleaning the remaining fruit from the tree. The cost analysis for this harvest system was limited to early and midseason oranges and grapefruit or from 14 to 20 weeks of machine operation per year.

Discussion

The estimated harvest costs in this study do not include any corrective pruning that may be necessary in using this harvest system. Tree skirts must be raised in most cases to permit the movement of the catching frames under the trees. The tree must have about 18 inches of clearance at the trunk and 3 to 4 feet at the drip of the tree. It is also advantageous to have an access hole for the tree shaker to the main scaffold limbs of the tree. Providing the operator with a view of the main limbs increases the harvesting efficiency and reduces bark damage. Pruning the trees to reduce the number of shaker attachments necessary would no doubt increase fruit removal efficiency and increase the harvest rate. The cost of such pruning would have to be offset by an equivalent reduction in harvest cost.

Tree size is not a limiting factor with this harvest system as long as the tree is large enough to provide an attachment for the tree shaker clamp and there is enough room under the tree for catching equipment. Fruit damage may be increased in large trees due to the fall through the tree foliage.

The harvest trials reported here were conducted in level groves with relatively loose sand. Sand did not affect the operation of this system, but rolling terrain would affect shaker maneuverability and fruit drainage on the collecting surfaces unless some leveling device was built into the machine.

The labor required to operate this equipment must have some aptitude for operating farm equipment. One man on the harvest crew could be eliminated if the deflector harvest unit was self-propelled rather than tractor pulled or if the fruit were conveyed directly into a truck, eliminating the wire basket handling system. These modifications of the harvest system might bring about further savings on picking costs.

The performance of this harvest system in high yielding trees of early and midseason oranges and grapefruit is comparable to hand picking on a per box cost basis. Results of 1 year's test to study the effect of tree shaking on subsequent yields indicate that this will not be a major problem in early and midseason oranges and grapefruit. A large reduction in subsequent yields has been detected in 'Valencia' oranges. This is expected because of the large amount of small, immature fruit shaken off at harvest time.

Fruit harvested by this system will, for the present time, be limited to cannery utilization.

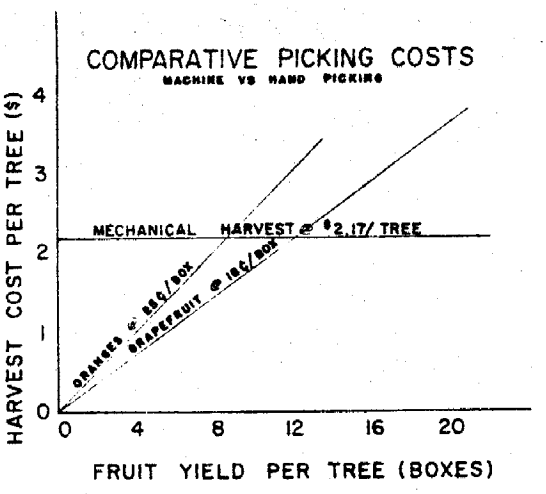


Figure 4.

References

1. Coppock, G. E., and P. J. Jutras. 1960. Mechanizing citrus fruit harvesting. Transactions of the ASAE, General Edition 3(32): 130, 131, and 132.
2. ..... . 1961. Picking citrus fruit by mechanical means. Proc. Fla. State Hort. Soc. 74: 247-251.
3. ....., and P. J. Jutras. 1962. Harvesting citrus with an inertia shaker. Proc. Fla. State Hort. Soc. 75: 297-301.
4. Hedden, S. L. 1964. Engineering problems in harvessing citrus. Transactions of the ASAE, Vol. 7, No. 2. 188-189.