Technical Notes: Citrus Harvest Mechanization in Florida-Current Situation

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ABSTRACT

MECHANICAL harvesting systems consisting of abscission chemicals, shakers, windrow and pickup machines, and bulk-handling trucks are economically close to competing with hand harvesting, in good grove conditions, for about 22% of Florida orange production.

INTRODUCTION

The Florida citrus industry produced approximately 11.3 million t of citrus during the 1979-80 season (Florida Agricultural Statistics—Citrus Summary, 1980) of which approximately 83% was processed into products. Citrus harvesting for fresh and processed fruit, still a manual task, extends from September to July and employs a peak labor force of 35,000 workers (Citrus Industrial Council, 1980). In general, the current supply of harvest labor is greater than the demand. However, the citrus industry is concerned about the future availability of harvesting labor because it is seasonal in nature, employs a high percentage of transients, and requires a large number of persons.

Several mechanical harvesting systems have been developed for processing fruit which has a January to July harvest season though they are not acceptable to the citrus industry under current conditions. The most promising of these systems, factors affecting industry acceptance, and, essential areas for improvement are presented here.

MECHANICAL HARVESTING SYSTEM

The system which currently holds the greatest promise of attaining industry acceptance for harvesting processing fruit consists of: (a) abscission chemicals applied to loosen the fruit, (b) air or limb shakers for fruit removal, (c) mechanical windrow and pickup of the fruit and (d) the direct loading and bulk transport of fruit to a roadwide semi-trailer.

Abscission chemicals are applied with a dilute orchard sprayer. Subsequent fruit loosening depends on a number of factors (Wilson et al., 1977), but is usually adequate for harvest in 3 to 7 days. Excessive amounts of abscission chemical can be detrimental to fruit quality and the trees, so it must be used with discretion.

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Although some preharvest fruit drop occurs, most of the fruit is removed with either a limb shaker or an air shaker (Whitney and Sumner, 1977). The air shaker moves continuously down-the-row at 0.8 to 2.4 km/h and its fruit removal efficiency (80 to 90%) and field capacity (15 to 35 t/h) are heavily dependent upon uniform fruit loosening from the abscission chemical. It is better suited to harvesting heavily foliaged, compact trees that do not have prominent limbs. The limb shaker has slightly higher removal efficiencies (90 to 99%) which is not as dependent on uniformly loosened fruit. It has a lower field capacity (4 to 10 t/h) and is better suited for large, open trees with prominent limbs.

Fruit shaken to the ground is mechanically windrowed either into the center between two tree rows or at the tree drip-line, mechanically picked up, and loaded into a 3275 kg capacity grove truck which transports and loads the fruit into a semi-trailer at roadside (Sumner and Churchill, 1977). Fruit recovery efficiency of the windrow and pick up operation ranges from 95 to 98% at a loading rate of 10 t/h.

Fig. 1 illustrates an economic model of the estimated current cost of a mechanical harvesting system under good conditions in early and midseason oranges. Assumed equipment for the system, valued at $191,000, includes dilute sprayer, 45 kW tractor, tank truck, windrow rake, pickup machine, high-lift truck, and two limb shakers. Total system life is 2000 h (5 seasons), has a capacity of 10 t/h, and a fruit recovery efficiency of 95% using seven skilled and 2 unskilled workers at $5 and $7/h, respectively.

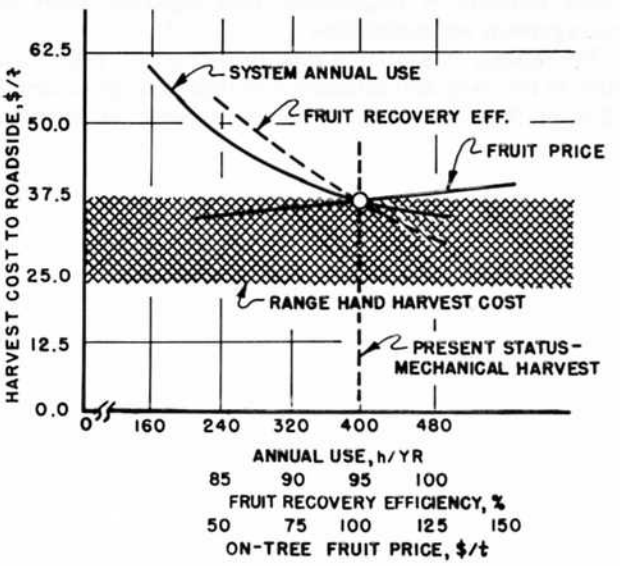

Fig. 1—Economic model—mechanical harvesting of Florida oranges.

Fig. 1 shows that at 400 h annual use, 95% recovery efficiency, and \$96/t fruit price, the mechanical harvesting cost is \$35/t, near the top of the range for hand harvesting cost. The cost of mechanical harvesting at other values of the three factors (annual use, fruit recovery efficiency, fruit price) can be estimated by varying only one factor at a time. For example, if fruit recovery efficiency is increased to 100% (annual use = 400 h, fruit price = \$96/t), harvesting cost is reduced to \$30/t (follow fruit recovery efficiency curve). If the level of more than one factor changes simultaneously, all three curves would shift.

FACTORS AFFECTING INDUSTRY ACCEPTANCE

Interest in harvest mechanization becomes especially acute when the ratio of harvesting cost to fruit price increases. High ratios in 1967 and 1973 stimulated interest in mechanical harvesting. Since 1978, grower interest in mechanical harvesting has subsided because high fruit prices have decreased the ratio, and an adequate labor force has been available.

Management of a mechanical harvesting system must extend over all three sectors of the industry: production, harvesting and utilization because provisions must be made to schedule fruit into the processing plant before the abscission chemical is applied. The entire operation can be upset if the fruit fails to loosen. Considerable management skill is required to utilize abscission chemicals. One must be able to evaluate weather patterns during the winter season when there is an alternating flow of cold and warm fronts across the Florida peninsula and in the late spring when rain showers occur almost daily. Very little abscission activity is obtained at temperatures below 16 °C or when rain occurs within 2 h after chemical application.

POTENTIAL AREAS FOR IMPROVEMENT

Mechanical harvesting is not generally economically competitive with hand harvesting for the following reasons: (a) the equipment and material costs are high relative to the overall annual system life use (ha per season) of the harvesting system, (b) the fruit recovery efficiency has been too low, particularly when fruit prices are high, (c) implementation problems exist because the citrus industry is fragmented into separate areas of management accountability.

Technology is available now to harvest an estimated 50% of the early and midseason orange acreage or about 22% of the total bearing orange acreage in Florida. Another 20% of the bearing orange acreage could be harvested mechanically provided mature 'Valencia' (late season) oranges could be selectively removed without damage to the young fruit of next years' crop. Abscission chemicals have been developed that will loosen the mature Valencia with minimal or no damage to the young fruit. These chemicals have reduced but not eliminated shaker damage to the young fruit. Increasing the predictibility of the abscission chemical through a better understanding of the interaction of ambient temperature, fruit physiology, and chemical concentration would further improve annual use and fruit removal efficiency of the systems.

About 20% of Florida citrus is grown in areas where drainage furrows are located at intervals of one to eight tree rows. The present mechanical harvesting system is adaptable to relatively flat terrain with four to eight rows of trees between furrows. Special equipment is needed for one to two tree rows between furrows. Smaller trees 4 to 5 m in height with a higher tree density per hectare would enhance the operation of the air shaker.

CONCLUSION

Mechanical harvesting technology for processed citrus has progressed to the stage where its cost is approaching economic competitiveness with hand harvesting for about 22% of the Florida orange acreage. The basic concepts of mechanical harvesting systems have been identified and many of the machine design requirements have been determined. Acceptance of mechanical harvesting systems would be improved if they were adapted to more citrus fruit types and a larger percentage of the Florida citrus acreage. Integrated production systems designed for mechanical harvesting higher density plantings would further improve the acceptability of mechanical harvesting.

References

1. Unpublished data, Citrus Industrial Council, Lakeland, FL. 1980.
2. Florida Agricultural Statistics, Citrus Summary. 1980. Fla. Crop and Livestock Reporting Serv., Fla. Dept. of Agric. and Cons. Serv., Tallahassee.
3. Sumner, H. R. and D. B. Churchill. 1977. Collecting and handling mechanically removed citrus fruit. Proc. Int. Soc. Citriculture. 2:413-418.
4. Whitney, J. D. and H. R. Sumner. 1977. Mechanical removal of fruit from citrus trees. Proc. Int. Soc. Citriculture. 2:407-412.
5. Wilson, S. C., R. E. Holm, and R. K. Clark. 1977. Abscission chemicals—aids to citrus fruit removal. Proc. Int. Soc. Citriculture. 2:404-406.