FRUIT HANDLING SYSTEMS FOR FLORIDA CITRUS

by

S. L. Hedden
Member ASAE

D. B. Churchill
Member ASAE

The citrus industry of Florida may be uniquely organized compared to other fruit growing areas. Citrus fruit is produced under a variety of ownership schemes and the harvesting is handled in several different ways. A citrus grove owner (quite often an absentee owner) may:

1. Harvest his own fruit by hiring pickers and owning the picking containers and equipment.

2. Belong to a cooperative which has a harvesting department.

3. Sell his fruit on-the-tree to a private harvesting company, packinghouse, or processor who then picks the fruit with their own crew.

4. Contract with a private harvesting company to pick and haul the fruit to wherever the grower may have sold it.

Further, the approximately 303,500 ha of bearing citrus grown in Florida represent a broad variety of production conditions within the state (Fla. Ag. Stat. 1982). Some producers harvest fruit in all the production areas and therefore must utilize systems that adapt to several situations and have high mobility. Field handling of citrus fruit is the only portion of the harvest operation that has been successfully mechanized and adopted throughout the industry.

The Florida field box has not been used as a picking container in recent years but it is still the legal unit of measure in buying and selling citrus fruit in Florida (Florida Statute 601.86). The field box described in the statutes, besides having specified length, width, and height measurements, has total cubical capacity of not more than 0.08 m^3 (4800 cu. in.). This volume is further defined to hold 40.9 kg of oranges or 38.6 kg of grapefruit. The field box system of fruit handling was essentially the same from 1875 (Bowman et al. 1971) until the early 1960s. Citrus production as well as labor costs increased rapidly, and it became increasingly difficult to find people willing or capable of lifting, stacking, or dumping 45 to 50 kg filled containers many times daily. With the advent of frozen concentrated orange juice in the early 1950s, an ever increasing amount of oranges produced in Florida went directly to the processing plant rather than finding their way as fresh fruit packinghouse eliminations. Currently, about 94% of Florida oranges are processed into juice products (Fla. Agr. Stat. 1982).

The purpose of this paper is to discuss the more important handling systems used for Florida citrus fruit destined for either fresh or processing outlets. The discussion is confined to the placement of the fruit in a suitable field container after it has been removed from the tree and its movement to a

The authors are: S. L. HEDDEN and D. B. CHURCHILL, Agricultural Engineers, USDA-ARS, Lake Alfred, Florida.

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Picking bags have proved to be suitable and useful containers, especi
the single ground picking. In terms of picker work productivity single-
tioners have worked wery well particularly in high fructification pla
While, according to the trials, the alternative of using machines wit
pickers doesn't seem to be effective because of the considerable single
ductivity decrease.
The experiences we got let us state the necessity to organize a chain
picking fruits from the ground with picking bags and bulk-bins first
from high with the single-man positioner, in order to get the highest
vity. Besides, according to productivity indexes we gathered, only on
is necessary after four hours'work.
As far as mechanical harvesting is concerned the percentage of the fr
on the tree, especially on the orange, suggest that further research
vement should be carried out to better treatment effectiveness workin
machines and trees. The response of the tree might be more favour
the use of more complex shakers allowing a continuous variation of fr
and oscillation extent. The tree should be properly pruned so that it
structure wouldn't lessen the oscillations. Conclusions referred to the
data are not optimistic of course. The damage high incidence, besides
think that favourable perspectives might concern the grape-fruit only
ded that fresh fruit market is supported by by-product industry.

REFERENCES

BLANDINI G., F.PETRONE, G.RACITI, A.SCUDERI, S.SISINNA.1978. Prove di
integrata in Calabria e Sicilia.Quad.n.1 P.F. Mecc.Agr.CNR: 23-49.

BLANDINI G., F.PETRONE, G.RACITI, A.SCUDERI, S.SISINNA.1978. Mechaniz
sting of citrus in Italy. Proc.Inter.Soc.of Citriculture, Sidney: 93-

BLANDINI G., F.PETRONE, S.SISINNA.1979. Raccolta integrata degli agru
lia e Calabria. Proc.3° Conv.Naz.AIGR, Catania: 3° vol., 181-197.

BLANDINI G..1979. Fattori che influenzano la produttività del lavoro
colta degli agrumi. Proc. 3° Conv.Naz.AIGR, Catania: 3° vol., 211-222

BLANDINI G., F.PETRONE, G.RACITI.1979. Risultati e prospettive della
meccanica degli agrumi. Proc.3° Conv.Naz.AIGR, Catania: 3° vol., 237-

BLANDINI G., F.PETRONE, S.SISINNA.1979. Il trasporto superpalettizzat
frutta nelle aziende agrumicole.Proc.3°Conv.Naz.AIGR,Catania:3°vol.,2

BLANDINI G..1981. Nuove tecniche di raccolta di agrumi in impianti a
stretti o su terrazze. Tec.Agr.3-4: 3-19.

BLANDINI G. et al.1981. Meccanizzazione della potatura e della racco
agrumi. Acc.Naz.Agr., Bologna, 80 p.

RACITI G., A.SCUDERI, F.INTRIGLIOLO.1979. Riflessi della raccolta in
gli agrumi sulla qualità del prodotto.Proc.3°Conv.Naz.AIGR,catania:3
198-210

roadside loading area.

FRESH FRUIT HANDLING

Mechanization of citrus handling for packinghouse fruit started with the use of two wheeled trailers holding 820-1020 kg of fruit which were moved and placed by farm tractors. The trailers were hitched 5 or 6 together and pulled to the packinghouse when the fresh fruit packinghouse was near-by. Use of this system for fresh fruit lasted a very short period because of the rapid increase in Florida highway traffic and packinghouses became fewer and larger so that very little fruit was available immediate to the appropriate packinghouse.

In the late 1950s, the pallet bin and tractor fork-lift system used in deciduous fruits was adapted to Florida conditions (Herrick 1962) (Fig. 1). Considerable research was done on bin design to make it withstand the repeated handling cycles in the field and resist decay under the semi-tropical climat of Florida.

Fig. 1 Pallet Bin Handling With Tractor Fork-lift

At the same time, a grapple-type pickup head was developed by the industry for the loader-boom used in handling fruit for processing (Fig. 2). The loader-boom grasps the bin by the top rail and 6 to 8 bins are stacked on th flat, narrow truck body of the loader. Pallet bins for this system must hav a strong top rail for lifting and the side panels must be firmly fastened to the bottom pallet structure. An advantage to this method of handling pallet bins is that the loader-boom can handle bins on sloping terrain or in a ground depression and the bins do not have to be aligned for fork entry.

A pallet bin holds 409 kg of oranges but has only 1/3 the surface area of the equivalent 10 field boxes which reduces the occurrence of peel abrasion proportionately. Measurements made on the bulk density of citrus (Grierson 1966) showed that the equivalent of 10 field boxes (0.79 m^3) of either grape fruit or oranges occupies 0.72 m^3 when placed in a pallet bin. Research on degreening of early season oranges and grapefruit in pallet bins developed stacking patterns of the bins and redesign of air flow patterns so that citrus could be satisfactorily degreened and more fruit could be placed in a given space than with field boxes (Herrick 1962). Several large packing-houses hauling fresh fruit in bulk semi-trailers put fruit into pallet bins at the packinghouse when degreening is required early in the harvest season. Either of these two systems allow one loader-driver to service a 15-20 perso picking crew which formerly required 6 hand-loaders with the field box systems or three tractor drivers with the trailer system.

Fig. 2 Pallet Bin Handling With a Loader-Boom

PROCESSING FRUIT SYSTEMS

The two wheeled trailer system was used for processing fruit also by adding a trailer or truck-mounted basket elevator to the system. The elevator was placed next to the 40 m roadside semi-trailer and the small field trailers were backed up to the elevator for unloading. This system was over mechanized because of the special trailers and trucks required to transport the field trailers, tractors, and elevator from one grove to another in the citrus growing area of Florida. The standard field box remained in use as a picking container and was dumped by hand over the side of a high-lift truck by two loaders. Two loaders worked on each side of the truck and the driver kept the box count for the individual pickers. The high-lift body truck became a standard part of process fruit handling systems in the 1950s. This type truck holds 3 to 4 t of fruit as it is loaded in the citrus grove and transports the fruit out of the grove to a roadside semi-trailer. The high-lift body lifts approximately 2.5 m to the top of the semi-trailer and tilts side-ways over the side of the bigger truck.

A loader-boom developed by industry in the late 1950s was mounted on the high-lift truck next to the driver and was made to load and dump a 0.79 m^3 wire basket (Fig. 3). The wire baskets were tapered and nested for transport with two wheeled trailer pulled by the high-lift truck.

In the early 1970s, the wire basket used with the loader-boom for processing fruit was replaced by a round, molded polyethylene tub 1.5 m in diameter with a 7.6 cm wide channel - iron rim (Fig. 4). This tub was tapered, as was the wire basket, so they could be nested. It was also lighter in weight (50 kg vs. 62 kg) and could be rolled into place by the picker more easily than the square wire basket.

Another system developed in the late 1950s used a tractor equipped with a front-end loader and dump attachment that could lift a 0.79 m^3 metal basket over the side of a semi-trailer and dump the container. Field handling systems using farm tractors and trailers, fork-lifts, or front-end loaders were never adopted to the extent of the truck-mounted loader-boom with a flat bed or high-lift body. The truck-mounted equipment requires no supplemental transport to travel from grove to grove at highway speeds. The picking

Fig. 3 Loader-Boom on High-Lift Truck Handling a Wire Basket

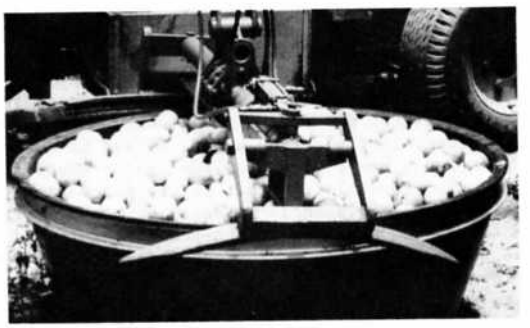

Fig. 4 Round Plastic Tub for Processing Fruit

containers are loaded on a trailer pulled by the high-lift truck or, in the case of pallet bins for fresh fruit, are transported by flat-bed semi-trailer to the harvest site.

It should be noted that field containers used for harvesting deciduous fruit may get used only once a year if the fruit is placed in cold storage or two to three times if other types of fruit with earlier or later harvest dates are grown. However, citrus is harvested up to 9 months of the year as fresh fruit and 6 months for processing. Therefore, a pallet bin may make 60 to 8 trips per season between the grove and packinghouse. Plastic tubs which are used only as a picking container in the field are handled 1200 to 1500 times during the harvest season. Table 1 shows relative volumes, cost, and container life for the various picking containers in use.

In addition to the labor savings accrued in the various mechanical handling systems, there is a 50 percent savings in unit container costs (Bowman et al 1971).

On several occasions during the past 20 years vacuum systems of handling fruit have been tried as part of various picking schemes. One such system was operated for several seasons as a means of moving fruit directly from th picker to a closed cylindrical hopper on a high-lift chassis which could dum directly into a roadside truck. Close management was required in matching

Table 1. Comparative Picking Container Data

Container	1983 Cost ($)	Capacity (F. Bx)	Service Life (yr)	Empty Weight (kg)	Ann. Cost per Unit ($)	Labor[a] Crew
Field Box	$ 9.00	1	3	4.5	3.00	6
Pallet Box	85.00	10	6	41.0	1.41	2
Wire Basket	120.00	10	8	62.0	1.50	1
Plastic Tub	110.00	10	8	50.0	1.37	1

[a](Hooks 1983)

picking rates of 6 to 8 pickers working with a vacuum system. The fruit pooled in the vacuum hopper but each tube inlet contained a fruit counte which tallied individual picker output. Picker productivity was not impr but no containers or handling equipment were required and records showed the harvest contractor saved 5 cents per box in harvest costs. Another h vest company is using a similar vacuum handling system on an individual m positioner. Each machine collects approximately 4000 kg of fruit before emptying into the roadside truck and is used two 8 hr shifts per day.

During the late 1960s, several people in the citrus industry felt that fr handling and hauling costs for processing fruit could be reduced if fruit were dropped on the ground in the citrus grove, picked up as needed, and brought into the processing plant. This system would reduce the large nu of semi-trailers required for holding fruit at the processing plant locat Initial field trials in which 'Valencia' oranges were poured from field b into a windrow on the ground resulted in sun-scalded fruit and a high dec rate if left up to 24 hours in the windrow condition (Hedden 1967). Howe the parallel development of abscission chemicals which caused a large per centage of fruit to fall on the ground before the picking operation made necessary to continue development of a system to gather the fruit from th ground into some suitable container.

Several fruit windrow and pickup machines were developed specifically for Florida conditions of clean cultivated sand (Sumner and Churchill 1977)(F 5 and 6). Two types of systems were developed to either pick up fruit fr windrow in the center of the row or from a windrow under the tree drip-li Machine capacities varied from 10-12.5 t/h. The center row system had th greatest capacity because fruit could be windrowed from under trees on bo sides of the drive middle. These systems required one operator for the w row machine and two operators for the tractor-pulled pickup machines. Tra elimination and sorting capability was provided on the pickup machines. A high-lift truck was towed behind the pickup machine and fruit was direct- loaded into it. Two high-lift body trucks were required to complete the systems if they were to be operated at their field capacity.

The drip-line pickup system was adaptable to Florida flatwoods citrus cul where there are 4 to 8 rows of trees between drainage ditches and sod midd with clean earth under the tree canopy (Hedden et al. 1979). It was esti- mated that approximately 22% of Florida citrus acreage is adaptable to th windrow and pickup system. Commercially manufactured equipment was avail for several years but is no longer available because marginal economics du to high energy and machinery costs and an abundant supply of available lab

Fig. 5 Windrow Rake Forming Double Windrow for Center Drive Pick-up

Fig. 6 Drip-line Pickup Machine

FUTURE OUTLOOK

Fruit volume vs. weight relationships change from season to season and within each season, particularly, if a freeze occurs. The fruit grower pays the picker by volume but sells to the processor by weight. Research is underway to weigh fruit as it is picked, tabulate picker output, and various other information through sensors and a micro-processor on the loader truck.

Since fresh fruit is a relatively small percentage of total production, ther is work underway to separate fruit of high external quality from processing fruit in the field or at the processing plant receiving facility rather than pick whole blocks of fruit for the packinghouse and eliminating most of it for processing.

If robotics prove adaptable to fruit picking, there may be an entire new system whereby juice is extracted in the grove and transported in tank trucks. Higher density plantings of several hundred trees per ha hold promise for higher fruit yields per land unit as Florida rising population continues to take land out of agricultural production. In-row straddle-type container handling equipment and over-the-row multi-purpose machinery will b used for both production and harvesting phases.

SUMMARY

Of the different citrus handling methods tried in recent years, the loader-boom methods with either pallet bins for fresh fruit or round tubs for processing fruit have been universally adopted in the Florida citrus industry. Present economics, system versatility, capacity and reliability are the main advantages of these systems. Changes in land use, however, are forcing growers to higher density plantings where conventional systems will not work.

REFERENCES

1 Bowman, Earl K., A. H. Spurlock, Scott Hedden, and William Grierson. 1971. Modernizing handling systems for Florida citrus from picking to packing line. U.S. Dept. Agr. MRR-914, 54 pp., illus.

2. Grierson, W., S. L. Hedden, and E. K. Bowman. 1966. Report on proposed standardization of 10-box containers. (Unpublished)

3. Florida Agricultural Statistics, Citrus Summary 1982. Florida Crop and Livestock Reporting Services.

4. Hedden, S. L. 1967. Study of handpicking methods of fruit separation. Report to Florida Citrus Research Council (Unpublished).

5. Hedden, S. L., H. R. Sumner, and D. B. Churchill. 1979. Collecting and handling mechanically harvested oranges in South Florida (LaBelle). Proc. Fla. State Hort. Soc. 92: 59-61.

6. Herrick, J. F. Jr. 1962. Handling Florida oranges in pallet boxes. U.S. Dept. Agr. MRR-529, 59 pp., illus.

7. Hooks, R. Clegg. 1983. Estimated cost of picking and hauling fresh Florida citrus, 1980-81 season. Univ. of Fla., IFAS, Econ. Int. Rept. (in press).

8. Sumner, H. R. and D. B. Churchill. 1977. Collecting and handling mechanically removed citrus fruit. Proc. Int. Soc. Citr. 7: 413-418.