Mechanical harvesting: rising phoenix or long dead zombie?

*By Bill Grierson**

Early this March, there was an industry meeting at the Citrus Research & Education Center, Lake Alfred to discuss possible revival of the Mechanical Harvesting Project (4). No, I was not there; I have served my time on that cross. But, should any group consider reactivating this long defunct and fantastically expensive project, it might be helpful to have a review of what went before by one who was involved from the very beginning. Understanding what went before might well determine whether the industry has a reborn Phoenix rising from the ashes, rather than a zombie from some best forgotten grave.

The Mechanical Harvesting Project started with a meeting in the office of Dr. Herman Reitz, Director of the then Citrus Experiment Station, some time in the season of 1956-57. (I now have no record of the exact date.) Herman Reitz and I were joined by a half-dozen experts from the U.S.D.A., all of whom had been involved in development of mechanical harvesting for some type of crop. The meeting started on a cheerful note, with our visitors taking the viewpoint that if olives and blackberries, castor beans and soy beans, canning tomatoes, sour cherries and prunes were all being harvested mechanically to some extent, could citrus be far behind?

Over the course of several hours, we analyzed the reasons for these successes. In all instances, they were presenting examples in which, for annual crops, the plant could be destroyed. Where tree crops were involved, they were, with one exception, always deciduous. The crop having matured, the leaves were dispensable, they were going to fall before winter anyway. Moreover, each of these products had a built-in abscission period; if left on the plant long enough, they would fall of their own accord. An exception was the olive, which is an evergreen tree whose fruit is typically harvested well before natural abscission. But for the great proportion of the crop harvested for its oil, fruit damage is of little or no consequence and the small, tough leaves are rather resistant to damage.

Citrus trees, in sharp contrast, are evergreen, making leaf damage unacceptable. Citrus fruits have no preordained abscission period, often hanging on the tree for months after acceptable maturity. The fruit is very susceptible to mechanical injury, and Valencia, Florida's principal orange variety, has two crops on the tree at harvesting - the mature 14-15 months old crop and the two to three months old crop for the following season.

Our visitors contemplated these problems and, like the young man in Matthew 19:22, went away sorrowful, leaving us to our own devices.

It was agreed that, until funds could be raised to hire a full time agricultural engineer, I would serve as Project Leader, Mechanical Harvesting, in addition to my regular duties.

The first step in attacking such a complex research problem is (or should be) to evaluate the existing situation. This I had long been doing anyway, modernization of harvesting being one of my continuing concerns (1). Compared with harvesting of tree fruits elsewhere in North America, it was obvious that the plantation was too close behind us. All picking involved use of back breaking "pole ladders," and cumbersome, spine distorting, single strap 90 lb. (41 Kg) "jumbo" picking bags. Most fresh fruit harvesting still used the 90 lb. (net), 105-110 lb. (gross) field box, although the pallet box project (1,2) was making some progress in displacing the monstrosity. This was in sharp contrast to harvesting of deciduous fruits for which the bags and ladders are almost invariably so light and convenient that school children, housewives, and retirees are commonly enlisted in the sharply seasonal harvests. Obviously our Florida picking equipment severely limited the potential pool of harvesting labor.

Now for enunciation of a basic, incontrovertible but exceedingly unpopular principle. In operations such as citrus harvesting we will never see "automation," and the term should be banished from the vocabulary of all concerned. Mechanization is possible and can come in small increments as increasing mechanization multiplies the productivity of essential workers. This is a necessary viewpoint, even if an often unwelcome one. In one committee meeting in which I expounded on this theme, an irritated citrus executive snapped at me:

"It's your job to do away with the picker."

"What do you suggest? Guns or gas?"

No one is ever going to "do away with the picker." We can, however, upgrade the picker's productivity, perhaps ultimately providing him (or her) with some very productive citrus picking machinery. But at that point, our "picker" has become a skilled machinery operator who must be paid accordingly. Whatever the ultimate solution to the citrus harvesting problem, we are going to need people to build, operate, and maintain the necessary equipment, and these will not be "casual labor."

Thus the first obvious move was to make picking less onerous and more productive in order to help keep such good pickers as we had, and to attract others who, though willing to work, could not possibly pick with a jumbo picking bag and a pole ladder. In the 1950s and early 1960s we still had some very good pickers. I know, I used to be out with them in the groves, riding in miserably uncomfortable crew buses with them and seeking, not only to help their employers cut costs and reduce fruit damage, but also seeking to give those who were willing to work a chance to make a better living. Even with such crude equipment, given productive trees, the best of them would pick 100 boxes a day. (Few today pick better than 60 boxes per day.) One such was Doyle Waid. You can meet him in John McPhee's delightful (and recently reissued) little book "Oranges" (5). McPhee mentions that Doyle Waid's picking supported a wife, four sons and an infant daughter. More than 20 years later I was delighted to find, quite by chance, that one of the ladies the other side of the counter in our local bank was Doyle Waid's daughter. That seemed fair and fitting, for her father was skilled at his trade and very hard working.

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I started by seeking a better ladder for which I designed a very light ladder of fiberglass tubing and fisherman's "steel leader line." Lacking any assigned funds, I enlisted the aid of a chance-met salesman for a plastics company. He sent his company in New England my design and a new pole ladder for comparison. The new-fangled ladder weighted about one third as much as the pole ladder and, when tested to destruction, proved about 2-1/2 times as strong. It was designed so that it could be slid into a tree without snagging and could be easily lifted with one hand.

So why are such ladders not in use today? The company estimated that, if given orders for 100 or more, they could sell them for between $100 and $125. However, I could find absolutely no takers. None, zilch, de nada! By 1966, when McPhee was interviewing Dr. Reitz for his book, he remarked that he had seen "...a picture of a man in California picking oranges from a king of crow's nest" ("Oranges" p. 29). "That is a seven thousand dollar ladder" said Herman Reitz, remembering the industry's rejection of our $100 ladder.

Eventually, it was agreed that the Florida Department of Citrus (FDOC) would raise funds for mechanical harvesting research by means of a per box levy. A meeting was called to discuss how these research funds should be spent. It was a very large meeting with, as the saying goes, "anybody who was anybody" present. I have no record of the exact date, but I well remember the day of the week. For some time after, Herman Reitz and I used to refer to that day as "Black Thursday."

Dr. Reitz opened up the meeting by reviewing our discussion with the experts who had successfully, mechanically harvested those other crops. But, since little of their work could be applied directly to citrus, it was obvious that there was going to be no quick, easy solution. Therefore, our first concern should be to retain each and every good picker we had. To retain those good pickers we would have to make picking a good job.

Then he turned the meeting over to me. I emphasized that any form of "automation" was impossible in the foreseeable future. Thus we had to start on the basis of increasing picker productivity, beginning by upgrading the picker's equipment.

The large sums that were to be raised could be expected to result in increasing degrees of mechanization. For that, machines would have to be built and maintained. Skilled machine operators would have to be paid on a scale equivalent to that of heavy equipment operators; and harvesting foremen would need to be better educated and trained than was then usual. I suggested that, as mechanization developed, some of the new funds might be assigned to the vocational schools to train necessary mechanics and perhaps even to the Community Colleges for a course to train "Mechanized Picking Foremen." Meanwhile, every priority should be given to retaining such pickers as were capable of being up-graded to operate complex machinery.

Our views were not well received. We were told rather bluntly by several speakers that if we were not capable of moving immediately into some form of mechanical harvesting, they would find someone who could. "It is just a matter of putting up enough money to get engineers who are capable of doing the job."

At the end of 1960 I left the experiment station for a period of over three years. When I returned, mechanical harvesting had become a major inter-agency project involving FDOC, University, and USDA engineers. I was assigned to a peripheral role, evaluating damage to mechanically harvested fruit. The USDA was to pay for a technician to assist in this. For this we hired the late Frank Cowart, an experienced citrus man with groves of his own. He was with us until the USDA withdrew their support in 1970.

As I write, I have a stack of Progress Reports beside me from which I will seek to glean insights that might be helpful to anyone reworking this field of endeavor. Also, in 1969-70 Robert L. Rackham, then a University of California Extension worker on sabbatical leave, worked with us on evaluation of mechanically harvested fruit. He and I summarized our findings in a national publication (6).

In the course of this project, fruit were shaken off with limb shakers, shaken off with oscillating air blasts, blasted with water jets, and pulled off with various mechanical devices, including vacuum tubes with rotating orifices. We checked the effect of each of them on the condition of the fruit. Fruit were caught on tarpaulins, on elaborate catching frames, or allowed to fall on the ground. (For this, the ground was sometimes worked into a fine tilth. At the least, the grove had to be rolled or chopped to destroy any previously fallen fruit.) Fruit on the ground were gathered up by hand or "windrowed" like hay and picked up with machines like giant potato diggers. Moreover, very

similar activities were going on in other citrus areas, principally California, Israel and Australia. Such activity resulted in a plethora of publications, review of which would be quite unsuited to this article. Instead, I will offer some brief general observations.

Tree damage

Many growers expressed concern lest vigorous shaking of their trees should result in root damage or some other form of concealed injury. Plots were harvested by the same method, limb shaking, air shaking, or hand picking, for five successive years. We noted no consistent difference in the trees, but melanose declined steadily in fruit from the mechanically shaken trees. The melanose fungus, Diaporthe citri, develops in dead wood and those big 25 H.P. limb shakers were very efficient dead wood pruners!

Fruit damage

The greatest fruit damage was always in the fruit that stayed on the tree the longest. A California team did an elaborate computer study calculating the chances of each falling fruit hitting a limb as it fell. (This took many weeks of field and computer time plotting the position of every fruit and computer time plotting the position of every fruit and every limb in three-dimensional computer coordinates.) Their presumption was that the fruit fell vertically. Not being computer wizards, Frank Cowart and I took a can of spray paint to the grove, sprayed some fruit (Eek! An illegal additive!), drew circles on the ground under each sprayed fruit and had one of the engineering group shake the tree. None of the sprayed fruit landed anywhere near the circles under them. The fruit didn't understand any more about that elaborate computer programming than we did.

Next, we wanted to know whether fruit damage occurred hitting the tree or hitting the ground. I equipped Frank with a "hard hat" and a fisherman's landing net and instructed him to catch a sample of fruit in free fall. I think he caught three in the course of a hot, frustrating afternoon. The solution was simple. We got the shaker operators to make successive 15 second shakes, each time picking up all the fruit that fell. Oranges (grapefruit are a different story) that came off in the first 15 or 30 seconds shaking suffered surprisingly little damage. Those that stayed on the tree through several minutes shaking were severely damaged.

Plugs vs. long stems

Plugs, although regrettably frequent in hand picking, were unusual in mechanically harvested fruit, but adhering stems were a real problem. This was particularly so at the cannery when FMC "in-line" extractors were being used. I had great hopes for the Agtech vacuum picker (really a very efficient picker's aid). It picked fruit very cleanly with an absolute minimum of plugs or adhering stems.

Varietal differences

Despite the firm belief of many in the citrus industry, postharvest decay in mechanically harvested oranges always tended to be less in thin-skinned oranges than in thick-skinned oranges. With thin-skinned oranges minor lesions tended to dry up without infection. With thick-skinned oranges, pathogenic fungal spores germinated freely in the spongy albedo (white part of the peel) causing decay. As a broad general observation, decay in mechanically harvested, thin-skinned Valencias tended to be no more than in hand harvested, thick-skinned Pineapples.

We checked whether mechanically harvested Duncan (seedy) grapefruit were suitable for making canned grapefruit sections; they were. Mechanical harvesting of seedless fresh fruit grapefruit was not practical due to high losses from blossom-end clearing ("wet wick," "water bottoms").

Weather conditions

I know of no studies correlating ease of abscission with weather conditions, though some may have been done. However, fruit damage tends to be sharply related to weather conditions. How this works is often misunderstood. It is water inside the fruit that causes the trouble. In damp, cloudy weather transpiration (water loss from the fruit) is severely restricted, particularly in the morning. Under such conditions the fruit is excessively turgid and liable to damage. In bright, dry, windy weather turgor pressure goes down rapidly, making the fruit much more damage resistant. A quick shower, wetting the fruit during such an afternoon, is of little or no consequence.

***Industry cooperation:* Canneries**

Left to their own devices, engineers tend to do horrible things to living, breathing fruit. (FDOC's Glenn Coppock was a shining exception. He even took university courses to help him understand tree and fruit physiology. This was truly exceptional.)

I used to protest loudly against abuse of the fruit in mechanical harvesting. After one meeting my boss, Herman Reitz, took me aside.

"Bill, we have a problem."

"We do?"

"Yes. You will have to learn to say "windrow" with no army adjectives!"

I was constantly told that it did not matter how roughly cannery fruit was handled because it was going to be juiced before it could rot. If this philosophy is to work, immaculately rapid scheduling between the mechanical harvester and the cannery extractors becomes essential. With an occasional exception, there seemed to be little comprehension of this on the part of cannery personnel.

***Industry cooperation:* Groves**

Development of any new, complicated equipment is ultimately dependent on continuous testing, testing, testing, and for mechanical harvesting this can only be done in the groves. I used to feel sorry for the engineers. Over and over again, when they would have a breakdown, the owner of the fruit would call in a commercial picking crew. Worse still, when labor was occasionally plentiful and picking rates reasonable, no one seemed to want to have experimental mechanical harvesting equipment in their groves. No individual grove owner should have to bear the extra expense of "if at first you don't succeed, try, try again." But something has to be arranged so that "test bed groves" are always available when needed.

Abscission sprays

It seems extremely unlikely that large scale mechanical harvesting will ever succeed without efficient abscission sprays (7). But, not only are the costs of developing citrus-specific abscission sprays extraordinarily high, the effectiveness of an individual abscission spray varies greatly with the growth status of the tree. In particular, efficiency tends to diminish as the Valencias regreen, which is typically the preferred time for harvest.

Reliance on chemicals

About the time of the Rackham and Grierson report (6) we were beginning to think that if the engineers could get the fruit off the tree reasonably fast, we could, using Benlate (benomyl) preharvest and 2-AB (2-aminobutane, secbutylamine) vapor treatment postharvest (3), get the fruit to the fresh fruit market. However (in the face of vociferous "anti-chemical" propaganda) Dupont has voluntarily withdrawn the fresh fruit clearance for Benlate and (in the face of rising costs of registration) Eli Lilly announced it was discontinuing its label application for 2-AB. Put not your trust in princes, especially the modern equivalent who control clearances for agricultural chemicals!

***Economics:* cannery vs. fresh fruit**

If handled rapidly enough from tree to extractor, losses in cannery fruit could be very low and any severely damaged fruit graded out would represent only the loss of their "delivered in price." Fresh fruit marketing takes days, or even weeks, greatly exacerbating decay losses in damaged fruit. Moreover, monetary losses from decay are incomparably greater than with cannery fruit. By the time decayed fruit show up in a distant market, their loss represents not only the original cost of the fruit at the packinghouse receiving dock, but also the cost of handling through the packinghouse, plus the cost of the shipping container, plus the cost of transportation to market, plus wholesale and retail marketing costs. Additionally, the economic loss, due to damage, to the shipper's reputation is intangible but very real. Currently, the most that fresh fruit shippers can expect if mechanical harvesting is successfully reinstated is that it will, in time, release pickers who would otherwise be picking for the canneries.

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