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HARVESTING ORANGES WITH A FULL-POWERED

POSITIONING LIMB SHAKER¹

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Abstract. The performance of a self-propelled full-powered positioning limb shaker was evaluated in four grove sites sprayed with an abscission chemical. The system increased the harvesting rate and reduced operator fatigue as compared with hand-assisted shaker positioning. Fruit removal efficiency was 96% in trees sprayed with an abscission chemical and 90% in unsprayed check trees. The harvesting rate was 15 to 36 trees/hour, depending on tree structure and number of limb attachments required per tree.

Limb shakers have been used to harvest early and midseason oranges in Florida for several years (3,4). The development of a self-propelled, one-operator shaker was reported by Coppock, 1973 (2) for use in a shake-pickup harvesting system. The shaker was a crank-drive inertia-type that was pendulously hung. It was controlled remotely from the operator's handle on the shaker. A similar limb shaker was also used with catch frames developed for harvesting citrus (1). These limb shakers were effective in removing a high percentage of fruit by imparting a long stroke to limbs at a low frequency and were not as dependent on the use of abscission chemicals, as were other mass-removal machines (air shaker, trunk shakers, and water shakers).

Unbalanced rotating weights have been used on trunk shakers to produce large shaking forces and small displacements at high frequencies. The large displacement required for shaking citrus limbs (5) can also be obtained with unbalanced rotating weights.

A self-propelled shaker unit with an unbalanced rotating weight limb shaker was developed by USDA (U. S. Department of Agriculture) engineers at the Agricultural Research and Education Center at Lake Alfred, Florida over the

past two years. The shaker unit was designed to reduce operator fatigue and increase harvesting rate above that of present limb shakers.

The objective of the tests described in this report was to field test and evaluate the FPP-RW (full-powered positioning-rotating weight) limb shaker unit in several grove sites.

Equipment and Methods

The FPP-RW limb shaker unit was used in all tests (Fig. 1). It consisted of a pendulously hung shaker mechanism weighing 700 pounds and a remote controlled hydraulically powered positioner mounted on a three-wheel transport system. The shaking mechanism (240 lb rotating weight with a 6-1/4-inch eccentric) had a maximum operating speed of 500 rpm and was powered by a 65-hp air cooled engine. The operator station was located at the rear of the shaker unit which gave the operator a view of the tree limbs along the axis of the shaker boom in most limb attachment situations.

Plot Test

Four plot tests were designed to evaluate the performance of the FPP-RW limb shaker unit in early and 'Valencia' orange varieties with and without the aid of abscission chemicals to loosen the fruit. The two abscission chemicals used were 'Acti-Aid' marketed by Tuco Division of Upjohn Company and 'Release' marketed by Agricultural and Veterinary Products Division of Abbott Labo-

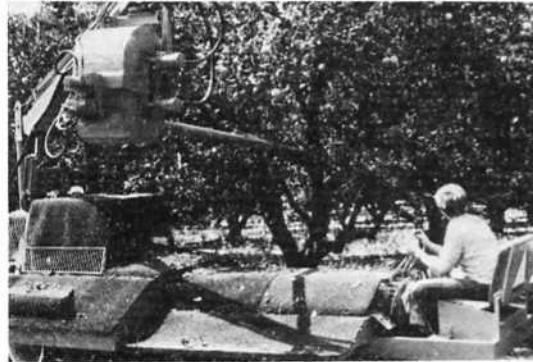


Fig. 1. The self-propelled full-powered positioning system with a rotating-weight limb shaker.

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ratories.² Data collected included: preharvest fruit drop, fruit left on trees after they were harvested, number of limb clamp attachments per tree, time spent shaking limbs, total harvesting time, and number of green fruit removed in 'Valencia' orange test. The same operator harvested all trees, and he shook limbs for a 90 to 95% fruit removal efficiency.

Chemical vs Check Test Twenty-four 'Parson Brown' orange trees that were about 15 ft high and spaced at 15 x 30 ft were harvested January 9, 1975. Treatments consisted of unsprayed check trees and trees sprayed with one unit of Acti-Aid and two units of Upjohn surfactant 'B' in 500 gallons of water per acre. Three trees per treatment were replicated four times for the time and motion data, and one tree per replication was selected for removal data.

Acti-Aid vs Release Test Forty-eight 'Parson Brown' orange trees approximately 18 ft high and spaced at 15 x 30 ft were harvested January 14, 1975, to evaluate the shaker performance as influenced by two abscission chemicals. The treatments were: (1) Trees sprayed with 1.4 units of Release and 1.2 liters of Ortho X77 surfactant in 500 gallons of water per acre, (2) trees sprayed with 1.4 units of Acti-Aid and 2.8 units of Upjohn surfactant 'B' in 500 gallons of water per acre. Four trees per treatment were replicated six times for the time and motion data, and one tree in each replication was randomly selected for fruit removal data. The treatments resulted in two abscission loosening levels. These levels were determined by counting preharvest drop of mature fruit.

'Valencia' Test I and II Ten 'Valencia' orange trees approximately 18 ft high and spaced 16 x 26 ft were harvested on May 12, 1975 (Test I) and May 28, 1975 (Test II). Treatments consisted of unsprayed check trees and trees sprayed with 5 units of Release and 2.16 liters of Ortho X77 surfactant in 900 gallons of water per acre. The shaker operator shook limbs for a high rate of mature fruit removal, but shaking was stopped as soon as removal diminished, so that the removal of young fruit would be minimized.

Field Test

The FPP-RW limb shaker unit was operated

in a continuous harvesting operation in two grove sites to determine its field performance.

Orange-co of Florida, Inc. Field Test This test was conducted with 'Parson Brown' orange trees approximately 16 ft tall and spaced at 15 x 30 ft. They had skirts about 2-1/2 ft above the ground and two to four main limb sections. Trees were sprayed with 1.4 units of Acti-Aid and 2.8 units of Upjohn surfactant 'B' in 500 gallons of water per acre. This grove site was the same one used for the Acti-Aid vs Release test, but limb, motion, and removal data were not recorded.

Patrick Fruit Co. Field Test The FPP-RW limb shaker unit was compared with a Pounds two-man operated, tractor-mounted, crank-drive shaker in a field harvesting operation at a grove owned by Patrick Fruit Co. For this test, 'Pine-apple' orange trees that were about 18 ft high and spaced 25 x 25 ft were used. They had five to seven main limb sections. The trees were sprayed with 1/4 to 1/3 units of Acti-Aid at the rate of 500 gallons per acre.

The experienced USDA operator operated the shaker in the grove to demonstrate to and teach Patrick Fruit Co. shaker operators to use the FPP-RW limb shaker unit. Then the newly trained men operated it for several days to compare it with the Pounds shaker.

Results and Discussion

Plot Tests

The harvesting results of the field plots are given in Table 1. These results showed that the fruit removal was 96.1% for trees sprayed with abscission chemical and 90.0% for unsprayed trees. Average limb attachments per tree were less for sprayed trees (2.4) than for unsprayed trees (4.1). The average harvesting rate was 35.6 trees/hr for sprayed trees and 22.5 trees/hr for unsprayed trees.

In the 'Valencia' tests (I and II) fewer green fruit were removed from the chemically sprayed trees than from the unsprayed trees, and the shaking time was about the same.

Field Tests

High leaf drop and a 26.2% preharvest fruit drop resulted from the abscission chemical appli-

Table 1. Data and Results of Plot Test With FPP-RW Limb Shaker

Test	Chemical		Acti-Aid		Valencia I		Valencia II	
	vs check		vs Release					
Date	Jan. 9		Jan. 14		May 12		May 28	
Variety	Parson Brown		Parson Brown		Valencia		Valencia	
No. trees	24		48		10		10	
Treatment	Chem.	Ck.	A.A.	Rel.	Chem.	Ck.	Chem.	Ck.
Limbs/tree, No.	2.9	4.4	1.9	2.1	2.0	3.4	3.2	4.6
Shake time/ limb, min	0.06	0.07	0.06	0.09	0.13	0.12	0.09	0.10
Fruit predrop, %	15.3	0	26.2	9.3	11.4	0	16.0	0
Fruit removed, %	94.9	91.6	98.3	96.2	95.7	89.7	95.5	88.6
Green fruit removed, No.	77	174	211	289
Harvest rate (trees/hr)	31.6	26.7	43.8	42.3	33.3	22.1	26.8	18.6
Fruit yield (lb/tree)	415	301	452	355	527	434	366	419

efficiency over that in other groves. Also, only one limb attachment was required in a high percentage of the trees to produce good shaking action and fruit removal from the entire tree. The harvesting rates, which were recorded for four 30-minute time periods, were 52, 62, 74, and 66 trees per hour respectively. These harvesting rates were for ideal harvesting conditions (loose fruit, open trees, minimum number of limbs, experienced operator and good weather). Ideal harvesting conditions do not occur in a high percentage of the average orange groves. However, the results indicated that under proper conditions, harvesting rates can be high with the FPP-RW limb shaker unit.

The abscission chemical applied in the Patrick Fruit Co. grove was not effective, and no leaves or fruit drop occurred before harvest time. About six limb attachments were made per tree, and it was difficult for the operator to get the shaker into the tree and make attachments. The harvesting rate with the FPP-RW limb shaker unit was 20 trees per hour with the experienced USDA operator. The harvesting rate with the Pounds shaker, which required two Patrick Fruit Co. operators, was only 10 to 12 trees per hour.

Shaker operators with the Patrick Fruit Co.

used the FPP-RW limb shaker unit for several days to compare the full-hydraulic-powered positioning system with the semi-powered system of the tractor-mounted shaker. After a day of operating, they were able to harvest 15 or more trees per hour. They liked the one-man full-powered positioning system because it required less operator effort and was more efficient than was the Pounds tractor-mounted shaker. The FPP-RW limb shaker unit had adequate shaking power and was effective in shaking large limbs. It also required fewer limb attachments than did the Pounds limb shaker. About one day was required for a new operator to get familiar with the shaker and its controls and to obtain a harvesting rate near the full shaker capacity in a particular grove situation. However, only two hours were needed to obtain what was considered an acceptable harvesting rate.

Problems found in the machine design were: (a) The shaker boom was too short, (b) wheel sweeps were needed to remove fruit from under the wheels, and (c) the limb clamp was too large and would not hold on wet limbs. The FPP-RW limb shaker harvested over 700 orange trees over the last two harvest seasons, with only a few minor changes and repairs.

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