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QUALITY OF 'VALENCIA' ORANGES MECHANICALLY HARVESTED BY THREE METHODS[1,2]

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Abstract. **Fruit harvested by three mechanical harvesting methods were evaluated for decay after storage for 7 days at 70°F (21°C) and 88% relative humidity to determine decay potential caused by each system. All fruit were sprayed with an abscission chemical prior to harvest. The decay potential increased with each succeeding operation in the harvesting system.**

Florida produced approximately 7.67 million tons (6.86 t) of oranges in the 1977-78 season (6). Ninety-four percent went into processed products. Citrus fruit is harvested almost entirely by hand labor, though mechanical removal systems for harvesting citrus have been under development since 1961 (5). Fruit removal by mechanical means is achieved by shaking limbs or foliage at varying degrees of intensity (7, 9, 10). The 'Valencia' orange cultivar which represents about 50% of Florida production has young and mature fruit on the trees at harvest time. The effectiveness of the abscission chemical RELEASE (5-chloro-3-methyl-4-nitro-1H-pyrazole), was tested on 'Valencia' oranges, and results showed potential for selective loosening of only mature fruit and also for reducing the energy required to remove the mature fruit (11). Gathering and pickup equipment for collecting and handling the oranges have also been investigated (2, 3, 4, 5).

The susceptibility of fruit to decay increases as handling increases. Wounds that damage the fruit peel provide excellent sites for fungi infection (8). Green mold caused by the fungus *Penicillium digitatum* Sacc. is the most common type of postharvest decay of citrus fruit. The organism gains entrance into the fruit only through injuries to the peel. Peel injuries occur during harvesting and subsequent handling operations (1). Abscission chemicals sprayed on the fruit generally cause pitting of the peel and injury that results in increased decay potential (11).

In 1976, a 3-year study was initiated to evaluate the effect of mechanical harvesting equipment on the decay potential of 'Valencia' oranges that were sprayed with the abscission chemical, RELEASE, by comparing the decay of samples harvested with three removal methods and two gathering and two pickup systems and stored under controlled conditions. In a separate test, three rates of chemical applications were evaluated to determine their effect on decay potential with one mechanical harvesting system. The results of these studies are presented in this report.

[1]Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

[2]Cooperative research by the USDA, Science and Education Administration, Agricultural Research, University of Florida, and Florida Department of Citrus.

Materials and Methods

Machine tests

Nine tests were conducted on approximately the same three harvest dates each year for 3 yr in a 'Valencia' orange block spaced 25 ft x 25 ft (7.6 m x 7.6 m) in which average tree height was 22 ft (6.7 m).

The removal methods used were an air shaker, a rotating-mass limb shaker, and a slider-crank limb shaker; the gathering systems were a drip-line rake and a center-of-the-row rake; and the pickup systems were an offset pickup and a center-of-row pickup. The air shaker consisted of two engines and three vane-axial-flow fans, with a total airflow of approximately 18,000 cfm (85 m^3/s). Two passes/tree were made, one on each side of the wide middle. The rotating-mass limb shaker consisted of a 240-lb (109-kg) rotating weight, with a 6.25-in. (16-cm) eccentric, operating at a maximum speed of 400 rpm (42 rads/s) and powered by a 60-hp (45-kW) engine. The slider-crank limb shaker had a total mass of approximately 760 lb (345 kg) and an eccentric of 8 in. (20 cm). The air shaker operated at a rate of 105 trees/h and had a travel speed of 1 mph (1.6 km/h), and the limb shakers operated at a rate of 20 trees/h), and averaged 5.5 attachments/tree. Removal percentages for the air shaker, rotating-mass-limb shaker, and slider-crank limb shaker were 87%, 94%, and 94%, respectively.

All fruit were sprayed with an abscission chemical (350 ppm RELEASE) approximately 4 days prior to harvesting. Researchers in the chemical field consider the application rate of 350 ppm to be the best for consistently effective fruit loosening.

Each of the nine tests conducted consisted of nine treatments replicated three times on one-row plots (Table 1). Treatment 1 consisted of hand-picking approximately 100 sound fruit for use as a check. Treatment 2 provided a reproducible amount of mechanical injury that could be established as a standard against which to compare the decay potential results of these tests (or of tests with future mechanical harvesting system). About 100 sound, hand-picked fruit were used, and about 50 at a time were placed in a

Table 1. Treatments used in machine tests with 'Valencia' oranges sprayed with 350 ppm RELEASE.

Treatment no.	Sample location	Method of harvest
1	—	Hand picking (check)
2	Tumbler drum	Hand picking
3	Ground	Air shaker
4	Ground	Rotating-mass limb shaker
5	Ground	Slider-crank limb shaker
6	Windrow	Rotating-mass limb shaker, drip-line rake
7	Windrow	Slider-crank limb shaker, center-of-the-row rake
8	High-lift truck	Rotating-mass limb shaker, drip-line rake, offset pickup
9	High-lift truck	Slider-crank limb shaker, center-of-the-row rake, center-of-the-row pickup

tumble mechanism and rotated at 24 rpm for 90 sec. The tumble mechanism consisted of a 55-gal (208 *l*) drum with two deflector bars inside that caused the fruit to bounce as they rolled from end to end of the drum. Treatments 3, 4, and 5 consisted of fruit removal, only; and each of treatments 8 and 9 consisted of removing, gathering, and picking up the fruit for evaluation of the decay potential resulting from mechanical injury for the total harvesting and handling operation.

In addition to the hand-picked samples for the check and for the tumbler treatment (treatments 1 and 2, respectively), approximately 100 fruit were hand collected after each of treatments 3 through 9. All samples were placed unwashed in crates and stored.

Only wholesome fruit were used for all tests. Any orange that had a puncture or split was removed and not included in the experiment. For the development and evaluation of postharvest decay, samples were placed in storage at a temperature of 70°F (21°C) and 88% relative humidity and checked for green mold. Decay counts were made on several samples after 3 days of storage and on all samples after 7 days of storage.

Chemical tests

Starting in 1976, tests were conducted for 3 yr in the same 'Valencia' orange grove used in the mechanical tests to study the effect on decay potential of using three rates of abscission chemical (RELEASE) prior to mechanical harvesting. Rates of 200, 300, and 400 ppm were used. Each test consisted of four treatments replicated three times. The same procedure was used for collecting and storing samples as in the machine tests. The harvesting system consisted of the rotating-mass limb shaker, drip-line rake, and offset pickup machine. The harvesting rate was the same as in the previous test. The sample location and treatments respectively were: 1) hand-picking, 2) tumbler—hand picking, 3) ground—rotating-mass limb shaker, 4) high-lift truck—rotating-mass limb shaker, drip-line rake, offset pickup. Fruit decay counts were evaluated as in the machine test.

Statistical analysis

The machine test data were subjected to Duncan's new multiple range test to evaluate mean differences for treatments. Data from the chemical test were subjected to analysis of variance to evaluate mean differences for treatment. The 5% level was considered significantly different.

Results and Discussion

The decay results of the machine tests are shown in Table 2. Samples from the slider-crank limb shaker (treatment 5) had the highest 3-yr percentage of average decay of the three mechanical harvesting removal methods. The total fruit decay resulting from treatments 8 and 9 did not differ significantly. This result indicated that both harvesting systems caused approximately the same amount of mechanical damage. The tumble treatment with 90 sec of tumbling (treatment 2) caused more decay potential than any other treatment. However, according to the Duncan's test, there was no significant difference between the results of treatments 2, and 9. Results of the machine tests indicated that mechanical handling of the fruit increased the decay potential of the fruit with each succeeding operation in the harvesting system. The normal time between picking oranges and processing is usually 2 days or less. The decay results for samples checked after 3 days varied from an average of 1.7% for hand-picked samples (treatment 1) to 5.4% for the total slider-crank limb shaker system (treatment 9), which is considerably less than decay after 7 days and would be acceptable for processed products. However, mechanically harvested fruit sprayed with an abscission chemical should be utilized as soon as possible after harvest.

Table 2. Machine test—3-yr decay average of 'Valencia' oranges sprayed with 350 ppm RELEASE, after 7 days storage at 70°F, 88%RH.

Treatment no.[z]	Decay, %[y]	Standard deviation
1	3.7 a	3.6
2	28.9 f	15.6
3	13.9 bc	7.9
4	11.0 b	6.6
5	15.4 c	9.0
6	17.5 cd	9.5
7	20.0 d	11.8
8	24.4 e	11.7
9	26.8 ef	15.3

[z]See Table 1 for descriptions of treatments.
[y]Values followed by unlike letters are significantly different at the 0.05 level of probability according to Duncan's multiple range test.

Analysis of variance of the fruit decay indicated that the level of chemical application used caused significant differences according to the F test. The results of the chemical tests are shown in Table 3. Fruit sprayed with 200 ppm had the lowest decay average over the 3-year of testing. Fruit sprayed with 300 ppm had a higher average decay potential than did the 400 ppm application. The inconsistency can probably be attributed to the variable weather conditions, which highly influence the chemical activity. Low rates of chemical application generally result in less decay potential of mechanically harvested fruit than high rates of chemical application.

Table 3. Chemical test with 'Valencia' oranges sprayed with abscission chemical RELEASE and stored at 70°F and 88% RH for 7 days.

Treatment no.		3 yr average of % decay at three rates		
		200 ppm	300 ppm	400 ppm
1	Hand picked	2.0	6.3	4.3
2	Sample from tumbler—hand picked	19.3	33.3	25.7
3	Sample from ground—harvested with rotating-mass limb shaker	8.3	17.0	15.0
4	Sample from Hi-lift truck—harvested with rotating-mass limb shaker, drip-line rake, offset pickup	21.0	21.0	19.0

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