Shaker Methods for Selective Removal of Oranges

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ABSTRACT

FIVE fruit removal methods were evaluated on three dates in each of 3 years under simulated commercial conditions to determine their ability to selectively remove mature 'Valencia' oranges without damage to the following year's young fruit crop. Fruit yields were not materially affected by harvesting at 90 percent removal efficiency with shaker removal methods early in the season before young fruit drop diminished. The slider crank shaker plus abscission chemical (RELEASE) removal method reduced subsequent fruit yield the least and the air shaker plus abscission chemical method reduced subsequent yield the most. Application of the abscission chemical did not affect the subsequent fruit yield response to the shaker-catchframe removal method.

INTRODUCTION

The Florida citrus industry produced approximately 6.7 million t (7.4 million tons) of oranges on 231,000 ha (572,000 acres) during the 1978-79 season (Florida Agricultural Statistics—Citrus Summary, 1979). About 40 percent of this production was the 'Valencia' cultivar, which is very desirable for processing (about 93 percent of the 1978-79 production was so used). Valencia normally reaches maturity suitable for processing after young fruit for the next crop have formed. Harvesting is done between April and July and at peak periods it requires about 35,000 pickers. Picking is strenuous and hazardous, and during periods when more desirable work is available, the industry experiences a shortage of pickers. The Valencia is harvested during warm and hot season of the year when workers start migrating to harvest other crops in states with cooler weather. Mechanical harvesting is expected to improve working conditions, reduce the drudgery of picking fruit, improve safety, and encourage year-round employment.

Mechanical harvesting systems with shakers to remove the oranges have been developed and demonstrated (Coppock, 1976; Sumner, 1977; Whitney and Sumner, 1977). Acceptance of these systems for Valencia oranges has been limited because of yield reductions, thought to be caused by excessive removal or injury to the young crop. An abscission chemical, RELEASE (5-chloro-3-methyl-4-nitro-1H-pyrazole), manufactured by Abbott Laboratories, has shown good potential for improving these shakers by selectively loosening only the mature fruit (Wilson et al., 1977).

Care must be taken during harvest to prevent removing or injuring young fruit. The young fruit increases in diameter, mass, and bonding strength as the harvest season progresses, thereby causing variable harvest conditions. Also, young fruit drop naturally during about a 6-week period beginning just after bloom. The interaction of these changes with the fruit detachment equipment plus varying weather conditions, makes selective mechanical harvesting of Valencia oranges difficult.

The effectiveness of shakers in conjunction with an abscission chemical in harvesting Valencia oranges depends primarily on (a) the level and uniformity of mature fruit loosening obtained from application of abscission chemical, (b) type of shaker used and its operation, and (c) stage of young fruit development at harvest. The effectiveness of abscission chemicals depends on weather and on the condition of the trees at the time of application. During the Valencia harvest season there is a period when mature fruit becomes less responsive to the abscission chemical (usually in May and early June) and a higher-than-normal application rate is required (Wilson et al., 1977).

This report covers a 3-year study (1976, 1977, 1978) to evaluate shaker fruit removal methods under simulated commercial conditions for their effectiveness in the selective removal of Valencia oranges as measured by differences in subsequent fruit yields.

MATERIALS AND METHODS

An experiment was established in a Valencia orange orchard typical of many older orchards grown on the ridge section of Florida. The orchard was situated on slightly rooling terrain with trees on rough lemon rootstock, spaced 7.6 m × 7.6 m (25 ft × 25 ft) and ranging in height from 6.1 m to 7.6 m (20 ft to 25 ft). The trees were hedged to a 2.5-m (7-ft) wide middle and undesirable limbs were removed in 1975. This pruning operation reduced the 1976 average yield from 408 to 286 kg (900 to 630 lb) per tree. The experiment consisted of five fruit removal methods (Table 1) evaluated on three different harvest dates (tests) spaced over the harvest season, which extends from April to July. Shaker-catchframe plus abscission chemical method (SNC) was omitted in Test 3 because a test was not essential at this date and it would have caused an unnecessarily large yield reduction. In each test, removal methods were assigned to single plots consisting of 43 to 45 trees in single rows. Three single-row plots were handpicked

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TABLE 1. DESCRIPTION AND PERFORMANCE OF FRUIT REMOVAL METHODS AVERAGED OVER 3 YR

Fruit removal methods*	Description	Fruit removal rate, trees/h	Fruit removal, % of yield
SNC	Slider-crank limb shaker mounted on catch frame (Coppock, 1971). Shaker speed variable to 5 Hz (300 cpm) with 181.5 kg (400 lb) unbalanced mass and 203-mm (8-in.) stroke. Total shaker mass of 272 kg (600 lb).	10	92
SAC	Same as above, except that abscission chemical applied	12	95
SAP	Slider-crank limb shaker (mfg. Roberts Harvester) mounted on self-propelled carriage (Sumner, 1977). Shaker speed variable to 4.2 Hz (250 cpm) with 272 kg (600 lb) unbalanced mass and 203-mm (8-in.) stroke. Total shaker mass of 345 kg (760 lb). Abscission chemical applied.	17	93
RAP	Rotating weight limb shaker mounted on self-propelled carriage (Sumner, 1977). Shaker speed variable to 5 Hz (300 cpm) with 109 kg (240 lb) unbalanced mass and eccentric of C. G. 15.9 cm (6.25 in.). Total shaker mass of 318 kg (700 lb). Abscission chemical applied.	17	94
FAP	Three-fan air shaker (Whitney and Sumner, 1977). Outlet velocity 144 to 193 km/h (90 to 120 mph) at 1.2 Hz (70 cpm) oscillation rate. Abscission chemical applied.	90	87

*(Code) S = slider-crank shaker; N = no abscission chemical; A = abscission chemical; R = rotating weight shaker; C = catchframe; P = ground pickup; F = air shaker.

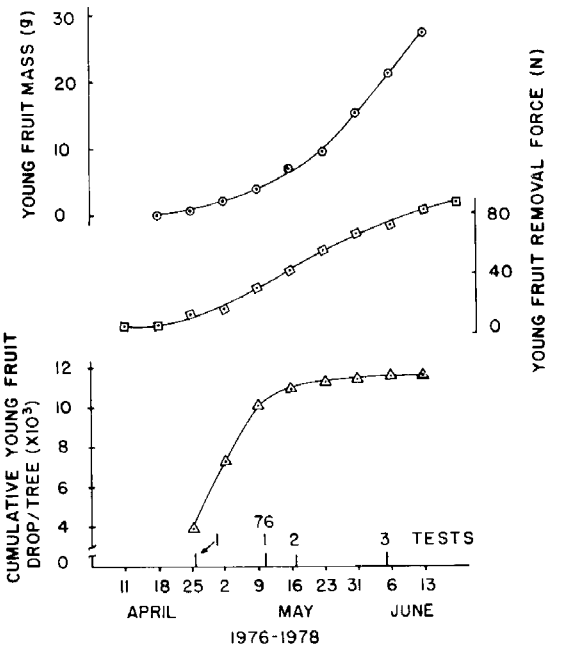

FIG. 1 Composite curves of young fruit mass, removal force, and droppage per tree during 'Valencia' orange harvest season for 1976, 1977 and 1978 seasons showing the approximate time Tests 1, 2, and 3 were conducted.

each season to measure the seasonal effect on fruit yield and to serve as a control for comparing methods.

The abscission chemical RELEASE was applied 4 to 5 days before harvest, with a modified AgTec sprayer manufactured by Ag-Chem Equipment Company, Inc. The spray mixture contained RELEASE in water in amounts for desired concentration and Ortho X-77 surfactant at 0.61 mL per L (2.5 mL per gal) of mixture. The rate of application was at 37.8 to 56.7 L (10 to 15 gal) per tree. The concentration of abscission chemical applied ranged from 250-400 ppm, depending on weather conditions and responsiveness of the fruit at the application time. A second application had to be made occasionally when the material was washed off by rain. For the shaker catchframe plus abscission chemical method (SAC), the chemical was applied at 250 ppm intended to given maximum fruit loosening but resulting in a minimum preharvest drop. For the other three methods in which the abscission chemical was applied, preharvest drop was not a consideration because all of the fruit dropped to the ground rather than caught on catchframes.

The fruit removal devices were operated to remove more than 90 percent of the mature fruit with a minimum removal of young fruit. Actual operation was left to the discretion of an experienced operator. The average young fruit mass, removal force and drop in the plots were determined each week to establish the relative status of fruit development when tests were conducted.

Peformance data were collected by dividing each plot into five 8-tree groups and randomly selecting one tree in each group for measuring fruit removal force (FRF), fruit drop before harvest, and the fruit left on the tree after harvest. Five FRF measurements were taken from each selected tree of the 8-tree groups. Fruit was caught on a catchframe (Coppock, 1976) in removal methods SNC and SAC, and was gathered by a rake-pickup system in the other removal methods (Churchill and Sumner, 1977). Fruit yield for the plots was determined by weighing the fruit gathered and correcting for fruit left on the trees. The effect of the removal methods on fruit yield was determined from the next year's plot yield. The deviations of treatment plot yield from the initial plot yield were compared with the deviations of the handpicked plot yield (control) from initial handpicked plot yield.

RESULTS AND DISCUSSION

The abscission chemical reduced the FRF by an average of 71 percent compared to the control. Preharvest drop of fruit ranged from 5 to 50 percent over the 3-year test period. The average percentage of fruit removed with the different methods ranged from 87 to 95 percent and the air shaker was the lowest (Table 1).

The composite curves in Fig. 1 of average young fruit mass, removal force and cumulative drop over 3 seasons show the relative status of young fruit development when tests were conducted. Test 1 in 1977 and 1978 was conducted early in the season when the young fruit mass and removal force were relatively small and when young fruit drop was large. Test 1 in 1976 was conducted later in the season, near the end of the natural fruit drop. Tests 2 and 3 were conducted at a time when the young fruit mass and removal forces were rapidly increasing and fruit drop was diminishing.

Fig. 2 shows the average initial (1976) and subsequent fruit yields per tree for the fruit removal methods tested in 1976, 1977, and 1978 seasons. Handpicked (HP) plots were harvested near June 1 each year as a control. The percent deviation of subsequent yields from the initial

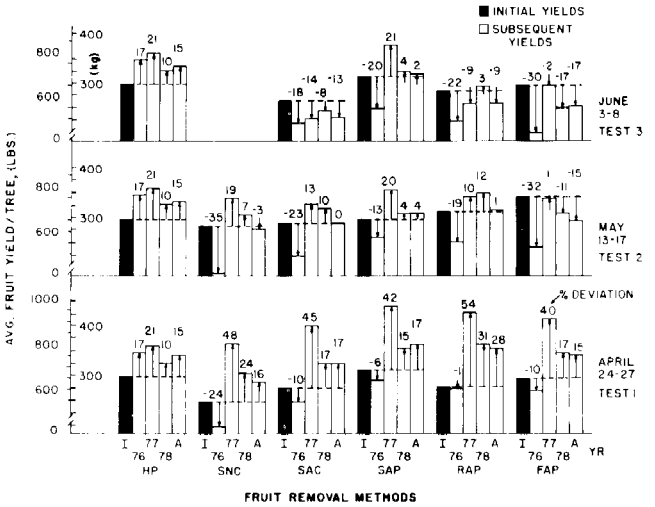

FIG. 2 The initial and subsequent plot yields and the percentage deviation of subsequent from initial plot yields for handpicked (HP) and 5 other fruit removal methods used in the 1976, 1977 and 1978 seasons. The removal methods code is: S—slider-crank shaker; N—no abscission chemical; A—abscission chemical; R—rotating weight shaker; C—catchframe; P—ground pickup; F—air shaker.

yield was used to measure effects of removal methods. Deviation will be used in this context. The deviations for handpick control were + 17, + 21 and +10 percent for 1976, 1977 and 1978 seasons, respectively, and reflect seasonal variation and tree recovery from the 1975 pruning.

The first harvest in 1976 (Test 1) was made about 2 weeks later in the season (May 10-12) than the first harvest in 1977 and 1978. The natural young fruit drop had diminished and may have contributed to the generally large negative deviation in the next year's yield for all removal methods. Yield deviations among removal methods in Test 1 (1977) ranged from + 40 to + 54 percent—about twice the + 21 percent for the handpick control. The response was similar in 1978. These results indicate that all mechanical methods may have caused less young fruit to drop during the natural drop period. The physiological aspect of this response needs further study. Comparing the deviations of the 3-year average yield of the removal methods with handpick control indicates the mechanical methods had no detrimental affect on fruit yields in Test 1.

Test 2 (May 13-17) in 1977 and 1978 showed a yield response pattern to the removal methods similar to that of Test 1, in that the deviations were positive. FAP method was an exception with a − 11 percent deviation. Comparing the deviations of the 3-year average yield of Test 2 for mechanical removal methods with the handpicked control indicates all methods tended to decrease subsequent fruit yield.

In Test 3, the yield deviations for all methods were largely negative except for the SAP method which in 1977 was comparable to the + 21 percent deviation of the handpicked control.

Generally, the SAP method reduced subsequent yield the least, with 3-year average yield deviations of + 17, + 4, + 2 percent for Tests 1, 2, 3, respectively. The FAP method reduced subsequent yield the most with 3-year average yield deviations of + 15, − 15, − 17 percent for Tests 1, 2, 3, respectively. The deviation of the 3-year average yield of the handpicked control for all test was + 15 percent, indicating the mechanical removed methods had no effect on yield in Test 1 but reduced yields in Tests 2 and 3. Comparison of method SNC with SAC indicated little yield response to the abscission chemical.

CONCLUSIONS

Shaker removal methods selectively harvested mature Valencia oranges without materially affecting long-term subsequent yields when used early in the season before young fruit drop diminished. Subsequent yields of trees harvested with shaker methods after the young fruit drop diminished were generally reduced. The slider-crank shaker plus abscission chemical method (SAP) reduced subsequent yields the least and the air-shaker plus abscission chemical method (FAP) reduced subsequent yields the most when compared over years and harvest dates. The abscission chemical did not affect the subsequent yield response to the shaker-catchframe method.

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