Four Years Of Abscission Studies On Oranges[1]

Abstract

There are 3 compounds which are known to effectively promote abscission of oranges. Typical results from spraying 'Hamlin' oranges showed that CZ-150 (hexamic acid) or ascorbic (or erythorbic) acid at 1-½% reduced the pull force from 14.5 to 7.0 pounds and per cent plugs from 90 to 5% within 6 days of application. Cycloheximide at 10 ppm caused a reduction to 5.0 pounds and 0% plugs. Cycloheximide appears to be practical for producing abscission of 'Valencia' oranges, provided application is no earlier than 8 weeks after bloom. Both CZ-150 and ascorbic (or erythorbic) acid effectively loosened mature 'Valencia' oranges, but may cause injury to the young green fruit with subsequent crop reductions as high as 80%. Commercial companies have applied for experimental labels on CZ-150 and cycloheximide. Ascorbic and erythorbic acids are classified as generally recognized as safe, and no USDA registration appears to be necessary for their use as an abscission spray.

Abscission chemicals have been shown to be effective harvesting aids, but the present chemicals have certain drawbacks. Some major problems encountered are reduction in effectiveness due to adverse weather conditions, inability of a chemical to effectively loosen all the fruit on the tree, and inability to loosen fruit without peel injury.

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Introduction

The development of more effective abscission chemicals has progressed greatly in the past 4 years. At the beginning of the period, only iodoacetic acid showed promise of producing useful abscission (4), although considerable defoliation often resulted from the treatments. Still, this compound was a necessary step in the development of these chemicals and served to create interest in this area. Since this time, several compounds have been found to initiate abscission of oranges with little or no defoliation. Ascorbic (AA) or erythorbic (EA) acid combined with other weak acids has proven an effective treatment (2, 6), and CZ-150 (hexamic acid) has also proven to be effective (7). An entirely different type chemical, cycloheximide (CHI) was shown to produce abscission of oranges and, in fact appeared to have some superior qualities when compared to other chemicals under test (3).

With the citrus labor situation becoming more acute each year, an overall move by the industry toward commercial usage of mechanical harvesting devices appears to be taking place. Therefore, the purpose of this paper is to present information concerning potential commercial performance of these chemicals, with particular emphasis on information relating to their current use by growers.

Materials and Methods

Whole citrus trees were sprayed with various chemicals, and pull tests were made on the fruit as described by Hendershott (4). Fifteen gallons of spray solution per tree was applied to most trees, unless speed-sprayer tests of large numbers of trees were made. In these cases, from 5 to 10 gallons of solution per tree were used. Ortho spray sticker was used with most of the tests with CZ-150 and AA or EA. From 0.0375 to 0.075% spreader, furnished by the Upjohn Company, was used with CHI sprays. Several commercial companies furnished many of the products tested.[2] Ratings of abscission inductiveness were based on the ability of the chemical to reduce the bonding force between the stem and fruit.

The information reported was obtained from the studies on many trees. Often the results of a test involved the collection of information where treatments included spraying from 1 to 30 or more trees. Because of the vast amount of in-

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[2]The following commercial companies furnished chemicals reported in this paper: Abbott Laboratories, Chas. Pfizer & Co., Inc., Hoffman-La Roche, Inc., The Upjohn Co., and Ortho Div. of Chevron Chemical Co. There were many other contributors to the abscission project, but results of their products are not reported here.

Table 1.--The effects of CZ-150 (hexamic acid) sprays on the removal (pull) force of interplanted Hamlin (HA) and Pineapple (PA) oranges.[1]

Chemical/conc.	Pull force (lb) 3 day post	4 day post	5 day post
1 lb/15 gal HA	8.9*	8.4*	8.8*
2 lb/15 gal HA	8.2*	8.4*	7.2*
Control HA	12.9	12.2	12.0
1 lb/15 gal PA	15.8	14.2	9.7*
2 lb/15 gal PA	7.5*	7.4*	6.3*
Control PA	12.7	14.5	12.0

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Table 2.--A comparison of the effects of various acidic phosphate additives on CZ-150 (hexamic acid) abscission activity.[1]

Concentration/additive	lb force	% plug
Control	19.01	60
3% CZ-150 only	16.52	50
4% CZ-150 only	11.93	20
3% + .05% phosphoric acid	14.79	35
4% + 0.05% phosphoric acid	11.05	5
3% + 0.1% phosphoric acid	15.60	30
4% + 0.1% phosphoric acid	1.86*	0
3% + 0.13% $(NH_4)_2$ H PO_4	14.29	25
4% + 0.13% $(NH_4)_2$ H PO_4	12.78	30
3% + 0.12% NH_4 H_2 PO_4	13.34	25
4% + 0.12% NH_4 H_2 PO_4	12.04	20
3% + 0.14% Na H_2 PO_4	15.30	20
4% + 0.14% Na H_2 PO_4	10.27	10

[1]Branch sprays of Valencia oranges using 10 fruits

mation collected this season, representative results were often taken to illustrate a particular situation. Care was used not to select the very best or worst information available for any one treatment or chemical.

Results

CZ-150 produced acceptable loosening of early and midseason oranges as shown in Table 1. As has often been observed in past tests, the 'Pineapple' variety responded to the abscission spray slightly better than 'Hamlin.' The 2 varieties had been interplanted in this test. The 2 lb/-15 gal (1.75%) concentration was more effective than the 1 lb/15 gal (0.87%) concentration.

When various acidic phosphates were combined with CZ-150, its effectiveness was enhanced (Table 2), with the most striking drop in pull force resulting from the 4% CZ-150 + 0.1% phosphoric acid applications. In numerous other tests with CZ-150 conducted throughout the fruit season, the inclusion of 0.05 to 0.25% phosphoric acid usually enhanced fruit loosening. Higher concentrations caused excessive leaf drop.

Tests with AA or EA during the 1968-69 fruit season were essentially the same as those of CZ-150, and the results were very similar to those obtained in previous years (6, 7).

Some variation in responses due to variety, location, and condition of the fruit were noted with CZ-150 (Table 3). Seedling oranges appeared to be more responsive to abscission chemicals than the standard budded varieties tested, and oranges which had been partially frozen appeared to be more sensitive than unfrozen oranges. Fruit maturity seemed to be relatively unimportant provided it was not abnormally green or overly ripe (senescent). The presence of residual amounts of synthetic auxin weed killers in the soil[3] apparently reacted adversely with applied abscission chemicals which reduced the effectiveness of CZ-150 (as well as other compounds which were under test).

[3]Evidently a spray containing 2,4-D or 2,4,5-TP had been applied for vine control during the preceding summer.

Table 3.--A comparison of tests made with CZ-150 sprayed at different dates on several varieties of oranges at various locations in the State.

Variety	Date sprayed	Grove location	Concentration (%)	Pull force (lb)	% plug
Hamlin	11/25/68	SF	1-3/4%	9.3+	20
Hamlin	11/25/68	SF	7/8%	11.8++	80
Hamlin	-	SF	Control	15.6	76.6
Hamlin	12/8/68	LB	2% (pH 1.5)	5.2+	6.7
Hamlin	12/8/68	LB	1% (pH 1.8)	10.2++	68.3
Hamlin	-	LB	Control	14.6	100
Hamlin	1/6/69	R-1	1-1/2%*	6.9+	-
Hamlin	-	R-1	Control*	13.5	-
Parson Brown	1/17/69	R-2	1-1/2%*	4.4+	-
Parson Brown	-	R-2	Control*	13.0	-
Seedling Pineapple	1/16/69	SF	1-1/2%	4.7+	0
Seedling Pineapple	1/16/69	SF	3/4%	6.9+	6.7
Seedling Pineapple	-	SF	Control	14.5	93.3
Pineapple	1/15/69	LB	2%**	10.5++	17.8
Pineapple	1/15/69	LB	1%**	13.3	60
Pineapple	-	LB	Control**	14.7	88
Pineapple	2/1/69	SB	1-3/4%	6.3+	0.0
Pineapple	2/1/69	SB	7/8%	9.7++	20
Pineapple	-	SB	Control	14.5	80

* Fruit showing slight to moderate freeze injury.

** + Residual amounts of synthetic auxin weed killers present in soil.

+ Significant from control at 1% level.

++ Significant from control at 5% level.

SF = Southern Fruit Distributors (Winter Garden).

LB = Coca Cola Company (Lynchburg block), west of Lake Alfred.

R-1 = Roper grove, Winter Garden (15 miles south).

R-2 = Roper grove, Winter Garden (25 miles south).

SB = Coca Cola Company (Summit block), north of Lake Alfred.

CHI produced somewhat better results than AA, EA, or CZ-150. A typical comparison of abscission test results, and other related factors, between CHI and CZ-150 applied to 'Hamlin' oranges is shown in Table 4. At optimum concentration, CHI appeared to produce abscission slightly faster than CZ-150, and observations relating to weather indicate strongly that CHI is less subject to rains following spraying than the weak acids. However, field observations indicated a 24-hour dry period following spraying of all compounds appeared beneficial. CHI caused a moderate to severe pebbling of the fruit peel in contrast to the distinct peel burn caused by the weak acids. None of the chemicals produce abscission suitable for fresh fruit, but the peel injury should not prevent processing the fruit.

CHI was the only acceptable chemical for the 'Valencia' variety according to 1 year's data available with this compound. Eight weeks following full bloom, which occurred about April 3, 1969, and using concentrations of 25 ppm, 'Valencia' oranges loosened with little or no leaf drop and no injury to the immature, green fruit (Table 5). Prior to this time, extensive injury to the young, green fruit occurred; and heavy foliage loss often resulted. Spraying 'Valencia' oranges before blooms opened also caused extensive leaf and blossom shedding.

The increase in young fruit loss following a spray of 15 ppm CHI applied April 28, 1969, is graphically shown in Figure 1. Mechanical shaking of the treated and control trees produced much more young fruit drop with the former.

The weak acids AA, EA, and CZ-150 successfully loosened mature 'Valencia' oranges in tests made this season and in past seasons (7); but severe pitting and development of necrotic (dead) areas on young, green fruit was always noted. Although young fruit did not fall immediately, in every case it was obvious by the following spring (when the crop had matured) that trees sprayed with these compounds had markedly reduced crops. Reductions occurred whether the trees were sprayed in March (before bloom) or as late as early June.

Major problems relating to weather conditions were noted occasionally in past years, but were particularly acute during portions of the 1968-69 fruit season. Specific reasons for failures due to weather were difficult to document as specific instrumentation for this purpose was not attempted. However, a comparison of Weather Bureau records and

Table 4.--A comparison of the abscission-producing ability and related factors of CZ-150 (hexamic acid) and cycloheximide applied as dilute sprays to Hamlin oranges.

	CZ-150	Cycloheximide
Typical pull force at optimum concentration[1]	7.0 lb	5.5 lb
Number of days required to produce loosening	4-6	3-5
Amount of peel injury	Slight to moderate	Moderate to severe
Dry period necessary (no rain)	At least 1 day	Few hours
Effective concentration	1-1/2% (15,000 ppm)	5-20 ppm

[1]Both compounds consistently produced pull force reductions significant from the control at the 1% level.

test results obtained indicated that, in general, periods of cold temperatures (night temperatures in the 30 to 40° F range, day temperatures not exceeding 65° F) and dry conditions caused an overall delay in abscission-producing effects of all chemicals, but usually did not otherwise prevent obtaining good fruit abscission. Typical delays ranged from a few days up to 2 weeks longer than the normal abscission-induction period of 4 to 6 days. Cold, relatively rainy periods often resulted in failures of all compounds tested. The weak acids appeared to be more subject to losses due to adverse weather conditions than CHI (Table 6).

Discussion

Although CHI appeared to be somewhat more effective in producing fruit loosening than AA, EA, or CZ-150, the latter compounds produced acceptable results. Field experience has shown that reduction of the pull force of the fruit below 6.0 pounds, measured by the standard pull tester (4), may cause excessive fruit drop which could interfere with mechanical harvester operations. Therefore, pull force reduction by a chemical to the range of 5.5 to 7.5 pounds force would appear to be sufficient.

In other areas of comparison, CHI is advantageous in that a very small concentration is necessary to produce abscission, thus eliminating the logistics problem created by using large quantities of chemicals. Although the compound is relatively toxic, residue studies made by the Upjohn Company (5) on citrus products, manufactured at the Florida Citrus Experiment Station from fruit sprayed with CHI, indicated no detectable amounts of the chemical should remain when the fruit is processed. Because of the recent ban on the use of cyclamates by FDA, the question of issuance of residue tolerances for CZ-150 (hexamic acid) is now very much in doubt. However, AA and EA are safe and evidently no USDA registration is necessary for their use. Experimental labels have been requested from FDA by the respective manufacturers of CZ-150 and CHI.

The biggest problem with the weak acids has been the cost of the compounds. Tests at the Citrus Experiment Station indicate that $1 per tree, for one which has at least 5 boxes, is the maximum allowable cost for chemical and spray application where the purpose is to augment operation of an inertia shaker (1). For use in increasing the efficiency of picking crews, such sprays might have to be substantially lower in price to justify their use. It is hoped that all these compounds can be mar