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Relative Effectiveness of Dilute and Concentrated Abscission-chemical Sprays in Loosening 'Valencia' Oranges from Trees[1]

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Additional index words. cycloheximide, glyoxal-dioxime, 5-chloro-3-methyl-4-nitro-1H-pyrazole

Abstract. **Ethylene production, hydrolytic enzyme activity, and fruit removal force (FRF) were more uniform and consistent when abscission chemicals were applied as dilute as compared to concentrated sprays to 'Valencia' orange (*Citrus sinensis* (L.) Osbeck). Cycloheximide (Acti-Aid), glyoxal-dioxime (Pik-Off), 5-chloro-3-methyl-4-nitro-1H-pyrazole (Release), and Acti-Aid plus chlorothalonil (Sweep) were applied to 'Valencia' orange branches, each holding 100 to 120 fruit. The FRF's resulting from commercial concentrate and dilute sprays of Acti-Aid and Acti-Aid plus Sweep were similar to those in the branch tests. Equal amounts of chemical were applied in the dilute and concentrate sprays. Likely, the variation in coverage from concentrate sprays caused ethylene levels to vary greatly in the fruit (0 to 5.7 ppm). In turn, levels of hydrolytic enzyme activity varied as much as 10×, and fruit loosening was inconsistent (0 to 9.7 kg FRF). Release and Acti-Aid plus Sweep were more consistent than Pik-Off and Acti-Aid in dilute spray applications.**

Few studies have focused on the effectiveness of low-volume (concentrate) applications of abscission-inducing chemicals on citrus fruit (1, 3). Observations in the field have led to the conclusion that concentrated sprays are not effective (10), but little data are available to substantiate the conclusion. Low-volume applications of pesticides have been evaluated in numerous studies and have been recently reviewed (5, 8, 9).

Citrus fruit are loosened almost exclusively by use of dilute spray applications (2, 3, 4, 10), and up to 5,000 liters/ha (approximately 500 gal/acre) may be needed for good coverage of large trees. If more concentrated sprays could be used, such that the application rate need only be, say, 500 liters/ha (50 gal/acre), savings in time, fuel, equipment size, and water use could be realized.

The effectiveness of most abscission chemicals used on citrus is due to ethylene generated by the rind when wounded; (2-chloroethyl)phosphonic acid (ethephon) is an exception.

Acti-Aid, Pik-Off, Release, Acti-Aid plus Sweep, and other combinations loosen citrus fruit to different extents. The extent of loosening also depends on cultivar, temperature, moisture, tree condition (3), and completeness of the spray application on the fruit. Nevertheless, low-volume applications can cover fruit (5) by greater number of small droplets while the chemical dosage remains the same.

The purpose of this study was to determine the relative effectiveness of high- and low-volume applications of abscission

[1]Received for publication July 7, 1979. This paper reports the results of research only. Mention of a pesticide or proprietary product in this paper does not constitute a recommendation by the U.S. Department of Agriculture nor does it imply registration under FIFRA.

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chemicals in loosening 'Valencia' oranges from trees, and to determine why one type of application is superior to the other.

Materials and Methods

Branches of 'Valencia' orange trees with 100 to 120 fruit were sprayed in April with Acti-Aid, Pik-Off, Release, or Acti-Aid plus Sweep. Dilute sprays were applied at a rate of 20 liters/tree; and concentrates, at a rate of 2 liters/tree. The trees were sprayed between 10 and 12 AM on days with no rainfall and temperatures ranging from 26 to 31°C. Hand sprayers (8.5 liter) were used, and the nozzles and spray pressure were adjusted so that spray deliveries approximated those from concentrate or dilute applicators. Droplet size was not measured, but the branches were covered from the outside by each type of application. Triton X-100 (0.1%) was used as a wetting agent, and each treatment was replicated 3 times (Tables 1 and 2).

Acti-Aid and Acti-Aid plus Sweep were applied by commercial concentrate and handgun dilute sprayers to 'Valencia' orange trees in one whole tree test with 3 replications of 2 trees each. The FRF of 20 fruit per tree was measured 5 days after application.

Internal ethylene concentrations, hydrolase levels, and loosening were determined by previously described methods (7) 3 days after spray applications. Ten fruit were used for each analysis and replication. Carboxy methyl cellulose (CMC) was used as a substrate for hydrolase activity, and the results are presented in Fig. 1 and 2 as decrease in viscosity hr^{-1} per 10 separation zones.

Table 1. Internal ethylene concentration of fruit and fruit removal force (FRF) 3 days after dilute spray application.[z]

Treatment (ppm)	Ethylene (ppm)		FRF (kg)	
	Avg	Range	Range	Avg
Acti-Aid				
5	0.2	0.0 – 0.4	7.4 – 8.4	7.8
15	1.6	0.9 – 2.3	4.7 – 6.8	5.4
Acti-Aid + Sweep				
5 + 125	0.4	0.1 – 0.8	5.1 – 8.1	6.7
15 + 125	3.3	2.4 – 4.2	2.2 – 3.4	3.1
Pik-Off				
150	2.1	1.1 – 3.1	1.2 – 4.8	3.7
300	4.0	2.1 – 6.4	1.0 – 4.2	2.9
Release				
125	1.2	0.4 – 1.8	3.0 – 5.4	4.7
400	3.6	2.8 – 4.1	0.4 – 3.1	2.8
Control	0.1	0.0 – 0.1	7.1 – 9.4	8.7

[z]Values are averages of 3 replications, each of which consisted of 10 fruit.

Table 2. Internal ethylene concentration of fruit and fruit removal force (FRF) 3 days after concentrated spray application.[z]

Treatment (ppm)	Ethylene (ppm)		FRF (kg)	
	Avg	Range	Range	Avg
Acti-Aid				
50	0.5	0.0 – 1.1	5.1 – 10.2	8.2
150	1.3	0.8 – 1.9	3.2 – 9.4	6.4
Acti-Aid + Sweep				
50 + 125	0.6	0.0 – 1.1	2.6 – 9.7	7.1
150 + 125	2.4	0.5 – 4.1	0.0 – 8.1	4.2
Pik-Off				
1500	1.5	0.1 – 3.1	0.0 – 8.9	7.8
3000	2.6	0.3 – 5.7	0.0 – 7.8	2.9
Release				
1250	1.0	0.1 – 2.1	2.3 – 8.8	4.0
4000	2.6	0.5 – 4.5	0.0 – 7.4	3.4
Control	0.1	0.0 – 0.2	6.4 – 9.2	8.1

[z]Values are averages of 3 replications, each of which consisted of 10 fruit.

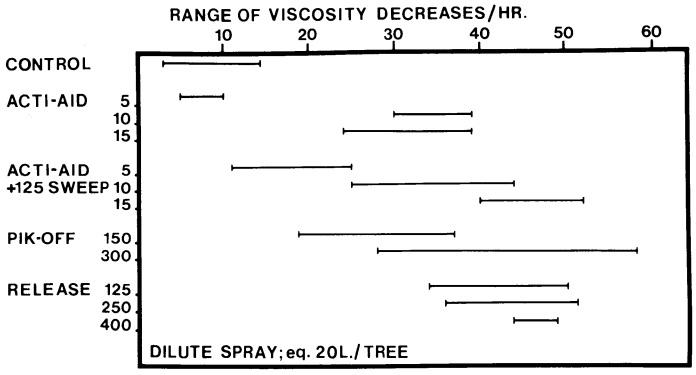

Fig. 1. Decrease in viscosity (centipoises) of carboxy methyl cellulose by hydrolytic enzymes in separation zone tissue of fruit with dilute spray; 10 fruit per sample.

Results and Discussion

Dilute sprays. Averages and ranges of ethylene levels in the fruit increased as the concentration of chemical increased (Table 1). FRF values decreased as ethylene increased. Average internal ethylene concentration was highest in fruit sprayed with 300 ppm Pik-Off; however, the range of ethylene levels was also greatest. The range of FRF values reflect this high variability. If only the average FRF values are considered, Acti-Aid plus Sweep, Pik-Off and Release at the highest rates of application caused nearly equal loosening of the fruit. The other ethylene levels and ranges are similar to those reported before (6) and reflect the variability of field-plot experiments.

Concentrate sprays. Internal ethylene levels were lower and the ranges in ethylene levels generally wider than those found in fruit sprayed with dilute solutions (Table 2). Also, the FRF ranges were broader for the concentrated sprays than for the dilute sprays. The concentrated sprays caused complete loosening in some cases and none at all in others within the same treatment. The range of FRF was the narrowest for unsprayed fruit (6.4 to 9.2 kg) and second and third narrowest for the Acti-Aid-treated fruit, but the amount of loosening with either level of Acti-Aid is not sufficient for mechanical harvest.

Hydrolytic enzymes. The hydrolytic enzyme activity in separation-zone tissue, when measured by decrease in viscosity

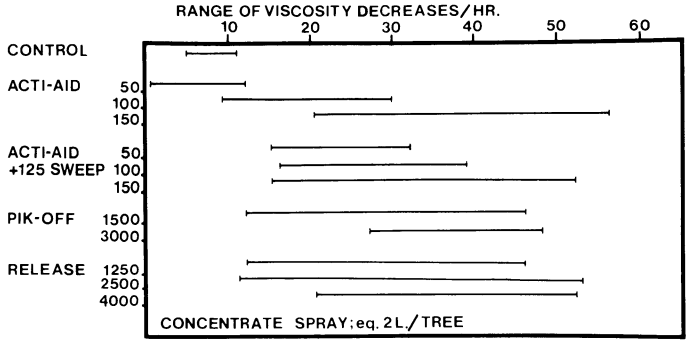

Fig. 2. Decrease in viscosity (centipoises) of carboxy methyl cellulose by hydrolytic enzymes in separation zone tissue of fruit with concentrate spray; 10 fruit per sample.

Table 3. FRF of 'Valencia' oranges 5 days after dilute and concentrate applications of Acti-Aid and Acti-Aid plus Sweep.[z]

Treatment[y] (ppm)	FRF (kg)	
	Avg	Range
Dilute Acti-Aid		
10	7.1	6.1 – 9.1
20	3.2	2.1 – 4.7
Dilute Acti-Aid + Sweep		
10 + 125	5.2	4.4 – 6.8
20 + 125	2.7	1.4 – 5.3
Concentrate Acti-Aid		
100	6.2	3.7 – 8.4
200	3.6	0.4 – 8.7
Concentrate Acti-Aid + Sweep		
100 + 125	5.8	2.9 – 9.2
200 + 125	3.2	0.0 – 8.7
Control	9.1	6.8 – 10.1

[z]Values are averages of 3 replications, 2 trees each, 20 fruit per tree.
[y]Dilute spray applied to runoff; concentrate spray applied 10× with commercial concentrate sprayer.

of CMC, was more variable in fruit sprayed with the concentrated rather than dilute abscission chemicals (Fig. 1 and 2). Enzyme activity in separation zones of fruit sprayed with dilute Pik-Off was more variable than in other fruit. Apparently, Acti-Aid levels were not high enough to increase enzyme activity sufficiently for good loosening. Release was the most efficient of the dilute sprays, as judged from consistency (Fig. 1). All concentrate sprays were more variable and inconsistent in increasing enzyme activity than dilute sprays (Fig. 2).

Whole tree tests. FRF averages of 'Valencia' oranges receiving comparable levels of Acti-Aid were nearly the same regardless of type of application (Table 3). Sweep increased the effectiveness of Acti-Aid slightly in these tests. However, the ranges resulting from the concentrate sprays were greater than those resulting from dilute applications. Only the 20 ppm dilute application of Acti-Aid or Acti-Aid plus Sweep resulted in consistent loosening. These trees were not mechanically harvested, but hand shaking of branches caused 93% harvest of fruit from trees receiving dilute sprays versus 72% from the trees receiving concentrate sprays. Therefore, if the 2 types of sprays are to be evaluated, the ranges of FRF must be considered. Also, 20% defoliation resulted from the concentrate sprays versus less than 5% from the dilute sprays.

Results of this research and of other studies (1, 2) indicate that concentrate sprays are not satisfactory for citrus fruit loosening. Even the range in FRF for dilute-spray treatments was broader than desired; and in some cases, fruit were not adequately loosened. For efficient mechanical harvest, fruit should be loosened so that the FRF is about 2.5 kg. Otherwise, an excessive amount of fruit would remain on the trees or longer harvest times would be required. Most likely the lack of good coverage of the fruit because of interference from leaves is the reason for the poor performance of concentrated sprays. Excessive defoliation from concentrated sprays has been observed (10). In contrast to abscission chemicals, insecticides are primarily directed onto the leaves, which harbor much of the insect population, and are suitable for use as concentrates. Different rates and combinations of chemicals that are more efficient than single chemicals for loosening citrus fruit (4, 6) would most likely give similar results to those presented here.

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