

Citrus Section

Proc. Fla. State Hort. Soc. 90:1-4. 1977.

COMBINATIONS OF ABSCISSION CHEMICALS FOR LOOSENING OF FLORIDA PROCESSING ORANGES¹

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Additional index words. Release, Acti-Aid, Pik-Off, Sweep, Brix/acid ratio, 'Pineapple', 'Valencia'.

Abstract. Combinations of glyoxal dioxime (Pik-Off) and cycloheximide (Acti-Aid) with and without chlorothalonil (Sweep) were evaluated for abscission of 'Pineapple' and 'Valencia' oranges and compared to combinations using 5-chloro-3-methyl-4-nitro-1H-pyrazole (Release) as the base abscission chemical. All abscission chemical treatments were effective in loosening 'Pineapple' oranges when applied before, but not during, the January freeze. After the freeze, the fruit removal force of untreated fruit dropped 50% and it took 50% less abscission chemical to abscise fruit than before the freeze. With 'Valencia' oranges, addition of Acti-Aid and Sweep greatly improved Pik-Off induced abscission and delayed fruit retightening. However, Pik-Off-based combinations were not as effective or consistent as combinations of Release with Acti-Aid plus Sweep. Acti-Aid and Pik-Off gave adequate 'Valencia' fruit loosening in March and April, but not in May and June. Release and Release combinations with Acti-Aid and Sweep also gave better 'Valencia' fruit abscission in March and April than in May and June, but were much more effective than Acti-Aid and Pik-Off especially during the May-June period. Abscission chemicals and combinations advanced 'Valencia' fruit maturity (Brix/acid ratio) by lowering the acid level. Use of this finding as a practical means of adjusting fruit maturity is under investigation.

A cost of \$6 to \$8 million and an 8 to 10 year development period are currently required to obtain full EPA clearance and to complete all necessary market development tests for a new agricultural chemical. Government regulations have made the development process more difficult and harder to justify, especially in limited acreage crops. Abscission chemical development has reached a stage where new products will be slow to reach the grower. Therefore, it appears that the citrus industry may have only those chemicals now under development for use during the next 5 to 10 years. Cycloheximide (Acti-Aid, trademark of Upjohn Company) is the only chemical with full registration clearance on oranges for processing. Glyoxal dioxime (Pik-Off, trademark of CIBA-GEIGY Corporation) and 5-chloro-3-methyl-4-nitro-1H-pyrazole (Release, trademark of Abbott Laboratories) are currently under development and have received Temporary Tolerance status. Although these chem-

icals generally give satisfactory fruit loosening when used alone, some means to improve their effectiveness was deemed essential (3, 5, 12).

A new approach was tried in 1975 by combining Acti-Aid with chlorothalonil (Sweep, trademark of Diamond Shamrock Corporation). Sweep is not an abscission chemical but enhances Acti-Aid-induced abscission (4). This led to combining Acti-Aid and Sweep with Release, which improved fruit loosening even during the 'Valencia' [*Citrus sinensis* (L.) Osbeck] unresponsive period (5, 10). This paper gives the results of additional tests with these chemicals and combinations and also of tests determining the effectiveness of combinations involving Pik-Off, which has often given erratic loosening, especially with 'Valencia' oranges (3, 4, 5).

Another aspect of the research involved determining the effect of abscission chemicals on fruit maturity, specifically the Brix, acid, and Brix/acid ratio. In addition, the January freeze gave the opportunity to determine the effectiveness of abscission chemicals before, during, and after the freeze.

Materials and Methods

Chemicals were applied to replicate branches of mature 'Pineapple' trees at Lake Wales and 'Valencia' trees at Auburndale, Haines City, and Lake Alfred with pressurized hand sprayers using the standard abscission chemical protocol developed by the Florida Department of Citrus (8, 12). One standard test comparing Release, Pik-Off, Acti-Aid, Release plus Acti-Aid, and Release plus Acti-Aid plus Sweep was conducted 2 to 4 times a week during the entire season. Abscission chemicals were applied with a handgun using 10 to 15 gallons per tree to mature 'Valencia' trees at Haines City to determine their effect on fruit loosening and maturity. All chemicals and chemical combinations except Pik-Off used alone were applied with 0.1% X-77 surfactant. Fruit removal force (FRF) and fruit drop were recorded in the branch tests 7 days after treatment and daily during the whole tree tests. The ° Brix and % acid content of the juice were determined by standard procedures (9) from a sample of 20 fruit per treatment from an April 15 branch test and a 3 bag fruit sample from each whole tree treatment from a May 17 test.

Results and Discussion

The effectiveness of Pik-Off combinations with Acti-Aid and Sweep were evaluated in 'Pineapple' branch tests (Fig. 1). As reported previously, Sweep was not active as an abscission chemical (4). Acti-Aid concn up to 5 ppm caused little fruit loosening and no fruit drop. Pik-Off at 100 ppm reduced the FRF by 47%, by 73% at 200 ppm and by 92% at 300 ppm. Addition of Acti-Aid alone and Acti-Aid plus Sweep increased Pik-Off-induced fruit loosening especially when measured as fruit drop. The most effective treatment was 300 ppm Pik-Off plus 5 ppm Acti-Aid plus 250 ppm Sweep.

¹The authors wish to acknowledge the technical help of J. Cooper, Roxy Hoover, E. R. Harben, and E. H. Rowland.

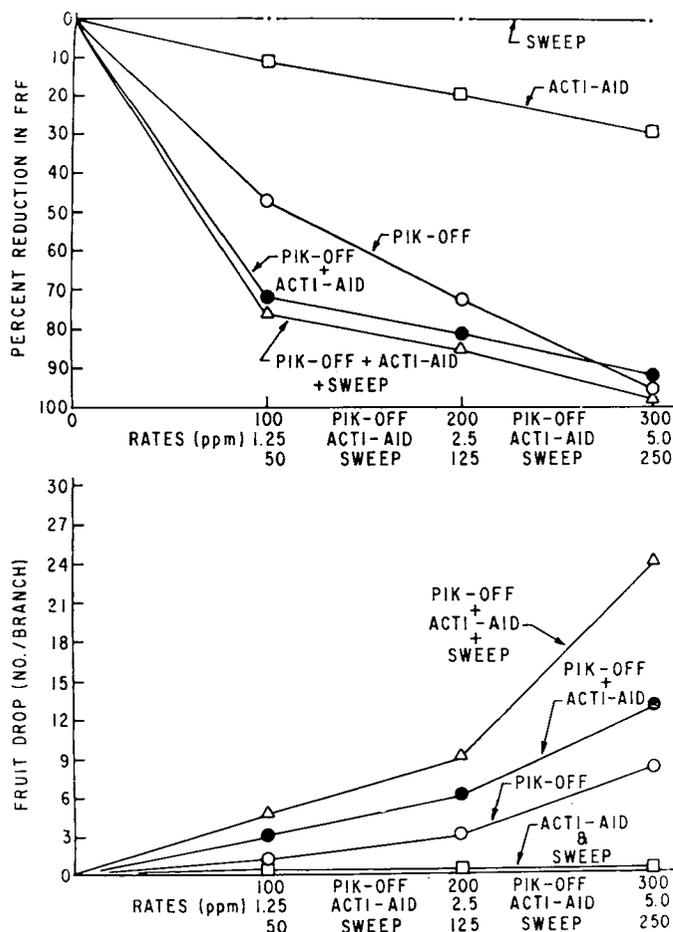


Fig. 1. Comparison of Pik-Off and Pik-Off combinations for reduction in FRF (top) and fruit drop (bottom) of 'Pineapple' oranges in a branch evaluation.

The branch test results with Pik-Off combinations were evaluated on entire 'Valencia' trees and compared to combinations using Release as the base chemical (Fig. 2). When used alone, 300 ppm Pik-Off lowered the FRF only 64% from 23.75 lb to 8.50 lb which may not be adequate for certain types of mechanical harvesting. Fruit treated with Pik-Off began to retighten 4 days after treatment. This observation was noted in 1976 and is believed to result from a short peak period of ethylene production (5). Addition of 2.5 ppm Acti-Aid extended the period of maximum loosening one day while addition of 2.5 ppm Acti-Aid plus 250 ppm Sweep extended the loosening period 2 additional days beyond that obtained with Pik-Off alone. Our results agree with those reported by Rasmussen who demonstrated that the increased fruit loosening period obtained by adding Sweep and Acti-Aid to Pik-Off was due to higher and more prolonged levels of fruit ethylene production (7). However, in contrast to Rasmussen's research, we were unable to obtain good fruit loosening with lower than recommended label rates of Pik-Off (i.e., 300 ppm) in combination treatments. This is in direct contrast to Release combinations where the Release rate may be reduced 40% or more by addition of Acti-Aid and Sweep (Fig. 2, 5, 10). In the current experiments, 250 ppm Release was slightly more effective than 150 ppm Release plus 2.5 ppm Acti-Aid. The 3-way combination of 150 ppm Release plus 2.5 ppm Acti-Aid plus 250 ppm Sweep resulted in the best loosening. The results with Release combinations were similar to those obtained in 1976 and confirm the value of the combination chemical approach (10, 11).

In the standard branch evaluations conducted during

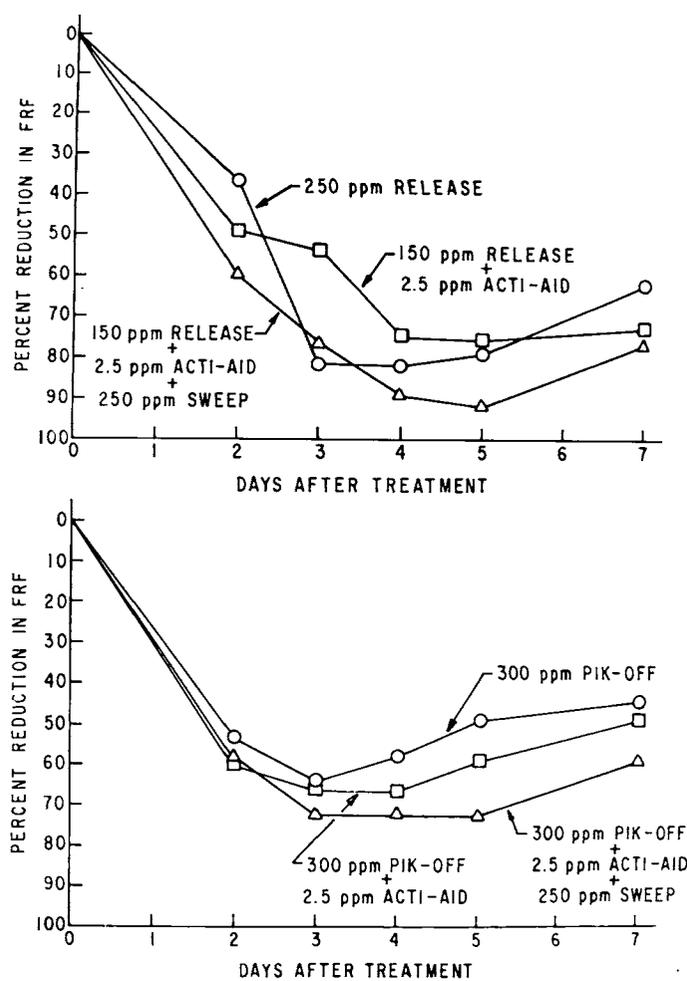


Fig. 2. Comparison of Release combinations (top) and Pik-Off combinations (bottom) for reduction in FRF of 'Valencia' oranges in a tree test.

January with 'Pineapple' oranges, all the treatments, except 20 ppm Acti-Aid on January 6, were generally effective during the first 2 weeks (Fig. 3). The first freezing period (8 hr below 32°F) was on January 17-18. Release (250 ppm) applied on January 17 did not give acceptable loosening, while 20 ppm Acti-Aid and 50 ppm Release plus 5 ppm Acti-Aid plus 250 ppm Sweep were effective. However, none of the treatments gave appreciable fruit loosening when applied on January 18 which was followed by 10 hr of below 32°F temperature on January 18-19. A week after the freeze on January 26, all treatments were very effective. However, by this time the control FRF had dropped over 50% to 8.75 lb,² presumably due to ethylene production by the fruit following freeze injury (2). Other tests conducted in the 3 weeks following the freeze demonstrated that excellent 'Hamlin' and 'Pineapple' fruit loosening could be obtained with a 50% or more reduction in concentration of abscission chemicals (data not reported).

The remainder of the 1977 branch evaluations concentrated on comparing Pik-Off, Release, and Acti-Aid with 2- and 3-way combinations of Release with Acti-Aid and Sweep for 'Valencia' orange abscission (Fig. 4). All of the treatments including 300 ppm Pik-Off were very effective in 27 tests during March and April. However, during May and June, 300 ppm Pik-Off and 20 ppm Acti-Aid did not result in acceptable fruit loosening. During this period 200 ppm Release plus 5 ppm Acti-Aid plus 250 ppm Sweep was as

²1 pound (lb) = 0.4536 kg.

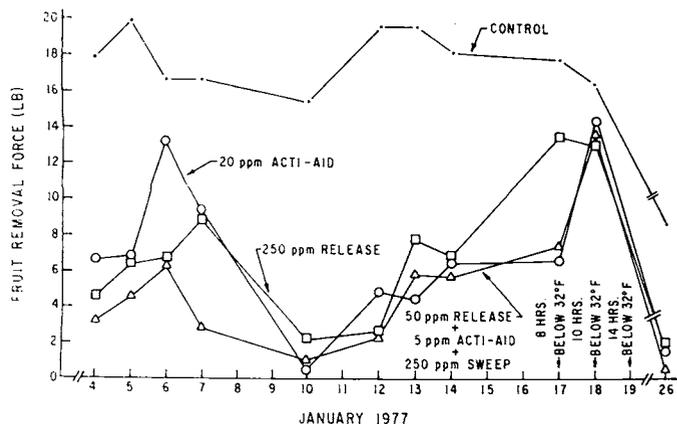


Fig. 3. Evaluation of abscission chemicals for loosening of 'Pineapple' oranges in branch tests during January 1977.

effective as 250 ppm Release and both treatments were better than 200 ppm Release plus 5 ppm Acti-Aid. The lowered effectiveness of abscission chemical treatments in May and June corresponds to similar results obtained the past 2 seasons and has led to naming this the unresponsive period (3, 5).

The data in Fig. 4 and the previous studies suggest that the ideal period to harvest 'Valencia' oranges with abscission chemicals is during March and April. The fruit not only respond best to abscission chemical treatment during this period, but the weather for application of chemicals and fruit harvest is more ideal. However, 'Valencia' harvesting is generally not as great during this period as compared to later in the season because maximum fruit maturity has not been reached.

Abscission chemical treatment of citrus fruit induces ethylene production (5) which is known to alter maturity in many fruits (1). With this in mind, 'Valencia' fruit treated with abscission chemicals were monitored for maturity changes as measured by ° Brix and % acid content (Table 1). This test indicated that abscission chemical treatments could raise the Brix/acid ratios by up to 4.5 units principally by decreasing the fruit acid levels. Similar findings were made in May, although the Brix/acid ratios were increased by only 0.41 to 2.57 units. However, the control Brix/acid ratio had risen from 10.11 on April 15 to 14.45 on May 17. At least one grower-harvester, who uses abscission

Table 1. Effect of Abscission Chemical Treatment on 'Valencia' Brix/Acid Ratio.

A) April 15, 1977 Branch Test	Parameter Measured	Abscission chemical treatment (ppm)				
		None (0)	Pik-Off (300)	Release (250)	Release (150) + Acti-Aid (5)	Release (150) + Acti-Aid (5) + Sweep (250)
	°Brix	9.4	9.5	10.0	9.9	9.2
	Acid (%)	0.93	0.64	0.78	0.78	0.68
	Brix/Acid	10.11	14.84	12.82	12.69	13.53
B) May 17, 1977 Tree Test	Parameter Measured	Abscission chemical treatment (ppm)				
		None (0)	Pik-Off (400)	Release (250)	Release (150) + Acti-Aid (2.5) + Sweep (250)	Pik-Off (400) + Acti-Aid (2.5) + Sweep (250)
	°Brix	12.8	12.4	12.3	13.1	13.0
	Acid (%)	0.89	0.84	0.72	0.80	0.79
	Brix/Acid	14.45	14.86	17.02	16.48	16.45
	FRF (lb)	23.65	10.48	5.40	3.78	6.09
	Fruit Drop (No./Tree)	0	77	549	753	152

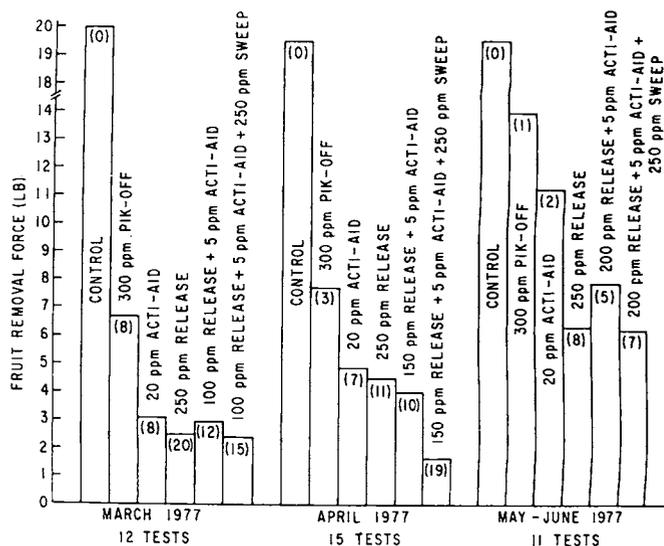


Fig. 4. Evaluation of abscission chemicals for loosening of 'Valencia' oranges in branch tests from March through June 1977. Values in () are fruit drop per branch.

chemicals extensively, also confirmed obtaining consistently higher ratios from fruit treated with abscission chemicals (Schirard, J., personal communication). Extensive tests will be conducted during the 1977-78 fruit season to verify these findings and to determine whether the concept has commercial utility.

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Proc. Fla. State Hort. Soc. 90:4-6. 1977.

LOOSENING OF ORANGES WITH PIK-OFF, RELEASE, ACTI-AID AND SWEEP COMBINATIONS¹

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Additional index words. Citrus, abscission.

Abstract. Glyoxal-dioxime (Pik-Off) combined with cycloheximide (Acti-Aid) and chlorothalonil (Sweep) loosened 'Hamlin' and 'Valencia' oranges. The fruit removal force (FRF) of 'Hamlin' oranges was lowered to about 5 lb (2.3 kg) and that of 'Valencia' oranges to 4 to 7 lb (1.8 to 3.2 kg). 'Valencia' oranges responded more erratically than 'Hamlin', especially during May, the "nonresponsive" period. The combination of 75 ppm Pik-Off, 5 ppm Acti-Aid plus 100 ppm Sweep lowered the FRF to an acceptable level in 3 to 5 days with no excessive defoliation or fruit damage when surfactants were added to the sprays. Defoliation was not a problem in any of the tests, however; young 'Valencia' fruit were damaged by 150 ppm Pik-Off or 10 ppm Acti-Aid. Pik-Off combined with 5-chloro-3-methyl-4-nitro-1H-pyrazole (Release) and Sweep loosened 'Valencia' oranges in April but not in May or June.

Cycloheximide (Acti-Aid), glyoxal dioxime (Pik-Off), 5-chloro-3-methyl-4-nitro-1H-pyrazole (Release) and chlorothalonil (Sweep) have been used in Florida for loosening citrus fruit and thus facilitating mechanical harvesting (1, 2, 3, 4). Most combinations of Release, Acti-Aid and Sweep are more effective than the individual chemicals (6).

The response from Pik-Off has been variable (3); hence, it has not been widely accepted by the industry. Release and Pik-Off have been cleared by EPA for only experimental use on citrus. Because Pik-Off apparently has not been used in combination with other fruit-loosening chemicals, I undertook to determine whether or not Pik-Off combination sprays would be as effective as other combination sprays and more effective than Pik-Off alone. Pik-Off combinations have been used in our field tests the past 2 years and results from several combinations with Acti-Aid and Sweep used on 'Hamlin' and 'Valencia' (*C. sinensis* (L.) Osbeck) oranges for loosening of the fruit will be reported.

Materials and Methods

The concentration of chemicals and dates of application for each cultivar are given in the results. Several concns of

¹This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.

Pik-Off, Release, Acti-Aid, Sweep, and Triton X-100 were tested in combination sprays. Triton X-100, Ag-Chem activator and X-77 surfactants were compared alone and in some combinations in one field test (Table 3). A hand gun was used to completely cover the trees with 5 to 8 gal (19 to 30 liters) of spray per tree depending on size. Two tree plots were used except as noted in the results. The trials were conducted in commercial citrus groves, mostly on rough lemon (*C. jambhiri* Lush.) and 'Hamlin' on Carrizo citrange (*C. sinensis* X *Poncirus trifoliata*).

Ethylene (6), defoliation, fruit drop and damage (3) were determined by previously described methods. No statistical analyses were used since many of the mean fruit removal force (FRF) values would be significantly different but of no practical importance.

Results and Discussion

'Hamlin' oranges. When either 5 or 10 ppm Acti-Aid was used with 75 ppm Pik-Off, the fruit on trees sprayed in December were loosened so that they required about 5.0 lb FRF (Table 1). The loosening caused by 150 or 75 ppm Pik-Off alone was not adequate for effective mechanical harvesting. Generally, the FRF should be lowered to about 5 lb for efficient mechanical harvesting. In January and February all treatments caused good fruit loosening. Therefore, the choice of sprays to use on 'Hamlin' oranges in these months depends on cost, and amount of defoliation and rind damage. Fruit damage was considerably less by 75 ppm Pik-Off plus 5 ppm Acti-Aid than by higher levels of either chemical used alone. Defoliation was less than 5% in all trees.

The FRF values reported here are slightly higher than those reported by others who used 10 ppm Acti-Aid and

Table 1. Fruit removal force for 'Hamlin' oranges 5 days after application of Pik-Off alone or in combination sprays.

Treatment [†] ppm	FRF [*]		
	Dec	Jan	Feb
150 Pik-Off	7.8	4.7	5.0
75 Pik-Off	8.4	4.2	4.2
75 Pik-Off + 10 Acti-Aid	4.9	3.8	2.3
75 Pik-Off + 5 Acti-Aid	5.4	5.1	6.2
75 Pik-Off + 5 Acti-Aid + 100 Sweep	5.3	4.7	4.2
Control	18.0	14.7	10.2

^{*}Average of 10 fruit from 2 replications.

[†]Contains 0.1% Triton X-100.