Table 4. Height, yield and juice quality of 5-year-old 'Ruby' grapefruit and 'Pineapple' orange trees on selected rootstocks.[z]

Rootstock[y]	Tree height (ft)	Yield (boxes/tree)	Weight/fruit (lb)	Juice content (%)	Brix	Acid (%)	Brix/acid ratio
			Pineapple orange				
Car	6.6 abc[x]	0.8 abc	.39 n.s.	57.9 ab	13.0 cde	.74 cde	16.9 cd
Cha	3.9 fg	0.5 bcde	.32	60.5 a	15.1 ab	.78 bc	19.3 a
F3	7.3 a	1.2 ab	.41	57.5 ab	12.2 e	.74 cde	16.5 d
F8	5.6 cd	1.5 a	.31	57.7 ab	14.2 abcd	.86 a	16.7 d
F12	5.6 cd	0.6 abcd	.39	57.5 ab	13.7 bcde	.76 cd	18.1 abc
F13	6.2 bcd	1.5 a	.42	55.7 b	12.5 e	.72 de	17.5 bcd
FDT	3.2 g	0.6 abcd	.30	57.3 b	15.6 a	.84 ab	18.5 ab
Mort	5.7 cd	1.5 a	.35	58.5 ab	14.1 abcd	.78 bc	19.3 a
R x T	3.7 fg	0.4 bcde	.33	57.4 b	14.2 abcd	.78 bc	18.3 ab
S x S	4.5 ef	0.6 abcd	.34	58.7 ab	14.5 abc	.78 bc	18.7 ab
UV	4.2 f	0.7 abc	.45	58.6 ab	12.6 cd	.71 e	17.7 bcd
Jac[w]	5.4	0.6	.36	57.6	13.5	.77	17.6
SwC[w]	5.8	0.6	.41	58.0	12.4	.75	16.5
			Ruby grapefruit				
Car	6.0 ab	0.9 abcd	0.86 abc	54.7 abcd	9.3 abc	1.03 cd	9.0 ab
Cha	5.3 abcd	0.5 defg	0.79 bc	56.1 ab	8.9 abc	1.01 cde	8.8 ab
F3	6.6 a	1.3 ab	0.84 abc	56.0 ab	8.6 c	1.02 cde	8.5 b
F8	6.2 ab	1.0 abc	0.92 abc	53.4 bcd	8.5 c	1.01 cde	8.5 b
F12	5.4 abc	0.7 cdef	0.82 bc	52.8 cd	9.5 abc	1.07 bc	8.8 ab
F13	5.8 ab	1.8 a	0.96 ab	52.8 cd	8.5 c	0.95 e	8.9 ab
FDT	4.0 cd	0.8 bcde	0.80 bc	53.7 bcd	9.8 ab	1.04 cd	9.5 a
Mort	5.9 ab	1.8 a	1.06 a	53.6 bcd	8.8 bc	1.02 cde	8.7 ab
R x T	3.8 d	0.8 bcde	0.70 v	57.8 a	9.1 abc	0.97 de	9.4 a
S x S	4.6 bcd	0.9 bcd	0.80 bc	51.8 d	10.0 a	1.11 a	9.0 ab
UV	6.0 ab	0.7 cdef	0.96 ab	52.8 cd	8.9 abc	1.09 ab	8.3 b
Jac	3.8 d	0.6 defg	0.75 bc	55.9 abc	9.5 abc	1.03 cd	9.2 a
SwC	6.1 ab	1.0 abc	0.96 ab	55.0 abc	9.1 abc	1.00 cde	9.1 ab

[z]Based on data from the 1979-1980 season.
[y]See Table 1 for the complete list of rootstocks.
[x]Mean separation within columns by Duncan's multiple range test, 5% level; n.s. = not significant.
[w]Not included in the statistical analysis.

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THE EFFECT OF ADDITIVES ON THE EFFICIENCY OF ABSCISSION-INDUCING CHEMICALS ON 'VALENCIA' ORANGES IN FLORIDA

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Abstract. **During the past 6 years, several chemicals, buffers, surfactants and ethylene-generating chemicals have been added to Acti-Aid,[1] Release and Pik-Off, and to combinations of these to increase loosening of 'Valencia' oranges [*Citrus sinensis* (L.) Osb.] grown on the ridge and on the Merritt Island citrus-growing areas of Florida. Most of the additives did not increase abscission chemical activity; however, ethephon and CGA 15281 did increase ethylene in the fruit the first day and fruit loosening after 3 days, but excessive defoliation occurred. Calcium chloride ($CaCl_2$) added to reduce the amount of defoliation reduced the fruit loosening caused by ethephon and CGA 15281. Urea caused increased damage to the rind with abscission chemicals, and generated more ethylene, but not enough to increase 'Valencia' fruit loosening during the nonresponsive period. Triton X-100 and Chevron X-77 were equally effective and consistently increased the effectiveness of abscission-inducing chemicals when compared to other surfactants. Sweep was inconsistent and carboxymethyl cellulose (CMC) was ineffective in prolonging ethylene generation and in increasing fruit loosening.**

[1]Mention of a trademark, warranty, proprietary product, or vendor does not constitute a guarantee by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Several reports show that combinations of abscission-inducing chemicals are consistently more effective than single chemical sprays (5, 6, 9); however, for loosening of early and midseason oranges, single chemical sprays may be adequate (10). Several surfactants have been used to increase the effectiveness of Acti-Aid and Release (2, 3). Pik-Off generally is more effective without a surfactant (9).

Although chemical combinations are more effective than single chemicals for loosening of 'Valencia' oranges, the fruit removal force (FRF) of all fruit may not be lowered sufficiently for successful mechanical harvesting (6, 9). Decreased chemical absorption, ethylene synthesis, and response to ethylene by Valencia oranges occur during May. This period of less response to abscission chemicals is commonly referred to as the nonresponsive period.

Therefore, in this report, the results of several years' study of the effectiveness of abscission-inducing chemicals when used on 'Valencia' oranges before and during the nonresponsive period are reported. Several combinations, surfactants, combinations with ethephon and CGA 15281, urea, $CaCl_2$ and the extender Sweep, and CMC have been used in several groves in two Florida areas.

Materials and Methods

'Valencia' orange [*Citrus sinensis* (L.) Osb.] trees ranging in age from 18 to 35 years on rough lemon [*C. limon* (L.) Burm. f.], Carrizo [*C. sinensis* (L.) Osb. X *Poncirus trifoliata* (L.) Raf.] and sour orange (*C. aurantium* L.) rootstocks in the ridge and Merritt Island citrus-growing areas were used. Sprays were applied with handgun sprayers between 10 a.m. and 2 p.m. The results of tests in which rain occurred within 12 hr of spray application were discarded. The compounds used are listed in Table 1. Treatment rates for surfactants, adjuvants, abscission chemicals, buffers, urea, $CaCl_2$, CMC, Sweep, and ethephon, and CGA 15281 are given in the tables. The rates of abscission chemicals and combinations of chemicals studied have been most effective in loosening oranges in Florida when all factors, such as defoliation, rind damage, young fruit drop, and FRF, are considered (5, 6, 9, 10). Fruit removal force (FRF) after 5 days and ethylene after 3 days were determined by described methods (5, 9). The rates of $CaCl_2$ (7), urea (4), and pH level (1) are those that increased absorption of growth regulators or abscission chemicals by other crops.

Table 1. Brand, common and chemical names of compounds studied.

Brand name	Chemical and common name
Acti-Aid	3-[2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl]glutarimide - cycloheximide
CGA 15281	(2-chloroethyl)methylbis(phenylmethoxy)silane
CMC	carboxymethyl cellulose
Ethephon	(γ-chloroethyl)phosphonic acid
Pik-Off	ethanedial dioxime - glyoxime
Release	5-chloro-3-methyl-4-nitro-1*H*-pyrazole
Sweep	2,4,5,6-tetrachloroisophthalonitrile-chlorothalonil

Results and Discussion

Triton X-100 and Chevron X-77 were equally effective and were, in general, slightly better than γ-butyrolactone, Agchem Activator, or Regulaid in aiding the absorption of abscission-inducing chemicals by 'Valencia' oranges in 2 citrus-growing areas (Table 2). Only small differences between the FRF resulting from various treatments exist, but the data indicate that Triton X-100 and Chevron X-77 were more consistent when used with the abscission chemical combinations used. The FRF of the fruit from Merritt Island was lower than that of fruit from the ridge area of Florida. The Merritt Island fruit also responded more to abscission chemicals than did the fruit from the ridge. Warmer temperatures (11) and different cultural practices probably caused this response.

Table 2. Effect of several surfactants on fruit removal force of 'Valencia' oranges when used with abscission-inducing chemicals in 2 citrus-growing areas of Florida in April.[z]

Treatment (ppm)	Fruit removal force (lb.) 5 days after spray[z] 1	2	3	4	5
Ridge					
10 Acti-Aid + 125 Release	4.7 a	3.8 a	7.1 b	4.5 a	6.4 b
5 Acti-Aid + 125 Release	5.9 a	6.1 a	8.3 c	7.2 b	6.9 b
20 Acti-Aid	6.8 b	5.9 a	8.4 c	6.7 b	7.1 b
125 Release	5.1 a	6.2 a	7.9 b	8.9 b	7.5 b
Unsprayed	20.3				
Merritt Island					
10 Acti-Aid + 125 Release	3.9 a	4.2 a	7.0 c	6.4 bc	5.3 b
5 Acti-Aid + 125 Release	4.2 a	5.1 b	6.8 c	5.9 bc	5.2 b
20 Acti-Aid	6.0 a	5.7 a	6.7 b	6.7 b	6.0 a
125 Release	5.8 a	5.4 a	7.0 b	6.0 ab	5.9 a
Unsprayed	17.4				

[z]Tested on 20 fruit/treatment (3-yr avg). Surfactants were sprayed at a rate of 0.1%. 1 = Triton X-100, 2 = Chevron X-77, 3 = γ-butyrolactone, 4 = Agchem Activator, 5 = Regulaid. Means within rows followed by different letters are significantly different at the 5% level.

Calcium has been used with ethephon on pineapples (4) and with ethephon and CGA 15281 on citrus (7) to raise the pH and decrease defoliation when the ethylene-generating chemicals are used for flower induction and loosening or induction of color formation in fruit. Ethephon and CGA 15281 have been used with other abscission-inducing chemicals to increase loosening with less rind injury (8). Increased defoliation is associated with ethephon and CGA 15281 applications. Calcium chloride reduced the amount of defoliation caused by the abscission chemical combinations, but it also decreased the FRF response for most cases (Table 3). Whether or not higher levels of ethephon and CGA 15281 could be used with Ca for the desired result needs further study.

Sweep in some cases extends the time for which abscission chemicals are effective in stimulating ethylene synthesis (5, 6). Carboxymethyl cellulose disperses the abscission chemicals in a film similar to that of Sweep. Therefore, CMC or Sweep was added to several combination sprays and compared at 2 locations (Table 4). Sweep significantly increased the effectiveness of 10 ppm Acti-Aid + 125 ppm Release on Merritt Island fruit but was ineffective on ridge fruit. Sweep with Acti-Aid plus Pik-Off did not decrease FRF more than Acti-Aid plus Pik-Off alone. When used with abscission-inducing chemicals, CMC either had no effect or decreased the amount of fruit loosening; less rind injury of the CMC-treated fruit was observed, but less ethylene was produced, resulting in less fruit loosening.

Urea was used with the abscission chemicals to increase their absorption into the rind tissue (Table 5). Urea had no overall effect on fruit loosening when used in combinations, even though ethylene synthesis was stimulated slightly except by the 10 ppm Acti-Aid plus 150 ppm Pik-Off treatment because of the increased rind damage. Ethy-

Table 3. Fruit removal force and leaf drop of 'Valencia' oranges sprayed with abscission-inducing chemicals with and without $CaCl_2$.[z]

Treatment (ppm)	Fruit removal force (lb.) 5 days after spray[z, y]		Percentage leaf drop[x]	
	Control	$CaCl_2$[w]	Control	$CaCl_2$
10 Acti-Aid + 100 ethephon	8.1 bc	8.0 b	12	8
10 Acti-Aid + 200 ethephon	7.4 bc	8.2 b	18	7
10 Acti-Aid + 100 CGA 15281	8.9 c	9.6 b	14	5
10 Acti-Aid + 200 CGA 15281	7.2 b	8.5 b	17	9
10 Acti-Aid	10.7 d	10.9 d	12	12
10 Acti-Aid + 125 Release + 200 ethephon	4.1 a	6.2 a	26	12
10 Acti-Aid + 125 Release + 200 CGA 15281	4.6 a	6.5 a	22	13
10 Acti-Aid + 125 Release	7.0 b	6.9 ab	14	11
Unsprayed	18.3 e	17.4 e	2	2

[z]Tested on 20 fruit/treatment (2-yr avg).
[y]Means within columns followed by different letters are significantly different at the 5% level.
[x]Measured on 5 shoots tagged before spraying.

Table 4. The effectiveness of Sweep and CMC as adjuvants to abscission-inducing chemical combinations when used on 'Valencia' oranges in 2 citrus-growing areas of Florida.[z]

Treatment (ppm)	Fruit removal force (lb.) 5 days after spray[y]	
	Merritt Island	Ridge
10 Acti-Aid + 125 Release	4.4 b	4.7 a
10 Acti-Aid + 125 Release + Sweep[x]	3.3 a	4.4 a
10 Acti-Aid + 125 Release + CMC[x]	6.1 c	5.1 ab
10 Acti-Aid + 150 Pik-Off	5.4 bc	6.2 c
10 Acti-Aid + 150 Pik-Off + Sweep	6.2 c	6.0 bc
10 Acti-Aid + 150 Pik-Off + CMC	7.3 d	5.8 bc
Unsprayed	20.2 e	18.7 d

[z]Tested on 20 fruit/treatment (3-yr avg).
[y]Means within columns followed by different letters are significantly different at the 5% level.
[x]125 ppm Sweep, 250 ppm CMC.

Table 5. Fruit removal force and ethylene production of 'Valencia' oranges sprayed with abscission-inducing chemicals plus 200 ppm urea.[z]

Treatment (ppm)	Fruit removal force (lb.) 5 days after spray		Ethylene (ppm) 3 days after spray	
	Control	Urea	Control	Urea
5 Acti-Aid + 125 Release	5.2 ± 0.7	4.9 ± 1.2	1.07	1.80
10 Acti-Aid + 125 Release	4.4 ± 1.2	5.0 ± 0.8	1.59	1.89
5 Acti-Aid + 150 Pik-Off	6.0 ± 2.3	6.1 ± 1.4	1.52	1.74
10 Acti-Aid + 150 Pik-Off	5.9 ± 1.8	5.4 ± 2.1	1.59	1.60
Unsprayed	18.4 ± 5.0	19.2 ± 3.7	Trace	Trace

[z]Tested on 20 fruit/treatment (2-yr avg).

lene synthesis was sufficient in fruit for good loosening, and the small increase caused by the addition of urea did not affect fruit loosening. Generally, the pH 7.0 buffer did not increase the effectiveness of the abscission chemical when applied to 'Valencia' oranges in April.

Ethephon and CGA 15281 in pH 7.0 buffered solutions increased fruit loosening when applied with 10 ppm Acti-Aid compared to 10 ppm Acti-Aid alone in April (Table 6). However, in these tests, 125 ppm Release caused as much fruit loosening as the ethephon and CGA 15281 combinations with Acti-Aid. Ethephon and CGA 15281 did not increase fruit loosening when applied with Release.

Table 6. Effect of pH 7.0 phosphate buffer on the effectiveness of ethephon and CGA 15281 as adjuvants to abscission chemicals when used on 'Valencia' oranges in April.[z]

Treatment (ppm)	Fruit removal force (lb.) 5 days after spray[y]	
	Buffer	Control
100 Ethephon	12.3 d	12.7 de
200 Ethephon	11.2 d	10.5 c
100 CGA 15281	11.8 d	11.9 cd
200 CGA 15281	11.9 d	12.0 d
100 Ethephon + 10 Acti-Aid	4.9 ab	5.1 b
100 Ethephon + 125 Release	5.2 b	4.9 ab
100 CGA 15281 + 10 Acti-Aid	4.3 a	4.0 a
100 CGA 15281 + 125 Release	5.0 b	5.2 b
10 Acti-Aid	6.4 c	6.2 b
125 Release	3.6 a	3.8 a
Unsprayed	20.7 e	17.7 f

[z]Tested on 20 fruit/treatment (2-yr avg).
[y]Means within columns followed by different letters are significantly different at the 5% level.

Of all combination and additive sprays, Acti-Aid plus Release in most cases with either Triton X-100 or Chevron X-77 was the most consistently effective fruit-loosening treatment. Whether 5 or 10 ppm Acti-Aid should be used with 125 ppm Release depends, to a certain extent at least, on the FRF of the presprayed fruit.

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