

Discussion

The results obtained thus far support the use of glyoxime at 200 to 300 PPM as an effective and selective chemical abscission agent for use on 'Valencia' oranges in Florida. Exact volumes of spray per acre have not been established but dilute and 2X concentrate have provided good coverage and response.

Peel burn on the mature fruit appears necessary to induce the exogenous release of ethylene responsible for the abscission response. The degree of burn appears to be related to concentration, temperature, and time and increases as these factors increase. Daytime temperatures of 80°F. or above usually produce maximum fruit loosening within 3 days of application. Such temperatures occur most of the time during the 'Valencia' harvest period in Florida. Fruit harvested at 3 to 5 days have exhibited less burn than did fruit allowed to remain on the tree or ground 7 days or more. This burn was very superficial and did not penetrate into the fruit.

Little phytotoxicity has been observed on young fruit or blossoms and leaf drop has never exceeded 5% even at extremely high rates.

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COLORING AND LOOSENING OF CITRUS FRUITS WITH ETHEPHON

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Abstract. 'Robinson,' 'Lee,' 'Nova,' 'Orlando,' 'Hamlin,' 'Temple,' 'Dancy,' and 'Murcott' fruit were sprayed with ethephon in the field to enhance external fruit color. Effective for color improvement, without causing excessive defoliation, were 200 to 300 ppm ethephon applied 1 week before anticipated harvest. Ethephon at 500 ppm improved rind color best, but induced excessive defoliation. The improved rind color reduced the need for postharvest ethylene degreening. In many tests, ethephon that partly loosened the fruit aided in reducing rind plugging when the fruit was harvested. Ethephon applied by speed sprayer was as effective as that applied by hand-gun. Ethephon had no adverse effect on the storage life of the fruit.

Fall-maturing cultivars usually require some ethylene degreening after harvest to obtain ex-

ternal color that is satisfactory for marketing. The length of postharvest degreening varies with the color of the fruit at harvest, the cultivar, and other factors. Exposure to ethylene degreening for more than 36 hr often damages the fruit (2). We have reported that preharvest sprays of ethephon ((2-chloroethyl)phosphonic acid) aid on-the-tree degreening and reduce and sometimes eliminate postharvest ethylene degreening (3, 4, 5). In addition, ethephon sprays improve rind carotenoid pigmentation and fruit-loosening (3, 4, 5).

This report summarizes the 1973-1974 field evaluations of effects of ethephon on several cultivars, including 'Orlando' tangelo, and 'Temple' and 'Murcott' hybrids, which had not been evaluated before. Application of ethephon with a hand sprayer or a speed sprayer was also evaluated.

Materials and Methods

Plant material. Trees used in these tests were as follows: Fort Pierce Grove—'Robinson,' 'Lee,' and 'Nova' tangerine hybrids (*Citrus reticulata* Blanco X (*C. paradisi* Macf. X *C. reticulata*))

and 'Orlando' tangelos (*C. paradisi* X *C. reticulata*) on 'Cleopatra' mandarin (*C. reticulata*) rootstock (7 to 10 years old); Sebring Grove—'Robinson' and 'Nova' tangerine hybrids on rough lemon (*C. limon* (L.) Burm. f.) (14 years old); Windermere Grove—'Hamlin' orange (*C. sinensis* (L.) Osbeck) on 'Cleopatra' mandarin (10 to 12 years old); Winter Garden Grove—'Temple' and 'Murcott' hybrids on 'Cleopatra' mandarin (7 to 10 years old); and Haines City Grove—'Dancy' tangerines on rough lemon (10 to 15 years old).

Preharvest spray applications. Ethepon was applied as dilute sprays at 0, 200, 250, 300, 400, and 500 ppm by a power sprayer equipped with a handgun (200 psi) or by speed sprayer. Volume of spray material applied was 4 to 6 gal/tree (depending on tree size) with the handgun and 500 to 650 gal/acre with the speed sprayer (depending on tree size and number of trees/acre). The important criterion was good fruit coverage. No surfactant was used in these tests.

Handgun-applied tests had the following single-tree replications: Sebring 'Robinson' and 'Nova' test, 2; Windermere 'Hamlin' test, 3; Winter garden 'Temple' and 'Murcott' test, 2; and Haines City test, 2. Speed sprayer-applied tests had the following replications: Fort Pierce Grove—'Robinson,' 'Lee,' 'Nova,' and 'Orlando' test, 6; and Sebring 'Robinson' and 'Nova' test, 50. Most cultivars were sprayed when the fruits were commercially mature and showed some color break. Dates of application are shown in the results.

Postharvest color and degreening. From each test tree (2 trees/treatment in speed sprayer tests) 20 fruit samples were harvested randomly 6 to 7 days after spray application for color readings. Chlorophyll (chloro) and carotenoid (carot) levels were measured on intact fruits with a light-transmittance difference meter as described previously (1). In addition, postharvest degreening and storage tests were conducted on 100 to 200 fruits from each tree. Fruits were degreened at 85° F (29° C) with 5 to 10 ppm ethylene. Degreening time was determined by visual color changes, and fruits with good color were considered acceptable for marketing. After degreening, the fruits were washed and waxed and held at 70° F for weekly decay observations.

Leaf and fruit drop. Leaf and fruit drop were estimated weekly for several weeks after spraying on most tests and expressed as percentage of drop. Shoots were tagged, and leaves were counted to determine leaf drop on the 'Hamlin' test. Fruit

plugging was determined on 20 hand-harvested fruit per test tree.

Results and Discussion

Coloring and degreening. Speed sprayer application of 300 ppm ethepon on October 10 effectively degreened 'Robinson,' 'Lee,' 'Nova,' and 'Orlando' fruits (Table 1). The 'Robinson,' 'Lee,' and 'Nova' fruits were legally mature internally, but the 'Orlando' fruits were not. 'Robinson' fruits had full color break and were being harvested commercially; the 'Orlando' fruits were light green; and the 'Lee' and 'Nova' fruits were green with a slight color break. The degreening periods (72 to 120 hr) were longer than normal because the ethylene room was 80° F rather than 85° F in this one test. 'Orlando,' 'Lee,' and 'Nova' fruits showed some natural degreening before the second test on October 25 (less rind chloro). All cultivars responded to 200 ppm ethepon, and the treated fruits required only 24 hr of ethylene degreening, as compared to 60 to 72 hr for untreated fruits. The 'Orlando' fruits, although degreened with 200 ppm ethepon and 24 hr ethylene, did not develop color typical of fully ripened fruit.

Degreening responses of 'Robinson' and 'Nova' fruits were similar with handgun and speed sprayer applications in a test near Sebring applied on October 6. Both 200 and 250 ppm ethepon in-

Table 1. Ethepon effects on 'Robinson,' 'Lee,' and 'Nova' tangerine hybrids and 'Orlando' tangelo fruit coloring, leaf drop, and fruit loosening.

Cultivar and treatment ^z	Application date	Rind chloro (AOD)	Leaf drop (%)	Fruit drop (%)	Fruit plugging ^y (%)	Degreening time ^x (hr)
Robinson						
Check	Oct. 10	0.25	0	0	4	48
300 ppm	Oct. 10	0.19	15	0	6	24 ^z
Lee						
Check	Oct. 10	0.58	0	0	2	168
300 ppm	Oct. 10	0.29	18	3	0	96*
Check	Oct. 25	0.46	0	0	-	72
200 ppm	Oct. 25	0.35	1	0	-	24*
Nova						
Check	Oct. 10	0.53	0	0	12	144
300 ppm	Oct. 10	0.33	10	1	22	120*
Check	Oct. 25	0.39	0	0	-	72
200 ppm	Oct. 25	0.32	0	0	-	24*
Orlando						
Check	Oct. 10	0.49	0	0	10	84
300 ppm	Oct. 10	0.31	1.6	0	6	72 ^z
Check	Oct. 25	0.45	0	0	-	60
200 ppm	Oct. 25	0.32	1	0	-	24 ^z

^zSprays were applied with a speed sprayer, and fruit color, plugging, and degreening were evaluated 7 days after application. Grove was near Fort Pierce.

^yFruit were harvested by pulling rather than by clipping.

^xFruit were treated on October 10, 1973, and were degreened at 80° rather than 85° F.

^zTreatment value followed by * differed statistically from corresponding check value at 0.05 level.

duced degreening. The data indicate that 300 ppm may have reduced the degreening time further (Table 2). 'Robinson' fruits had a good color break, whereas the 'Nova' fruits were green with only a slight color break.

greatly enhanced. Best color enhancement in this test was with 400 and 500 ppm ethephon. No post-harvest ethylene treatment tests were conducted. The coloring responses with rates up to 300 ppm were similar to those in previous work (1).

'Temple' and 'Murcott' fruits in a grove near Winter Garden responded to ethephon sprayed on January 22 (Table 4). During the week after spraying the air was warm. 'Murcott' and regular 'Hamlin' oranges responded to 200, 300, and 500 ppm ethephon applied on November 7 (Table 3). These fruits were commercially mature internally and light green when sprayed. These rates reduced the ethylene degreening time by as much as 75%.

'Dancy' tangerines were sprayed on December 21 with 200, 300, 400, and 500 ppm ethephon (Table 3). During the week after treatment, the air was cool, but the fruits were degreened with 300, 400, and 500 ppm, and orange rind color was

bloom 'Temple' fruits, which had degreened naturally on the tree before spraying, had not developed full orange rind color. In addition, numerous late-bloom 'Temple' fruits were green. Late-bloom 'Temple' fruits were only partly colored with ethephon. Sixty hours of postharvest ethylene treatment was required for unsprayed 'Temple' fruit and 48 hr for 250-ppm-sprayed fruit. The requirement for ethylene degreening was mainly for the late-bloom fruit.

In general, preharvest degreening responses of 'Robinson,' 'Lee,' 'Nova,' 'Hamlin,' and 'Dancy' fruits with 200 to 300 ppm ethephon on coloring were similar to those previously reported (3, 5, 6). External rind carotenoid pigmentation was also improved. These tests on 'Orlando,' 'Temple,' and 'Murcott' fruits showed on-the-tree degreening and coloring responses similar to those of the other cultivars.

Leaf and fruit drop. Some leaves dropped from all sprayed trees, but generally 5% or less dropped with 200 ppm, and usually 15% or less with ethephon applications up to 300 ppm. Leaf drop of 21% (Table 3) on 'Hamlin' oranges with 500 ppm ethephon was based on counts on tagged shoots. Older leaves were more sensitive to ethephon and accounted for most of the leaf drop. On these trees, 8% of the leaves dropped on shoots with leaves 1 year old or less compared to 30% of those on shoots with some leaves older than 1 yr. Twigs on trees sprayed with 500 ppm had only a trace (less than 1%) of dieback.

Cool air the week after the 'Dancy' test (Table 3) gave minimal leaf and fruit drop at 200 and 300 ppm. Leaf drop was about 8% on 'Dancy' trees with 400 ppm and 20% with 500 ppm ethephon. The second week after spraying was warm (70's and 80's F), and more leaves and fruit dropped. Leaf drop did not exceed 10% with rates up to 300 ppm, but both leaves and fruit dropped excessively with 400 and 500 ppm ethephon. Leaf drop with 250 ppm was about 10% on 'Temple' trees and 5% on 'Murcott' trees (Table 4). A new-growth flush on the 'Temple' trees was injured by 200 and 250 ppm ethephon. Many of the leaves on new terminals abscised, and twigs died back slightly (1%) on the 250-ppm-sprayed trees. In general, 'Orlando' and perhaps 'Lee' trees had more leaf drop at comparable ethephon rates than 'Robinson,' 'Nova,' 'Hamlin,' 'Temple,' 'Dancy,' and 'Murcott' trees. 'Orlando' fruits responded to higher ethephon concentrations, but 200 ppm appeared best because of excessive defoliation at higher rates.

Table 2. 'Robinson' and 'Nova' tangerine fruit coloring and loosening by ethephon applied by handgun or speed sprayer.

Cultivar and treatment ^z	Rind chloro ^z (ΔOD)	Leaf drop (%)	Fruit drop (%)	Fruit plugging ^y (%)	Degreening time (hr)
<i>Speedsprayer applied:</i>					
<i>Robinson</i>					
Check	0.41	0	0	10	60
200 ppm	0.24	10	0	11	36**
250 ppm	0.24	12	0	14	36**
<i>Nova</i>					
Check	0.57	0	0	44	108
200 ppm	0.32	5	0	11	72*
250 ppm	0.30	10	8	1	72*
<i>Handgun applied:</i>					
<i>Robinson</i>					
200 ppm	0.23	3	0	-	-
250 ppm	0.24	5	0	-	-
300 ppm	0.21	8	0	-	-
<i>Nova</i>					
200 ppm	0.31	10	1	-	-
250 ppm	0.26	7	5	-	-
300 ppm	0.23	13	10	-	-

^zSprays were applied on October 16, 1973, with a speed sprayer or handgun (6 gal/tree), and fruit color, plugging, and degreening were evaluated on October 23, 1973. Grove was near Sebring.

^yFruit were harvested by pulling rather than by clipping.

*See Table 1.

Table 3. Ethephon effects on 'Hamlin' orange and 'Dancy' tangerine fruit coloring, leaf drop, and fruit loosening.

Cultivar and treatment ^z	Rind color		Leaf drop		Fruit drop		Fruit plugging ^y	Degreening time
	(Δ OD)	(Δ R)	(%)		(%)		(%)	(hr)
<u>Hamlin</u>	Nov. 14		Nov. 14	Dec. 4	Nov. 14	Dec. 4	Nov. 14	
Check	0.32	-	1	1	0	0	8	48
200 ppm	0.26	-	1	2	0	0	11	36
300 ppm	0.26	-	3	14	0	T ^w	19	24**
500 ppm	0.21	-	6	21	2	13	10	12*
<u>Dancy</u>	Dec. 28		Dec. 28	Jan. 3	Dec. 28	Jan. 3	Dec. 28	
Check	0.27	0.46	0	T	0	T	35	-
200 ppm	-	-	2	3	0	T	20	-
300 ppm	0.22	0.49	4	10	0	3	14	-
400 ppm	0.21	0.54	8	15	0	13	5	-
500 ppm	0.21	0.52	20	35	3	30	1	-

^zSprays were applied to Hamlin trees on November 7, 1973, and to Dancy trees on December 21, 1973, with a handgun (5 gal/tree). Hamlin trees were near Windermere, and Dancy trees were near Haines City.

^y,^xSee Table 1.

^wTrace (less than 1%).

Table 4. Ethephon effects on fruit color, leaf drop, and fruit loosening on 'Temple' and 'Murcott' trees.

Cultivar and treatment ^z	Rind color		Leaf drop	Fruit drop	Fruit loosening ^y	
	chloro	carot			Total plugging	Clean separation of stem from fruit
	(Δ OD)	(Δ R)	(%)	(%)	(%)	(%)
<u>Temple</u>						
Check	0.20	0.48	0	0	20	3
150 ppm	0.23	0.49	2	0	15	45
200 ppm	0.20	0.52	5	0	8	60
250 ppm	0.17	0.55	10	1	0	80
<u>Murcott</u>						
Check	0.24	0.50	0	0	15	8
150 ppm	0.21	0.53	2	0	25	8
200 ppm	0.21	0.52	5	0	10	35
250 ppm	0.21	0.53	5	0	12	53

^zSprays were applied on January 22, 1974, with a handgun (4 gal/tree), and evaluation was made on February 6, 1974. The grove was located near Winter Garden.

^yFruit were harvested by pulling rather than by clipping.

Essentially no fruit dropped on any of the cultivars tested at 200 ppm, but in several tests a few fruit dropped with rates of 250 and 300 ppm, particularly with 'Nova' (Table 2). About 19% of the fruit dropped on 'Hamlin' oranges and 30% on 'Dancy' tangerines sprayed with 500 ppm ethephon, mostly 2 to 4 wks after treatment. This fruit loosening was delayed by cool air during the first week of treatment. Plugging (hole in rind made when fruit is pulled from the stem) of hand-harvested fruit varied from test to test, but was much less severe on sprayed fruit than on unsprayed fruit. The effectiveness of ethephon in aiding hand-harvest and reducing plugging is clearly evidenced in the 'Nova' (Table 2), 'Dancy' (Table 3), and 'Temple' (Table 4) tests.

Leaf drop and fruit loosening responses of 'Robinson,' 'Lee,' 'Nova,' 'Dancy,' and 'Hamlin' cultivars to 200 to 300 ppm ethephon are similar to those previously reported (3, 5, 6). 'Orlando' trees appeared to be more sensitive to ethephon. In general, trees sprayed with 200 to 300 ppm ethephon flushed, flowered, and set a crop of fruit in a manner similar to that for unsprayed fruit.

Postharvest storage and fruit decay. Fruit were stored for 2 to 3 wk at 70° F after degreening, washing, and waxing. Decay varied from test to test, and ethephon-sprayed fruit decayed at rates equal to or less than those of unsprayed fruit. The primary decay in 'Robinson,' 'Lee,' 'Nova,' and 'Orlando' fruit harvested in October and November was stem-end rot (*Diplodia* and *Phomopsis*), whereas that in 'Dancy,' 'Temple,' 'Murcott,' and 'Orlando' fruit harvested in December and January was green mold (*Penicillium*). Sprayed 'Murcott' and 'Temple' fruit stored at 70° F for 3 wk decayed at a rate similar to that of unsprayed fruit (Table 5). The primary decay was green mold. Our observations of no adverse effect of ethephon on the shelf life of the fruit were similar to our previous ones with other cul-

Table 5. Effect of ethephon on postharvest² decay of 'Temple' and 'Murcott' fruit.

Cultivar and treatment ^y	Decay ^x (%) after 3 wk at 70° F			
	S	P	M	T
Temple				
Check	0	16	0	16
150 ppm	0	8	0	8
200 ppm	0	17	1	18
250 ppm	0	15	1	16
Murcott				
Check	0	6	4	10
200 ppm	0	3	4	7
250 ppm	1	2	5	7

²Murcott fruit were washed, treated with 1% 2-AB (2-aminobutane) and waxed, and Temple fruit were washed, treated with TBZ (thiabendazole) and waxed before storage.

^yTrees were sprayed on January 22, 1974.

Temple fruit were harvested on January 28, and Murcott fruit were harvested on February 8, 1974.

^xS = stem end rot; P = *Penicillium* mold; M = miscellaneous mold types; T = total decay.

tivars (1, 6). Generally, where ethephon reduced the ethylene degreening time, less fruit decayed during storage.

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