Ethephon-induced Defoliation Patterns and Subsequent Yields in Citrus

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Abstract. Effects of 0, 250, 500 and 750 ppm (2-chloroethyl)phosphonic acid (ethephon) on defoliation of 'Robinson', and 'Nova' tangerines (Citrus reticulata Blanco × (C. paradisi × C. reticulata)), 'Orlando' tangelo (C. paradisi × C. reticulata) and 'Owari' satsuma trees (C. reticulata Blanco) were studied in 1974. Effects of 0, 250 and 400 ppm on defoliation, fruit plugging, yield, and color of 'Robinson' tangerines were studied in a second grove in 1974 and 1975. Old leaves were more subject to abscission from ethephon applications, whereas young leaves were relatively tolerant. Fruit yield was not reduced on 'Robinson' trees treated in the fall with up to 400 ppm ethephon. Fruit color, leaf drop, and fruit loosening were increased significantly by 250- and 400-ppm ethephon.

Ethylene is used as a postharvest treatment to degreen early-maturing fruit in Florida. Def greening periods longer than about 36 hr may result in heavy fruit loss from decay (2, 6, 9). Ethephon can be used before harvest to degreen fruit on the trees (3, 4, 8, 9, 10, 11). Preharvest degreening reduces decay caused by extended exposure of fruit to ethylene (10). Besides degreening, ethephon also improves rind carotenoid pigmentation (10, 11) and fruit loosening (8, 9, 10, 11). Ethephon is currently registered for use at 200 to 250 ppm on tangerines and tangerine hybrids. The main disadvantage of preharvest degreening is that ethephon may cause excessive defoliation at concentrations that otherwise would give desirable responses. The purpose of this study was to determine the ages of leaves lost due to ethephon application, and the effects of such losses on fruit yields in the subsequent year.

Materials and Methods

Leaf drop, fruit color, yield, degree of fruit separation, and tree growth in a 'Robinson' tangerine (Citrus reticulata Blanco × (C. paradisi × C. reticulata)) grove were studied. The trees were about 12 years old and were on rough lemon (C. limon (L.) Burm. f.) rootstock. Forty-eight trees were chosen for uniformity and divided into 8 blocks of 6 trees each. Trees were sprayed with 0, 250, and 400 ppm ethephon on either October 14 or 19, 1974. Four of the 8 blocks were used for leaf-drop studies. Eight limbs per tree were tagged, and the number of leaves on each flush segment was recorded at intervals of 0, 3, 6, 9, 15, 22, and 52 days after spraying. Trees were resprayed at the same rates on either Oct. 1 or 14, 1975, respectively. Fruit were harvested 7 days after spraying. Because no difference between the 2 dates of application was found, all plots were combined for a single harvest on Oct. 26, 1976. Fruit color responses were determined by transmittance

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The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked advertisement solely to indicate this fact.

2This paper reports the results of research only. Mention of a chemical 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.
measurements of chlorophyll levels in samples of 20 fruit per tree 7 days after spraying (3). Values were reported as the difference in optical densities at 695 and 740 nm (ΔOD695-740 nm). Degree of fruit separation was recorded as 1) plugged, where the peel was torn to expose the interior of the fruit; 2) partial, where abscission was incomplete or the stem was broken above the calyx; and 3) complete abscission, where the fruit abscised at the calyx. Trunk circumferences were measured near the graft union before treatment in 1974 and again in Oct. 1975.

Nine-year-old trees of ‘Owari’ satsuma, ‘Robinson’ and ‘Nova’ tangerines, and ‘Orlando’ tangelo in a 2nd grove were used for leaf-drop studies only. There were 4 completely randomized blocks of 4 trees for each variety. Each block was on a different rootstock, Carrizo citrange (C. sinensis (L.) Osbeck × Poncirus trifoliata Raf.), Sanguine Grosse Ronde sweet orange (C. sinensis (L.) Osb.), Seville sour orange (C. aurantium L.), and Troyer citrange (C. sinensis (L.) Osb. × P. trifoliata Raf.). Trees were sprayed Nov. 25, 1974, with 0, 250, 500, and 750 ppm ethephon. Leaf abscission data were determined in the same manner as for the first test, except that only 4 branches were used per tree and only the total number of leaves was counted.

Results

Leaf abscission on ‘Robinson’ tangerine trees began within 3 days of treatment and was largely completed 9 days after treatment (Fig. 1). Treatment with 250 ppm ethephon induced heavy leaf abscission in 1974. Analysis of the data for 1974 and 1975 showed that treatment with 400 ppm did not result in significantly greater leaf losses than 250 ppm by day 22 (Table 1). Leaf losses in 1974 and 1975 were similar (Table 1, Fig. 1). Also, differences in leaf loss between the 2 dates of application were small and inconsistent in both 1974 and 1975 (Table 1).

Leaf age (position on limb) was a major factor in leaf abscission (Fig. 2). Ethephon accelerated leaf drop from older flushed leaves and did not materially affect leaves on the latest 2 flushes. This pattern of leaf abscission was the same for the control trees, except that losses were less and slower. Abscission from the 6th (oldest) flush was often erratic due to the small sample size.

The heavy defoliation induced by ethephon in 1974 and 1975 did not reduce the fruit yields recorded in 1975 and 1976 (Table 2). Ethephon at the recommended rate, 250 ppm, had no effect on the subsequent crop. Date of application also had no significant effect. Ethephon at 400 ppm gave a small but significant increase in yield following the 1974 application but not after the 1975 treatment. The lack of effect of defoliation on the subsequent fruit crop was also evident in the low correlation, 0.124, between leaf drop 52 days after treatment in 1974 and yield in 1975.

Application of the recommended rate of ethephon improved fruit color and reduced the incidence of plugging by loosening the fruit (Table 3). At 400 ppm, color and loosening responses were greater than at 250 ppm. In 1974, 250 ppm ethephon fully degreened the fruit. Although chlorophyll levels were similar, the 400-ppm-treated fruit had better color because of higher carotenoid levels. Some fruit drop occurred with 400 ppm ethephon treatment.

The average yearly increases in trunk circumference for the 0, 250 and 400 ppm treatments were 3.1, 3.3, and 2.9 cm respectively. Differences between treatments were not significant.

The 2nd test showed differences in defoliation responses between cultivars (Fig. 3). However, leaf drop was excessive at all concn, even 250 ppm. Defoliation of ‘Robinson’ was greater than in the first test (Fig. 1). Although subsequent yields were not determined, some reduction in flowering was observed on trees that were sprayed with 500 and 750 ppm ethephon. Twig dieback also was observed, but all trees produced a new leaf canopy with spring growth.

Discussion and Conclusions

Our work showed that fall defoliation caused by the use of ethephon did not reduce yields in ‘Robinson’ tangerine trees. Ethephon treatment induced abscission of the oldest leaves first (no very young expanding leaves were present on these trees). Old, inside leaves are of limited value to the tree due to senescence and shading. Many of these leaves would normally be lost before or during the spring bloom. In work on oranges, defoliation caused a marked reduction in yield (5). However, defoliation was induced in the spring, when it might be expected to have more effect than in the fall; and leaves were removed manually and uniformly from all parts of the tree. ‘Robinson’ yields were significantly increased by 400 ppm ethephon in 1975. The increase was small and further testing is needed to confirm this response. However, when properly timed, ethephon has been shown to increase flower initiation in apples (7). Because flower induction in citrus may occur in the fall (1), the increased yield of ‘Robinson’ might indicate an increase in flowering from the ethephon application.

Fruit color and loosening were better with 400 ppm ethephon than 250 ppm. Although defoliation may not be serious on healthy trees, the use of concn as high as 400 ppm may result in excessive fruit drop. Our data indicate that the

Table 1. Leaf drop from ‘Robinson’ tangerine trees 22 days after ethephon treatment: by year, rate, and date of application.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean leaf drop (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td></td>
</tr>
<tr>
<td>1974</td>
<td>18 NS²</td>
</tr>
<tr>
<td>1975</td>
<td>14</td>
</tr>
<tr>
<td>Ethephon rate</td>
<td></td>
</tr>
<tr>
<td>0 ppm</td>
<td>4 A²</td>
</tr>
<tr>
<td>250 ppm</td>
<td>20 B</td>
</tr>
<tr>
<td>400 ppm</td>
<td>25 B</td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Series 1</td>
<td>17 NS</td>
</tr>
<tr>
<td>Series 2</td>
<td>15</td>
</tr>
<tr>
<td>All interactions</td>
<td>NS</td>
</tr>
</tbody>
</table>

²NS = Not significant.

³Means separation within variables by Duncan's multiple range test, 1% level.

Fig. 2. Effect of ethephon concn on percentage leaf drop from different growth flushes of 'Robinson' tangerines at various intervals after treatment, 1974. Age 1 was the most recent (terminal) growth, 6 was the oldest growth with leaves.

Table 2. Yields of 'Robinson' tangerine trees in 1975 and 1976, as affected by rate and date of application in 1974 and 1975.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean yield per tree (boxes)^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethephon rate</td>
<td>1975</td>
</tr>
<tr>
<td>Control</td>
<td>5.2 a</td>
</tr>
<tr>
<td>250 ppm</td>
<td>5.1 a</td>
</tr>
<tr>
<td>400 ppm</td>
<td>5.7 b</td>
</tr>
<tr>
<td>Date</td>
<td>1st</td>
</tr>
<tr>
<td>5.2 NS</td>
<td>5.5</td>
</tr>
</tbody>
</table>

^2Standard field box of 90 lb. (40.8 kg).  
^XMeans separation by Duncan's multiple range test, 5% level.  
NS = not significant.
response. If original leaf densities differ, such an index of responses may not be satisfactory. In both tests, initial leaf densities were similar within a cultivar. In the 'Robinson' test 1, light penetration through the canopy to the ground surface was measured. These averaged 40 to 60 microeinsteins m\(^{-2}\) sec\(^{-1}\), or 2 to 3% of the incoming radiation (400-700 nm). These measurements indicate a relatively dense canopy. Comparison of light penetration measurements showed no consistent effect of treatment, suggesting that defoliation had not opened the canopy.

**Literature Cited**


**Starch Content and Amylase Activity in Avocado Fruit Pulp**

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**Abstract.** Amylase activity in detached avocado fruit (*Persea americana* Mill. cv. Fuerte) was directly correlated with ripening processes such as the climacteric rise in respiration, ethylene evolution, and softening. The term amylase designates the total amylolytic activity of avocado fruit but its exact nature was not studied. Amylase activity was higher in young than in mature fruits. After harvest, amylase activity started to rise with the onset of the respiratory climacteric. Parallel to the increase in amylase, a decrease in the starch content of the fruit pulp was observed. The disappearance of starch during softening was also demonstrated by electron microscopy. The possible role of starch as substrate and that of amylolytic activity as energy supplier, for metabolic processes in the fruit, is discussed.

The metabolic activity of avocado during ripening is one of the highest known in fruits. Biale and Young concluded (3) that, despite the high fat content of the mature avocado, available evidence does not support the idea that lipids are utilized as respiratory substrates during the course of the climacteric. Sugars disappear with ripening (1, 5) and so do insoluble pectins (7), but whether they account for all the substrates required in respiration remains to be determined (3).

Hydrolysis of starch during ripening is a common feature in fruits such as banana (11), mango (2) and pear (14). Starch was reported to be present in avocado pericarp plastids (4, 16).

Studies of starch-hydrolyzing enzymes have been described in some fruits such as pear (14), mango (12) and tomato (6). The main amylolytic enzymes in plants are α- and β-amylases and phosphorylase. The reaction products of α-amylase are known to be dextrins, oligosaccharides, maltose and glucose; that of β-amylase is maltose, and the product of phosphorylase activity is glucose-1-phosphate (9).

In order to test the hypothesis that amylase activity might contribute to the pool of substrates for respiration, changes in amylolytic activity during development and ripening of avocado pericarp were studied, and some characterization of this activity has been attempted. The possible role of starch as a substrate and that of amylolytic activity as an energy supplier for metabolic processes in the fruit is discussed.

**Materials and Methods**

**Plant material.** Fruits of the 'Fuerte' cultivar were harvested periodically, starting in June with very young fruit (62 g and 1.6% oil content) and ending in Dec. with completely mature fruit (313 g and 14.9% oil content). Fruits were stored at 20°C. Ethylene (8 μl/liter), was applied for 48 hr at 20°C, starting on the day of harvest. Ethylene-free air was applied to the controls.

**Enzyme extraction.** Acetone powders were prepared from fruit pulp, as described previously (15). The powder (400 mg) was extracted with 10 ml of 0.02 M phosphate buffer at pH 6.6 for 1 hr at 1°C. The slurry was centrifuged for 20 min at