

<sup>z</sup>PBS = pinhole blossom scar

<sup>y</sup> Appearance rating:

1. No defects; 2. Slight defects, not objectionable;
3. Moderate defects, slightly objectionable; 4. Severe, objectionable; 5. Extreme, appearance very poor.

Fig. 2. Internal appearance rating of blossom-end types. Data are combined for all cultivars.

individually inspected to determine if the pinhole is present and then judged to determine if the channel extends into the locule. Positive identification requires cutting which

Table 2. Percent of table-ripe fruit that leaked from the blossom end when subjected to a 2-kg force from a Cornell pressure tester for 5 seconds.

Cultivar	Packinghouse	Blossom-end type		
		Normal	PBS <sup>z</sup>	Catfaced
		----- (% Leakers) -----		
Flora-Dade	A	0	2.2	0
FTE-12	B	0	1.6	0
Duke	C	0	1.1	4.3
Duke	D	0	1.8	2.2

<sup>z</sup>Pinhole blossom scar.

renders fruit unsaleable. These problems make it impractical to grade for PBS on a commercial scale.

In previous studies tomatoes with PBS appear to have been termed "normal" (3) or "concave blossom ends" (5). In both studies they were distinguished from catfaced fruits. The data presented above indicate that application of the grade standards for catfacing to tomatoes with PBS is unnecessary. Fruits with PBS were otherwise well-shaped, had good internal appearance and presented little threat of leaking during marketing.

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## ETHYLENE AS RELATED TO FRUIT RIPENING IN PEACHES<sup>1</sup>

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*Additional index words.* *Prunus persica*, aminoethoxyvinylglycine, ethrel, 1-amino-cyclopropane-1-carboxylic acid (ACC), ethionine, methionine, silver nitrate.

**Abstract.** Ethylene production of 'Flordagold' and a numbered peach selection (Fla 3-2) was studied as related to ripening. Fruits at the firm-ripe stage were treated with different concentrations of Ethrel, aminoethoxyvinylglycine (AVG), 1-amino-cyclopropane-1-carboxylic acid (ACC), Ethionine, Methionine, silver nitrate and a combination of ethrel and silver nitrate. In general, ethylene production was much

higher in the 'Fla 3-2' than in 'Flordagold' which might reflect the higher firmness values in 'Flordagold' compared to 'Fla 3-2'. Maximum ethylene production was observed with ACC; ethrel produced slightly lower levels of ethylene. Ethylene production was inhibited by both silver nitrate and AVG and stimulated by ethionine, methionine and ACC. It was concluded that peach fruit has primarily the methionine pathway for ethylene production.

Ethylene is recognized as an important ubiquitous plant hormone involved in many developmental processes including fruit ripening (1). It has been associated with development (12), storage and shelf-life (5) of many fruits.

Silver nitrate (4, 7, 11) and aminoethoxyvinylglycine (AVG) (3, 7) were found to inhibit ethylene action and production. AVG reduced endogenous ethylene production and overcame the increased ethylene production brought about by other promoting chemical applications (7).

On the other hand, ethylene production was found to be accelerated by ethylene releasing chemicals or those contributing to ethylene biosynthesis. Methionine and 1-amino-cyclopropane-1-carboxylic acid (ACC) were found to be ef-

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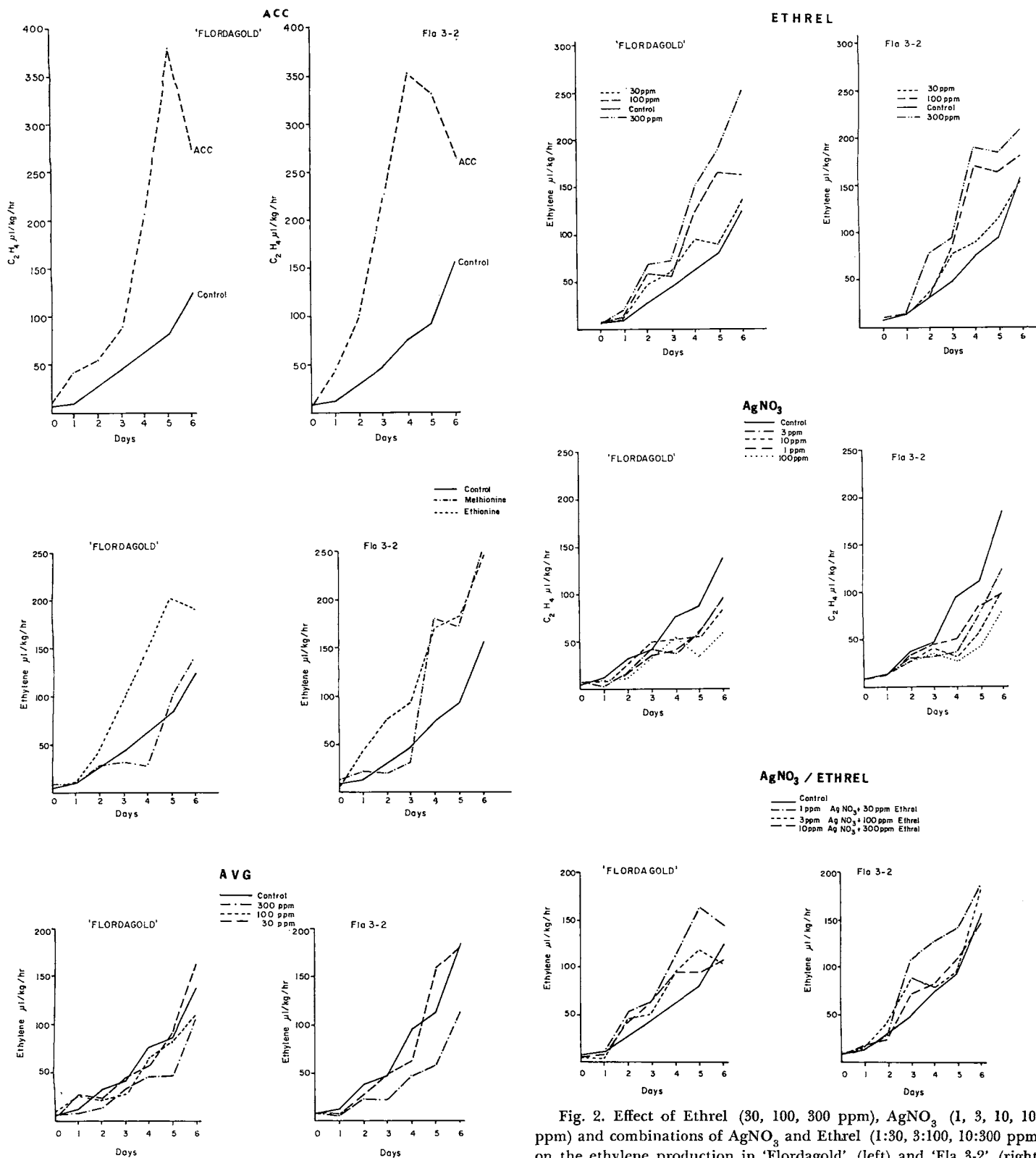


Fig. 1. Ethylene Production by 'Flordagold' (left) and 'Fla 3-2' (right) peaches as influenced by ACC (100 ppm), AVG (30, 100, 300 ppm), Ethionine (100 ppm) and Methionine (100 ppm).

fectively converted to ethylene in apples (2, 8). Ethephon is commercially used to induce ethylene and fruit ripening in many fruits such as banana (6, 9).

The objective of this work was to study the post-harvest physiology of two new Florida peach cultivars in response to compounds involved with ethylene biogenesis.

Fig. 2. Effect of Ethrel (30, 100, 300 ppm), AgNO<sub>3</sub> (1, 3, 10, 100 ppm) and combinations of AgNO<sub>3</sub> and Ethrel (1:30, 3:100, 10:300 ppm) on the ethylene production in 'Flordagold' (left) and 'Fla 3-2' (right) peaches.

### Materials and Methods

'Flordagold' and a numbered peach selection 'Fla 3-2' fruits were harvested at the firm-ripe stage from the University of Florida Experimental Orchard. Fruits were divided into 7 groups and each received one of the following treatments: Ethrel (30, 100 and 300 ppm), AVG (30, 100 and 300 ppm), L-Ethionine (100 ppm), L-Methionine (100 ppm), ACC (100 ppm), silver nitrate (1, 3, 10 and 100 ppm)

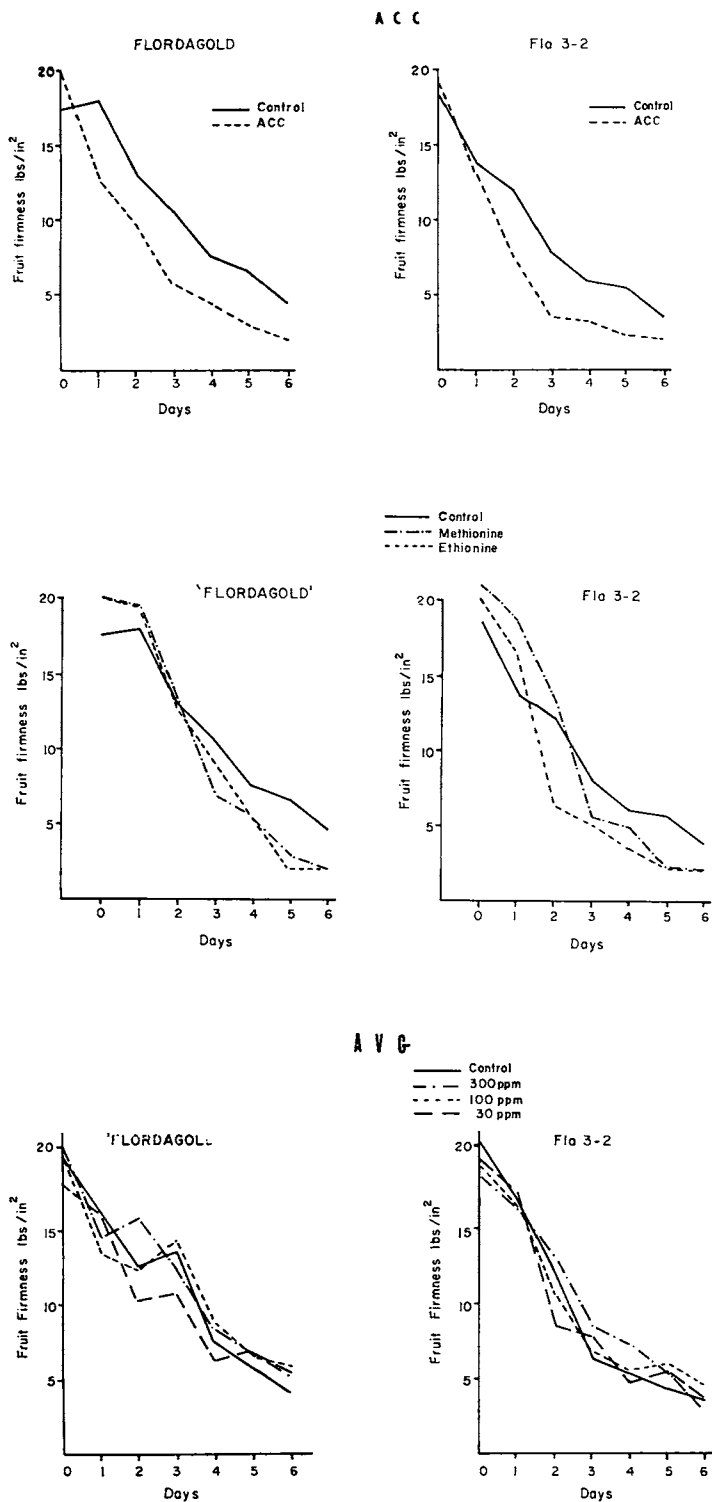


Fig. 3. Fruit firmness of 'Flordagold' (left) and 'Fla 3-2' (right) peaches as influenced by ACC (100 ppm), AVG (30, 100, 300 ppm), Ethionine (100 ppm) and Methionine (100 ppm).

and a combination of silver nitrate and Ethrel (1:30, 3:100 and 10:300 ppm).

Fruits were cut at the bottom to improve chemical penetration. Treated and untreated (control) fruits were packed in foam containers and placed on shelves in a storage room of  $18 \pm 1^\circ\text{C}$ . Samples were taken daily, starting after 6 hours and continuing for 7 days.

Gas sample measurements were taken after enclosing fruits in gas-tight glass jars for 1 hour prior to sampling. Quantities of ethylene in the samples were determined using

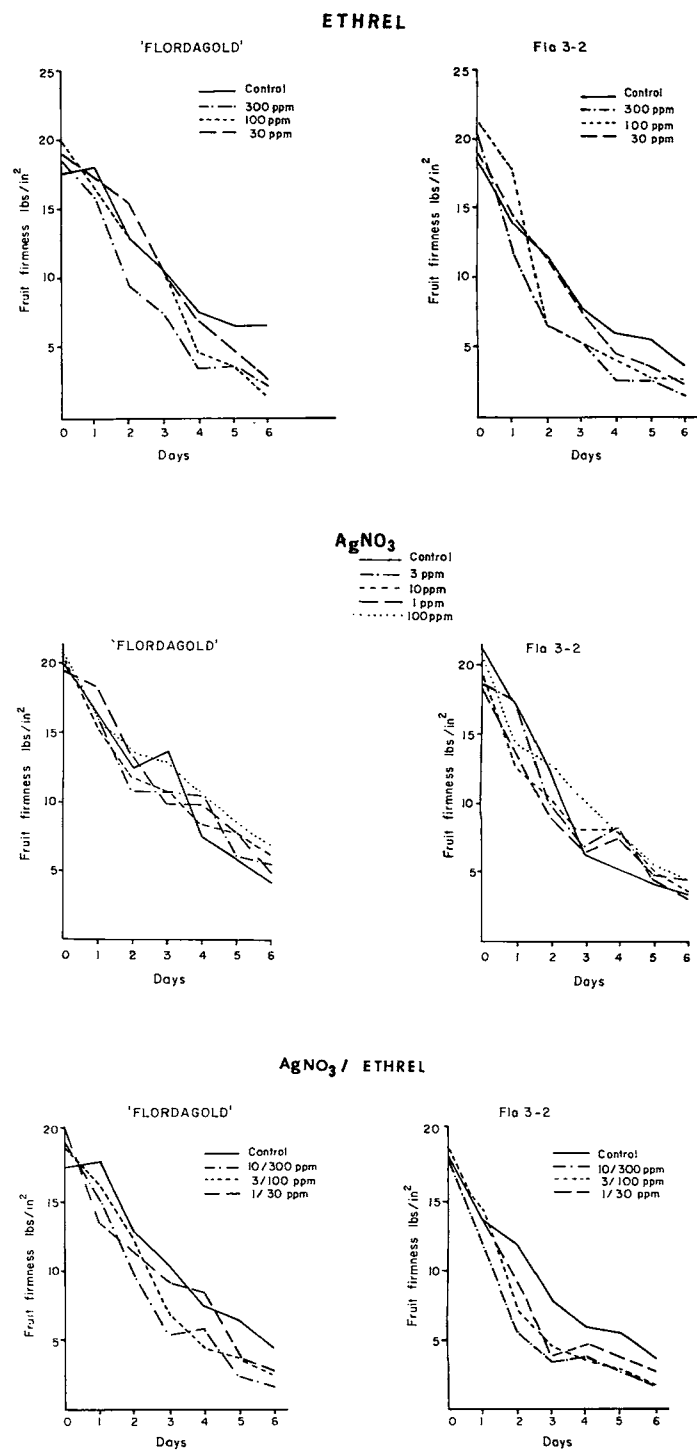


Fig. 4. Fruit firmness of 'Flordagold' (left) and 'Fla 3-2' (right) peaches as influenced by Ethrel (30, 100, 300 ppm), AgNO<sub>3</sub> (1, 3, 10, 100 ppm) and combinations of AgNO<sub>3</sub> and Ethrel (1:30, 3:100, 10:300 ppm).

a Varian Aerograph Series 200 gas chromatography equipped with a sampling valve and a flame detector and a column of activated alumina F-20, 6 ft, 20/80 mesh and 1/8". Column temperature was maintained at  $95^\circ\text{C}$  (injector at  $150^\circ\text{C}$ ). The N<sub>2</sub> and H<sub>2</sub> gas flow-rate was 25 ml/minutes (air flow rate was 300-350 ml/minutes). Areas under the peaks on chromatograms were used as indexes of quantities based on standard curves. Results were expressed as  $\mu\text{l C}_2\text{H}_4/\text{kg}/\text{hour}$ .

Fruit firmness was determined by a Magness-Taylor pressure tester equipped with 5/16" plunger. The peel was removed prior to pressure testing. Total soluble solids (TSS)

Table 1. Effect of Ethrel, ACC, Ethionine, Methionine, AVG and combinations of AgNO<sub>3</sub> and Ethrel on acidity (g citric acid/100 ml juice) of 'Flordagold' and 'Fla 3-2' peaches at the 1st and 6th day of treatment.

Treatment <sup>z</sup> (ppm)	Ethrel		ACC		Ethionine		Methionine		AVG		AgNO <sub>3</sub> /Ethrel <sup>z</sup>	
	Day		Day		Day		Day		Day		Day	
	1	6	1	6	1	6	1	6	1	6	1	6
<b>'Flordagold'</b>												
30	.07	.08	—	—	—	—	—	—	.05	.08	.06	.08
100	.07	.08	.05	.08	.06	.06	.07	.08	.06	.08	.05	.06
300	.05	.07	—	—	—	—	—	—	.06	.07	.05	.06
Control	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07
<b>'Fla 3-2'</b>												
30	.06	.07	—	—	—	—	—	—	.06	.08	.05	.06
100	.05	.08	.06	.08	.08	.07	.06	.07	.06	.08	.05	.07
300	.05	.07	—	—	—	—	—	—	.05	.08	.05	.07
Control	.06	.07	.06	.07	.06	.07	.06	.07	.06	.07	.06	.07

**Analysis of Variance**

Treatments	ns <sup>y</sup>	ns	ns	ns	ns	ns	**x
Cultivars	ns	**	**	ns	ns	ns	ns
Days	**	**	**	**	ns	**	**

<sup>z</sup>Concentrations of AgNO<sub>3</sub>/Ethrel were 1:30, 3:100, 10:300 and control.

<sup>y</sup>Not significant.

\*Significant at 1% level.

and acidity of fruit juice were determined using a T/C hand refractometer and the NaOH titration method, respectively. The acidity is expressed as gram of citric acid in 100 ml juice ( $f = .0064$ ).

Analysis of variance was used to test for differences among treatments, chemicals, days and interactions according to their *F* values (10).

**Results**

The present study demonstrates that ethylene production was higher overall in 'Fla 3-2' than in 'Flordagold'.

Table 2. Effect of 1, 3, 10 and 100 ppm AgNO<sub>3</sub> on the total soluble solids (TSS) and acidity of 'Flordagold' and 'Fla 3-2' peaches at the 1st, 3rd and 6th day of treatments.

Treatment (ppm)	T.S.S. (%)			Acidity (g citric/100 ml juice)		
	Day			Day		
	1	3	6	1	3	6
<b>'Flordagold'</b>						
1	9.4	11.8	12.4	.05	.06	.08
3	10.4	10.6	10.8	.06	.07	.07
10	11.0	11.2	11.0	.07	.07	.08
100	9.6	10.8	11.8	.06	.06	.08
Control	11.8	12.8	12.2	.07	.05	.07
<b>'Fla 3-2'</b>						
1	10.0	9.8	11.2	.06	.07	.09
3	9.4	9.4	10.8	.07	.06	.07
10	9.8	10.8	10.8	.07	.06	.07
100	9.4	10.8	10.8	.06	.05	.07
Control	10.8	10.4	11.8	.06	.05	.07

**Analysis of Variance**

Treatments	**z	**
Cultivars	**	ns <sup>y</sup>
Days	**	**

<sup>z</sup>Significant at 1% level.

<sup>y</sup>Not significant.

**Ethylene Production**

ACC, Ethionine, Ethrel and Methionine were found to enhance ethylene production in fruits of both cultivars (Fig. 1, 2). ACC followed by Ethionine result in fruit tissue producing more ethylene than either Ethrel or Methionine.

The amount of ethylene initiated from the ACC treatment was almost 3-fold the amount in the untreated (174.4: 58.5 and 219.9:69.9 in 'Flordagold' and 'Fla 3-2', respectively (Fig. 1). Increase in ethylene production was 97 and 62% when fruits were treated with Ethionine and Methionine respectively. Ethrel, an ethylene releasing chemical, resulted in ethylene production increases as the concentration of the treatment increased (Fig. 2). Ethrel (300 ppm) induced increases up to 95-105% over untreated fruits of 'Fla 3-2' and 'Flordagold', respectively.

In general, ethylene production increased with ACC, Ethionine, Ethrel and Methionine the first 2 days of treatment. The second day of the treatment being the key day for a marked increase in ethylene production, presumably a portion of this increase in ethylene is from the fruit tissue

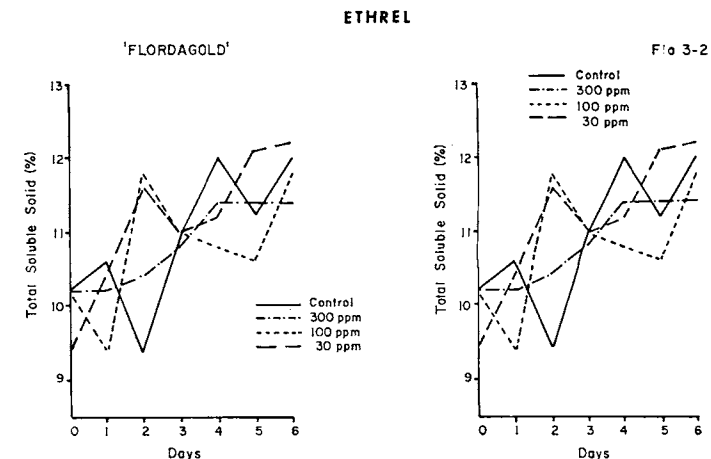


Fig. 5. Fluctuations of total soluble solids (TSS) in fruits of 'Flordagold' and 'Fla 3-2' peaches after Ethrel treatment.

Table 3. Total Soluble Solids (TSS) of 'Flordagold' and 'Fla 3-2' fruits as affected by Ethrel, ACC, Ethionine, Methionine, AVG and combinations of AgNO<sub>3</sub> and Ethrel at 1st and 6th day of treatments.

Treatment <sup>z</sup> (ppm)	Ethrel		ACC		Ethionine		Methionine		AVG		AgNO <sub>3</sub> /Ethrel <sup>z</sup>	
	Day		Day		Day		Day		Day		Day	
	1	6	1	6	1	6	1	6	1	6	1	6
<b>'Flordagold'</b>												
30	10.4	12.2	—	—	—	—	—	—	10.2	11.6	10.2	11.2
100	9.4	11.8	10.8	12.8	9.8	11.4	9.8	11.4	10.0	11.6	9.0	11.4
300	10.2	11.4	—	—	—	—	—	—	9.8	10.8	11.2	10.8
Control	10.6	12.0	10.6	12.0	10.6	12.0	10.6	12.0	11.8	12.2	10.6	12.0
<b>'Fla 3-2'</b>												
30	10.0	10.8	—	—	—	—	—	—	9.2	11.0	10.2	10.8
100	9.8	10.8	9.6	10.8	9.8	11.8	10.2	10.8	10.1	11.2	10.2	10.8
300	9.0	10.6	—	—	—	—	—	—	9.2	11.0	9.8	11.0
Control	9.3	10.4	9.3	10.4	9.3	10.4	9.3	10.4	10.8	11.8	9.3	10.4

#### Analysis of Variance

Treatments	**y	ns <sup>x</sup>	**	**	**	**
Cultivars	**	**	**	**	**	**
Days	**	**	**	**	**	**

<sup>z</sup>In case of AgNO<sub>3</sub>/Ethrel, treatment concentrations are 1/30, 3/100, and 10/300 ppm of each and control.

<sup>y</sup>Significant at 1% level.

<sup>x</sup>Not significant.

systems. The degree of increase was almost the same in both cultivars. Methionine treatment was effective only on 'Fla 3-2' and after the 4th day.

The effect of AVG (Fig. 1), silver nitrate (Fig. 2) and a combination of silver nitrate with Ethrel (Fig. 2) were used to study the inhibitory effects on ethylene production and fruit quality indicators.

AVG treatments resulted in a decrease in ethylene production (Fig. 1). This was more pronounced in 'Fla 3-2' than in 'Flordagold' (44.8 vs. 34.5%) when treated with 300 ppm AVG. The lower concentrations (30 and 100 ppm) were less effective.

Silver nitrate (Fig. 2), caused a significant inhibiting effect on ethylene production, and confirmed the hypothesis that silver ions could be considered an antiethylene agent (4). The 100 ppm silver nitrate treatment was more inhibitory than other concentrations and amounted to more than a 50 percent inhibition when compared to the control. It was more inhibitory than AVG and was more pronounced with 'Fla 3-2' fruits than with 'Flordagold' fruits.

The noncompetitive inhibitory effect of Ag<sup>+</sup> on ethylene production was studied in the presence of an ethylene releasing chemical, Ethrel, in peaches tissues (Fig. 2). As shown in Fig. 2 increasing the concentration of Ethrel increased tissue levels of ethylene. Ethylene was one-third the amount released by untreated fruits in either cultivar (31-36%) and was less than the Ethrel treatment alone.

#### Fruit Firmness

Fruit firmness was overall higher in 'Flordagold' than in 'Fla 3-2'. AVG (Fig. 3) and AgNO<sub>3</sub> (Fig. 4) generally reduced the softening of fruits, especially those treated with AgNO<sub>3</sub>. Again, effect was more pronounced in 'Flordagold' than in 'Fla 3-2'.

All other treatments caused significant reductions in fruit firmness except the Methionine and Ethionine treatments (Fig. 3). ACC (Fig. 3) greatly accelerated softening in both cultivars followed by the Ethrel/silver nitrate combinations (Fig. 4).

Regarding cultivars treatment interactions, there were

significant differences in fruit firmness when fruits were treated with AgNO<sub>3</sub>, AVG, Ethrel and AgNO<sub>3</sub>/Ethrel combinations.

#### Acidity

There was no significant difference in fruit acidity between cultivars due to treatments (Table 1). However, slight increases in juice acidity was observed as with treatments duration (except with Methionine). A significant difference among treatments was only observed in the AgNO<sub>3</sub> (Table 2) and AgNO<sub>3</sub>/Ethrel treatments (Table 1).

#### Total Soluble Solids (TSS)

The total soluble solids was significantly affected by the different chemical and treatments used in all cases except Methionine and Ethionine (Table 3). ACC, Ethrel (Fig. 5) and AgNO<sub>3</sub>/Ethrel (Table 3) caused significant increases in TSS and these increases were more pronounced with 'Flordagold' peach than with 'Fla 3-2'.

Application of AVG and AgNO<sub>3</sub> (Tables 2 and 3) generally caused slight reductions in TSS. This reduction was less in 'Fla 3-2'.

#### Discussion

This investigation was done to study the postharvest physiology of 2 new Florida peach cultivars. The responses of 'Flordagold' and 'Fla 3-2' peaches to external chemical treatments were evaluated as the ripening processes progressed. There were marked increases in ethylene production (6). The dramatic increase of ethylene production in fruits is closely associated with the increase in respiration and with ripening (6). An ethylene releasing chemicals (Ethrel), intermediate chemicals in ethylene biosynthesis (ACC) and the well known *in vivo* precursor of ethylene production in fruit tissues, Methionine, (2, 8) were demonstrated to accelerate the production of ethylene and to hasten fruit ripening processes.

Ethylene production has been associated with fruit firmness (5). The present data showed real differences in ethy-

lene and fruit firmness of the 2 cultivars in response to the different chemicals. Treatments of ACC, Ethrel, Ethionine and Methionine accelerated ethylene evolution in peaches and caused considerable decreases in fruit firmness. This was in contrast to antiethylene agent of silver nitrate and AVG which prevented fruit from softening which would be due to the blockage of ethylene biosynthesis in peach tissues. When Ag+ were present along with ethylene, the softening reaction was not inhibited.

The exceptional high fruit firmness of 'Flordagold' peach at maturity, ripening and during storage stages (5) was confirmed. There were low production rates of ethylene by 'Flordagold' when compared to 'Fla 3-2' peaches. This was apparently also reflecting in a slower rate of loss of firmness.

The action of the various chemical on whole fruit did not allow us to determine the basis for the difference in ethylene biogenesis between the two cultivars. However 'Flordagold' did respond differently to added methionine than did 'Fla 3-2'.

In general, there were no remarkable differences in TSS and juice acidity between the 2 cultivars, however the different treatments did produce some differences when cultivars and periods of treatments were analyzed. It seemed reasonable to conclude that TSS and acidity were not contributing to the difference between the two cultivars.

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## UTILIZATION OF THE FLOW-THROUGH SYSTEM FOR RIPENING INITIATION OF TOMATOES<sup>1</sup>

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**Abstract.** Catalytic generation of ethylene for ripening initiation of tomatoes in Florida is a common practice. Although this practice is very safe there are the disadvantages of high concentrate costs and accumulation of CO<sub>2</sub> which interferes with ripening.

An alternative flow-through system was developed which blends the required amount of tank ethylene (150 ppm) with fresh air and passes this mixture through the ripening room at the rate of 1 room air change in 6 hours. This rate of change is sufficient to maintain CO<sub>2</sub> concentration below 2%.

The flow-through system was recommended for commercial use on a trial basis in the spring of 1980. It is estimated that 40 to 50% of the tomato ripening rooms in Florida have now converted to the new system. Additional 37% have modified their ripening practices to allow for air changes in the rooms.

Construction of special rooms for ripening tomatoes with exogenous ethylene began in Florida in 1968. Prior to that time some tomato ripening initiation with exogenous ethylene had taken place in existing rooms which had been appropriately modified. By 1971 one manufacturer in Florida had constructed 35 air-tight tomato ripening rooms with temperature and humidity control and ranging in capacity from 10,000 to 15,000 cu. ft. Harllee-Gargiulo, Inc. became

the "World's leading user of ethylene gas technique for ripening tomatoes".<sup>2</sup>

At that time ethylene from high pressure cylinders was injected into ripening rooms generally by the method of cylinder differential weight (pounds ethylene per room). Atmospheric samples taken from some of these rooms one hour after injection showed ethylene concentrations up to 15,000 ppm; CO<sub>2</sub> up to 8% also accumulated in these ripening rooms. Ripening rooms were opened each 12 or 24 hours for a short period of time to allow the tomatoes to "breathe", after which time rooms were closed and more ethylene introduced. The Florida Fire Prevention Code states in part that ethylene shall be introduced by some means under positive control and measured so that the quantity introduced does not exceed one part ethylene to one thousand parts of air (1,000 ppm). The flammable range of ethylene is 3.1 to 32% (31,000 to 320,000 ppm). Generally tomatoes were ripened safely with this technique but the rare accidents that occurred were traced to poor practices such as "... a few minutes before the wall blew out a loud hissing noise was heard. The shop foreman said the normal operation was that the cylinder of gas was turned on by one employee and 10 minutes later another worker was to shut it off", or "... a rubber hose connected the cylinder of ethylene to a galvanized pipe which was stuck through the wall to the ripening room. The cylinder valve was opened and ethylene was allowed to enter the room until the galvanized pipe showed signs of frosting".

Development of catalytic generators eliminated the hazards associated with poor practices employed by a few

<sup>1</sup>Florida Agricultural Experiment Station Journal Series No. 3414.

<sup>2</sup>Aluma Shield News Vol. 2, Supplement to the Packer, September 4, 1971.