PRE- AND POSTHARVEST GIBBERELLIC ACID AND 2,4-DICHLOROPHENOXYACETIC ACID APPLICATIONS FOR INCREASING STORAGE LIFE OF GRAPEFRUIT

LOUISE FERGUSON², M. A. ISMAIL³, F. S. DAVIES² AND T. A. WHEATON⁴
University of Florida, IFAS, Agricultural Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850

Additional index words. Citrus paradisi Macf., decay, peel firmness, peel color, senescence.

Abstract. Preharvest gibberellic acid (GA₃) and 2,4-dichlorophenoxyacetic acid (2,4-D) sprays applied at colorbreak extended the harvest season of 'Marsh' seedless grapefruit (Citrus paradisi Macf.) in both the 1980-81 and 1981-82 seasons. GA₃ + 2,4-D delayed overripe color development, loss of peel puncture strength and decreased fruit drop. Experiments were carried out comparing effectiveness of a preharvest GA₃ + 2,4-D spray, postharvest GA₃ + 2,4-D dip, and combined spray and dip treatments on peel quality and decay during storage. Fruit harvested in January, March and May were stored for 12 wk at 60°F. GA₃ + 2,4-D treated fruit had significantly less overripe color, greater puncture strength, and less decay than controls. The three treatments were equally effective for January and March harvests while preharvest and combined treatments were more effective than a postharvest treatment in May. Preharvest sprays significantly reduced fruit drop after March.

If storage life of grapefruit could be extended, late season domestic and Japanese markets, requiring about 3-4 wk shipping time, could be expanded. One problem in extending grapefruit storage life is late season decline in peel quality; namely color, puncture resistance and increased decay. The peel becomes an unmarketable orange yellow, is easily punctured due to lack of resistance and decay increases in long term storage (11). Current commercial packinghouse fungicide and wax applications decrease decay but do not reduce yellow-orange color development or loss of firmness.

Preharvest sprays of GA₃ + 2,4-D maintained better peel quality of tree-stored (2, 4, 6) and harvested (1) grapefruit by delaying overripe color development and loss of peel puncture strength. Postharvest GA₃ dips maintained peel quality of 'Shamouti' oranges (7) and other citrus in the same way (11). Preharvest applications of 2,4-D extended tree storage life of grapefruit by delaying abscission thus decreasing late season fruit drop (5). Postharvest 2,4-D dips were reported to maintain peel quality and decrease decay

Two sets of 40 'Marsh' white seedless grapefruit trees (Citrus paradisi Macf.) on rough lemon rootstock (C. jambhiri Lush.) from the same grove were used successively during the 1980-81 and 1981-82 seasons. Trees were growing in Astatula fine sand, hedged north-south in 15 x 30 ft (4.5 x 9.1 m) spacing and had low-volume under-tree irrigation. Normal grove production practices were followed. The 40 trees were divided into a 20-tree preharvest control treatment and 20-tree preharvest spray treatment. Completely randomized single tree plots were used during 1980-81 and 2-tree plots during 1981-82. When all fruit was slightly past colorbreak on December 12, 1980 and November 11, 1981 approximately 13 gal (50 liters) of an aqueous combination of GA₃ (20 ppm), 2,4-D (20 ppm) and X-77 surfactant (.025% v/v) was sprayed on each preharvest treatment tree. Control trees were not sprayed. Counts of fruit dropped within the dripline were done monthly.

On January 26, 1981; March 28, 1981; May 18, 1981; January 18, 1982; March 15, 1982; and May 10, 1982 approximately 60 fruits per tree were randomly harvested from the 4 quadrants of each tree. Blemished fruit were removed and the remainder was washed on a packinghouse line and air dried. Initial seed sprouting counts were done on 10 fruits per tree. An additional 20 fruits per tree were used to obtain initial peel color measurement by Hunter Color Difference Meter (8), peel puncture strength by Instron penetrometer (9), and juice quality by automated system analysis (3). Peel color was tested on 1 location per fruit, peel firmness on 4. The remaining fruit was combined within each of the 2 preharvest treatments, control and preharvest spray, and then divided into 2 equal lots within these treatments. One lot from each field treatment was postharvest dipped for 1 min in an aqueous combination of GA₃ (100 ppm), 2,4-D (500 ppm), and X-77 surfactant (.025% v/v). These pre- and postharvest treatments produced 4 storage treatments; a control treatment without preharvest spray or postharvest dip, a treatment with postharvest dip only, a treatment with preharvest spray only, and a treatment with both spray and dip. All fruits received 1000 ppm thiabendazole (TBZ), were dried and waxed on a packinghouse line, packed into cartons, 4 replications per storage treatment, and stored at 60°F (15.5°C) and 95% relative humidity for 12 wk.
Results and Discussion

Effects on fruit drop. Preharvest GA₃ + 2,4-D decreased fruit drop significantly (Fig. 1). The acceleration of drop rate which normally begins in late March to early April (2) was sharply decreased both seasons. Preharvest GA₃ + 2,4-D sprays may also decrease post freeze fruit drop losses. Freezes occurred on January 12 and 13, 1981 and January 13, 1982. Counts taken shortly after were significantly higher for untreated trees. In addition these differences in drop between treated and control trees were more marked for the more severe freeze of January, 1981 and persisted with little change both seasons until normal March acceleration in drop rate. This suggests that differences in January drop rates were the result of untreated trees losing more fruit due to freezing temperatures than GA₃ + 2,4-D treated trees.

Effects on color. GA₃ + 2,4-D delayed overripe color development when applied before or after harvest (Fig. 2). Fruit from preharvest treated trees had significantly lower a/b ratios than controls on all 6 harvest dates, confirming an earlier Florida report (2). Fruits which received any of the GA₃ + 2,4-D treatments still had significantly lower a/b ratios than controls after 12 wk in storage. From January to March, all treatments were equally effective in delaying overripe peel color but in May, combined pre- and postharvest treatment was significantly more effective than postharvest, but not preharvest treatment. Therefore prior to April there was no advantage to combined pre- and postharvest treatment as either treatment alone delayed color development equally well. Preharvest or combination pre-

![Graph](image1)

Fig. 1. Effect of a preharvest GA₃ + 2,4-D spray on preharvest fruit drop. Both seasons differences were significant at 5% level by analysis of variance by January and continued the rest of the season.

![Graph](image2)

Fig. 2. Comparison of preharvest, postharvest, and combined pre- and postharvest GA₃ + 2,4-D treatments on peel color at harvest (bottom of bar) and after 12 wk of storage (top of bar). Treatment means within a harvest date at bottom (harvest) and top (after storage) separated by Duncan’s multiple range test, 5% level.

and postharvest treatments were best for fruit harvested in May as they produced significantly less overripe color and decreased drop which accelerates after March (2) (Fig. 1). If only a single GA$_3$ + 2,4-D application is possible preharvest is preferable as it consistently produced a lower a/b ratio than postharvest applications and decreased late season fruit drop, allowing extension of the harvest season.

**Effects on peel puncture resistance.** GA$_3$ + 2,4-D maintained peel puncture resistance when applied either pre- or postharvest (Fig. 5). Fruit from preharvest treated trees had significantly higher puncture resistance than controls, confirming earlier data by Ali-Dinar et al. (2). However, for harvested fruit they reported puncture resistance from 1.38 to 2.00 lbf. (.62 to .91 kgf.) compared to the 3.07-4.78 lbf. (1.4 to 2.2 kgf.) here. Our values agree favorably with two other Florida reports (Davies, F. S. and M. A. Ismail, and Rose, A. J., both private communications) and one Australian report (4). Fruit treated before or after harvest, or at both times, had consistently higher puncture resistances after 12 wk of storage, than controls. All treatments were equally effective for January and March harvests but for May harvests combined pre- and postharvest treatments were significantly better than preharvest treatments which in turn were significantly better than postharvest treatments.

Therefore, through March there was no advantage to combined pre- and postharvest treatment as a single preharvest or postharvest treatment maintained peel puncture resistance through storage as well. After March, preharvest, or combined pre- and postharvest treatments, were more effective than a postharvest treatment. However, if only a single GA$_3$ + 2,4-D application is possible, preharvest treatment is preferable as it also decreased late season fruit-drop losses (Fig. 1).

**Effect on decay.** The GA$_3$ + 2,4-D treatments decreased decay in storage (Fig. 4). There were no significant differences between preharvest, postharvest and pre- and postharvest applications combined; all had significantly less decay than untreated control fruit. Onset of decay was 1 to 2 wk earlier, and stem-end rot was more frequent, in control fruit. These data agree with earlier reports of 2,4-D's ability to decrease grapefruit decay, particularly stem-end rot, when applied postharvest (12, 13). Preharvest or postharvest applications of GA$_3$ have been reported to delay peel senescence therefore maintaining peel quality in storage (11) and postharvest applications have been reported to decrease stalk-rot in stored grapefruit (Israel Citrus Marketing Board, private communication).

**Effect on juice quality.** Juice content, °Brix, % acid,
Brix/acid ratio and individual fruit weights did not display any significant, consistent differences due to treatment either at harvest or after 12 wk in storage. Seed sprouting was unaffected by all treatments during either season. This disagrees with an earlier Florida report (2) while confirming another (1).

These results confirm earlier reports of preharvest GA$_3$ + 2,4-D sprays maintaining grapefruit peel quality on the tree (2, 4, 6) and in storage (1) without affecting internal quality (2, 4, 6). Preharvest GA$_3$ + 2,4-D was the best treatment under most circumstances. Overripe color development and loss of puncture resistance were retarded more effectively through storage when GA$_3$ + 2,4-D was applied preharvest. This is consistent with Goldschmidt and Eliati's (7) report of GA$_3$ delaying color development more effectively in unharvested than harvested 'Shamouti' oranges. Preharvest GA$_3$ + 2,4-D also produced better peel quality in tree-stored fruit and delayed abscission, therefore extending the harvest season. Postharvest GA$_3$ + 2,4-D dips, though less expensive and as effective as the preharvest spray in maintaining peel quality and decreasing decay of stored fruit harvested through March, did not enable extension of the harvest season. Applying both a preharvest spray and a postharvest dip was advantageous only for fruit harvested in May. Otherwise a preharvest spray or postharvest dip had the same effect.

Despite GA$_3$'s effectiveness in slowing peel senescence in grapefruit, seed germination in late season fruit still remains a problem. Seed germination results in the development of off flavors and lowers the grade of fresh market and processing fruit.

**Literature Cited**


**FRUIT MATURITY AS RELATED TO ETHYLENE IN 'DELITE' BLUEBERRY**

S. Z. A. EL-AGAMY, M. M. ALY AND R. H. BIGGS
Fruit Crops Department,
University of Florida,
Gainesville, FL 32611

Additional index words. Vaccinium ashei, climacteric.

Abstract. There was a significant correlation between ethylene production by 'Delite' blueberry and fruit ripening as related to 9 different maturity stages from green to dark blue. Rates of ethylene production were determined by detaching the fruits, placing in moistened chambers, collecting at 1-hr intervals periodically, aerating between collections and measuring ethylene evolved by gas chromatography. Ethylene production by detached fruits was lowest in green fruit, highest in pink fruit and then low to intermediate as fruits became blue in color. With all stages, there was a lag-phase in ethylene production that lasted for 5 days, or somewhat longer for more immature fruit, after fruits were detached from bushes.

The dramatic increase in ethylene production evolved from fruit associated with the increase in respiration and ripening (2, 8). Increase in respiration rate was also associated with redness of blueberry fruit (1). There was a question concerning the nature of blueberry fruit as related to the occurrence of a climactic state (4, 5, 7, 8). Lowbush blueberry was considered once as a nonclimacteric fruit (4, 5) but recent studies indicate that blueberries have a definite climacteric rise in respiration and should be considered a climacteric-type fruit (6, 7, 8).

Rabbiteye (Vaccinium ashei Reade), a southern hexaploid commercial blueberry needs further study from the standpoint of ripening and storage to develop good practices for handling this type of fruit. The objective here was to investigate fruit ripening of the rabbiteye blueberry as related to ethylene production.

**Materials and Methods**

Fruit of 'Delite' rabbiteye blueberry were collected at different stages of fruit development. Fruit were classified as A) green-mature, B) green + 25% pink, C) 50% pink, D) 75% pink, E) pink, F) bluish pink (pink + 50% blue), G) 75% blue, H) blue (commercial picking), and I) blue-black (full-ripe, beyond commercial handling). Fruits were kept at 18°C and ethylene samples were taken every 24 hr for 8 days.