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IMPORTANCE OF POSTHARVEST EVALUATIONS IN A FRESH FRUIT BREEDING PROGRAM: USDA 77-19 A CASE IN POINT

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Abstract. **Development of new citrus fruit cultivars for the fresh market is recognized as essential for the US citrus industry to remain competitive. The breeding selection USDA 77-19 is a new grapefruit-like hybrid developed by the USDA citrus breeding program. The original hybrid, USDA 75-8, was selected in 1973 from a population of 'Pearl' tangelo × grapefruit hybrids. Budwood of USDA 75-8 was irradiated in 1980 to generate seedless mutants and USDA 77-19 was a low seed content selection made from the irradiated material. Fruit of USDA 77-19 are non-bitter and reach commercial maturity in early September. USDA 77-19 has the potential to fill a niche for an early-ripening low acid non-bitter grapefruit. The fruit have been evaluated in taste tests and have good consumer acceptance. In an effort to determine the market potential for USDA 77-19, we conducted trials to determine the postharvest performance of fruit. We found that USDA 77-19 fruit were highly susceptible to stem end rot, and that the disease was aggravated by exposing the fruit to ethylene. Fungicide treatment reduced the amount of stem end rot, but not to acceptable levels. In addition, in one trial we observed that USDA 77-19 fruit were highly susceptible to chilling injury. Such postharvest problems suggest that USDA 77-19 may only be suitable for local marketing. Results of this work support the concept that development of new fresh market citrus fruit cultivars must include not only field trials, but also postharvest trials to ensure the marketability of the fruit.**

Although Florida is a world leader in the production of fresh citrus fruit, during recent years the demand for fresh Florida citrus has decreased (Brown et al., 1999). Factors contributing to the decrease in demand for fresh Florida citrus include: availability of a wider assortment of fresh fruits, increased demand for easy-to-peel citrus, changing consumer demographics and for grapefruit in particular the fear of drug interactions (Brown and Brown, 2001).

To remain competitive citrus growers require new scion types to meet changing consumer preferences. One of the objectives of the USDA, ARS scion breeding program is development of early season non-bitter grapefruit varieties. Towards this objective, selective hybridizations between grapefruit and other citrus types were made. In 1973 the hybrid USDA 75-8 was selected from a population of 'Pearl' tangelo × grapefruit hybrids. Budwood of USDA 75-8 was irradiated in 1980 to produce seedless mutants. Two low seed count selections, USDA 77-19 and USDA 74-15, were made from the irradiated material. Budwood of USDA 77-19 and USDA 74-15 was grafted onto 'Cleopatra' mandarin, 'Carrizo' citrange, and sour orange rootstocks. A set of 12 trees, four on each rootstock, was planted at the Whitmore Foundation Research Farm. Trees of USDA 77-19 and USDA 74-15 propagated on 'Swingle' rootstock were also planted at a grove owned by Mr. Orie Lee located in St. Cloud, Fla. Following initial evaluations, USDA 74-15 was eliminated from further consideration due to poor flavor and low yields.

Performance of USDA 77-19 trees in the field has been evaluated for several years. Fruit of USDA 77-19 reach minimum maturity standards in late September when the rind is still green. The rind is of medium thickness and develops a yellow color later in the season. The albedo and section walls of USDA 77-19 are non-bitter and the fruit are mild flavored with low acidity. Results of taste tests indicate that consumers like the flavor of USDA 77-19 and that they would purchase the fruit if available (Chaparro, unpublished). The early maturity date, lack of bitterness, and consumer acceptance suggest that USDA 77-19 has potential to fill a market niche and may be a viable candidate as a novel citrus fruit type for the fresh market. Based on this potential, we were interested in determining how USDA 77-19 performed during postharvest handling. With this objective in mind, we conducted experi-

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ments over three years to determine the effects of ethylene and fungicide treatments on the postharvest behavior of USDA 77-19 fruit.

Materials and Methods

Experiment 1. The objective of this experiment was to compare the postharvest performance of USDA 77-19 with a standard grapefruit cultivar. USDA 77-19 fruit were harvested on 1 Dec. 2001 from two locations: 1) the foundation farm at Leesburg and 2) a commercial grove in St. Cloud. Duncan fruit were harvested from the foundation farm. The fruit were transported to Ft. Pierce and treatments were administered on the day after harvest.

Each sample of fruit was divided into two equal size lots. One of each of the lots was dipped for 30 s into water containing 0.25% (vol/vol) Silwet L-77 (OSi Specialty Chemicals, Danbury, Conn.). The second lot was dipped for 30 s into water containing Silwet plus thiabendazole at 1,000 ppm. Following the dip treatment each lot of fruit was divided again into two equal sized lots. One half of the lots was exposed to ethylene (ca. 100 ppm at 28 °C) overnight, the other half of the lots was placed immediately at 10 °C. Following ethylene treatment the fruit were also placed at 10 °C. Fruit were held at 10 °C for 3 weeks. After 3 weeks at 10 °C the fruit were transferred to 20 °C. The fruit were held at 20 °C for 1 week and then evaluated for condition. Each treatment combination was replicated three times; replicates consisted of 30 fruit.

Experiment 2. In the first experiment fruit were harvested in December, which is late for the early maturing USDA 77-19 fruit. In this experiment our objective was to evaluate fruit that were harvested early in the season and therefore more representative of the expected harvest period for USDA 77-19. We used 'Foster' an early maturing grapefruit variety for comparison with USDA 77-19 in this experiment. Fruit of USDA 77-19 and 'Foster' were harvested on 19 Oct. 2002. USDA 77-19 fruit were harvested from a grove in St. Cloud, Fla. and 'Foster' fruit were harvested from the Whitmore foundation farm. The fruit were transported to Ft. Pierce where they were washed, and any fruit with visible defects were discarded. Fruit from each genotype were divided into two groups of 120 fruit. The fruit were immersed in water containing 0.25% (vol/vol) Silwet L-77 for 30 s (control) or water containing surfactant plus thiabendazole fungicide (1,000 ppm) for 30 s. Following this treatment each group of fruit was divided into two groups of 60 fruit each. The fruit were then placed into rooms maintained at 25 °C and >95% relative humidity, with or without ethylene (5 ppm) for 72 h. Following ethylene treatment all fruit were transferred to a room maintained at 10 °C and >95% relative humidity for 10 d and then transferred to a room at 20 °C for 7 d. After 7 d at 20 °C fruit color was measured with a Minolta chromameter (model CR-300, Minolta Camera Corp., Osaka, Japan). The *Commision Internationale de l'Eclairage* a* and b* color index scale was use and expressed as a*/b* ratio. The fruit were also examined and incidences of physiological and pathological disorders were recorded. Following an additional 4 d at 20 °C, the incidence of disorders was again recorded.

Experiment 3. The objective of this experiment was to determine the effects of washing and fungicide treatment on the postharvest performance of USDA 77-19 fruit. Fruit were harvested from 4 single tree replicates from the St. Cloud grove on 2 Dec. 2003 and transported to Ft. Pierce. The following day any fruit with visible defects were eliminated and 3 groups of 30 fruit were selected from the remaining fruit in each replicate. The fruit were then subjected to one of three treatments: 1) no treatment (control); 2) washed on a standard citrus washer; or 3) washed and immersed in water containing 0.25% (vol/vol) Silwet L-77 plus thiabendazole (1,000 ppm) for 30 s. Following treatment, the fruit were stored at 10 °C and >95% relative humidity for 3 weeks at which time they were inspected and the incidence of physiological and pathological disorders recorded.

Results and Discussion

Experiment 1. Fungicide and ethylene treatments had significant effects on the condition of both 'Duncan' and USDA 77-19 fruit following storage at 10 °C for 3 weeks followed by 1 week at 20 °C (Fig. 1). Regardless of fungicide or ethylene treatment greater than 80% of the 'Duncan' fruit were free of physiological or pathological disorders at the time of rating. This is in striking contrast to the USDA 77-19 fruit which never had more than 60% sound fruit. Among the USDA 77-19 fruit, those from the Leesburg grove had a greater incidence of disorders than did fruit from the St. Cloud grove. Ethylene treatment resulted in a substantial decrease in the percentage of sound fruit for USDA 77-19, but not for 'Duncan'. Treatment of USDA 77-19 fruit without fungicide resulted in essentially no sound fruit. Treatment of USDA 77-19 fruit with ethylene resulted in a very high incidence of stem-end rot (Fig. 2). The level of ethylene used in this experiment (100 ppm) was extremely high compared with recommend levels of 5 ppm for degreening of Florida grapefruit (Brown and Miller, 1999); however, this level was used in order to insure an ethylene response would be induced. Interestingly, even though the level of ethylene was exceedingly high, there was not a pronounced increase in the incidence of stem-end rot in 'Duncan' grapefruit.

Experiment 2. The effects of ethylene treatment on rind color of 'Foster' grapefruit and USDA 77-19 fruit is presented in Fig. 3. With or without ethylene treatment, USDA 77-19 fruit were significantly less green (less negative a/b value)

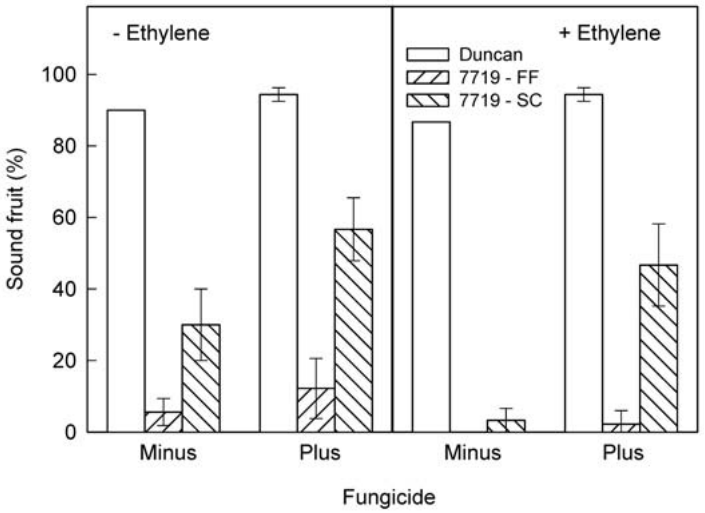

Fig. 1. Effects of fungicide and ethylene treatments on condition of USDA 77-19 and 'Duncan' grapefruit following storage at 10 °C for 3 weeks plus 20 °C for 1 week.

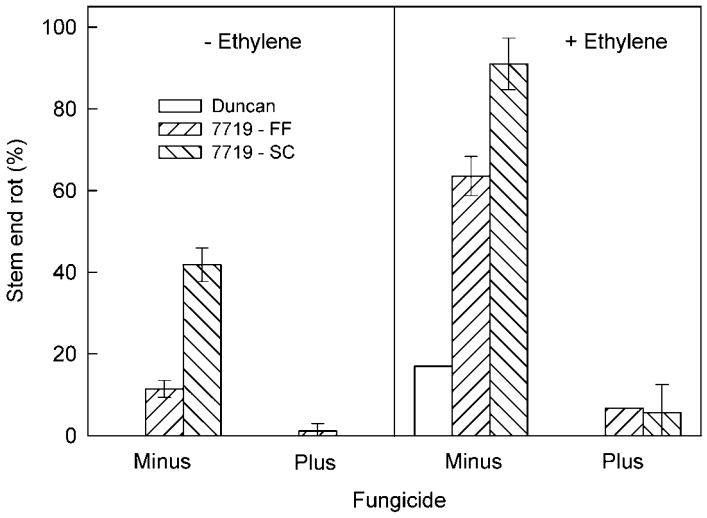

Fig. 2. Effects of fungicide and ethylene treatments on the incidence of stem-end rot on USDA 77-19 and 'Duncan' grapefruit following storage at 10 °C for 3 weeks plus 20 °C for 1 week.

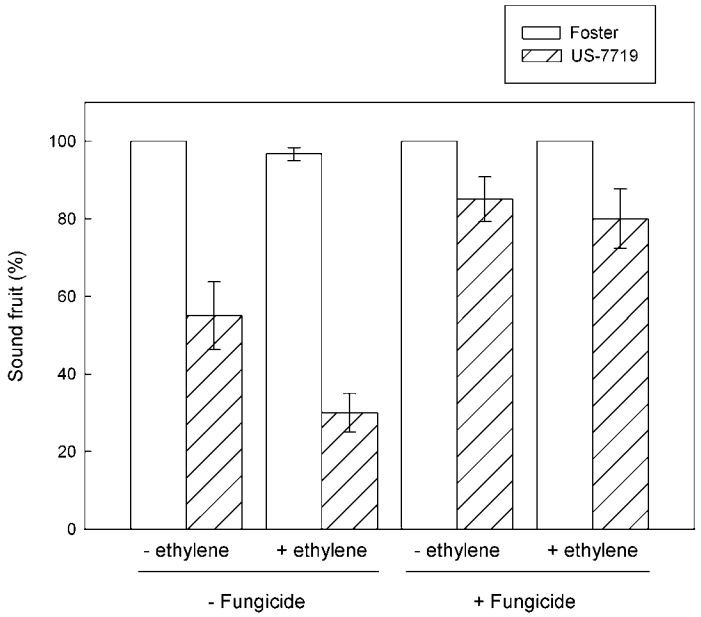

Fig. 4. Effects of fungicide and ethylene treatments on condition of USDA 77-19 and 'Foster' grapefruit following storage at 10 °C for 10 d plus 20 °C for 7 d.

than were 'Foster' grapefruit (Fig. 3). Although both USDA 77-19 and 'Foster' grapefruit had a significant loss of green color in response to ethylene, the response was more pronounced in 'Foster' than in USDA 77-19. As seen in the previous experiment, ethylene treatment resulted in a reduction in the percentage of sound USDA 77-19 fruit in the absence of fungicide treatment (Fig. 4). However, in fungicide treated fruit this effect was less pronounced.

Experiment 3. In the third experiment we determined the effects of washing and fungicide treatment on the condition of USDA 77-19 fruit following storage at 10 °C for 4 weeks. In this experiment it was observed that regardless of treatment, nearly 100% of the fruit developed a disorder that resembled chilling injury (Fig. 5). Treatment with thiabendazole fungicide did result in a slight decrease in the incidence of this disorder and this is in agreement with previous reports that thiabendazole can reduce chilling injury in grapefruit (Shiffmann-Nadel et al., 1972; Wardowski et al., 1975). It should be noted that wax was not applied to the fruit in this experiment and wax is known to minimize the incidence of chilling injury on grapefruit (Chalutz et al., 1985; Davis and Harding, 1960). However, USDA 77-19 fruit were stored at 10 °C in previous experiments and did not develop this disorder.

Approximately 30% of the fruit in the control and washed treatments developed stem-end rot compared with less than 10% of the thiabendazole-treated fruit. Other forms of decay (principally *Penicillium* molds) appeared on about 20% of the control fruit and this percentage was reduced slightly on washed and washed and thiabendazole-treated fruit.

The results of this study indicate that USDA 77-19 fruit are highly susceptible to postharvest disorders (Figs. 1, 3, and 5) especially stem end rots (Fig. 2). In contrast to USDA 77-19, 'Duncan' and 'Foster' grapefruit were much less prone to de-

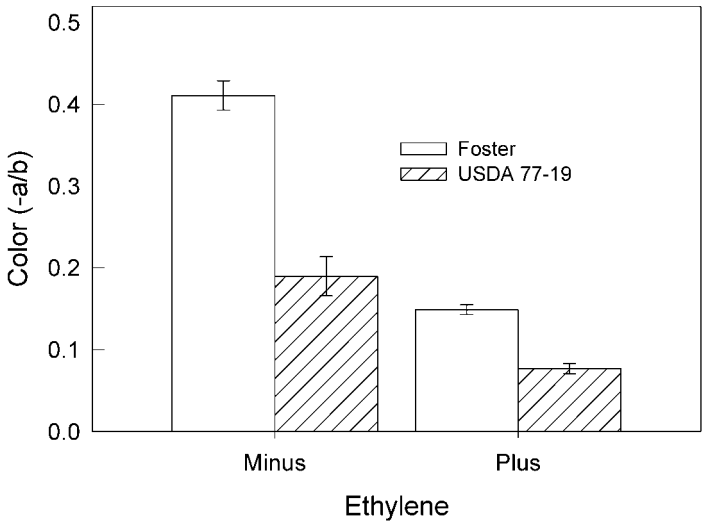

Fig. 3. Effects of ethylene treatment on color of USDA 77-19 and 'Foster' grapefruit.

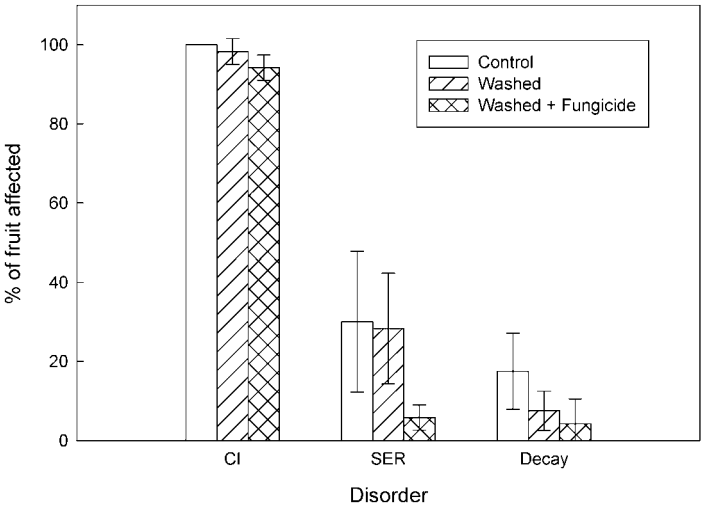

Fig. 5. Effects of washing and fungicide treatment on postharvest disorders of USDA 77-19 fruit following storage at 10 °C for 3 weeks.

velop postharvest disorders. Although there were differences in the amount of postharvest disorders on USDA 77-19 fruit sampled from the Leesburg location compared with the St. Cloud location (Figs. 1 and 2) the differences were not as great as between UDSA 77-19 grown at Leesburg and 'Duncan' grown at Leesburg. Exposure of USDA 77-19 fruit to ethylene resulted in an increase in the amount of postharvest disorders (Figs. 1, 2, and 4); however, the detrimental effects of ethylene were lessened by application of thiabendazole prior to ethylene treatment.

The development of chilling injury-like symptoms on USDA 77-19 fruit in the third experiment was surprising. In each previous experiment USDA 77-19 fruit had been stored at 10 °C and there were no chilling injury-like symptoms. In addition, 'Marsh' grapefruit that had been stored in the same room with the USDA 77-19 fruit did not develop CI, even though they had been in storage for 8 weeks. Additional tests are warranted to determine the chilling sensitivity of USDA 77-19 fruit. It has been observed that USDA 77-19 trees have a more tropical character to them than do grapefruit (Chaparro, unpublished) and this suggests a basis for a greater sensitivity of the fruit.

USDA 77-19 fruit offer the benefits of early maturity, low acid and lack of bitterness in the albedo and segment membranes; however, results of our studies indicate that USDA 77-19 fruit are prone to develop physiological and pathological disorders during postharvest handling. Such postharvest disorders place severe limitations on how the fruit could be marketed and suggest that alternative handling practices may be required for USDA 77-19. For example, the sensitivity to ethylene suggests that perhaps USDA 77-19 fruit could be marketed without degreening similar to 'Oroblanco' fruit (Porat et al., 2001). In addition, the propensity for stem-end rot indicates that USDA 77-19 fruit would require treatment with fungicide to prevent postharvest decay. The development of chilling injury in one of the experiments indicates that additional experiments are needed to determine the optimum storage temperature for USDA 77-19 fruit.

Determining how new citrus varieties respond to degreening, handling temperature and storage duration is necessary to make recommendations for growers, packers and shippers. If new varieties are to be competitive in the world market they must be able to withstand the rigors of postharvest handling and transportation and arrive at the consumer in top condition. Only by integrating postharvest evaluations into the breeding program can the development of new varieties that reach a broad market be developed.

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