

Figure 1. In the aftermath of Hurricane Irma, the rootstock seed-source plantings at the Southwest Florida Research and Education Center lost virtually all fruit from US-802, US-897 and US-942.

## Maximizing rootstock seed production

## By Fernando Alferez, Deived Uilian de Carvalho, Daniel Boakye, Tim Gast and Manjul Dutt

ndemic HLB in Florida has provoked increased pressure to replant and reset infected groves. This has resulted in concern from citrus growers and nursery operators about seed availability for the most popular rootstocks in the state. In the past, all rootstock fruit (both early and late maturing) was harvested at the same time, between October and December. However, a late harvest of the early-maturing rootstock varieties has resulted in decreased fruit yield, stemming primarily from mature fruit drop and resulting in subsequent seed yield reduction.

### HURRICANE SEASON AND HARVEST TIMING

The possibility of hurricanes hitting Florida poses an added threat to seed production since the peak of the Atlantic hurricane season precedes traditional seed harvesting dates. On Sept. 10, 2017, Hurricane Irma damaged the seed source trees and severely affected the industry's ability to produce adequate seeds for nurseries that year. There was massive fruit drop in the hardest hit areas, especially from US-802, US-812, US-897 and US-942 varieties (Figure 1), when fruit was almost ready to be harvested.

Seed availability from the Southwest Florida Research and Education Center (SWFREC) in Immokalee, the U.S. Department of Agriculture in Fort Pierce and the Whitmore Foundation in Leesburg decreased by 66% compared to the previous season. Since fruit could have been harvested before the peak of the hurricane season (late August through September), University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) researchers investigated early seed germination potential.

It is advantageous to know in advance when the fruit is mature enough to contain viable seeds. After evaluation of seeds of the US-942 and US-897 varieties through two consecutive growing seasons, research has determined that fruit can be harvested as early as August without losing germination potential. This has resulted in informed decisions on when to harvest the fruit of each variety before the peak of hurricane season.

### **RESEARCH PERFORMED**

Researchers tested several possible seed maturation indicators — including peel color development, fruit growth dynamics and size, and the onset of natural fruit drop — to determine in advance when a seed is mature enough to germinate. They found that natural fruit separation and drop (the abscission process), which usually begins once the fruit is fully mature and starts to senesce, and probably contains viable seeds, is a good indicator of seed maturity. As soon as a seed is mature enough to germinate, the fruit that contains it can drop.

> ...advancing the harvest of US-942 and US-897 fruit to August does not impact seed viability...

Fruit was treated at different maturation stages with a precursor of ethylene, the abscission-promoting gaseous hormone, in an in vitro system. The ability of the fruit to abscise (separate) from the stem in response to the ethylene gas was then assessed. This ethylene precursor is a chemical named 1-aminocyclopropane-1carboxylic acid (ACC) that can be dissolved in water and applied to detached fruits through the stem by using a disposable pipette. Fruit separation from the stem (Figure 2, page 24) was then monitored.

Researchers hypothesized that the window of the fruit's response to ethylene determines when the seed is ready to germinate. They found that for some early-maturing varieties such as US-897 and US-942, abscission and fruit drop in response to the ethylene treatment occurs as early as July and August, respectively. Subsequent work showed that seeds harvested from fruits in July and early August and placed in a tissue culture medium germinated normally. No viability was lost, thus demonstrating seed maturity was adequate.

US-942 and US-897 seeds extracted a few weeks later in mid-to-late August



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**Figure 2.** An in vitro system is used to assess fruit abscission (an indicator of both fruit and seed maturity). On the left, fruit from US-802 rootstock with about 5 centimeters of stem has a pipette attached to it and parafilm wrapped around the pipette-stem union to prevent leaking of the solution containing the ethylene precursor. On the right is a fruit that was responsive to the ethylene by separating from the stem. Note how the peel around the fruit abscission zone has changed color from green to yellow-orange, another indicator that the fruit is responsive to the ethylene.

and early September had the highest germination rate (around 96%). This indicates that harvesting these two varieties can be advanced by several months without losing viability while avoiding fruit drop and major losses. In contrast, late-maturing US-802 harvested at the same time had a germination rate of around 80%.

After determining that advancing the harvest of US-942 and US-897 fruit

to August does not impact seed viability, seed yield increased (Table 1, page 25). Consequently, harvesting in August through September is being adopted for the UF/IFAS SWFREC rootstock seedsource trees to increase seed supply.

#### **ONGOING WORK**

Vigorous seeds with good viability are necessary to produce strong citrus rootstocks. The ability of the seeds to germinate and establish seedlings rapidly depends on seed vigor. This depends on seed maturation and can be influenced by the extent of cold storage.

In general, the more mature a seed, the longer it can be stored. It is possible that harvesting seeds earlier may have an impact on storability and decrease the time that a seed can be cold-stored without losing germination capacity or vigor. Therefore, it is necessary to know



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Wauchula	WAUC-AM 1310

**Table 1.** Advancing the harvest of fruit toAugust increased seed yield.

	Increase in Number of Seed Quarts Harvested	
Rootstock	Harvest in August 2018 vs. December 2016	Harvest in August 2018 vs. October 2017 (after Hurricane Irma)
US-897	25%	66%
US-942	33%	100%

the maximum time a seed can be coldstored and still be viable as it relates to its maturity. Hence, it is important to determine how these parameters may interact with the harvest time to allow for fruit harvesting and seed extraction at the right time.

UF/IFAS obtained funding from the Florida Nursery, Growers and Landscape Association (FNGLA) last year to determine the appropriate time that the early harvested seeds can be maintained in cold storage for optimum seed vigor and germination. This will ultimately allow for better planning so nurseries can produce and supply liners in a timely fashion. In a nutshell, knowing the adequate time parameters regarding harvesting and storage life will help preserve seed quality while creating better and stronger seed germination and vigorous rootstocks for nurseries.

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Fernando Alferez is an assistant professor, Daniel Boakye is a Ph.D. student, Tim Gast is a biological scientist and Deived Uilian de Carvalho was a visiting Ph.D. student, all at UF/IFAS SWFREC in Immokalee. Manjul Dutt is a research assistant scientist at the UF/ IFAS Citrus Research and Education Center in Lake Alfred.

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