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The Texas certified virus-free citrus budwood program after 20 years

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ABSTRACT

Following the detection of *Citrus tristeza virus* (CTV) in a Texas citrus nursery in 1992, the Texas legislature passed a bill (House Bill 2807) in 1996 establishing a mandatory citrus budwood program. The important commercial citrus grapefruit and sweet orange varieties were indexed for the main pathogens, and were subjected to shoot-tip grafting. In 1998, the first foundation trees were established, and increase trees were propagated from them. At the time, only nurseries in the southern portion of the state where commercial citrus production occurs were required to obtain budwood from the program. Certified budwood of other varieties was obtained from the Citrus Clonal Protection Program (CCPP) at the University of California, Riverside to provide certified budwood of non-commercial varieties. The discovery of Huanglongbing (HLB) in Florida prompted Texas to protect its budwood sources using insect-resistant screen. New foundation trees were established in a screenhouse, and a US federal grant was obtained to construct a screenhouse complex for additional foundation trees and increase budwood trees. A back-up germplasm collection is maintained in a screenhouse located in Stephenville in north Texas. In 2013, all commercial nurseries in South Texas were required by law to propagate citrus in screenhouses, and in 2018, this was extended across the state to include nurseries which propagate citrus primarily for the homeowner market. The collection now houses approx. 140 varieties, and supplies an average of 250,000 buds annually to the 14 currently certified citrus nurseries in Texas. All trees in the collection are tested annually by PCR for CTV and HLB, and for other viruses and viroids every 3-5 years.

Additional index words: Texas, Citrus, budwood, propagation

In 1930, the Texas citrus industry became concerned about the uncontrolled introduction of citrus stock into Texas, and the Commissioner of Agriculture issued a temporary ruling to stop the practice (Anon, 1930). Nothing further happened for the next 18 years. The widespread occurrence of citrus psorosis in the Lower Rio Grande Valley (LRGV) of Texas in the 1940's (Fawcett, 1948), resulted in the launch of the first pathogen-free budwood program in the state (Sleeth, 1959). However, because program was voluntary, formal certification was not sustained. Nevertheless, the incidence of psorosis declined due in part to the distribution of psorosis-free budwood which resulted in over 90% of new trees being propagated from psorosis-free sources, and the loss of many old infected trees due to freezes (Davis, 1986).

The discovery of *Citrus tristeza virus* (CTV) in a commercial citrus nursery in 1992 (Skaria, 1993), prompted the industry to act decisively since the vast majority of trees in the LRGV are grafted on sour orange rootstock (da Graça and Sauls, 2000), rendering them susceptible to quick decline. In 1997, the Texas legislature passed House Bill 2807 which mandated the use of pathogen-free budwood for citrus propagation in the LRGV (Skaria et al., 1997).

The main commercial grapefruit and sweet orange varieties were subjected to pathogen clean-up via shoot-tip grafting (STG) (Skaria et al., 1996). Varieties of interest for residential use were obtained from the CCPP (Kahlke et al., 2005).

While the need of clean budwood was driven by the presence of two viruses in Texas, *Citrus psorosis virus* (CPsV) and CTV, biological, serological and molecular assays have also demonstrated the presence of *Citrus tatter leaf virus* (CTLV) (da Graça and Skaria, 1996) and several viroids (Kunta et al. 2007, 2013) in Texas. No disease symptoms occurred in Texas citrus as the dominant sour orange rootstock is tolerant to these pathogens. However, the demonstration that some hybrid rootstocks with resistance or tolerance to CTV were suitable for Texas conditions (Louzada et al., 2008) introduced a potential for disease expression since these were all hybrids of trifoliate orange and mandarin which are sensitive to some of these agents.

Initially, the foundation trees established from the STG sources and the subsequent increase trees propagated to supply the nurseries of the STG were planted in the open (Figs. 1 & 2). The first buds (22,025) were sold in 2000 (Kahlke et al., 2000), and by 2004 a total of 282,060 from 56 varieties had been supplied to nurseries (Kahlke et al., 2005). However, the detec-

tion of citrus huanglongbing (HLB) (aka citrus greening) in Florida (Halbert, 2005), as well as the detection of its vector, the Asian citrus psyllid (*Diaphorina citri*), in Texas (French et al., 2001), meant that Texas had to take action to prevent HLB infecting budwood supplies by constructing insect-resistant structures (Fig. 2).

Fig. 1 The original foundation trees planted in the field in 1998.

In 2013, all commercial nurseries in South Texas were required by law to propagate citrus in screenhouses in 2018, this was extended across the state to include nurseries which propagate citrus primarily for the homeowner market.

This paper describes the growth and development of the Texas budwood program over the past 20 years, from the cutting of the first budwood in 1998 to the present.

INSECT RESISTANT STRUCTURES

The first step was to build an insect-resistant screenhouse for foundation trees. This was completed in 2008 using internal funds (Fig. 2). A grant was then successfully obtained from the US Department of Commerce Economic Development Administration to construct a complex made up of four separated screenhouses for foundation, increase and rootstock seedling propagation. This was completed in 2011. Two additional screenhouses were constructed to house scion (second generation foundation) trees (Fig. 3). These structures all have double entrances, air curtains and canker disinfection systems. In addition, a screenhouse at the Texas A&M AgriLife Research Center in Stephenville, 100 miles southwest of Dallas was renovated in 2011 to provide a back-up collection of the most important varieties for Texas nurseries (Fig. 4). These

Fig. 2. Increase budwood trees with the original foundation tree screenhouse (2008).

structures all have double entrances, air curtains and canker disinfection systems.

VARIETIES

Priority was given to the main commercial varieties grown in the LRGV, primarily the red pigmented grapefruits (Rio Red and Star Ruby), and the popular sweet oranges (Marrs, N-33 navel, Everhard navel and standard Valencia). However, there is a strong interest in the community for home-grown citrus, so additional varieties have been introduced under permit from the Texas Department of Agriculture from the University of California Citrus Clonal Protection Program and more recently the Florida Department of Agriculture and Consumer Services Bureau of Citrus Budwood Registration. These include other varieties of grapefruit and sweet oranges, as well as lemons, limes, mandarins (including satsumas), kumquats, pummelos and several rootstocks. There are now 124 varieties available to the public in the Texas program. In addition, there are 16 proprietary varieties held on behalf of the license owners.

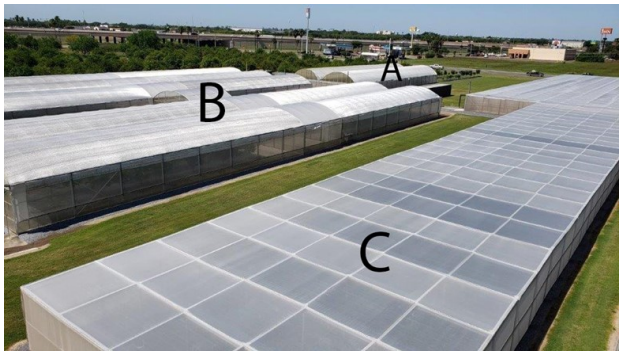

Fig. 3. Texas citrus budwood screenhouse complex. A- original foundation screenhouse; B- Main screenhouse for foundation and increase trees; C – Screenhouses for scion trees.

Table 1. List of citrus varieties in the Texas certified pathogen-free germplasm collection (* main commercial varieties).

Navel oranges	***Grapefruits***	***Mandarins***	***Blood oranges***	***Kumquats***
Bahianinha	Cocktail hybrid	Clementine	Delfino	Meiwa
Cara Cara	Duncan	Daisy	Moro	Nagami
Fukumoto	Flame	Dancy	Ruby	
Lane Late	Kinkoji	Encore	Sanguinelli	***Kumquat hybrids***
N-33*	Oroblanco hybrid	Fairchild	Tarocco	Calamondin
Palmer	Ray Ruby	Fallglo	Vaniglia Sanguigno	Eustis limequat
Rio Grande	Redblush	Honey		Indio mandarinquat
Skaggs	Reed Marsh	Kinnow	***Pummelo***	Nippon orangequat
Washington	Rio Red*	Lee	Chandler	
	Star Ruby	Nova	Reinking	***Citrons***
Valencia Oranges		Page	Hirado Buntan	Buddha's Hand
Delta	***Limes***	Pixie	Sarawak	Etrog
Olinda*	Australian finger	Ponkan	Thong Dee	
Rhode Red	Mexican	Seedless Kishu	Valentine Hybrid	***Rootstocks***
Standard	Palestine Sweet	Shiranui		Cleopatra
	Persian (Bearrs)	Sudachi hybrid	***Tangelos***	C-22 (Bitters)
Other oranges	Rangpur	Sunburst	Minneola	C57 (Furr)
Akcay Sekeri	Thornless Mexican	W.Murcott Afrourer	Orlando	C146
Earlygold			Pearl	Flying dragon
Hamlin	***Lemons***	***Satsumas***	Wekiwa	Sour Orange*
Madame Vinous	Corona Foothill Eureka	Brown Select		US 802
Marrs*	Frost Eureka	China S-9	***Tangors***	US 812
Parson Brown	Frost Lisbon	Dobashi Beni	Dweet	US 897
Pineapple*	Limoneira 8A Lisbon	Early St. Ann	Kiyomi Iyo	US 942
Republic of Texas	Meyer (Valley)	Louisiana Early	Temple	Volkamer lemon
Ruby Sweet	New Zealand lemonade	Miho Wase	Wilking	X639
Shamouti	Pomona seedless	Miyagawa hybrid		
Vernia	Ponderosa	Okitsu Wase		
Xuegan	Seedless Lisbon	Silverhill		
Westin	Variegated Pink Eureka	Xie Shan		

CERTIFIED NURSERIES

Currently there are 11 certified commercial nurseries in Texas, eight of which are in the LRGV. Two nurseries propagate trees solely for orchard plantings (Fig. 5), four are wholesale nurseries, and the remainder are small-scale providing trees for the homeowner market (Fig. 6).

Fig 4. Texas citrus germplasm back-up collection at the Texas A&M AgriLife Research & Extension Center in Stephenville.

Fig. 5. Commercial screened citrus nursery in the Lower Rio Grande Valley.

Fig. 6. Commercial screened citrus nursery in the Upper Gulf Coast area of Texas.

PATHOGEN SCREENING

According to TDA regulations, all trees in the program are tested annually for CTV (Saponari et al., 2008) and *Candidatus* Liberibacter spp. which is associated with HLB (Li et al., 2006; Zheng et al., 2016). Other viruses CPsV (Osman et al., 2015), CTLV (Park et al., 2018), *Citrus leaf blotch virus* (Ruiz et al., 2009) and viroids (*Citrus exocortis viroid*, *Hop stunt viroid* and *Citrus dwarfing viroid*) (Lin et al., 2015; Rizza et al., 2008) are tested for every 3-5 years by RT-qPCR. For example, 1254 samples were tested for HLB and CTV and 479 composite samples were tested for other viruses and viroids in 2019.

No infected trees have been detected for any of these pathogens.

BUDWOOD SALES AND TRENDS

The demand for budwood varies from year to year, depending on orders from growers. There is a steady requirement for nurseries to produce trees for re-sets, while new orchard establishment makes up the rest of the commercial orders. The 2016 peak was repeated in 2019 (Fig. 7).

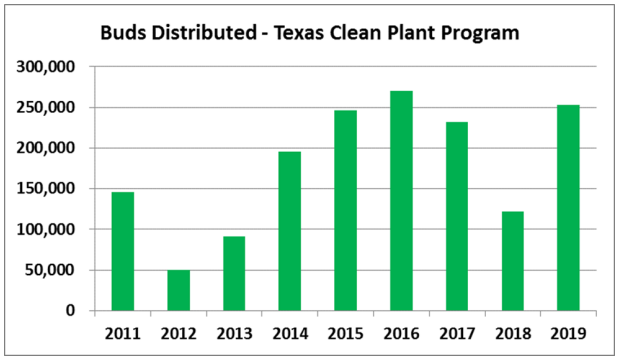

Fig. 7. Annual citrus budwood distribution to citrus nurseries in Texas: 2011-2019.

Fig. 8 displays the variety trends since 2013. The demand for grapefruit, the major citrus type grown in the LRGV, dropped dramatically in 2016/17, but came back in 2018. There was a brief demand for Pineapple sweet orange (2016-17).

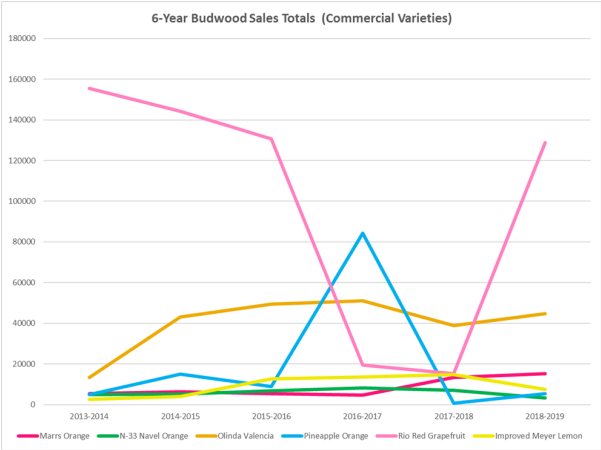

Fig. 8. Commercial citrus budwood variety demand: 2013-2019.

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