Proc. Fla. State Hort. Soc. 116:249-251. 2003.

YOUNG TREE GROWTH IN A FLATWOODS ROOTSTOCK TRIAL WITH DIAPREPES WEEVIL AND *PHYTOPHTHORA* DISEASES

KIM D. BOWMAN[1]
USDA, ARS
U.S. Horticultural Research Laboratory
2001 S. Rock Road
Ft. Pierce, FL 34945

JAMES H. GRAHAM
University of Florida
Citrus Research and Education Center
Lake Alfred, FL 33850

ROBERT C. ADAIR, JR.
Kerr Center For Sustainable Agriculture
Vero Beach, FL 32968

Additional index words. Carrizo citrange, *C. grandis*, *C. reticulata*, grapefruit, *Poncirus trifoliata*, rootstock improvement, Swingle citrumelo

Abstract. **A field trial of new rootstocks budded with Flame grapefruit was planted in May 2000 at a site affected by *Phytophthora nicotianae*, *Phytophthora palmivora*, and *Diaprepes abbreviatus* (PXD) near Vero Beach, Florida. The trial contained advanced rootstock selections from the USDA breeding program, as well as Swingle, Carrizo, and Cleopatra. Soil in the test area is primarily Winder, and nearby trees are heavily infested by Diaprepes weevil. Trees in the trial were inoculated at the time of planting with diseased roots from nearby trees declining from PXD. Initial growth of trees on some rootstocks was strong, while trees on others were severely stunted. After 18 months, grapefruit trees on Cleopatra and three of the hybrids were significantly larger than trees on Swingle. After 24 months, comparison of soil cores showed a strong correlation between the amount of Phytophthora on the roots and tree size. After 36 months, trees on US-802, US-942, US-897, and Cleopatra were growing strongly, while trees on Swingle and some other rootstocks were small and weak. There are apparent large differences between the tested rootstocks in their ability to tolerate these PXD conditions with grapefruit scion.**

Florida citrus groves are severely damaged by infestation from Diaprepes root weevil (*Diaprepes abbreviatus*). In some areas with heavy flatwoods soils, a complex of *Phytophthora nicotianae* and *P. palmivora* diseases with Diaprepes weevil (PXD) has been observed to be especially devastating (Graham et al., 2003). Unfortunately, all currently-used rootstocks are relatively susceptible to Diaprepes weevil (Lapointe and Bowman, 2002) and there is no known pest management strategy for infested sites on heavier flatwoods soils that allows sufficient control of PXD with affordable levels of chemical inputs. For areas that can be planted with new trees, availability and use of a new rootstock that is resistant or tolerant to PXD would probably provide the most economical solution to the problem.

Although no currently-used rootstocks combine sufficient tolerance to PXD with other needed characteristics, Cleopatra and some other citrus species appear to be able to tolerate PXD on heavy soils much better than many of the common rootstocks, including Swingle citrumelo (Bowman et al., 2002). New rootstocks combining good disease/pest resistance, adaptability to heavy soils, productivity, and fruit quality are urgently needed. The objectives of this study were to compare field performance of grapefruit trees on several promising new rootstocks with trees on some currently-used rootstocks under conditions expected to induce severe PXD. This report describes the rather large differences in growth between trees on the rootstocks in this trial through the first 3 years.

Materials and Methods

Seedlings of thirteen rootstock cultivars (Table 1) were grown and budded in a greenhouse nursery at the Whitmore Foundation Farm, Lake County. The rootstocks chosen for the experiment were 'Carrizo' citrange (*C. sinensis* [L.] Osbeck × *P. trifoliata*), 'Swingle' citrumelo (*C. paradisi* Macf. × *P. trifoliata*), 'Cleopatra' mandarin (*C. reticulata*), as well as specific hybrids between *Citrus* spp. and *P. trifoliata* that had been selected within the USDA rootstock breeding program based on performance in previous trials (Bowman, 1998; Bowman and Roman, 1999; Wutscher and Bowman, 1999; Wutscher and Hill, 1995). Budwood of 'Flame' grapefruit was obtained from a screenhouse source at Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Winter Haven, Fla. (Clone S-DPI-800-1-26-71-X-E), and was determined by ELISA testing as free of citrus tristeza virus. After budding, the potted experimental trees were relocated to the greenhouse nursery at the new U.S. Horticultural Research Laboratory in Ft. Pierce to complete nursery tree development. Seven strong budded trees of each rootstock were selected and transplanted to a field test row (1200 ft. long) in the K10 block at the Kerr Center for Sustainable Ag-

Table 1. Plant material tested.

Rootstock	Parentage
Swingle citrumelo	*Citrus paradisi* × *Poncirus trifoliata*
Carrizo citrange	*Citrus sinensis* × *P. trifoliata*
Cleopatra	*C. reticulata* Blanco
US-801	*C. reticulata* 'Changsha' × *P. trifoliata*
US-802	*C. grandis* 'Siamese' × *P. trifoliata*
US-809	*C. reticulata* 'Changsha' × *P. trifoliata*
US-812	*C. reticulata* 'Sunki' × *P. trifoliata*
US-827	*C. limonia Osbeck* × *P. trifoliata*
US-852	*C. reticulata* 'Changsha' × *P. trifoliata*
US-896	*C. reticulata* 'Cleopatra' × *P. trifoliata*
US-897	*C. reticulata* 'Cleopatra' × *P. trifoliata*
US-942	*C. reticulata* 'Sunki' × *P. trifoliata*
US-952	(*C. paradisi* × *C. reticulata*) × *P. trifoliata*

This research was supported in part by the Florida Citrus Production Research Advisory Council, Projects No. 981-30I, 025-02I and 003-01P. Mention of a trademark, warranty, proprietary product, or vendor does not imply an approval to the exclusion of other products or vendors that also may be suitable.

[1]Corresponding author.

riculture, Vero Beach, on 2 May 2000. Trees were planted at a spacing of 3.8 m × 7.6 m (12.5 ft × 25 ft) into the west row of a double-row bed and immediately to the east of several beds of citrus trees severely affected by the PXD complex. To inoculate the rootstock trial with *Phytophthora* disease, roots from trees on the adjacent beds that were severely infected by *Phytophthora* were harvested and placed just beneath each tree in the planting hole at the time of planting. The experimental design included seven trees on each of the 13 rootstocks arranged in seven randomized complete blocks.

Soil in the trial was Winder fine sand and Manatee loamy fine sand. Drainage was accomplished by furrows between the raised double beds running 1,200 ft to drainage ditches located at each end of the grove. During periods of low rainfall, the trial was irrigated from an artesian well (1300-1600 ppm TDS) and water was supplied to the trees using a well-maintained micro-irrigation system, with irrigation frequency determined by tensiometer readings. Due to high levels of *Phytophthora* spp. present, a low salt index liquid fertilizer (5-0-8) derived from calcium nitrate, and potassium nitrate was injected into the irrigation system supplemented with applications of 8-4-8 w/ minor of granular fertilizer by hand four times (0.5 lb each) per year. Additional applications of slow release nitrogenous (N-Sure, 28-0-0) and micronutrient (Key-Plex 445) fertilizers were applied to the foliage of the trees using a hoop sprayer 3-4 times per year. *Phytophthora* spp. control was performed with two foliar applications per year of phosphorous acid products. An IPM program for *D. abbreviatus* was practiced throughout the trial, which included two applications of ovicidal sprays of Micromite 80WG at the onset of adult emergence typically in early spring and fall. One application of an adulticide (Orthene) was made in Feb. 2002 due to an especially high population of adult weevils. One to two applications of Admire 2F were applied each year during periods of leaf flushes as a soil drench to the base of trees. Otherwise, conventional caretaking practices for non-bearing citrus trees were performed.

On 23 April 2002, four cores were taken about 12 cm away from the trunk of each tree in the trial, one at each cardinal direction. Each sample was then mixed, wetted to field capacity and allowed to drain overnight. The wetted sample was mixed again, and a 10 cm^3 aliquot was diluted into 90 cm^3 of 0.25% water agar and shaken to mix. Five 1-mL aliquots were plated onto PARPH plates (1 mL per plate), and incubated at room temp in the dark for approximately 72 h. Plates were examined for colony development as described previously (Graham, 1995). Colonies were presumptively identified to *Phytophthora* species by colony morphology and then confirmed as *P. palmivora* or *P. nicotianae* microscopically by sporangial characteristics.

Tree trunk caliper was measured 5 cm above and below the graft union at 3 years after field planting. Calipers were converted to trunk cross sectional areas (TCSA) for analysis. The data were tested by analysis of variance using Statistica version 6.0 (StatSoft, Tulsa, OK) and Duncan multiple range test was used for mean comparison within columns when the F-test was significant at $P < 0.05$.

Results and Discussion

At 3 years after field planting, only one of the 91 trees in the trial had died (a Flame/US-812). However, many other trees remained small or appeared very unhealthy (Fig. 1). Scion trunk measurements (Table 2) indicated more than a 3-fold difference in size between the strongest rootstock (US-802) and the weakest rootstock (US-952). The four rootstocks that grew the best under these PXD conditions (US-802, US-942, US-897, and Cleopatra) produced trees that had more than double the scion TCSA of trees on Swingle, the most common rootstock used for citrus in Florida.

Fig. 1. The Flame rootstock trial at 3 years of age. The Flame trial is the row that runs diagonally through the center of the photograph from the upper left to the lower right corners. Larger trees infested by PXD are on left edge of picture, younger trees in another trial are to the upper right.

A comparison of rootstock TCSA identified a greater than 4-fold difference in size among the best and worse performing rootstocks in the trial. Trees on US-802 rootstock had a significantly larger rootstock TCSA than trees on any other rootstock in the trial. There were some changes in the relative sizes of trees on the different rootstocks, depending on whether TCSA for the scion or rootstock were being compared. This was probably due, at least in part, to the differences between rootstocks in their tendency to overgrow (increase in caliper faster than) the scion. For example, Swingle and US-802 rootstocks generally have a rather large rootstock overgrowth, while the rootstock US-852 generally has very little rootstock overgrowth.

Table 2. Grapefruit tree trunk cross sectional area (mm^2) in field trial at 3 years old.

Rootstock	Scion TCSA	Rootstock TCSA
US-802	2284 a	5694 a
US-942	1934 ab	2986 bc
US-897	1912 ab	3460 b
Cleopatra	1897 ab	2732 bcd
US-896	1662 bc	2031 def
US-801	1555 bc	2337 cde
US-852	1538 bc	1683 ef
US-812	1523 bc	2025 def
US-827	1367 cd	2370 cde
US-809	1216 cde	1765 ef
Carrizo	987 def	1395 f
Swingle	880 ef	2052 def
US-952	663 f	1329 f
F test, P <	0.000001	0.000001

Mean separations for significant ANOVA within columns were by Duncan's multiple range test at $P < 0.05$.

Comparison of Phytophthora (combined *P. nicotianae* and *P. palmivora*) populations around trees on the different rootstocks identified a significant relationship ($r^2 = 0.6426$) between total Phytophthora at 2 years and TCSA measured at 3 years (Fig. 2). Rootstocks with the highest levels of Phytophthora were those that grew the least vigorously. The relationship of Phytophthora disease to rootstock performance in Winder soil is also being studied in greenhouse tests (Bowman et al., 2002). It appears that susceptibility of a rootstock to Phytophthora is an important factor influencing overall tree health under the conditions of this field trial.

Despite the application of a pesticide program for management of Diaprepes weevil and related Phytophthora diseases, PXD was obviously having a great impact on growth and health of most trees in the trial. It should be noted that all trees in the study, including the most vigorous rootstock, US-802, grew less vigorously than grapefruit trees grown in the absence of PXD. Based on previous experience, it is certain that grapefruit on Swingle or Carrizo rootstocks would not be profitably grown under these conditions. It is unclear yet whether the best performing rootstocks tested in this study will be sufficiently tolerant of PXD to permit successful commercial production of grapefruit under these conditions.

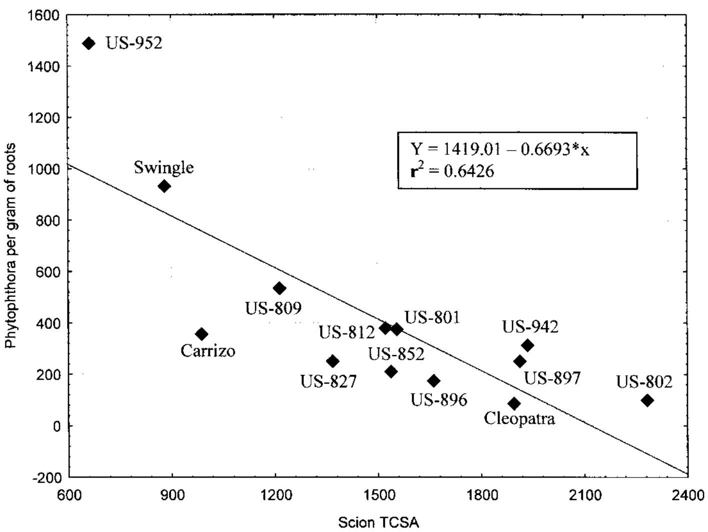

Fig. 2. Comparison of scion TCSA (at 3 years) to total phytophthora per gram of roots (at 2 years) for each rootstock.

Although greenhouse and laboratory testing can aid in selection of the most promising rootstock candidates, field testing of candidate rootstocks is necessary to determine rootstock tolerance to a wide range of pest, pathogen, environmental, and soil conditions. Effect of a new candidate rootstock on field tree size, fruit yield and quality can only be adequately measured through long-term field trials. Full assessment of the potential commercial value of the promising new rootstocks US-802, US-897, and US-942 for PXD sites must await at least 4-6 more years of continued testing at this site and probably other tests at similar sites.

Literature Cited

Bowman, K. D. 1998. Performance of 'Fallglo' Citrus Hybrid on Ten Rootstocks in Lake County. Proc. Fla. State Hort. Soc. 111:177-180.

Bowman, K. D., J. P. Albano, and J. H. Graham. 2002. Greenhouse testing of rootstocks for resistance to *Phytophthora* species in flatwoods soil. Proc. Fla. State Hort. Soc. 115:10-13.

Bowman, K. D. and F. M. Roman. 1999. New rootstocks for orange and mandarin. Proc. Caribbean Food Crops Soc. 35:119-130.

Graham, J. H. 1995. Root regeneration and tolerance of citrus rootstocks to root rot caused by *Phytophthora nicotianae*. Phytopathology 85:111-117.

Graham, J. H., D. B. Bright, and C. W. McCoy. 2003. *Phytophthora-Diaprepes* Weevil Complex: *Phytophthora* spp. relationship with citrus rootstocks. Plant Dis. 87:85-90.

Lapointe, S. L. and K. D. Bowman. 2002. Is there meaningful plant resistance to *Diaprepes abbreviatus* (Coleoptera: Curculionidae) in citrus rootstock germplasm? J. Economic Entomol. 95(5):1059-1065.

Wutscher, H. K. and K. D. Bowman. 1999. Performance of 'Valencia' orange on 21 rootstocks. HortScience 34:622-624.

Wutscher, H. K. and L. L. Hill. 1995. Performance of 'Hamlin' orange on 16 rootstocks in east-central Florida. HortScience 30:41-43.