Table 3. Summary table of total tree counts of citrus groves at MINWR Group 2 from the FASS database for 1994.

Variety	No. Trees
Hamlin Oranges	872
Early Seedy Oranges	324
Navel Oranges	5775
Pineapple Oranges	2411
Valencia Oranges	3761
White Grapefruit	216
White Grapefruit	723
Pink Grapefruit	1228
Ruby Red Grapefruit	1383
Dancy Tangerine	113
Unid. Mandarins	20
Sunburst Tangerine	153
Temple	2252
Minneola Tangelos	1638
TOTAL	20869

obtained with the oblique color video. Incorporation of video data into the GIS system could improve future assessment of grove health and provide archival data on previous grove conditions.

The work was done with minimal expense using Kerr Center resources. The information obtained is being incorporated into a GIS system for the management of MINWR groves using the Kerr Center's Sustainable Citrus Program (SCP). Because of the mixed nature of varieties and native growth in the groves, it will be necessary to continue to conduct ground surveys of each grove until accurate tree counts are obtained and mapped. Additional aerial photographic surveys will be performed with color infrared film to detect tree health and water damage. Once an accurate inventory of all groves is made, the sequential use of color and/or infrared aerial photography will make it possible to rapidly determine if any major changes have occurred and pinpoint where. This will refine yield estimates and greatly assist with management plans and decision making. In addition the imagery will be entered into a GIS system to study other trends that may not be observed in annual inventories such as disease and insect movements. The relatively low cost of the entire tree inventory using existing and available photography has made it a very cost effective and useful project.

Literature Cited

Blazquez, C. H. and F. W. Horn, Jr. 1980. Aerial Color Infrared Photography: Applications in Citriculture. NASA Ref. Pub. 1067 81 p. National Aeronautics and Space Administration, Washington 20546.

Blazquez, C. H., G. J. Edwards and F. W. Horn, Jr. 1978. Citrus grove mapping with color infrared aerial photography. Fla. State Hort. Soc. 91:5-8.

Blazquez, C. H., F. B. Esparza and R. P. Muraro. 1986. Citrus tree inventory and damage assessment with aerial color infrared photography and an interactive computer program. Tech. Papers. Amer. Soc. Photogram. and Remote Sensing. 5:119-134.

Blazquez, C. H., O. Lowe, J. B. Sisk and M. H. Bilbrey. 1988. Use of aerial color infrared photography, dual color video, and a computer system for property appraisal of citrus groves. Photogram. Eng. and Remote Sensing 54:233-336.

Blazquez, C. H., B. Abbitt, D. Hitchcock and R. Rudy. 1989. Relationship between tree count and citrus grove production. Fla. State Hort. Soc. 102:82-84.

Glazer, F., B. Pinette and C. H. Blazquez. 1998. Semi-automated analysis of aerial citrus grove images. Proc. First Int. Conf. Geospatial Info. Agric. Forest. 2:577-586.

Holland, M. 1993. How FASS forecasts the citrus crop. Citrus Inds. 24-26.

Yang, C., G. L. Anderson, J. H. Everitt and D. E. Escobar. 1998. Mapping plant growth and yield variation from aerial digital photography. Proc. First Int. Conf. Geospatial Info. Agric. Forest. 2:577-586

Proc. Fla. State Hort. Soc. 111:177-180. 1998.

PERFORMANCE OF 'FALLGLO' CITRUS HYBRID ON TEN ROOTSTOCKS IN LAKE COUNTY[1]

KIM D. BOWMAN

U.S. Department of Agriculture, Agricultural Research Service
U.S. Horticultural Research Laboratory
2120 Camden Road, Orlando, FL 32803

Additional index words. Tree growth, fruit production, fruit quality, Citrus reticulata.

Abstract. **A replicated rootstock field trial for 'Fallglo' (hybrid of *Citrus reticulata* Blanco) was established in 1992 at the Whitmore Foundation Farm in Lake County to compare performance on ten rootstocks, including Carrizo citrange, Swingle citrumelo, Cleopatra, Sun Chu Sha, and six new USDA hybrids. Yield, fruit quality, tree size, and tree health information were collected for 1995-98 from the trial and differences between performance on the different rootstocks were documented. Three new USDA hybrid rootstocks appeared to be equal or superior to the standard rootstock cultivars in productivity and fruit quality when used with 'Fallglo' scion in this location. One hybrid of 'Sunki' (*C. reticulata*) × Flying Dragon trifoliate (*Poncirus trifoliata* [L.] Raf.), identified as HRS 942, and a hybrid of 'Sunki' (Benecke trifoliate (HRS 812) appeared to be especially good candidates for additional field testing.**

Fallglo', a hybrid of 'Bower' × 'Temple' released by USDA in 1987, has been a successful early fresh fruit variety for some Florida growers (Hearn, 1987; Tucker et al., 1993). This cultivar generally reaches best quality in November, but is more

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.

commonly marketed in October because it does not compete favorably with 'Sunburst' tangerine. 'Fallglo' fruit are generally large, easily peeled, juicy, somewhat tart, and seedy. 'Fallglo' trees do not require cross pollination but are more sensitive to cold than many other mandarin cultivars. Common sources of information about rootstocks for Florida citrus (Castle et al., 1993; Wutscher and Hill, 1995) have generally not provided much specific guidance on performance of rootstocks for mandarins. Although some information is available about performance of 'Fallglo' on six rootstocks (Hearn, 1987), the best yielding of these rootstocks have serious shortcomings for many areas. Several new hybrid rootstocks under development by USDA appear promising for oranges in Florida (Bowman et al., 1998; Wutscher and Hill, 1995; Wutscher and Bowman, in press). The objective of this trial was to compare the field performance of 'Fallglo' on 4 common rootstocks and 6 new USDA hybrids in Lake County.

Materials and Methods

Seedlings of the ten rootstock cultivars were budded in a field nursery at the Whitmore Foundation Farm, Lake County, in Spring 1991. The rootstocks chosen for the experiment were Carrizo citrange (*C. sinensis* [L.] Osbeck × *P. trifoliata*), Swingle citrumelo (*C. paradisi* Macf. × *P. trifoliata*), two mandarins (*C. reticulata*), and hybrids of 'Pearl' (*C. paradisi* Macf. × *C. reticulata*), 'Sunki' (*C. reticulata*), or Rangpur (*C. limonia* Osbeck) with *P. trifoliata*. Budwood of 'Fallglo' was taken from a tree at the Whitmore Foundation Farm that was typical of the cultivar and one of the original sources of plant material supplied to the citrus industry following the release of the cultivar in 1987. This source tree was identified as infected with a mild strain of CTV virus. The budded trees were transplanted to the field test plot at the Whitmore Foundation Farm on 7 April 1992 at a spacing of 4.6 m × 6.1 m (15 ft × 20 ft). The original design included trees on each rootstock arranged in four randomized complete blocks, interspersed with trees of several other fruiting cultivars, and with a border row on all 4 sides. Unequal numbers of trees were available at planting for each of the rootstocks in the trial and some trees were lost during the transplanting and establishment phases, so that yield, fruit quality, tree size, and dieback comparisons were based on 4-10 trees per rootstock (74 trees total). There was at least one surviving tree on each rootstock in each block.

Soil was Astatula fine sand with a pH of 6.2, good natural drainage, and a gentle slope down to the east. Irrigation in the block was by overhead rotary sprinkler. During the bearing years, fertilizer was applied by broadcast spreader in three equal applications of 16-0-16 with Mg and Zn, at a rate of 68 kg (150 pounds) N per acre in 1995 and 1996, and 91 kg (200 pounds) N per acre in 1997 and 1998. Leaf and soil analyses conducted in July 1996 and January 1997, respectively, confirmed that soil fertility and tree nutrient status were appropriate for healthy trees.

Weeds were controlled by 1-2 applications/year of glyphosate (Roundup) and oryzalin (Surflan) in 2.4 m bands (8 ft) within rows and periodic cultivating or mowing between rows. Chemical pest control was applied three times per year by speed sprayer. The first application was at 2/3 petal fall and contained copper hydroxide and fenbutatin-oxide (Vendex) or pyridaben (Nexter). A second treatment, containing ethion, oil, copper hydroxide, and abamectin (Agri-Mek), was applied when the May flush reached full expansion. Finally, fenbutatin-oxide or pyridaben was reapplied in August to combat expanding mite populations.

Yields were measured in standard 95 pound boxes and were cooperatively collected by a commercial harvesting crew and the USDA Whitmore Farm crew. Fruit harvest generally covered several days, and mean harvest dates were 16 Oct. 1995, 15 Nov. 1996, 7 Nov. 1997, and 26 Oct. 1998.

Two 30-fruit samples were collected from trees on each rootstock shortly before harvest, one sample was a composite of trees in the south and west portions of the block and the other sample a composite from the north and east portions of the block. Sampling dates were 15 Oct. 1995, 21 Oct. 1996, 14 Oct. 1997, and 20 Oct. 1998. Total soluble solids and total acids were the only fruit quality factors evaluated in 1995. Rind color was measured using a chromameter (model CR 300; Minolta Camera, Co., Osaka, Japan) and was only evaluated in 1997 and 1998.

Tree size measurements were taken before harvest in Oct. 1998. Trunk diameter canopy was measured at 15-25 cm above the soil line, and tree diameter was measured down the row. Canopy volume was calculated by the formula (diameter^2 (height)/4. The data were tested by analysis of variance using Statistica ver 5.0 (StatSoft, Tulsa, Okla.) and comparison of the means was by Tukey honest significant difference test at $P \leq 0.05$.

Results and Discussion

Cumulative yields of 'Fallglo' trees on the 10 rootstocks differed significantly (Table 1), and would probably be quite

Table 1. Yield of 'Fallglo' trees on 10 rootstocks.[z]

HRS Code	Rootstock	Boxes fruit/tree[y] 1995	1996	1997	1998	Cumulative yield
942	Sunki × Flying Dragon trif. or.	0.9 a	1.3 a	1.8 ab	1.3 ab	5.3 a
812	Sunki × Benecke trif. or.	0.5 a	1.0 ab	1.9 a	1.7 a	5.1 a
	Cleopatra mandarin	0.6 a	0.8 ab	1.4 abc	1.2 abc	3.9 ab
	Carrizo citrange	0.7 a	0.6 ab	1.5 ab	0.9 abc	3.7 abc
	Swingle citrumelo	0.8 a	0.5 b	1.4 abc	0.9 abc	3.5 abc
827	Rangpur × Swingle trif. or.	0.6 a	0.6 ab	1.1 abcd	1.1 abc	3.4 abc
955	Pearl × Flying Dragon trif. or.	0.7 a	0.5 b	1.1 bcd	0.7 bc	2.9 bc
	Sun Chu Sha mandarin	0.4 a	0.4 b	0.7 cd	0.5 bc	1.9 bc
953	Pearl × Flying Dragon trif. or.	0.8 a	0.3 b	0.6 cd	0.2 c	1.9 bc
937	Sunki × Flying Dragon trif. or.	0.3 a	0.4 b	0.4 d	0.4 bc	1.5 c

[z]Mean separation within columns by Tukey honest significant difference test at $P \leq 0.05$.
[y]Yield measured as standard 95 pound boxes of fruit per tree.

important in commercial production. Although yields were similar for all 10 rootstocks in the first year of harvest (1995), differences in cropping began to appear in the 1996 season and continued through the harvest of 1998. The order of relative yield remained nearly the same for the 1996, 1997, and 1998 crops, and the cumulative total, with three overlapping groups apparent. At the top of the list were hybrid rootstocks HRS 942 and HRS 812, which had cumulative yields of 5.3 and 5.1 boxes of fruit per tree, respectively. These rootstocks were significantly different in performance from the four rootstocks at the bottom of the list, HRS 955, Sun Chu Sha, HRS 953, and HRS 937. The four other rootstocks, Cleopatra, Carrizo, Swingle, and HRS 827, were intermediate in yield and could not be clearly separated from either the best or worst performers.

Some measures of fruit quality for 'Fallglo' differed significantly among the 10 rootstocks (Table 2). One hybrid of 'Pearl' × Flying Dragon (HRS 953) had fruit with significantly higher soluble solids, higher total acids, lower ratio, and smaller diameter than most of the other rootstocks. It also yielded fruit with higher juice content than trees on Swingle, as did another 'Pearl' × Flying Dragon hybrid (HRS 955). However, both of these rootstocks were among the lowest in yield per tree, and may only be of interest for high density plantings. No other significant differences in total solids, acids, ratio, diameter, color, or juice content are worthy of note.

Tree size also differed significantly among the 10 rootstocks (Table 3), with a canopy volume ranging from 1.8 m^3 for HRS 953 to 8.2 m^3 for Carrizo. Trunk caliper, tree height, and tree diameter gave similar results for relative tree size on the rootstocks tested in this group. Canopy volume (which combines height and diameter) is presented as a good indicator of overall tree size. Hybrids HRS 937, HRS 953, and HRS 955 produced trees that were significantly smaller than Carrizo, Cleopatra, and HRS 812. Trees on Sun Chu Sha were significantly smaller than trees on Carrizo and HRS 812. Intermediate-size trees were produced on Swingle, HRS 942, and HRS 827, and they were only significantly different from the smallest rootstock, HRS 937. Twig dieback, a common problem in commercial blocks of 'Fallglo', was observed to vary widely from tree to tree in the trial. However, there were no significant differences among the rootstocks for this trait when evaluated in Oct. 1998.

The release of 'Fallglo' was accompanied by information about performance on six rootstocks (Hearn, 1987). The two most productive of these, rough lemon and sour orange, are probably poor choices for new plantings of 'Fallglo' in central Florida because of susceptibility to blight, cold, and *Phytothora nicotianae* Breda de Haan in rough lemon, and susceptibility to Citrus tristeza virus (CTV) in sour orange. Several new hybrid rootstocks under development by USDA have appeared to be superior to the common rootstocks for commercial production of oranges (Bowman et al., 1998; Wutscher and Bowman, in press; Wutscher and Hill, 1995). Comparison of 'Fallglo' performance on the most likely commercial rootstocks to that on several new USDA hybrids indicates that the hybrid rootstocks HRS 942, HRS 812, and HRS 827 performed at least as well as the common rootstocks, through the first four harvests. 'Fallglo' tree losses in the block appear to have been almost entirely due to poor trees from the nursery or severe mechanical damage. The block has not yet presented a good opportunity to evaluate resistance to freeze damage, blight, severe CTV, or other less common biotic and abiotic factors. However, the hybrid selections HRS 942, 812, and HRS 827 have been found highly resistant to *Phytophthora nicotianae* in greenhouse testing and appeared to be tolerant of severe CTV in another field trial (Wutscher and Bowman, in press). This trial will continue to be monitored to evaluate long term health, survival, and productivity of the different rootstocks.

Problems with propagation of nursery trees for the trial resulted in inadequate numbers of trees on some of the rootstocks ready for initial field planting and some young trees failing to survive initial establishment in the test block. This has lessened the value of the trial for differentiating performance of the rootstocks, but does not appear to reflect any particular problems with propagation on the standard rootstocks or the more promising hybrid rootstocks (based on other unpublished experiments involving propagation on these same rootstocks).

The rootstocks with the highest and lowest yields in this trial were from the same cross, 'Sunki' × Flying Dragon. This reflects the power of sexual recombination to create individual hybrids that have extremely good or bad combinations of genetic characteristics from the same set of parents. We know little about a new hybrid rootstock's characteristics or potential for good performance based only on its parentage. Outstanding new rootstocks, such as HRS 942 and HRS 812, are usually selected from among dozens or hundreds of individually unique hybrids from the same or similar crosses. Therefore, extensive testing is required to identify rootstocks worthy of widespread use, and growers must be careful to avoid similar but unproven rootstocks.

Table 2. Fruit quality of 'Fallglo' trees on 10 rootstocks.[z]

HRS Code	Rootstock	Fruit dia. (cm)	Rind color (a/b)	Juice content (%)	Total soluble solids (%)	Total acids (%)	TSS /TA Ratio
942	Sunki × Flying Dragon trif. or.	7.8 a	0.08 a	51 ab	9.8 bc	0.98 bc	10.1 a
812	Sunki × Benecke trif. or.	7.9 a	0.06 a	51 ab	9.6 c	0.96 c	10.1 a
	Cleopatra mandarin	7.8 a	0.12 a	49 ab	9.8 bc	0.98 bc	10.1 a
	Carrizo citrange	8.0 a	0.16 a	48 ab	9.7 bc	0.95 c	10.2 a
	Swingle citrumelo	7.7 ab	0.12 a	44 b	10.0 bc	1.06 b	9.5 ab
827	Rangpur × Swingle trif. or.	7.6 ab	0.17 a	51 ab	10.0 bc	0.99 bc	10.2 a
955	Pearl × Flying Dragon trif. or.	7.7 ab	0.13 a	52 a	10.4 ab	1.04 bc	10.2 a
	Sun Chu Sha mandarin	8.0 a	0.19 a	46 ab	9.8 bc	0.99 bc	10.1 a
953	Pearl × Flying Dragon trif. or.	7.3 b	0.14 a	52 a	10.8 a	1.17 a	9.2 b
937	Sunki × Flying Dragon trif. or.	7.9 a	0.15 a	48 ab	9.9 bc	1.02 bc	9.8 ab

[z]Means of two 30-fruit samples collected at each of four harvests for brix, acid, and ratio, three harvests for fruit diameter and juice content, and two harvests for rind color. Mean separation within columns by Tukey honest significant difference test at $P \leq 0.05$.

Table 3. Tree size and twig dieback of 'Fallglo' trees on 10 rootstocks at 6.5 years age.[z]

HRS Code	Rootstock	Trunk caliper (cm)	Tree height (m)	Tree diameter (m)	Tree volume (m^3)	Twig dieback (1-5)[y]
942	Sunki × Flying Dragon trif. or.	9.2 abc	2.7 abc	3.0 abc	5.9 abcd	2.8 a
812	Sunki × Benecke trif. or.	10.0 ab	3.0 a	3.1 a	7.6 a	2.6 a
	Cleopatra mandarin	10.3 ab	2.8 abc	3.0 abc	6.9 ab	2.8 a
	Carrizo citrange	11.2 a	3.0 ab	3.1 ab	8.2 a	3.4 a
	Swingle citrumelo	8.8 abcd	2.8 abc	3.0 abc	6.1 abc	2.6 a
827	Rangpur × Swingle trif. or.	7.9 bcde	2.6 abcd	2.8 abcd	5.7 abcde	2.3 a
955	Pearl × Flying Dragon trif. or.	6.4 de	2.0 de	2.3 cd	2.9 de	2.7 a
	Sun Chu Sha mandarin	9.3 abc	2.4 bcd	2.4 bcd	3.8 bcde	2.6 a
953	Pearl × Flying Dragon trif. or.	5.9 e	1.6 e	1.9 d	1.8 e	3.5 a
937	Sunki × Flying Dragon trif. or.	7.1 cde	2.2 cde	2.4 cd	3.1 cde	2.0 a

[z]Mean separation within columns by Tukey honest significant difference test at $P \leq 0.05$.
[y]Dieback was scored on a subjective scale, from 0 = none to 5 = very severe, in October 1998.

Acknowledgments

The author is grateful to R. Driggers, C. Spriggs, M. Rutherford, C. White, C. Griner, and R. Lewis for assistance in data collection, plot establishment and care.

Literature Cited

Bowman, K. D., H. K. Wutscher, R. D. Hartman and A. E. Lamb. 1997. Enhancing development of improved rootstocks by tissue culture propagation and field performance of selected rootstocks. Proc. Fla. State Hort. Soc. 110:10-13.

Castle, W. S., D. P. H. Tucker, A. H. Krezdorn and C. O. Youtsey. 1993. Rootstocks for Florida Citrus. Univ. of Florida publication SP42.

Hearn, C. J. 1987. The 'Fallglo' citrus hybrid in Florida. Proc. Fla. State Hort. Soc. 100:119-121.

Tucker, D. P. H., C. J. Hearn and C. O. Youtsey. 1993. Florida Citrus Varieties. Revised edition. University of Florida, Gainesville, publication SP 102.

Wutscher, H. K. and K. D. Bowman. *In press.* Performance of 'Valencia' orange on 21 rootstocks. HortScience.

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

Proc. Fla. State Hort. Soc. 111:180-182. 1998.

OBSERVATIONS ON THE COMPATIBILITY, GROWTH, AND CROPPING OF CALAMONDIN, 'MEIWA' AND 'NAGAMI' KUMQUAT ON SEVERAL ROOTSTOCKS

J. J. FERGUSON
Horticultural Sciences Department, IFAS
University of Florida
Gainesville, FL 32611-0690

W. S. CASTLE
Citrus Research and Education Center, IFAS
University of Florida
Lake Alfred, FL 33850-2299

Additional index words. Ornamental citrus.

Abstract. **Calamondin, 'Meiwa' and 'Nagami' kumquat trees were grown for five years on several rootstocks in an unreplicated demonstration trial. Calamondin trees on all rootstocks except for Carrizo citrange and Swingle citrumelo grew well and had heavy yields. 'Meiwa' trees on Carrizo citrange, Swingle citrumelo, ridge pineapple and sour orange died but trees on other rootstocks generally grew and yielded well. 'Nagami' trees on all rootstocks also grew and yielded well with some limb breakage because of heavy crops. Further confirmation of these preliminary observations in replicated field trials could provide growth and yield information for calamondins and kumquats on a range of rootstocks for homeowner and speciality markets.**

Calamondins and kumquats are not major commercial citrus crops worldwide, but they are frequently used as ornamentals in the landscape and for other homeowner uses. Calamondins are usually grown from rooted cuttings in containers or in the landscape where as highly productive grafted trees they can reach 3 to 4 meters in height. Fruit are used to flavor drinks and in marmalades and jellies. Calamondins have also been used occasionally to study photosynthesis, fruit setting, fruit ripening and abscission in citrus species (Cooper and Horanic, 1972; Krezdorn and Powell, 1969). Kumquats are grown as grafted trees both in containers and in the landscape and field. Plant size may vary depending on rootstock but can reach 3 to 4 meters in height, with 'Nagami' being a more vigorous and larger tree than 'Meiwa' kumquat. Kumquat fruit, especially 'Meiwa' fruit, is eaten whole and is used

Florida Agricultural Experimental Station Journal Series No. N-01616.