*Proc. Fla. State Hort. Soc.* 120:92–96. 2007.

# 'Hamlin' Orange Trees on Flying Dragon Trifoliate Orange, Changsha Mandarin, or Koethen Sweet Orange x Rubidoux Trifoliate Orange Citrange Rootstock at Three In-row Spacings in a Flatwoods Site

William S. Castle*, James C. Baldwin, and Ronald P. Muraro

*University of Florida, IFAS, Department of Horticulture, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850*

Additional index words. *Poncirus trifoliata*, Malabar soil series, orchard design, planting density

**'Hamlin' orange trees on Flying Dragon trifoliate orange [*Poncirus trifoliata* (L.) Raf.], Changsha mandarin (*Citrus reticulata* Blanco), or a citrange {Koethen sweet orange [*C. sinensis* (L.) Osb.) x Rubidoux trifoliate orange]} rootstock were planted in a commercial site of Malabar series soil near Indiantown, FL, in Apr. 1982. The split plot trial was planted on double-row beds with 21.5 ft between rows and in-row spacings of 7.5, 10, and 12.5 ft. In-row spacing did not affect tree survival, which was about 85% after 21 years. Tree losses were mostly from citrus blight. The trees on Flying Dragon were smaller (<7 ft) at age 10 years than those on the other rootstocks, which were 8.5 to 9.0 feet tall. Plant height increased as the distance among trees in the row increased, but the differences were small. The trees on Flying Dragon had about 6.8 boxes/tree at age 12 years in cumulative yield over four seasons between 1990 and 1994 regardless of spacing. The Flying Dragon cumulative yield extrapolates to 67% higher productivity for a hypothetical acre of trees at 7.5 ft in-row spacing vs. 12.5 ft. The cumulative yields/tree across the three spacings for those on the other rootstocks were 10.3 boxes for Changsha and 9.4 for K x R citrange; however, cumulative yields increased to 11.5 and 10.7 boxes, respectively, at the 12.5-ft spacing. Mean juice quality measured in four seasons was about 6 pounds-solids/box. An economic interpretation showed that when tree vigor was properly matched with spacing and site conditions, closely or moderately spaced trees have the potential to be profitable.**

Orchards of closely spaced, size-controlled trees have always intrigued horticulturists and fruit growers. Such orchards are innately seen to lead to higher productivity, particularly early in the life of an orchard, along with higher efficiencies of operation and management, including harvesting. Thus, they offer financial rewards that may exceed those of a conventionally spaced orchard despite higher establishment costs and requiring a more intensive, generally higher level of management.

Orchards of small, closely spaced trees have been researched, evaluated, and are now used commercially among deciduous fruit growers in many places around the world including the United States. Apple trees in particular have been adapted to these systems (Castle, 2006; Sparks, 2007). Citrus industries, however, have lagged behind in adopting this approach. In citrus field studies conducted in Florida, California, and elsewhere, the potential of orchards with correctly matched tree vigor and spacing with site variables has been demonstrated (Boswell and Atkin, 1978; Castle and Phillips, 1980; Koo and Muraro, 1982; Phillips, 1974; Wheaton et al., 1986, 1991). Other technologies have also been demonstrated with citrus, as in Australia where long-term research proved the economic potential of closely spaced trees on appropriate rootstocks that were dwarfed using viroids (Long et al., 1977). Nevertheless, while considerable research has been conducted on the subject of citrus orchard design, the results have not been sufficiently compelling to adopt new approaches. Among the reasons is the absence of the requisite size-controlling rootstocks and scion selections and other technologies to control tree size. Only one size-controlling rootstock, Flying Dragon trifoliate orange, has developed any commercial interest although many others have been evaluated and are currently being created with new technologies like somatic hybridization (Castle, 1980; Grosser et al., 1998).

We conducted a field trial to investigate the hypothesis that when scion–rootstock combinations of different tree vigor were well matched with spacing and site conditions, they would produce yields and incomes that exceeded conventional grove systems. In Florida, interest in orchard design has been revitalized by the presence of two bacterial diseases, canker and huanglongbing (HLB or greening disease). Orchard designs involving higher planting densities and trees with low to moderate vigor are appealing, possibly for management advantages, such as controlling the psyllid vector of HLB (smaller tree size), and because of early and sustained yields allowing for financial options like grove replacement.

## Materials and Methods

A cooperative tree spacing trial was planted in 1982 on virgin land near Indiantown in Martin County, FL, as part of a larger rootstock investigation. A uniform portion of a 100-acre block was selected based on the Martin County U.S. Natural Resources and Conservation Service Soil Survey. The soil in the spacing trial area was of the Malabar series, a soil very suitable for citrus with proper water management. Malabar sand is an Alfisol with an argillic (clay) horizon deeper than 40 inches. Typically, the

*Corresponding author; email: bcastle@ufl.edu

surface horizon is very dark gray sand with gray to brownish yellow sand underneath to the sandy loam argillic horizon.

Standard double-row raised beds, 45 ft wide × 660 ft long, were formed at the site and microsprinkler irrigation installed with one sprinkler/tree. Different microsprinkler caps were used so that the volume of water applied in each row was similar regardless of tree spacing. 'Hamlin' trees were propagated on Changsha mandarin, a citrange (Koethen sweet orange x Rubidoux trifoliate orange) or Flying Dragon trifoliate orange rootstock in a commercial nursery. The experimental unit in the three-replicate split plot trial was a two-row bed with a fixed distance between rows of 21.5 ft. In each bed, trees on one rootstock were planted 7.5, 10.0, or 12.5 ft apart in the two rows for equivalent planting densities of 162, 203, or 270 trees/acre, respectively. The main plot treatment was in-row spacing. Thus, there were three adjacent beds with the same in-row spacing, but each bed of trees was planted with one rootstock.

Cultural practices were typical for the region with annual nitrogen applications of about 160 lb/acre. No tree hedging or topping was required during the trial period. When the trees reached containment size, they were usually irrigated with two to three 4-h applications/week. Tree height was measured periodically on a sub-sample of 12 representative trees in each bed. The same trees were also used to measure yield during commercial harvest and to collect samples of about 60 fruit that were processed through official state test house equipment to generate standard juice quality data. In some years, the cooperator provided yield data obtained from whole beds. Tree losses and their apparent causes were recorded regularly. Tree decline from citrus blight was generally confirmed with trunk injection to measure water flow. All data were analyzed according to the experiment design using SAS–GLM and the least significant difference method to compare means when no significant interactions occurred between treatment factors. Tree survival percentage data were arcsin transformed before analysis. A financial analysis was performed using the last 4 years of cumulative yield and juice data. The analysis assumed land ownership with site clearing and renovation, an average nursery tree cost of $6.00 based on the past several years, a harvesting cost of $2.18/box, and a juice solids price of $1.30/pound. Grove care and production costs were assumed to be $915/acre.

## Results

**Tree survival.** Only about 10% to 20% of the trees were lost in the trial after 21 years regardless of rootstock or spacing (Table 1). In most instances, tree loss was from citrus blight as might be expected of the trifoliate orange rootstock and its hybrid, but the losses were much lower than often reported for such rootstocks (Castle and Baldwin, 1995; Castle et al., 1993). Also, blight losses were not increased by tree proximity and root grafts that may have formed between adjacent trees as has been observed among trees planted as close as 7.5 ft in the row compared to a more conventional spacing of 12.5 ft (Tucker et al., 1998).

**Tree height.** By age 10 years, most trees had grown to a mature size and changed little in height thereafter. Tree height was determined largely by rootstock and less so by spacing (Table 1). Tree height increased as in-row spacing increased regardless of the rootstock, but the differences in tree height were generally only about 1 to 2 ft. The tallest trees (9.5 ft) were those on Changsha mandarin rootstock growing at the 12.5-ft spacing. The smallest trees were those on Flying Dragon trifoliate orange which were 7 ft or less in height at all in-row spacings. There were some taller individual trees among those on Flying Dragon trifoliate orange, but they were probably on off-type rootstocks not removed in the nursery roguing process.

**Yield.** The first yield recorded was in the 1986–87 season. The trees were 4 years old and cropping for the first time. Yield ranged from about 0.4 to 0.8 boxes/tree. Yield was then measured again during the 1990–91 season and for three seasons thereafter. Those 4 years of yield data, collected when the trees were 8 to 12 years old, are the basis of the cumulative yields discussed in this report.

Rootstock and in-row spacing had independent effects with rootstock having the larger influence on yield (Table 1). Cumulative 4 year yields in boxes/tree were essentially the same for the trees on Changsha mandarin or K x R citrange, but lower for the trees on Flying Dragon trifoliate orange (Table 1). The differences among rootstocks were largely related to tree size, i.e., the larger trees were more productive. Cumulative yield increased significantly as in-row spacing increased from 7.5 ft to 10 ft, but not thereafter.

**Juice quality.** Fruit samples were collected in November and December and averaged ~6 pounds-solids (PS)/box over the four seasons between 1990 and 1994 (Table 1). Except for Brix : acid ratio, in-row spacing did not affect juice quality as reported in previous Florida spacing trials (Wheaton et al., 1995); however, all juice variables were affected by rootstock. Fruit from the trees on the Flying Dragon trifoliate orange and the K x R citrange had similar Brix values. They were higher than those from the trees on Changsha mandarin leading to a similar difference among rootstocks in PS/box.

## Discussion and Conclusions

Planting densities above the normal for Florida citrus can be profitable but their success requires the proper matching of scion–rootstock vigor with tree spacing and site conditions as shown in this and other Florida research (Phillips, 1974; Wheaton et al., 1986, 1990, 1995a, 195b). The similarities in tree heights among the spacings for each rootstock in our trial indicate that close spacing did not limit tree canopy development. Some trees like those on Flying Dragon trifoliate orange probably could be planted closer than 7.5 ft in the row and between rows.

Among the questions that can be addressed in any study of tree planting density are:

**Individual tree performance.** The objective in orchard design is to maximize tree potential and economic return over a planted land area, but it is the individual tree that determines grove performance (Wheaton et al., 1978). Of particular interest is whether individual trees of the right vigor and at close spacing can crop adequately to provide sustainable good economic returns. Our data indicate that this is possible because the 'Hamlin' trees on each rootstock yielded about two to three boxes/tree when planted as close as 7.5 ft in the row. The trees at the closer in-row spacings generally produced less fruit/tree, but are highly productive when tree yield is adjusted for trees/acre.

**Long-term yield performance.** There are two key questions of concern. First, can closely spaced trees continue to yield well and provide above average profitability? Second, will profitable groves of closely spaced trees eventually be surpassed by groves of more conventionally spaced trees?

Trees of standard vigor when planted close together normally perform reasonably well as young trees, but they eventually

Table 1. Performance of 'Hamlin' sweet orange trees on several rootstocks at three spacings. Trees were planted in Apr. 1982. Fruit samples were collected 7 Nov. 1990, 19 Nov. 1991, 10 Dec. 1992, and 24 Nov. 1993. Tree height was measured in Dec. 1992, percent tree survival measured in Oct. 2003.

| | In-row | | Yield (boxes/tree) | | Juice quality[z] | | | | | Tree | % Tree |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rootstock | spacing (ft) | Year | Annual | 4-yr cumulative | % Juice | Acid | Brix | Ratio | PS/Box | ht (ft) | survival |
| Changsha mandarin | 7.5 | 1990–91 | 2.4 | | 61.4 | 0.7 | 9.9 | 14.6 | 5.5 | | |
| | | 1991–92 | 2.4 | | 62.1 | 0.7 | 10.4 | 16.0 | 5.8 | | |
| | | 1992–93 | 2.5 | | 61.5 | 0.7 | 11.5 | 17.5 | 6.4 | 8.5 | |
| | | 1993–94 | 1.3 | 8.6 | 58.2 | 0.7 | 11.6 | 16.1 | 6.0 | | |
| | | | | | *60.8* | *0.70* | *10.8* | *16.0* | *5.9* | | 84 |
| | 10.0 | 1990–91 | 3.3 | | 60.0 | 0.8 | 10.7 | 14.3 | 5.8 | | |
| | | 1991–92 | 2.9 | | 61.4 | 0.6 | 11.2 | 17.4 | 6.2 | | |
| | | 1992–93 | 3.2 | | 58.9 | 0.7 | 11.3 | 16.5 | 6.0 | 9.0 | |
| | | 1993–94 | 1.5 | 10.9 | 55.8 | 0.8 | 11.2 | 14.5 | 5.6 | | |
| | | | | | *59.0* | *0.72* | *11.1* | *15.7* | *5.9* | | 80 |
| | 12.5 | 1990–91 | 3.4 | | 60.2 | 0.7 | 10.4 | 14.6 | 5.6 | | |
| | | 1991–92 | 2.2 | | 60.1 | 0.6 | 10.3 | 17.2 | 5.6 | | |
| | | 1992–93 | 4.0 | | 59.1 | 0.7 | 10.9 | 16.4 | 5.8 | 9.5 | |
| | | 1993–94 | 1.9 | 11.5 | 56.1 | 0.8 | 10.7 | 13.2 | 5.4 | | |
| | | | | | *58.9* | *0.70* | *10.6* | *15.4* | *5.6* | | 86 |
| Flying Dragon TF | 7.5 | 1990–91 | 1.8 | | 60.3 | 0.7 | 10.6 | 14.3 | 5.8 | | |
| (FDT) | | 1991–92 | 1.9 | | 61.4 | 0.7 | 11.2 | 17.0 | 6.2 | | |
| | | 1992–93 | 1.8 | | 59.0 | 0.6 | 12.0 | 20.0 | 6.4 | 6.8 | |
| | | 1993–94 | 1.0 | 6.5 | 54.5 | 0.7 | 11.9 | 16.9 | 5.8 | | |
| | | | | | *57.7* | *0.65* | *11.4* | *17.1* | *6.0* | | 87 |
| | 10.0 | 1990–91 | 1.9 | | 60.8 | 0.7 | 10.6 | 14.3 | 5.8 | | |
| | | 1991–92 | 1.8 | | 61.5 | 0.7 | 11.6 | 17.7 | 6.4 | | |
| | | 1992–93 | 1.8 | | 57.3 | 0.6 | 11.6 | 18.8 | 6.0 | 6.3 | |
| | | 1993–94 | 1.1 | 6.6 | 51.4 | 0.8 | 11.7 | 15.6 | 5.4 | | |
| | | | | | *57.7* | *0.68* | *11.4* | *16.6* | *5.9* | | 88 |
| | 12.5 | 1990–91 | 1.8 | | 63.0 | 0.7 | 10.8 | 15.9 | 6.1 | | |
| | | 1991–92 | 2.1 | | 62.7 | 0.6 | 11.0 | 18.4 | 6.2 | | |
| | | 1992–93 | 2.2 | | 57.6 | 0.6 | 12.4 | 20.8 | 6.4 | 7.0 | |
| | | 1993–94 | 1.1 | 7.2 | 53.1 | 0.7 | 12.4 | 17.6 | 5.9 | | |
| | | | | | *59.1* | *0.65* | *11.6* | *18.2* | *6.2* | | 85 |
| Koethen x Rubidoux | 7.5 | 1990–91 | 1.9 | | 60.9 | 0.7 | 10.4 | 15.5 | 5.7 | | |
| (K x R) | | 1991–92 | 1.9 | | 59.8 | 0.6 | 11.6 | 18.5 | 6.2 | | |
| | | 1992–93 | 2.5 | | 57.4 | 0.6 | 12.4 | 20.2 | 6.4 | 7.7 | |
| | | 1993–94 | 1.5 | 7.8 | 54.3 | 0.7 | 11.1 | 16.9 | 5.5 | | |
| | | | | | *58.1* | *0.64* | *11.4* | *17.8* | *6.0* | | 91 |
| | 10.0 | 1990–91 | 2.7 | | 60.6 | 0.7 | 10.7 | 15.4 | 5.8 | | |
| | | 1991–92 | 2.9 | | 60.9 | 0.7 | 11.5 | 17.1 | 6.3 | | |
| | | 1992–93 | 2.4 | | 60.4 | 0.6 | 12.3 | 19.7 | 6.7 | 8.5 | |
| | | 1993–94 | 1.8 | 9.8 | 59.0 | 0.8 | 11.4 | 15.0 | 6.1 | | |
| | | | | | *60.2* | *0.69* | *11.5* | *16.8* | *6.2* | | 83 |
| | 12.5 | 1990–91 | 3.1 | | 58.3 | 0.7 | 10.5 | 14.3 | 5.5 | | |
| | | 1991–92 | 2.9 | | 59.4 | 0.6 | 10.6 | 17.4 | 5.6 | | |
| | | 1992–93 | 2.7 | | 59.8 | 0.6 | 12.5 | 20.0 | 6.7 | 8.8 | |
| | | 1993–94 | 2.0 | 10.7 | 59.9 | 0.8 | 12.1 | 16.0 | 6.5 | | |
| | | | | | *59.3* | *0.67* | *11.4* | *16.9* | *6.1* | | 88 |
| *Statisical analyses* | | | | | | | | | | | |
| Means: Spacing: | 7.5 | | | 7.6 | 59.0 | 0.66 | 11.3 | 17.2 | 6.1 | 7.6 | 87 |
| | 10.0 | | | 9.1 | 57.1 | 0.70 | 11.6 | 16.7 | 6.2 | 7.9 | 84 |
| | 12.5 | | | 9.8 | 59.1 | 0.67 | 11.3 | 17.0 | 6.0 | 8.4 | 86 |
| Rootstock: | Changsha | | | 10.3 | 58.9 | 0.70 | 10.8 | 15.6 | 5.7 | 9.0 | 83 |
| | FDT | | | 6.8 | 57.5 | 0.66 | 11.6 | 17.8 | 6.0 | 7.0 | 87 |
| | K x R | | | 9.4 | 59.5 | 0.66 | 11.6 | 17.7 | 6.2 | 8.3 | 87 |
| *P* values (Pr > F) | | | | | | | | | | | |
| Spacing (S) | | | | 0.0036 | 0.8861 | 0.2345 | 0.3031 | 0.0440 | 0.2366 | 0.0678 | 0.1631 |
| Rootstock (R) | | | | <0.0001 | 0.0598 | 0.0065 | <0.0001 | <0.0001 | 0.0003 | <0.0002 | 0.1613 |
| S × R | | | | 0.3524 | 0.0613 | 0.4763 | 0.0024 | 0.1881 | 0.0001 | 0.4719 | 0.3339 |
| Least Significant Difference | | | | | | | | | | | |
| Spacing | | | | 1.0 | | | | 0.90 | 0.2 | | |
| Rootstock | | | | 1.6 | | 0.03 | | 1.2 | 0.8 | 0.8 | |

[z]4-year mean values are in *italics*.

compete excessively with each other and grove performance declines. Florida spacing trials conducted on the deep sandy soils of the Ridge with more vigorous trees than in our trial have generally shown that trees at moderate spacing have provided the best long-term yields and economic returns (Koo and Muraro, 1982; Muraro et al., 1995). However, when tree vigor, spacing, and site factors are properly matched, it is possible that the more closely spaced trees may continue to outperform conventionally spaced trees. In our trial, yield measurements ceased when the trees were 12 years old, but occasional observations continued for another 10 years during which tree performance appeared to remain similar to what we recorded in the preceding years. We conclude that because the performance boundaries imposed by tree vigor, spacing, and site were not exceeded, the trial had long-term potential for economic success for all the tree-spacing combinations. Such success also requires tree survival. It is noteworthy that tree loss, particularly among the trifoliate orange and citrange rootstocks after 21 years in our trial, was minimal despite their known susceptibility to citrus blight (Castle, 1987).

**Grove economics.** The financial assessment shows the net incomes based on the last 4 years of yield and juice quality data. The analysis is incomplete because the preceding 3 years of data were not available; however, those data would have been for the first bearing years when the trees were producing relatively small crops and their contribution to the cumulative yield would have likewise been relatively small. However, if more complete data had been available, it would have been possible to determine important financial waypoints such as when breakeven occurred or when profits covered costs.

One persistent question in tree planting density studies is whether the higher initial costs of close planting are offset by higher yields and profitability above that for conventional groves. The average cumulative net incomes from the analyses showed that all rootstock–spacing combinations were profitable, but were increasingly profitable as planting density increased and to some extent, as tree vigor increased (Changsha mandarin net income > Flying Dragon or K x R citrange; Table 2). These results support the contention that matching tree vigor with spacing and site conditions is important. In our study, we apparently did not exceed the limits of this concept of orchard design because the combination with the highest net income was the most vigorous at the closest in-row spacing: 'Hamlin' on Changsha mandarin rootstock at 7.5 ft or 270 trees/acre. The role of proper spacing was also evident in the performance of the trees on Flying Dragon trifoliate orange. Their cumulative net incomes were relatively low at the 12.5- and 10.0-ft spacings, but more than doubled when the trees were planted at the 7.5-ft spacing. It is likely that the trees on Flying Dragon trifoliate orange would have continued to show better performance and cumulative net income at closer in-row spacing.

Another important question is whether other more conventional grove designs would be a superior long-term combination. Thus, an estimate for comparison with our results was calculated using data previously collected from several blocks of trees in the SW Florida citrus region (Roka et al., 2000). Using the same economic variables and 4-year tree age period as with our data, the cumulative net income of 'Hamlin' trees on Swingle citrumelo rootstock planted at ~150 trees/acre (~12 × 25 ft) was $6564. That income exceeds the cumulative net incomes for all rootstocks at either the 12.5- or 10-ft spacing in our trial except Changsha at 10 ft, but is about $900 to $3200 below the net incomes for trees at the 7.5-ft spacing (Table 2). However, that comparison is not conclusive without also knowing how the trees on Swingle citrumelo would have performed at closer in-row spacings or how more vigorous scion–rootstocks combinations would have performed at conventional spacings.

Our study has demonstrated the economic potential of closely spaced trees in a flatwoods environment using trees on rootstocks of moderate or relatively low vigor. Our results complement and support the results of other Florida studies showing the potential of close to moderately spaced trees (Koo and Muraro, 1982; Muraro et al., 1995; Wheaton et al, 1995a, 1995b). Furthermore, such benefits can be derived by varying only in-row spacing and using a moderate between-row spacing that allows the use of conventional grove production and harvesting equipment. In those circumstances, there are essentially no differences in site preparation costs among the in-row spacings. The only variable establishment costs are those related to the numbers of trees and irrigation sprinklers.

## Literature Cited


Boswell, S.B. and D.R. Atkin. 1978. Comparison of two 'Washington' navel plantings at several densities: A vigorous scion–rootstock combination vs. a less vigorous combination. Proc. Fla. State Hort. Soc. 91:40–43.

Castle, B. 2006. New production technologies for Florida citrus. Citrus Ind. 87(9):25–28.

Castle, W.S. 1980. Citrus rootstocks for tree size control and higher density plantings in Florida. Proc. Fla. State Hort. Soc. 93:24–27.

Castle, W.S. 1987. Citrus rootstocks, p. 361–399. In: R.C. Rom and R.F. Carlson (eds.). Rootstocks for fruit crops. Wiley, Hoboken, NJ.

Castle, W.S. and R.L. Phillips. 1980. Performance of 'Marsh' grapefruit


Table 2. Estimated establishment costs and net incomes for 'Hamlin' orange trees on three rootstocks and planted at three in-row spacings. Analyses are based on yield and juice data collected from a flatwoods field trial when the trees were 8 to 12 years old.

| Spacing of trees/acre | | Changsha mandarin | Flying Dragon trifoliate orange | Koethen x Rubidoux citrange |
|---|---|---|---|---|
| 12.5 ft | 162 | | | |
| Establishment cost | | $5067/acre | $5067/acre | $5067/acre |
| 4-yr cumulative net income[z] | | $6134 | $3609 | $5582 |
| 10.0 ft | 203 | | | |
| Establishment cost | | $5382 | $5382 | $5382 |
| 4-yr cumulative net income | | $6916 | $3375 | $5770 |
| 7.5 ft | 270 | | | |
| Establishment cost | | $5898 | $5898 | $5898 |
| 4-yr cumulative net income | | $9809 | $7919 | $7474 |

[z]Production cost: $915/acre; harvest cost: $2.18/box; price for juice solids: $1.30 /lb.

and ‘Valencia’ orange trees on eighteen rootstocks on a closely spaced planting. J. Amer. Soc. Hort. Sci. 105(4):496–499.
Castle, W.S. and J.C. Baldwin. 1995. Tree survival in long-term citrus rootstock field trials. Proc. Fla. State Hort. Soc. 108:73–77.
Castle, W.S., D.P.H. Tucker, A.H. Krezdorn, and C.O Youtsey. 1993. Rootstocks for Florida, 2nd ed. Univ. Fla. Coop. Ext. Publ. SP-42.
Grosser, J.W., J. Jiang, E.S. Louzada, J.L. Chandler, and F.G. Gmitter, Jr. 1998. Somatic hybridization, and integral component of citrus cultivar improvement: II. Rootstock improvement. HortScience 33(6):1060–1061.
Koo, R.C.J. and R.P. Muraro. 1982. Effects of tree spacing on fruit production and net returns of ‘Pineapple’ oranges. Proc. Fla. State Hort. Soc. 95:29–33.
Long, K., L. Fraser, P. Broadbent, and J. Duncan. 1977. Dwarfing of citrus trees by inoculation with a pathogen. Proc. Int. Soc. Citricult. 3:866–868.
Muraro, R.P., W.S. Castle, T.A. Wheaton, J.D. Whitney, and D.P.H. Tucker. 1995. An analysis of how planting density and rootstock vigor affect the economic performance of ‘Valencia’ trees. Proc. Fla. State Hort. Soc. 108:160–164.
Phillips, R.L. 1974. Performance of ‘Pineapple’ orange trees at three spacings. Proc. Fla. State Hort. Soc. 87:81–84.
Roka, F.M., R.E. Rouse, and R.P. Muraro. 2000. Comparison of yields by tree age and rootstock in Southwest Florida orange groves. Proc. Fla. State Hort. Soc. 113:115–119.
Sparks, B. 2007. Southern exposure. Tree fruit growers gain new perspectives at IFTA’s 50th annual conference in Tasmania. Amer. Fruit Grower 127(4):8–10, 12, 14.
Tucker, D.P.H., K.S. Derrick, and W.S. Castle. 1998. Answers to frequently asked questions about citrus blight. Citrus Ind. 79(1):38–40.
Wheaton, T.A., W.S. Castle, D.P.H. Tucker, and J.D. Whitney. 1978. Citrus concepts: Higher density plantings for Florida. Proc. Fla. State Hort. Soc. 91:27–33.
Wheaton, T.A., J.D. Whitney, W.S. Castle, and D.P.H. Tucker, 1986. Tree spacing and rootstocks affect growth, yield, fruit quality, and freeze damage of young ‘Hamlin’ and ‘Valencia’ orange trees. Proc. Fla. State Hort. Soc. 99:29–32.
Wheaton, T.A., W.S. Castle, J.D. Whitney, and D.P.H. Tucker. 1991. Performance of citrus scion cultivars and rootstocks in a high density planting. HortScience 26(7):837–840.
Wheaton, T.A., W.S. Castle, J.D. Whitney, D.P.H. Tucker, and R.P. Muraro. 1990. A high density citrus planting. Proc. Fla. State Hort. Soc. 103:55–59.
Wheaton, T.A., J.D. Whitney, W.S. Castle, R.P. Muraro, H.W. Browning, and D.P.H. Tucker. 1995a. Citrus scion and rootstock, topping height, and tree spacing affect tree size, yield, fruit quality, and economic return. J. Amer. Soc. Hort. Sci. 120(5):861–870.
Wheaton, T.A., J.D. Whitney, W.S. Castle, R.P. Muraro, H.W. Browning and D.P.H. Tucker. 1995b. Tree vigor important in citrus tree spacing and topping. Proc. Fla. State Hort. Soc. 108:63-69.