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ROOTSTOCK AND INTERSTOCK EFFECTS ON THE GROWTH OF YOUNG 'MINNEOLA' TANGELO TREES

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Abstract. **Two experiments were conducted to evaluate rootstocks or interstocks as means to control tangelo tree size. 'Minneola' (*Citrus paradisi* Macf. × *C. reticulata* Blanco) trees on 9 rootstocks were planted at a central Florida site at a spacing of 12.5 × 25 ft in Apr. 1986. The trees were killed by a freeze in Dec. 1989; however, at that time, when the trees were about 3.5 yr old, mean tree height was 6 ft and ranged from 6.8 ft for trees on Cleopatra mandarin (*Citrus reshni* Hort. ex Tan.) to 4.7 ft for those on Flying Dragon trifoliate orange [*Poncirus trifoliata* (L.) Raf.], a 30% difference. A separate 'Minneola' interstock trial was planted in an adjacent site in June 1986. Cleopatra mandarin was the rootstock for all trees. Each tree had an interstock of Cleopatra mandarin, Rangpur (*C. limonia* Osbeck) × Troyer citrange [*C. sinensis* (L.) Osb. × *P. trifoliata*], Flying Dragon trifoliate orange, or F80-3 citrumelo (*C. paradisi* × *P. trifoliata*) produced by double budding, or, by budding 'Minneola' onto Cleopatra then removing a ring of bark from the 'Minneola' portion of the trunk and replacing it with bark of one of the interstocks. When measured in July 1989, there were significant treatment effects on cross-sectional areas among the 3 trunk components. Flying Dragon was markedly larger than the scion or any of the other interstocks regardless of the method of propagation; also, the interstocks had virtually no effect on tree height as compared to the same germplasm used as a rootstock.**

'Orlando' and 'Minneola' tangelos are 2 of the oldest members of Florida's current portfolio of fresh fruit mandarin and mandarin hybrid cultivars. Tangelo acreage has declined in recent years primarily because of freeze damage in Lake County. Presently, there are about 8,500 acres of 'Orlando' trees and 2,700 acres of 'Minneola' trees located largely in Polk, St. Lucie, Hendry, and Highlands counties (Preliminary Tree Census, 1992, Fla. Agr. Stat. Service).

'Orlando' and 'Minneola' are self-unfruitful and only weakly parthenocarpic. Fruit set is generally achieved in Florida tangelo plantings by interplanting with other cultivars for cross-pollination. Tangelo trees are also inherently vigorous, a characteristic enhanced by propagation on Cleopatra mandarin, rough lemon (*C. jambhiri* Lush.), Carrizo citrange, and sour orange (*C. aurantium* L.), which have been the common commercial rootstocks in Florida (Citrus Budwood Registration Bureau). As a result, tangelo trees usually require regular hedging and topping beginning at an earlier age than many other cultivars, and are not well-suited to close planting. Smaller, less vigorous trees are desirable and would also help reduce harvesting costs.

Rootstocks affect tangelo tree size but their use for that specific purpose has received scant attention in Florida (Hutchison and Hearn, 1977; Krezdorn, 1977) or elsewhere (Fallahi et al., 1991; Roose et al., 1989). Most rootstock research for tangelos has involved 'Orlando' and has focused on yield and fruit quality. Relatively little is known about interstocks versus rootstocks for tree size control of citrus (Bitters et al., 1977; Krezdorn, 1978).

The objective of this study was to determine rootstock and interstock effects on 'Minneola' tangelo tree size and yield. A freeze terminated the trial after 3.5 yr, thus, tree growth is emphasized in this report.

Materials and Methods

Two adjacent 'Minneola' tangelo (Budline: SF-60-9-XE-521-2-38-X) experiments were established at a typical central Florida Ridge site near Clermont, FL. The trees were planted 12.5 ft × 22 ft (158 trees/acre) in a randomized complete-block design with 8, single-tree replications. The soil is Astatula fine sand.

Experiment 1 was planted in Apr. 1986 and consisted of 'Minneola trees on 9 rootstocks (Table 1). Experiment 2 was planted 2 months later and involved 'Minneola' trees on Cleopatra mandarin with an interstock. There were 8 treatments formed factorially from 4 interstocks and 2 methods of interstock propagation.

The interstocked trees were produced: a) by budding

Florida Agricultural Experiment Station Journal Series No. N-00658. The participation of Charlie Russ, Clermont, as grower-cooperator is gratefully acknowledged. He provided the site and grove care; however, it is more important to note that since the experiments were killed by the 1989 freeze, a new trial was begun at the same site in 1992. This commitment to research by Mr. Russ deserves special recognition. Also, the contributions of James C. Baldwin, Biological Scientist, are very much appreciated.

Table 1. Rootstock effects on the height of 3-yr-old 'Minneola' tangelo trees (expt. 1).

Rootstock	Tree ht, ft	Indexed to Cleo., %
Cleopatra mandarin	6.8 a[z]	100
Rusk citrange	6.6 ab	97
Swingle citrumelo	6.4 abc	94
F80-8 citrumelo	6.1 bc	90
Rangpur × Troyer citrange	6.1 bc	90
F80-3 citrumelo	5.9 bc	87
F80-19 citrumelo	5.8 c	85
Procimequat	4.8 d	71
Flying Dragon trifoliate orange	4.7 d	69

[z]Mean separation by Duncan's multiple range test, 5% level.

Cleopatra mandarin, F80-3 citrumelo, Flying Dragon trifoliate orange, or Rangpur × Troyer citrange onto Cleopatra mandarin seedlings; then, 'Minneola' was budded onto the interstock about 1 to 2 inches above the interstock/stock budunion; or b) by budding 'Minneola' onto Cleopatra mandarin and when those trees were ready for planting, a 1-inch-long ring of bark was removed about 3 inches above the budunion and replaced (with no change in polarity) with a like ring of bark of one of the same interstocks used above. The bark ring was wrapped with budding tape which was removed about 2 weeks later.

The trees in both experiments received routine grove care, including water and nutrients by fertigation through microsprinklers. 'Temple' pollenizer trees were planted in 1987 in a ratio of 1 row:2 'Minneola' rows.

Tree height and yield (by volume) were measured along with scion, interstock, and rootstock trunk circumferences which were converted to cross-sectional areas (CSA). Data were analyzed by ANOVA with mean comparisons by Duncan's multiple range test as appropriate.

Results and Discussion

A freeze in Dec. 1989 terminated both experiments when the trees were 3.5 yr old; nevertheless, most trees were already 6 to 7 ft tall and rootstock effects on tree height were clearly evident in expt. 1 (Table 1). The 'Minneola' trees on Cleopatra mandarin were the tallest, but the differences among the trees on many of the rootstocks were not significant. The trees on F80-3 and F80-19 citrumelo were intermediate in height and those on procimequat [*C. aurantifolia* (Christm.) Swing. × *Fortunella japonica* (Thunb.) Swing.) × *F. hindsii* (Champ.) Swing.] and Flying Dragon trifoliate orange were significantly shorter, by 30%, than those on Cleopatra mandarin. Yields/tree (data not given), obtained just prior to the freeze, ranged from 0.5 boxes (Cleopatra mandarin) to 1.2 boxes (80-8 citrumelo and Rangpur × Troyer citrange). Trees on Flying Dragon had a mean yield of 0.6 boxes.

In expt. 2, mean tree height was about 6.5 ft with no differences among treatments except for those trees with Flying Dragon interstock (data not given). They were slightly, but significantly, shorter suggesting that Flying Dragon has potential to reduce tree size as either an interstock or as a rootstock. The trunk CSA also seemed to indicate a physiological interaction between the 3 tree components that was different for Flying Dragon than for the other interstocks (Table 2). In general, scion, interstock, and rootstock trunk CSA were larger for the trees with a budded than a bark ring interstock. The trunk CSA of the scion and interstock were similar within a method of interstock propagation; however, for Flying Dragon, the interstock was markedly larger than the scion. Differences among the trunk components were also reported by Bitters et al. (1977) for lemon trees with citrus relatives as interstocks.

Citrus trees on many rootstocks of the genus *Citrus* do not vary greatly in vigor or size (Castle et al., 1989). The same rootstock species used as interstocks have less or no effect on tree growth, as observed in this study, as well as on other tree and fruit characteristics (Castle, unpublished data; Gardner, 1968). Thus, promising plant material for tree size control would have its maximum influence as a rootstock. Moreover, its use as an interstock is counteracted by the rootstock's characteristics; e.g., in a 'Hamlin' budded interstock trial, tree height was virtually unaffected by Flying Dragon interstock with vigorous Volkamer lemon (*C. volkameriana* Ten. & Pasq.) rootstock, but with the same combination on Carrizo citrange rootstock, tree height was about 30% less than for the control trees (Castle, unpublished data).

There are, however, certain advantages with suitable interstocks. They have been used to overcome vegetative incompatibility, and dwarfing apple rootstocks have worked successfully in controlling tree size as interstocks (Ferree and Carlson, 1987). Only trifoliate orange selections and citrus relatives have reduced citrus tree size as interstocks (Bitters et al., 1977; Castle, 1987). Flying Dragon as a rootstock consistently dwarfs trees in Florida, even more than other trifoliate orange selections (Castle et al., 1989; Wheaton et al., 1991). If Flying Dragon or other germplasm could be used as an interstock, that would allow different, perhaps more desirable, plant material to be used as the rootstock. Also, propagating an interstock by bark ring replacement, as demonstrated in this study, would be convenient and less time-consuming than double budding. Concerns about a bark ring interstock being

Table 2. Scion, interstock, and rootstock trunk cross-sectional areas (sq. inches) of 3-yr-old 'Minneola' tangelo trees on Cleopatra mandarin rootstock (expt. 2).

Variable	Scion		Interstock		Rootstock
Anal. variance					
Meth. prop.[z]	*[y]		***		***
Interstock	**		***		ns
MxI	*		***		ns
Means					
Grand	5.0		7.6		8.4
Method:					
budded	5.2		8.5		9.4
bark ring	4.8		6.7		7.4
Interstock:					
Cleo	4.8		5.6		
80-3	5.4		8.2		
RxT	5.4		5.3		
FDT	4.3		11.4		
Interaction:	Budded	Ring	Budded	Ring	
Cleo	5.1	4.6	6.1	5.1	
80-3	5.8	5.0	9.3	7.1	
RxT	5.8	5.1	5.5	5.2	
FDT	4.1	4.6	13.2	9.6	

[z]Method of interstocking: double budding or by bark ring replacement.
[y]ns, *, **, *** Nonsignificant or significant at P = 0.05, 0.01, or 0.001, respectively.

sloughed off do not seem justified. This method is generally thought to require transfer of cambial tissue so that continued growth of the interstock will occur; nevertheless, the procedure was completely successful in this study.

The smaller size of 'Minneola' trees on Flying Dragon in expt. 1 suggests that it should be evaluated further. Long-term 'Orlando' trials have shown that trifoliate orange selections reduce tree size without commensurate reductions in yield (Hutchison and Hearn, 1977; Krezdorn, 1977). A similar result occurred in expt. 1 indicating that with additional study, Flying Dragon may prove to be a desirable rootstock for 'Minneola' tangelo in Florida. Procimequat appeared promising as a tree-size-controlling rootstock in earlier work with 'Valencia' sweet orange; but, nursery trees on procimequat are slow growing and the yield and growth of field trees have been inconsistent and undesirable in some instances (Castle, 1987; unpublished data).

Tree height was not markedly affected by Swingle or F80-8 citrumelos or Rangpur × Troyer citrange as compared to Cleopatra mandarin, but the yields from trees on the former stocks were nearly 1.5 to 2.5 times greater. If that difference in yield is representative of the respective rootstocks, as observed in other experiments (Castle, 1980; Castle et al., 1986), then F80-8 and Rangpur × Troyer citrange also merit additional evaluation. Swingle citrumelo, as the contemporary Florida rootstock, is relatively new for 'Minneola' tangelo; however, its attributes as well as performance in expt. 1 and elsewhere (Castle et al., 1988) should encourage its general use for tangelos.

Despite the young age of the trees in this study, it is reasonable to conclude that:

- Within the range of germplasm tested, individual selections had more effect on tree size when used as a rootstock than as an interstock;
- Interstocking can be achieved by bark ring replacement; and,
- Flying Dragon is a promising rootstock for 'Minneola' tree size control.

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ENERGY REQUIREMENTS FOR FLORIDA CITRUS PRODUCTION[1]

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Abstract. **A spreadsheet-based microcomputer energy consumption model of Florida agricultural production has been developed. The Florida Agricultural Energy Consumption Model (FAECM) quantifies as many as 21 categories of direct and indirect energy inputs required for producing each of approximately 60 major and another 30 minor crop and livestock commodities. The model includes budgets for oranges, grapefruit, limes and other citrus to encompass all Florida citrus production. The model is based on production budgets converted to energy budgets, and production levels (acres or number of head).**

The model will be described. Results will be presented for Florida citrus production. Florida citrus production required 15.7 trillion Btu of direct energy and 30.4 trillion Btu of total primary energy in 1990. Oranges rank first among all Florida agricultural commodities in both direct and total primary energy consumption. Grapefruit ranks third in direct energy requirements and fifth in total primary energy requirements among all Florida agricultural commodities. Comparisons will be drawn with other Florida agricultural commodities, with all of Florida agriculture, and with total Florida energy consumption.

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