Citrus rust mite populations during tests in 1971, 1972 and 1974 were high and remained high in the untreated controls. Citrus rust mite populations in 1975, 1979 and the two in 1980 tests were moderate initially and increased during the test period. Rust mite populations fluctuated only slightly in the untreated controls during test periods in 1973 and 1978.

As may be seen in the 2 figures, control of citrus rust mites is a highly variable value. There are many factors which can influence length of control. These include population pressure, temperature, rainfall and season. Results obtained in tests reported here point out the importance of field-testing materials over several seasons under a variety of conditions to develop information on the range of control that a material will provide.

Acknowledgments

The author acknowledges the valuable assistance of C. R. Crittenden, T. B. Hull, and R. F. Kanavel in applying and evaluating these tests.

Literature Cited

1. Garrett, H. 1973. Citrus pest control program. Proc. Tall Timber Conf. Ecol. Animal Control by Habitat Management No. 5:89-92.
2. Johnson, R. B. 1958. Rust mite control with materials applied in oil emulsion. Proc. Fla. State Hort. Soc. 71:95-99.
3. McCoy, C. W. and T. L. Couch. 1982. Microbial control of the citrus rust mite with the mycoacaricide Mycar. Fla. Entomol. 65: 116-126.
4. Simanton, W. A. and K. Trammel. 1966. Recommended specifications for citrus spray oils in Florida. Proc. Fla. State Hort. Soc. 79: 26-30.
5. Thompson, W. L. 1946. Preventative sprays for mite control on citrus. Proc. Fla. State Hort. Soc. 59:60-65.
6. Yothers, W. W. and A. C. Mason. 1930. The citrus rust mite and its control. U.S. Dept. Agr. Tech. Bul. 176. 56 pp.

Proc. Fla. State Hort. Soc. 96:23-25. 1983.

GROWTH, YIELD AND COLD HARDINESS OF SEVEN-YEAR-OLD 'BEARSS' LEMON TREES ON TWENTY-SEVEN ROOTSTOCKS[1]

WILLIAM S. CASTLE
University of Florida, IFAS,
Citrus Research and Education Center,
700 Experiment Station Road,
Lake Alfred, FL 33850

Additional index words. citrange, citrumelo.

Abstract. **'Bearss' lemon** (Citrus limon **Burm. f.) trees containing an apparently mild isolate of exocortis were propagated on 27 rootstocks and planted near Indiantown in 1975. Tree height, width, and yield were measured in 1979 and also in 1981 when canopy volume and tree efficiency (yield/unit of canopy volume) were calculated. Mean tree height in 1981 ranged from less than 5.0 ft to 10.4 ft for trees on a hybrid of** C. sunki **Hort. ex. Tanaka x Swingle trifoliate orange** [Poncirus trifoliata **(L.) Raf.**] **and 'Murcott'** [C. reticulata **Blanco x** C. sinensis **(L.) Osb. hybrid?] respectively. Yield, which ranged from 0.4 to 3.3 boxes/tree in 1981, was commensurate with tree volume. There were no significant differences in tree efficiency. Trees were rated in May 1982 for cold damage which occurred the previous winter. Most trees were severely damaged or dead, but those on 'Murcott', Changsha mandarin** (C. reticulata)**, Swingle citrumelo** (P. trifoliata x C. paradisi **Macf.), and F80-8 citrumelo were apparently recovering.**

Among the common scion cultivars of citrus, the lemon is generally considered to be excessively vigorous in Florida. As a result, lemon trees are difficult to harvest and require more frequent hedging and topping to control tree size.

Various approaches have been taken to control vigor in lemon trees including the use of growth retarding chemicals (2, 4) and different tree planting angles (5, 9). Some size reduction has been obtained with rootstocks and interstocks in other lemon-growing areas such as California (1, 6), but the potential for rootstock control of vigor has not been explored in Florida. Therefore, an experiment was established to evaluate 27 rootstocks for their effects on tree vigor and yield.

Materials and Methods

Trees of 'Bearss' lemon on 27 rootstocks specifically selected for their potential to control tree vigor, were planted in a Floridana fine sand at Indiantown in 1975. The seed source of each rootstock was reported previously (7, 8). Division of Plant Industry clone 404-3-39 was used as the scion source. When the experimental trees were propagated, the budwood source tree was not known to be infected with exocortis. Indexing conducted after planting, however, indicated that exocortis was present and, therefore, the experimental trees were also considered to be infected.

Pairs of trees were set at a spacing of 15 x 27 ft along the center 2 rows of a 4-row bed. There were 3 replications in a completely randomized design. The trees received care typical for other commercial groves in the vicinity with irrigation provided by an overhead sprinkler system.

Tree height and width were measured in 1979 and 1981. Canopy volume was calculated using the equation: Volume = (.5236) (canopy height) (canopy diameter)^2. Yield was measured by volume using the standard field box, for October harvests in 1979 and 1981. Cold damage prevented obtaining yield data in other years. Tree efficiency was calculated as yield/unit of canopy volume. During the winter of 1981-82, many trees were severely cold damaged or killed. The extent of damage was rated in May 1982, using the following scale: 0-canopy reduced to about half of its original volume with considerable regrowth evident; 1-canopy killed back to the trunk with some new growth emerging; and, 2-dead.

Data were tested for significant treatment differences using an analysis of variance (AOV) with mean separation

[1]Florida Agricultural Experiment Stations Journal Series No. 5061.

by Duncan's multiple range test; however, only the standard error for a treatment mean is given for each variable where significance was indicated by the AOV (3).

Results and Discussion

Tree height and volume, yield, and the degree of cold damage were significantly affected by rootstock (Table 1). Trees on the commercial rootstocks Carrizo citrange and Swingle citrumelo were among the most vigorous as were those on many of the citrange, citrumelo, mandarin, and mandarin hybrid stocks. These trees had grown to about 9 to 10 ft in height within 4 years after planting (data not presented). They changed little in size thereafter because of cold damage sustained during the winter of 1979-1980 and the following year. The smallest trees such as those on the trifoliate orange stocks, particularly Flying Dragon, ranged in height from about 5 to 7 ft and were about 30 to 50% smaller than the most vigorous trees.

The smaller trees generally began to fruit about 1 year earlier than the larger trees, an advantage that could be particularly meaningful in commercial high density plantings of the less vigorous trees. The mean yield for the experiment was 0.8 boxes in 1979 and 2.0 boxes in 1981. Yield ranged from 0.4 to over 3 boxes/tree in 1981 but there were no differences in tree efficiency. Yield was directly related to canopy volume.

During the experiment, the trees were exposed to several freezes which caused the trial to be terminated in 1982 because of excessive tree loss. Virtually all trees had been rendered commercially useless except for those on Changsha mandarin, Murcott, and F80-8 and Swingle citrumelo. The trees on these 4 rootstocks formed a distinct group because they had the lowest and most consistent cold damage ratings (Table 1). These trees had recovered sufficiently to justify saving unlike the remaining trees which probably would have been replaced in a commercial planting.

The influence of exocortis infection appeared to be minor. Most of the rootstocks used are considered tolerant. Among the susceptible trifoliate orange stocks and its hybrids, bark scaling below the budunion was observed only on one tree budded to Flying Dragon and on all the W4 citrumelo-rooted trees.

The results of this study clearly show the potential for rootstock control of lemon tree vigor in Florida. Insufficient yield data and the young age of the trees permit only a preliminary evaluation of any specific rootstock. However, among the intermediate and small sized trees, those on Rangpur lime x Troyer citrange, F80-3 and Swingle citrumelo, Uvalde citrange, and Flying Dragon and Jacobsen

Table 1. Performance of 'Bearss' lemon on 27 rootstocks.[z]

Rootstock	Tree ht, 1981 (ft)	Canopy vol, 1981 (ft^3)	Yield (boxes) 1979	Yield (boxes) 1981	Cold damage rating[y]
Mandarins (*Citrus reticulata* Blanco)					
Changsha	9.5	297	1.0	2.0	0.0
Tim Shan	8.9	254	1.1	2.4	1.5
Kino kuni	8.6	197	0.4	1.6	1.5
Kadu mal	9.0	357	0.7	2.9	0.5
Mandarin hybrids					
Murcott [*C. reticulata* x *C. sinensis* (L.) Osb.?]	10.4	450	1.7	3.3	0.0
C-18 tangelo (*C. reticulata* x *C. paradisi* Macf.)	8.4	235	0.8	2.2	0.7
C. sunki Hort. ex. Tanaka x Swingle trifoliate orange	4.7	49	1.0	0.5	2.0
Trifoliate oranges [*Poncirus trifoliata* (L.) Raf.]					
Jacobsen	7.0	104	1.3	0.7	1.2
Flying Dragon	5.4	34	0.2	0.4	1.7
Citranges (*C. sinensis* x *P. trifoliata*)					
Uvalde	8.6	279	1.4	3.2	1.0
Morton	8.1	237	1.2	1.8	1.8
Carrizo	9.0	262	0.5	1.8	2.0
F81-10	8.4	239	0.9	1.7	1.7
F81-12	7.7	178	1.2	1.9	1.8
Citrumelos (*C. paradisi* x *P. trifoliata*)					
Swingle	9.0	239	0.9	2.6	0.0
F80-3	8.9	298	0.3	2.1	1.5
F80-5	9.4	341	1.0	3.2	1.2
F80-6	8.5	165	0.7	1.8	1.8
F80-8	9.5	428	0.7	3.1	0.3
W4	6.9	106	0.6	1.1	2.0
T/G	8.4	241	1.0	2.5	1.5
F81-19	9.5	389	0.9	2.6	0.8
F81-20	6.7	116	0.4	1.8	1.7
Other					
Rangpur lime (*C. limonia* Osb.) x Troyer citrange	7.5	108	0.5	1.1	1.5
C. aurantifolia (Christm.) Swing.	7.7	161	0.7	1.2	2.0
C. tachibana (Mak.) Tan.	7.9	178	0.8	1.7	1.2
Standard error	0.5	35.0	0.4	0.3	0.3

[z]The experiment included 6 trees on Nova, a mandarin hybrid rootstock, but they died within 3 years after planting.
[y]Rated on a scale of: 0 = moderate damage; 1 = severe damage, and 2.0 = dead.

trifoliate orange appear promising. Trees on these stocks have performed well in other experiments (7, 8) and merit continued evaluation. Their lower yields in comparison to the larger trees could be compensated for by closer planting. Even though the trees were growing in a relatively fertile soil with a high organic matter content, a 10 or 12 x 20 ft spacing might have been more appropriate for the smaller trees.

Two commercially important rootstocks, Carrizo and Swingle, were included in this experiment. Trees on these 2 stocks appeared to be well-adapted to the local soil environment and performed similarly except for cold tolerance. As previously observed (10), trees on Swingle were more cold tolerant than those on Carrizo.

Lemons are not likely to be a major crop in Florida. Nevertheless, it is evident that lemon tree vigor under Florida conditions can be reduced through the use of selected rootstocks. Furthermore, the relative rootstock effects observed in this study may be similar with other scion cultivars.

Acknowledgments

Appreciation is extended to the Coca Cola Company, Foods Division who provided a site and care for the experiment. Michael Patterson of Coca Cola, assisted in planting the experiment and Dr. R. L. Phillips selected and propagated the plant material.

Literature Cited

1. Bitters, W. P., D. A. Cole, and C. D. McCarty. 1977. Citrus relatives are not irrelevant as dwarfing stocks or interstocks for citrus. Proc. Intern. Soc. Citriculture 2:561-567.
2. Boswell, S. B., R. M. Burns, and H. Z. Hield. 1976. Inhibition effects of localized growth regulator sprays on mature lemon trees. HortScience 11:115-117.
3. Bryan-Jones, J. and D. J. Finney. 1983. On an error in "Instructions to authors". HortScience 18:279-282.
4. Burns, R. M., S. B. Boswell, and H. Z. Hield. 1976. Effects of growth inhibitors on Ventura lemon trees. Citrograph 61(10):335, 356, 382.
5. Burns, R. M., S. B. Boswell, and S. F. Wear. 1981. Growing lemons and grapefruit at an angle. Citrograph 66(9):217, 218.
6. Carpenter, J. B., R. M. Burns, and R. F. Sedlacek. 1981. Phytophthora resistant rootstocks for lisbon lemons in California. Citrograph 66(12):287, 291, 292.
7. Castle, W. S. 1980. Citrus rootstocks for tree size control and higher density plantings in Florida. Proc. Fla. State Hort. Soc. 93:24-27.
8. Castle, W. S. and R. L. Phillips. 1980. Performance of 'Marsh' grapefruit and 'Valencia' orange trees on eighteen rootstocks in a closely spaced planting. J. Amer. Soc. Hort. Sci. 105:496-499.
9. Wear, S. F. and J. D. Kirkpatrick. 1974. The sleeping beauties: horizontal lemon plantings. Citrograph 60(1):7, 8, 32.
10. Yelenosky, G. 1976. Cold-hardening young 'Valencia' orange trees on 'Swingle' citrumelo (CPB-4475) and other rootstocks. Proc. Fla. State Hort. Soc. 89:9-10.

Proc. Fla. State Hort. Soc. 96:25-28. 1983.

BACTERIA-INDUCED FREEZING OF YOUNG CITRUS TREES[1]

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

Additional index words. supercooling, freeze avoidance.

Abstract. **Leaves of 'Valencia' trees (*Citrus sinensis* L.) Osb.) on sour orange (*C. aurantium* L.) rootstock that were sprayed with ice nucleation-active (INA) bacteria started to freeze sooner than unsprayed leaves during freeze trials in a controlled-temperature room. Leaves sprayed with INA bacteria usually started to freeze before 23°F (−5°C), whereas unsprayed leaves remained in a supercooled freeze-avoidance state. Moisture on the leaves during freezing temperatures increased the risk of early freezing. Neither antibacterial streptomycin sprays nor non-INA bacteria prevented the freezing associated with INA bacteria. Nonbacterial INA agents also were found to cause earlier freezing in citrus leaves. Data suggest that INA agents play an active role in minimizing supercooling (freeze avoidance) in agricultural crops during freezes in Florida, but do not yet support concerns that INA bacteria are the major cause of freezing in citrus tissues during natural freezes. Additional and more detailed studies are needed to determine whether eliminating or controlling INA bacteria will significantly reduce freeze damage to citrus in Florida.**

There are bacteria in citrus plantings that decrease supercooling (cooling below 32°F (0°C) without ice forming) and cause early freezing in plant tissues (1, 9). These ice nucleation-active (INA) bacteria are strains of *Pseudomonas syringae* van Hall and *Erwinia herbicola* (Löhnis) Dye that induce ice to form at temperatures as warm as 30°F (−1°C). This small amount of supercooling precludes any beneficial effects of supercooling in avoiding damage in citrus plantings during natural freezes. Other researches (8, 12) have suggested that early freezing due to INA bacteria results in longer durations of ice in citrus tissues, which induces greater freeze damage. Citrus seemingly is not injured until ice forms in the tissues.

The importance of supercooling is not firmly established in citrus groves, but supercooling is probably the most energy-efficient freeze-avoidance mechanism that assures plant survival (4, 7). Supercooling is largely an unexplained and unpredictable event in the freezing of plants. Factors such as degree of vascular development (2), diameter of xylem vessels (3), and heterogenous nucleators (12) apparently play a role. Temperature-and/or water stress-induced cold-hardening regimes increase supercooling in citrus (14, 17, 20). But, supercooling does not segregate unhardened cold-hardy citrus types (18). The elimination or control of INA populations of bacteria supposedly would allow supercooling to develop and result in less freeze damage to citrus. Bactericides and antagonistic non-INA bacteria are 2 approaches to control INA bacteria below critical population levels (8).

The purpose of this study was to determine the activity of INA bacteria and other INA agents in freezing of citrus during controlled-temperature regimes. Interest was in determining frequency of freezing, critical temperatures, effectiveness of bactericides, and potential problem areas in citriculture.

[1]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that also may be suitable.