and granting of degrees in the 4-year B.S. degree programs in horticulture and agribusiness will be through UF/IFAS, College of Agriculture and Natural Resources as the agricultural land grant university.

The horticulture degree offering will be through the UF/IFAS Horticultural Sciences Department with specializations for majors in Fruit Crops (citrus) and Vegetable Crops. The Agribusiness Management Specialization with emphasis in economics and marketing will be offered through the Department of Food and Resource Economics. UF/IFAS faculty will teach the basic professional courses relating to the two majors at FGCU. The UF/IFAS courses will include selected natural resources/environmental courses related to production agriculture which complement the environmental sciences curriculum of FGCU. Students will complete their lower division courses prior to admission. The program is designed so students can get general education lower division courses relating to these two majors at FGCU, ECC, or other appropriate higher education institutions.

The UF 4-year B.S. degree programs offered with FGCU will not affect the ECC 2-year A.S. degree program in Citrus Production Technology. Initially the ECC citrus courses taught at SWFREC had ECC course numbers. Beginning with the fall semester 1995, the six citrus courses were assigned UF course numbers, and are accepted in the ECC A.S. degree program.

The Board of Regents has committed to developing a strong Department of Environmental Sciences for Florida Gulf Coast University which will enhance the offering of a large number of science courses that can be utilized in the B.S. degree program by the University of Florida through SWFREC. The selection of upper division courses offered is enhanced by use of video teaching and satellite down-links from the UF campus in Gainesville and other Research and Education Centers in the state.

Distance Education Technology

SWFREC is one of the College of Agriculture's Research and Education Centers cooperating in distance education techniques of beaming courses from the UF main campus in Gainesville by satellite down-link to the Research and Education Center in Immokalee. SWFREC was one of the first sites where selected courses were available via satellite. Many place-bound students who in the past would have had to forego continuing their education because of the move to Gainesville, have found that going to class is as easy as driving to the SWFREC in Immokalee. Many that are bound by jobs or families have found distance learning to be a desirable option for finishing a bachelor's degree or receiving academic training in a specialized area. Students get the same education as they would have gotten if they had moved to attend these classes on the main campus, and they pay the same fees.

SWFREC is fortunate to participate with other down-link sites in developing use of this technology for distance education which has become an important extension in the evolution of higher education. There appears to be a stronger interest in continuing education and adult education than in the past. From an educational perspective the place-bound students offer an exciting dimension to the classroom of distance learning. Many of these students bring with them work experiences and maturity not normally found in on-campus classes.

Education opportunities at the IFAS Southwest Center are growing as this agricultural area continues to grow and develop. The UF/IFAS SWFREC continues to work jointly with the community college and the new state university to meet the needs of both students and business. The SWFREC is committed to being a leader in developing and providing educational opportunities in southwest Florida.

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SOIL $CaCO_3$ CONCENTRATION AFFECTS GROWTH OF YOUNG GRAPEFRUIT TREES ON SWINGLE CITRUMELO ROOTSTOCK

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Abstract. **Many south Florida flatwoods soils are underlain by calcium carbonate ($CaCO_3$) rock, shell, or marl that can produce an alkaline root zone if mixed with the soil surface. Citrus rootstocks vary widely in their susceptibility to low Fe availability in high-pH soil. Young 'Flame' grapefruit trees (*Citrus paradisi* Macf.) on Swingle citrumelo rootstock (*C. paradisi* Macf. × *Poncirus trifoliata* [L.] Raf.) were planted in spring 1992, on 0.6 acres of land that contained calcareous soil in about one-fourth of the area. Trees grew well on soils with no $CaCO_3$ in the root zone, but poorly on soils that had visible rock on the soil surface. Where there was no free $CaCO_3$, soil pH ranged between 5 and 7. As soil $CaCO_3$ concentration increased from 0.2 to 0.6%, pH increased from 7.1 to 7.9, and above 0.6%, pH was above 8. As $CaCO_3$ in non-ground soil increased from 0 to 1.6%, leaf N concentration of 2-yr-old trees decreased from 2.4 to 1.8%, and canopy volume of 3-yr-old trees decreased from 600 to 200 ft^3. Grinding the soil did not improve correlation between tree growth and $CaCO_3$ concentration. $CaCO_3$ level did not affect leaf Fe concentration. Trees growing in acidic vs. calcareous soil had mean fruit yields of 60 vs. 10 lbs/tree, respectively. Yield dropped immediately**

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when $CaCO_3$ was present, regardless of concentration. The high pH condition prevented Swingle citrumelo rootstock from performing to potential, making it more advantageous for citrus growers to plant rootstocks more tolerant of high pH conditions in these areas.

Many south Florida flatwoods soils contain calcium carbonate ($CaCO_3$) rock, shell, or marl within 80 inches of the surface. In their native state, most of these soils have an acidic rooting zone, because the $CaCO_3$ lies low in the profile. When the soil is excavated and moved (as with land leveling and bedding prior to citrus planting), $CaCO_3$ can be mixed in the surface, creating a calcareous, high pH root zone.

Recent citrus expansion in southwest Florida involved development of large, contiguous land tracts that traversed numerous soil series, some containing $CaCO_3$. Calcareous soils became prevalent near ditchbanks, as well as interior grove zones where alkaline material existed within the water furrow depth. Since these areas appeared in an irregular pattern, they were not treated separately with respect to the rootstock chosen for large-scale planting.

Citrus rootstocks vary widely in their susceptibility to Fe chlorosis, induced by low Fe solubility under alkaline conditions (Wutscher and Olson, 1970). As a result of several field rootstock screening trials in Texas, Wutscher and Shull (1972, 1975) concluded that Swingle citrumelo, one of the most widely-planted rootstocks in the 1980s, is not suited for use on calcareous soils. Castle et al. (1988) surveyed 10 to 14-yr-old Florida citrus groves on Swingle citrumelo rootstock, and found poor growth where trees had been planted in localized surface limerock areas. Sudahono et al. (1994) found trifoliate hybrid rootstocks, particularly several citrumelos, to be susceptible to bicarbonate-induced Fe chlorosis in a greenhouse study. However, Swingle citrumelo has not always performed poorly where soil pH is above 7.0. Wutscher et al. (1975) and Castle et al. (1988) found that grapefruit on Swingle citrumelo planted at some high-pH sites in Texas and Florida was relatively highly-productive.

Southwest Florida calcareous soils can vary widely in $CaCO_3$ concentration and particle size (rock vs. shell vs. marl). Loeppert et al. (1984) investigated soil conditions in localized chlorotic areas within a sorghum field, and found soil carbonate level to be one of the dominant factors associated with chlorosis severity. Carter (1981) found that "active" $CaCO_3$, which is an estimate of silt and clay-sized carbonate particles, to be a better index of potential chlorosis problems than total $CaCO_3$.

In a nitrogen fertilizer experiment with grapefruit on Swingle citrumelo trees planted in a commercial grove on non-uniform soil, identically-fertilized trees grew less as the amount of observed $CaCO_3$ rock on the surface increased. The objective of this paper is to describe the relationship between soil $CaCO_3$ concentration and tree growth measured as canopy volume and fruit yield.

Materials and Methods

In April 1992, 'Flame' grapefruit trees budded on Swingle citrumelo rootstock were planted in a commercial grove on a newly-cleared, leveled, two-row bedded site in southwest Florida. Trees were planted 14.5 ft apart in north-south rows spaced 25 ft apart. A nitrogen fertilizer rate and source experiment was initiated on a grove section three rows wide and 72 trees long.

The experiment involved eight replications of nine fertilizer treatments in a randomized complete block design. Eight blocks were designated from north to south, each three rows wide and nine trees long. Each block was separated into nine plots, consisting of three adjacent trees in a row.

The soil in the four northernmost blocks had no visible $CaCO_3$ on the surface, but lime rock appeared in a transition zone in the fifth block. Rock was clearly visible in most of the sixth and seventh blocks, but diminished in the eighth block. The non-calcareous soil was Valkaria fine sand (siliceous, hyperthermic Spodic Psammaquent), and the calcareous soil was Hallandale fine sand (siliceous, hyperthermic, Lithic Psammaquent). The Hallandale soil contained fractured limestone bedrock at the 12-inch depth, some of which was brought to the surface during bedding.

Nitrogen fertilizer was applied at "low" and "high" rates of 0.15 and 0.30 lbs N/tree in 1992, 0.50 and 1.00 lbs N/tree in 1993 and 1994, and 0.63 and 1.25 lbs N/tree (75 and 150 lbs N/acre) in 1995, using controlled-release N applied twice per year, and water-

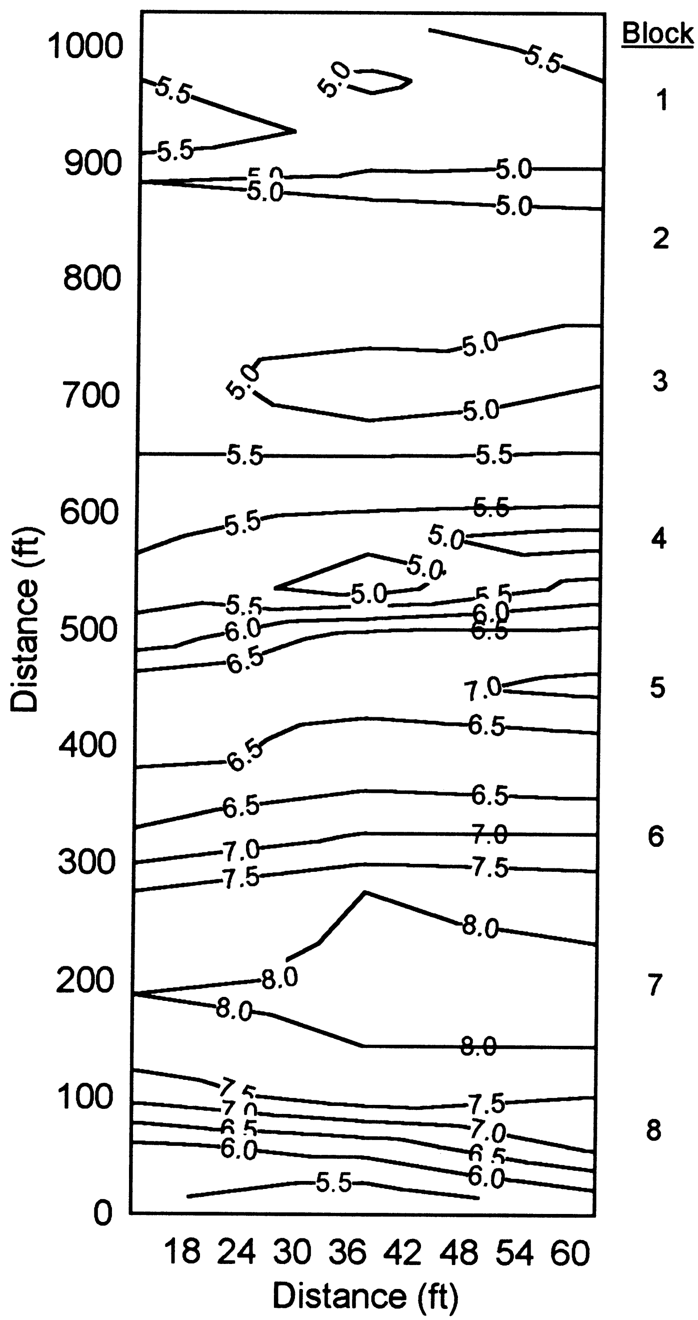

Figure 1. Soil pH contour map of the citrus grove experiment site, showing orientation of replications (blocks). North is at the top.

soluble N applied at least three times per year. Phosphorus, potassium, and magnesium fertilizers were applied uniformly at recommended rates for young citrus trees (Koo et al., 1984). The grove was irrigated with one micro-sprinkler/tree.

Differential tree growth with respect to $CaCO_3$ presence on the soil surface began to appear in the 2nd year of the experiment. Canopy expansion in parts of blocks six, seven, and eight (the calcareous zone) was inhibited, while trees in the first through fifth blocks, and most of block eight, grew normally. Tree size differences between the two areas became more pronounced in the 3rd and 4th years. Canopy volume of 3-yr-old trees in each plot was estimated using the formula for an oblate spheroid: $(4/3)(\pi)(\text{tree height}/2)(\text{canopy radius})^2$.

In the 4th year (1995), soil was sampled across the experiment site to measure spatial pH distribution. Eight 0.75-inch diameter, 6 to 8-inch deep cores were removed from the center of each plot and composited. The soil was dried at 160 F, and passed through a 0.04-inch (1-mm) screen. Limerock pieces that did not pass through the screen were discarded. The pH was measured in a 1:2 (v/v) mixture of soil and deionized water. Soil $CaCO_3$ concentration was measured in plots that had pH 7.0 or higher with the method of Loeppert et al. (1984).

The standard probe used to sample soil did not remove some of the larger rock pieces because of its narrow width, causing underestimation of the root zone $CaCO_3$ concentration. Soil was sampled from selected plots a second time by removing four cores per plot with a 3-inch diameter auger. The cores were composited, and split into two approximately equal sub-samples. One set of sub-samples was treated identically as the soil samples described above, and was designated the "screened only" sample. The other set of sub-samples was ground in a standard soil grinder (Custom Laboratory Equipment, Inc., Orange City, FL) for approximately 30 sec. The resulting sample was homogenized soil that entirely passed a 0.04-inch screen, designated the "ground and screened" sample. The pH and $CaCO_3$ concentrations were determined as above.

Grapefruit was harvested from each plot in mid-October 1995. All fruit from the center tree in each plot was picked, and the marketable-sized fruit was weighed. The influence of soil pH and $CaCO_3$ level on tree canopy volume and fruit yield was evaluated graphically, and with linear regression.

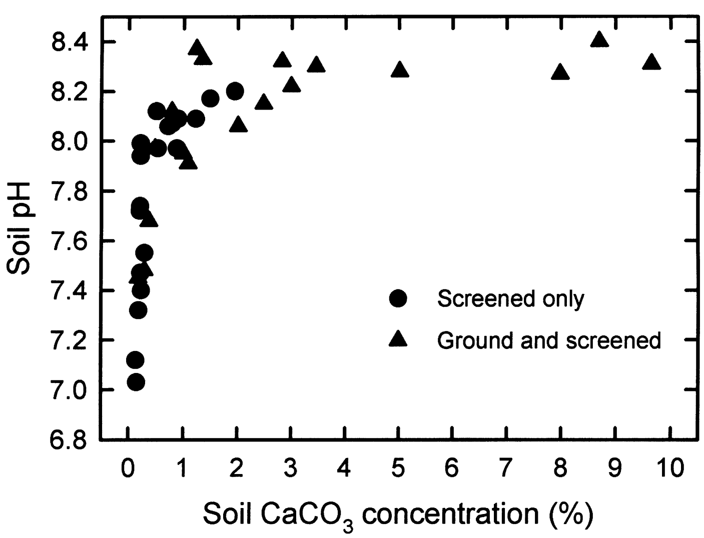

Figure 2. Relationship between soil pH and $CaCO_3$ concentration for plot samples.

Results and Discussion

Soil pH at the experimental site gradually increased north-to-south, from about 5.0 in blocks 1 to 3, to about 8.0 in block 7. The pH then quickly decreased to 5.5 at the south edge of block 8 (Fig. 1). Soil pH values above 7.0 were observed only with Hallandale fine sand, where $CaCO_3$ rock was visible at the surface. The presence of rock had a strong effect on soil pH, which was not less than 7.9 where $CaCO_3$ concentration was 1% or more (Fig. 2).

The area of weak trees matched the zone where soil pH was above 7.0 (Fig. 3). Tree canopy volumes in this zone were roughly half as large as those measured where pH was below 7.0. Weaker trees appeared slightly chlorotic compared to normal trees, but leaf

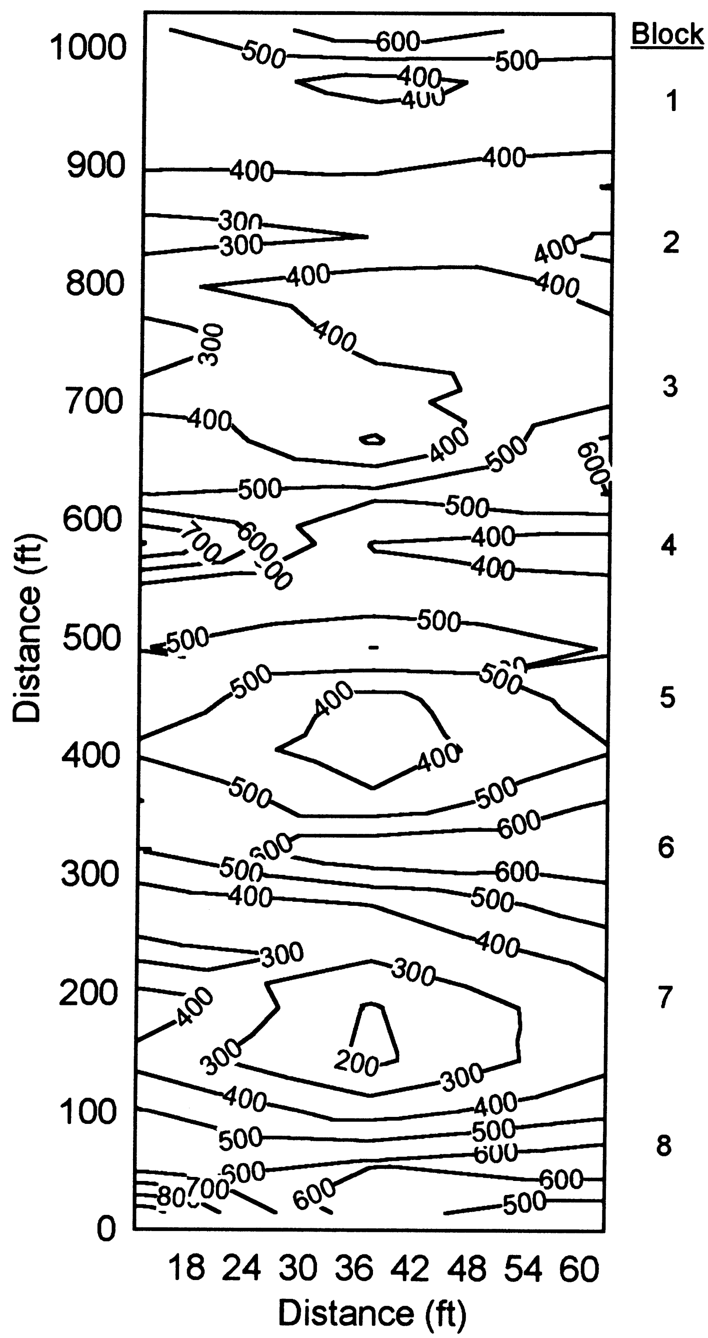

Figure 3. Citrus tree canopy volume (ft^3) contour map of the experiment site. North is at the top.

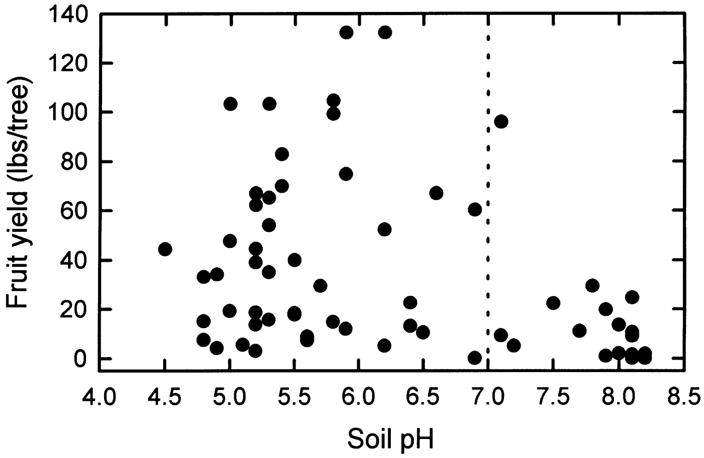

Figure 4. Influence of soil pH on yield of 3-yr-old grapefruit trees on Swingle citrumelo rootstock.

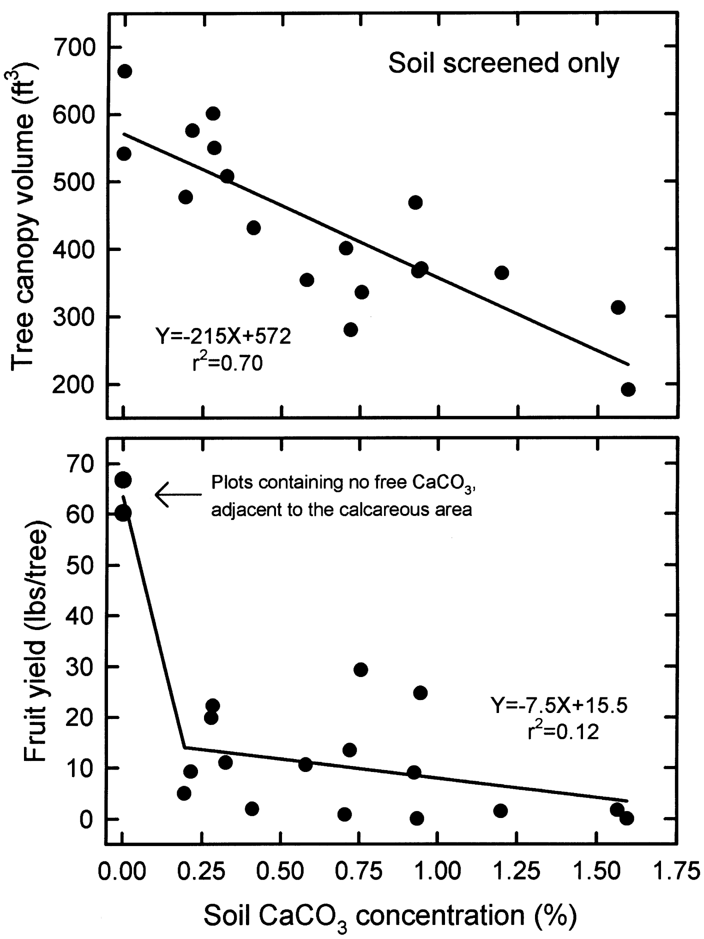

Figure 5. Influence of "screened only" soil $CaCO_3$ concentration on grapefruit tree canopy volume and fruit yield.

Fe concentration in summer 1994 leaf tissue was not significantly different between them. No other leaf nutrient level was affected by soil $CaCO_3$ except the N concentration in 1994, which decreased from 2.4% to 1.8% as $CaCO_3$ increased. Weaker trees had less-dense canopies and smaller leaves than normal trees. Fruit yield in the 3-yr-old grapefruit grove was typically variable, from trees with no fruit to trees with more than 130 lbs. Where soil pH was between 5.0 and 7.0, many yields were above 60 lbs/tree; where the pH was above 7.0, all yields but one were below 30 lbs/tree (Fig. 4).

The $CaCO_3$ concentration of "screened only" soil samples ranged from 0 to 1.6%, but soil grinding increased the $CaCO_3$ percentage 2 to 6 times, to a maximum of 9.7%. Canopy volume decreased linearly from about 600 ft^3 to 200 ft^3 as "screened only" soil $CaCO_3$ concentration increased from 0 to 1.6%, but fruit yield dropped off immediately as soon as $CaCO_3$ was present, regardless of its concentration (Fig. 5). Once the large drop-off occurred, there was an additional slight yield decrease as $CaCO_3$ concentration increased. Correlation of tree canopy volume and fruit yield with soil $CaCO_3$ concentration was not improved by grinding, probably because ground rock was not part of the "active" $CaCO_3$ as suggested by Carter (1981).

Many Florida citrus grove managers have reported excellent performance from Swingle citrumelo rootstock on acidic soils, but very poor performance on many high-pH, calcareous soils. Observations are usually confined to qualitative evaluations of tree growth relating to visibility of rock, shell, or marl on the soil surface. Growth reductions have never been quantitatively related to root zone $CaCO_3$ level. This study suggests that canopy growth of young grapefruit trees on Swingle citrumelo rootstock gradually decreases as soil $CaCO_3$ concentration increases, but fruit yield falls off sharply as soon as any $CaCO_3$ appears in the root zone. The data substantiate why citrus growers would be better-off planting rootstocks more tolerant of high pH conditions in areas with alkaline soil.

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