

Citrus Production on the Sandy Soils of Southwest Florida¹

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Introduction

This document integrates information that was presented at the Sand Land Workshop, held at the Dallas B. Townsend Hendry County Extension Center, LaBelle, Florida, 2003, dealing with citrus production on mineral soils of southwest Florida. The intent of this document is to review those challenges facing citrus growers dealing with soils, water management, and nutrients. Certain available strategies are evolving to efficiently produce citrus in southwest Florida on variable mineral soils and are reviewed herein.

Soil Genesis and Soil Characteristics Affecting Citrus Production

The unique combination of climate, landscape, parent material, and living organisms in southwest Florida has greatly influenced the formation of soils in this area (Figure 1). With time, many of these soils

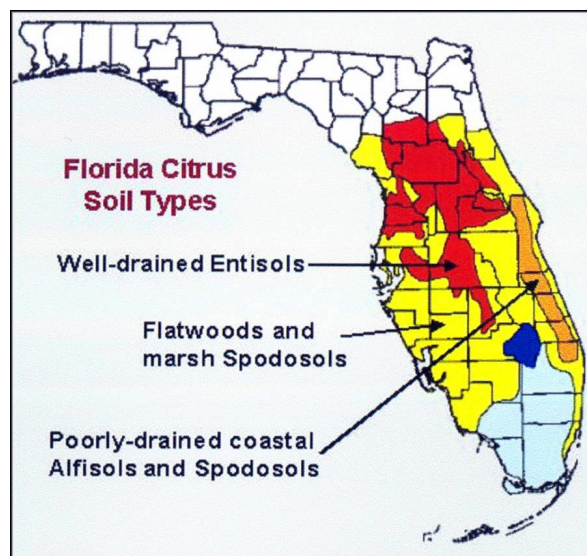


Figure 1. Map showing location of dominant soils used for citrus production in Florida.

have formed distinguishing characteristics, termed diagnostic horizons (See “Key to Soil Orders in Florida”, <http://edis.ifas.ufl.edu/SS113>). These horizons are identified by observing the soil with depth (Figure 2), such as the side of a pit or a road

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cut. In turn, these diagnostic horizons are useful for classifying soils and relating their characteristics to commercial crop production.

The surface horizon, designated by a capital A, usually appears gray to black and is almost always of sandy texture (Figure 2). Moving down the soil profile and just beneath the A horizon, a leached zone called the E horizon is often found. Nutrients and fine particles including organic matter are moved by water from this horizon. The E horizon is usually much lighter in color than the surface horizon, often gray to white.

Located beneath this leached zone, some soils have a distinct brown or black layer, called the Bh or spodic horizon (Figure 2). The Bh horizon is composed of organic matter that has been leached downward and by both physical and chemical means has been deposited in the lower part of the soil profile. Often high in aluminum and iron and usually with a low pH, the Bh is almost always sandy in texture. The Bh is weakly to strongly cemented, so it impedes vertical water flow through the soil and causes water to accumulate or perch above it. While often helpful for seepage irrigation of vegetables and row crops, the Bh may impede drainage for citrus.

In some soils, the Bt horizon is another diagnostic horizon that may be found below the leached zone or occasionally beneath the Bh horizon. This horizon is created by the deposition of clay particles, is usually mottled gray in color, and may be sandy or sandy loam in texture. Similar to the Bh horizon, the Bt horizon may allow a perched water table to develop.

Below these diagnostic horizons, substratum may be present. The C horizon denotes substratum that can be a variety of textures and colors but is usually unconsolidated materials (e.g., Figures 2 and 3). The R horizon denotes substratum that is limestone bedrock (not shown).

Using these diagnostic horizons, most of the mineral soils in southwest Florida can be classified. The USDA-NRCS (Natural Resource Conservation Service) has prepared soil survey reports for every county in Florida (<http://soils.usda.gov/>). These documents are invaluable for understanding soils

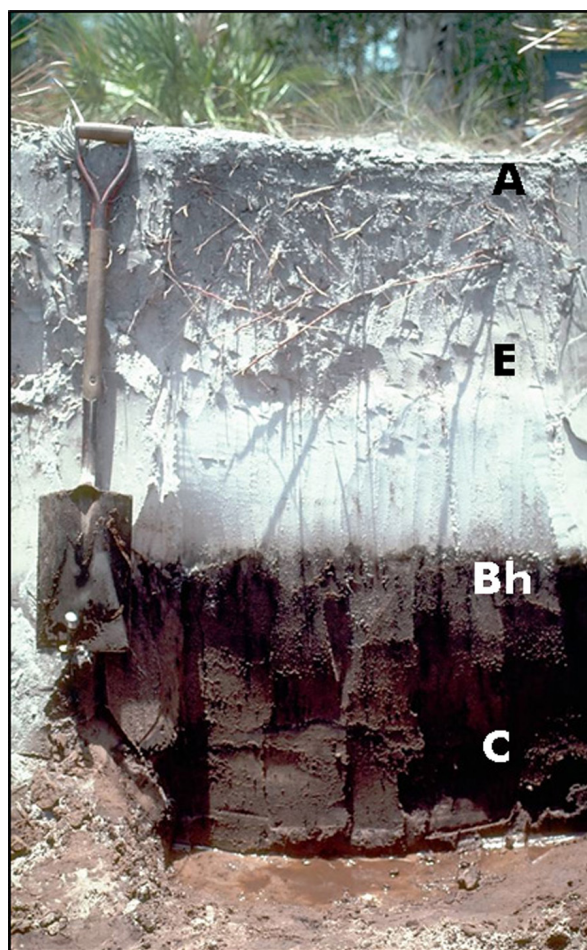


Figure 2. Immokalee soil series, showing the A, E, Bh, and C diagnostic horizons in the soil profile.

used for commercial citrus operations and contain maps showing the spatial distribution of soils in the landscape (See “Common Soils used for Citrus Production in Florida”, <http://edis.ifas.ufl.edu/SS403>).

While some soils may be better suited than others for citrus production, soils often occur in associations and complexes, which describe a mixture of soils within the named mapping unit in the surveys. Thus, soil survey maps are considered accurate but not precise. This statement means that the general management, as well as the chemical and physical characteristics within a mapping unit, is accurately described, but any one spot within the landscape may not be precisely described.

Further complicating precise characterization of specific points in the landscape is the fact that citrus in southwest Florida must be grown on raised beds. A raised bed is necessary to ensure adequate drainage during the rainy season. Depending upon the height

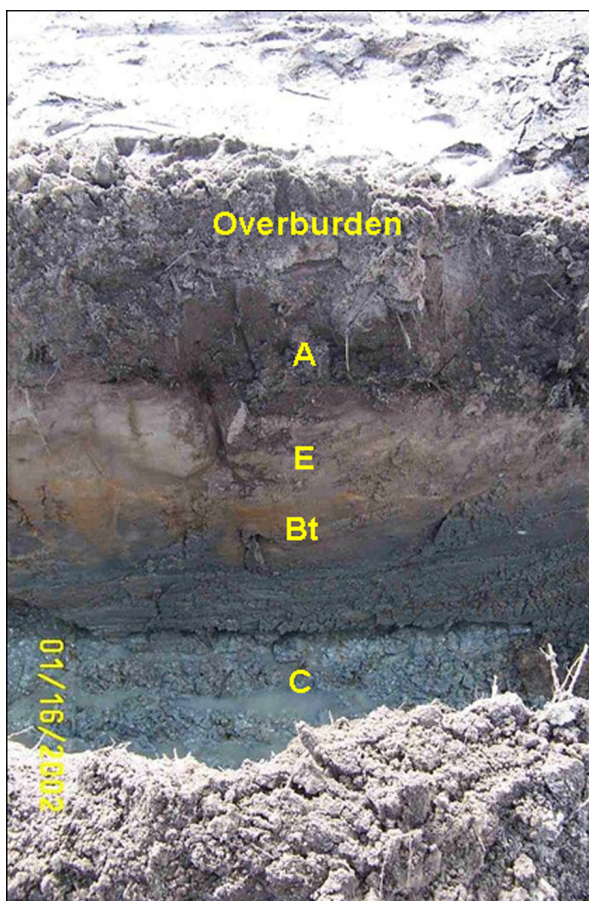


Figure 3. Riviera soil series, showing the A, E, Bt, and C diagnostic horizons in the soil profile. Overburden was created when the soil was contoured (bedded for citrus production in this case). (Picture courtesy of Mace Bauer.)

of the citrus bed, the soil may be a mixture since portions of the lower horizons may be deposited on top of the bed during construction (Table 1). Thus, young citrus trees may be planted in portions of the subsoil, rather than in the A horizon where most of the nutrients and organic matter of the original soil are located.

Table 1. Changes in organic matter in an undisturbed pasture soil (before bedding) and in the same soil after citrus bedding operations. Note that the organic matter originally in the soil (0-3 inches, pasture soil) is now found deeper in the bedded soil (6-12 inches, bedded grove).

Pasture soil		Bedded Grove	
Depth (inches)	Organic Matter (%)	Depth (inches)	Organic Matter (%)
0 – 3	2.30	0 – 3	0.99
3 – 6	1.43	3 – 6	1.15
6 – 12	1.00	6 – 12	1.85
12 – 18	0.48	12 – 18	1.25

Soils originally formed in sloughs, then graded through land-leveling and bedding techniques, may be quite difficult to manage for commercial citrus production. Often, these soils have been stripped of organic matter and clay that coat sand grains in other soils (Figure 4). These naturally formed uncoated sands are difficult to wet and difficult to drain. A common complaint of growers faced with cropping fields with uncoated sands is: “The places where I have problems with irrigation are the same places where I have problems with drainage.”



Figure 4. Uncoated sands are difficult to manage for good crop production and may be the underlying cause of most poorly producing areas in sugarcane fields of southwest Florida. Soils containing uncoated sands have poor water- and nutrient-holding capacities and are often found in the original landscape in low-lying areas.



Figure 5. Close-up of coated sand particles. The coating is often a combination of clay and organic matter (reddish-brown material on sand grains), which greatly improves crop production on soils that have coatings.

When uncoated sandy soils dominate a field, a grower should manage water and nutrients based upon crop response on soils containing uncoated sands, ignoring the other portions of the field. In the

opposite case, where uncoated sands are only a small portion of the field, then nutrient and water decisions should be based on response of citrus growing in those soils containing coated sands (Figure 5). Depending upon the shape and location of the poorly producing areas, coupled with the soil forming processes originally present in the original landscape, these areas can be:

1. Amended to increase their productivity;
2. Kept in marginal production, but not amended; or
3. Treated as a greenbelt without direct crop production.

Citrus Rootstock Selection Based on Southwest Florida Soil Characteristics

Using the diagnostic horizons discussed above, typical soils for citrus production have been classified into soil orders: Entisols, Alfisols, and Spodosols (Figure 1). The Entisols are usually well drained soils and are commonly found on the Florida Ridge. Both Spodosols (Figure 2) and Alfisols (Figure 3) are found in relatively flat areas on both the east and west coasts of Florida. These soils are often poorly drained. In southwest Florida, these soils are usually prepared for citrus production by bedding.

A set of experiments addressed apparent production problems of citrus trees on Swingle rootstock. In some cases where the county soil survey indicated only one soil series, the grove contained citrus planted on several rootstocks. However, only trees planted on Swingle rootstock showed any production decline. Where Swingle rootstock was used across several soil series, citrus decline was noted only on particular soil series.

These experiments showed that Swingle rootstock was highly sensitive to the depth of the Bt (argillic) diagnostic horizon. If the Bt horizon was close to the surface, then citrus on Swingle rootstock produced poorly (Figure 6). As the depth to this horizon increased, so did production from citrus on Swingle rootstocks; however, production on Swingle did not improve as rapidly as with other rootstocks

(for example, Sun Chu Sha rootstock, Figure 7). While this work was done measuring the depth to the Bt horizon, one can expect the same response from Swingle rootstock based upon the depth to the Bh horizon in Spodosols. Thus, Swingle rootstock should be chosen only after reviewing the depth to the Bt or Bh horizons within the field to be planted.

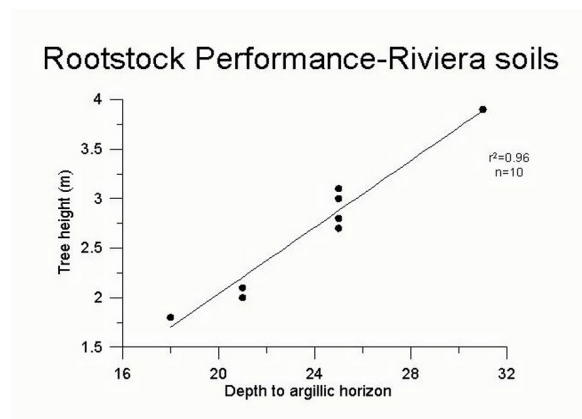


Figure 6. Tree height as a function of depth to Bt horizon for citrus on Swingle rootstock. (Figure courtesy of Mace Bauer.)

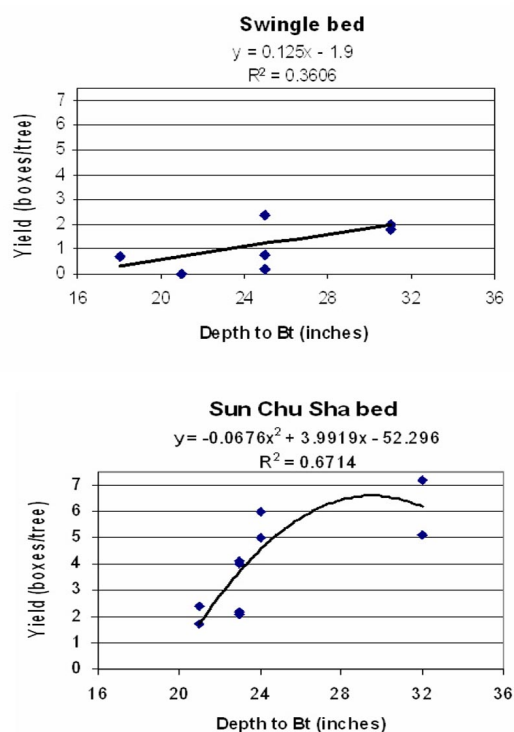


Figure 7. Comparisons of citrus yield as a function of depth to BT horizon for Swingle and Sun Chu Sha rootstocks. Citrus production on Swingle rootstock is highly sensitive to depth to the clay layer (Bt) compared to Sun Chu Sha production. (Figure courtesy of Mace Bauer.)

Further testing showed that Swingle rootstock was highly sensitive to decreasing levels of organic matter. A transect through a grove where the Bt horizon was at a constant depth (46 inches) but the organic matter decreased from 2.7% to 1.5% showed decreasing tree height with decreasing organic matter content.

Citrus bedding was also shown to affect the ability of Swingle rootstock to support commercial citrus production when the A horizon was quite shallow. Swingle rootstock contributed to citrus production normally in those situations where the A horizon was quite deep. Swingle rootstock produced most of its roots within the A horizon and did not penetrate into the E horizon to any great extent. Roots in the A horizon from Swingle rootstock were found to be dominantly on the crown side of the trees with only one third of the roots on the water-furrow side.

In summary, Swingle rootstock performance is enhanced when there is a deep A horizon. Other factors affecting Swingle rootstock are organic matter content of the A horizon and depth to either a Bt or Bh horizon.

Use of Compost in Citrus Production

The benefits of adding organic amendments to sandy soils have been well documented throughout Florida (see http://edis.ifas.ufl.edu/TOPIc_Organic or <http://swfrec.ifas.ufl.edu/composting/> for more information). Some of these documented benefits include:

- Increased water holding capacity;
- Increased cation-exchange capacity;
- Decreased erosion potential;
- Increased soil microbial activity;
- Improved soil tilth.

While these benefits can contribute to productivity in any sandy soil, in poorly drained soils the effect of compost can be both positive and negative. On the positive side, organic matter will contribute to higher water holding capacity within the

soil profile. Improved water holding capacity may achieve higher rainfall retention within the soil profile compared with non-amended soils and may reduce irrigation needs. Use of compost can also result in increased upflux (water moving upward in the soil profile due to capillary rise) due to introduction of finer particles (Figure 8).

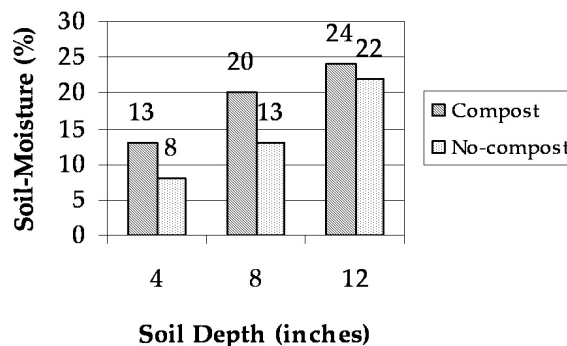


Figure 8. Improvement in moisture holding capacity of a southwest Florida sandy soil due to compost addition. Values represent the mean of biweekly sampling for 1 year after the addition of 50 tons compost per acre.

Use of compost may or may not improve drainage. Drainage rate is related to characteristics of subsurface horizons. In fine sands or loamy sands, the addition of organic matter may improve drainage by providing pathways for water to move downward or laterally. In sands or coarse sands, organic matter additions may have no effect on drainage and the organic matter may move with the water deeper into the soil profile. This loss of organic matter from the surface horizon may decrease other benefits of organic amendment for crop production.

Sources of organic materials in sufficient quantities for commercial citrus production are yard trimmings (YT, Figure 9), animal manures, household garbage (often called municipal solid waste or MSW), biosolids (sewage sludge or BS), wood-waste byproducts, or food waste. In 1999, 26.2 million tons of solid waste were produced in Florida, averaging approximately 9.5 lbs daily per person. If composted, this solid waste would yield:

- 15.7 million tons of compost per year of MSW;
- 3 million tons of YT;

- 230,000 tons of dry BS; and
- 490,000 tons of animal manure.



Figure 9. Yard trash from urban areas is problematic for municipalities due to disposal costs, but can be the feedstock for compost, a desirable product for commercial growers in southwest Florida.

Agricultural productivity is greatly enhanced by composting these materials (Figure 10). With proper levels of oxygen (air) and moisture, naturally occurring microbes digest the organic material aerobically. The resulting mature compost is much more predictable in its effects on crop production. Composting operations also greatly decrease the volume of the original material by as much as 60%. Thus, transport and field spreading costs are reduced, and the composting operation also adds value to the product. Mature compost will contribute to nutrient retention rather than create nutrient deficiencies. UF/IFAS recommends that growers add only mature compost to commercial fields. If a partially decomposed (so-called immature compost) high carbon organic source, such as YT, is applied to fields, then growers should increase nitrogen fertilizer rates (usually 30 pounds of nitrogen/acre is sufficient) to account for the likelihood of a temporary nitrogen deficiency in citrus.

Production managers should consider the original soil series, problem spots of which they are aware within their field, and other limiting factors, such as compost transportation and spreading costs. It is likely that the carbon source from the compost will help increase crop productivity. Therefore, application rate should be viewed as a realistic return



Figure 10. Yard trash materials are the feed stock for this commercial composting operation. The resulting compost will be added to soils for crop production enhancement.

on investment from the treated area of the field. For citrus production, annual application rates of 3 to 6 tons of compost per acre (usually containing 50% moisture) are typical in Florida citrus groves.

Compost can be produced on the farm or purchased from commercial composting operations in the area. On-farm composting operations greatly reduce the cost of the compost, but require an added level of management, labor, and land allocation.

Research is underway at Southwest Florida Research and Education Center (SWFREC), Immokalee, Florida, to better understand the effect of compost on water holding capacity, drainage, and upflux from the water table to the root zone in sandy soils of Florida. Also at SWFREC, compost from selected sources has been used to produce vegetables for the last 10 years. Soil organic matter has increased from the original 0.8% at the beginning of the experiment to 3%. In addition to increases in water holding capacity and crop yields, the need for inorganic fertilizer has been decreased by 50%. Increases of soil-test phosphorus, potassium, calcium, magnesium, micronutrients, and cation-exchange capacity within the treated soil has been due to regular additions of compost. This experimental location is now being used to demonstrate the positive effects of compost on sugarcane and selected forestry crops.

Assessing the economic returns from composted soil

Composted soil amendments can have multiple positive financial impacts on a citrus operation. Compost can reduce purchased fertilizer cost, lower fuel expenses resulting from less irrigation, and perhaps increase overall crop yield. For composted amendments to be profitable in a citrus operation, the combined benefits must be greater than the cost of compost, including its transport and application costs.

For growers who keep accurate accounting of their costs and production, the following formula can be used to assess whether added composted soil amendment would be profitable.

Benefits=(saved fertilizer costs (\$/ac)) + (saved fuel costs from less irrigation pumping (\$/ac) + (increase crop yield (bx/ac) * on-tree price (\$/bx).

Costs=(compost material, including transport and application (\$/ton)) * application rate (ton/ac).

So long as benefits are greater than costs, composted soil amendment should be part of the grower's production plan.

As an example, consider the application of 4 tons per acre of compost at \$28 per ton (includes short transportation and spreading costs), a cost increase of \$112/ac. The grower estimates a reduction in purchased fertilizer of \$20 per acre and a \$10 per acre fuel cost savings from reduced irrigation pumping.). If the grower's on-tree price is \$3.50 per box, yield would have to increase by more than 23 boxes per acre before the soil amendments contribute to the groves profitability.

Overall, the effects of compost are more pronounced with regular annual additions. In the humid, hot conditions of southwest Florida, compost continues to decompose when added to the soil. While residual effects are small, they are cumulative. Therefore, it is important that the economic assessment of compost be evaluated on the basis of the long-term effect on improved crop production.

In mineral soils, the weight of an acre furrow slice (one acre of soil to a six-inch depth) is assumed to be 2,000,000 pounds per acre. If the organic matter content of the soil before compost addition is 1%, then the weight of the organic matter in an acre furrow slice is 20,000 pounds or 10 tons/acre. For example, annual additions of 10 tons of wet compost per acre (moisture content is approximately 50%) will increase soil organic matter of the soil by 0.5% after 4 to 5 years. The remainder of the compost is lost due to decomposition. From these estimates, it is obvious that repeated additions, such as on an annual basis, are required to improve citrus production, especially on poorly producing areas of the field.

The use of precision agricultural techniques to apply compost in sufficient quantity to poorly producing areas within the field will likely prove to be the best solution in southwest Florida.