ECONOMIC LONGEVITY OF CITRUS TREES ON SWINGLE CITRUMELO ROOTSTOCK AND THEIR SUITABILITY FOR SOILS IN THE INDIAN RIVER REGION

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Abstract. Citrus trees on Swingle citrumelo (Citrus paradisi Macf. × Poncirus trifoliata [L.] Raf.) rootstock grow well throughout most of the citrus regions of Florida but certain soil characteristics limit the economic life of trees particularly in the Indian River region. Citrus growers and managers in the Indian River region were surveyed and interviewed in order to better understand the range of soil conditions suitable for Swingle rootstock. Site visits were conducted to 118 blocks within groves and their locations were recorded in a geographic database. Tree performance in these blocks was rated on a scale of Excellent to Poor. The area surveyed was about 59% of the total area in citrus production in the Indian River region and included about 14,200 acres of trees planted with Swingle citrumelo. Tree performance was clearly related to soil series as identified in USDA-NRCS soil surveys. The highest performance ratings were typically for trees growing on Malabar, Pineda, and Wabasso. Intermediate tree performance was reported at a large number of sites and had no apparent relationship to the soil type. Trees growing in depressional Winder and Riviera sands were consistently rated substandard to poor. Thus, tree performance was linked to soil series which in turn was related to the physiography of the region.

The soils used for citrus production in the Indian River region vary markedly between and within groves and blocks. The dominant soils of the region are of the Alfisols and Spodosols orders. Citrus plantings can also be found in soils of the Entisol and Mollisol orders, but to a more limited extent. The soil series of these orders and other series are differentiated by various factors including the thickness and depth to diagnostic horizons, soil texture, soil color, base saturation, or the presence of Ca and Mg carbonates. In general, these soils are poorly to very poorly drained.

These soils present special management concerns not found on the well-drained soils of the Florida Central Ridge.

Long-term commercial success of citrus on these soils depends significantly on selecting rootstocks that are tolerant of site conditions. Previously, the simple selection of a flatwoods rootstock was sour orange because it offered many desirable horticultural traits in addition to being well suited or adapted to virtually all soils and site conditions. However, its susceptibility to citrus tristeza virus eliminated sour orange from use in new plantings and has rendered many older commercial trees unproductive (Stover and Castle, 2002). As a result, trees on Swingle citrumelo were widely planted in place of sour orange using the established concept of selecting a single best rootstock for all soils.

Swingle citrumelo recently has been the most popular commercial rootstock in Florida (Annual Report, 2004). Many trees on this rootstock have been planted in the Alfisols and Spodosols of the Southern Florida Flatwoods. However, it is now clear that Swingle citrumelo is not suitable for every location where sour orange was previously successful (Bauer et al., 2004; Castle et al., 2002). We have typically observed considerable variability in performance and condition of trees on Swingle citrumelo and other rootstocks growing in Flatwoods soils. In some instances, trees decline, but usually not before they are 5 to 8 years old.

Many regional growers have experienced this tree decline that eventually leads to tree loss. Growers have become reluctant to plant trees on Swingle citrumelo and instead are planting trees on newer rootstocks with largely unknown characteristics. Some of these rootstocks appear to be well-adapted to most regional soils, but that characteristic may come at the expense of more important horticultural traits such as good fruit or juice quality.

Based on the known performance of currently available rootstocks, there is not one obvious best rootstock for all soils in the Indian River region. Some growers are looking to minimize the risks associated with replanting by using a combination of rootstocks with known characteristics, and newer rootstocks with largely unknown characteristics. Growers require clear information about the performance of Swingle citrumelo on various soils in order to consider its suitability as an option in replanted groves.

Our work reported here is part of a broader study to determine soil and site differences that might explain the variability in performance among trees on Swingle citrumelo (Castle et al., 2002). We identified several limiting factors (Bauer et al., 2004; Castle et al., 2002), but it became apparent that what we needed to confirm our findings over a larger scope of soil types. Here we chose surveying and follow-up field visits throughout the Indian River region as a validation procedure based on two hypotheses: 1) the economic longevity of plantings on Swingle citrumelo on Flatwoods soils can exceed 15 years on appropriate sites, and 2) some soils will produce a high incidence of tree decline, while other soils will have little decline.

Materials and Methods

We surveyed citrus growers in four Florida counties (Indian River, Martin, Okeechobee, St. Lucie) about their invento-
ry of trees on Swingle citrumelo and manager experiences with this rootstock. From survey responses, we selected one or more blocks within groves with either apparently healthy or declining trees for follow-up visits in order to gather more specific information about site characteristics and management history. Where the number of potential blocks was large within one grove, we selected blocks that were representative of tree performance and soil conditions at the site. Furthermore, because trees do not often decline until they are 5 to 8 or more years old regardless of the site or soils, only blocks which were at least 12 years old were considered of primary interest. However, sites were included in the survey when younger trees were performing poorly, or where trees had been prematurely removed because of poor performance.

Each block was identified by the manager and the block boundary was geo-referenced. Block boundaries were superimposed on the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) digitized soil surveys from the Florida Geographic Data Library (FGDL.org). Each manager was interviewed to gather descriptive and cultural information about their blocks. Also, these managers were asked to subjectively describe the overall performance of trees on Swingle citrumelo in their blocks. The general descriptors were: Excellent, Good, Intermediate, Substandard, Poor, or Uncertain. “Uncertain” was used in instances where new managers had limited information about the history of a planting and the associated tree performance.

**Results and Discussion**

Our survey encompassed a total area of 181,000 acres of citrus production (FASS, 2004). The respondents included several of the largest growers in the Indian River area as well as many landowners and managers with smaller acreage in citrus production. Thirty-two growers provided information about their operations and management history. The surveyed area was an estimated 107,000 gross acres, or ca. 59% of the citrus production acreage in the Indian River region. The estimated area of trees on Swingle citrumelo among the respondents was 14,200 acres.

**General Performance of Trees on Swingle Citrumelo Rootstock.** Our survey and follow-up personal contact procedures appeared to be very effective in locating blocks of good performing trees on Swingle citrumelo but less effective in locating blocks where trees performed poorly and land use had changed from citrus production to another use. Where trees thrived, the land use remained consistent and information was easier to gather about apparent successes than for places where trees failed and were removed. Therefore, a larger number of satisfied growers may have responded to the survey than was representative of the overall population. Nevertheless, we discussed tree conditions with the managers that accounted for over 60% of the citrus acreage in the Indian River area. Thus, our results provide a reasonably accurate performance summary associated with trees planted on Swingle citrumelo.

There were 118 blocks rated on a scale of Excellent (5) to Poor (1) and of these, 49 (42%) were rated as either Excellent or Good (Table 1). Although Swingle citrumelo was not well-suited to all conditions, there have been many successful plantings in the Indian River region. In the blocks rated Excellent or Good, the managers did not cite any apparent strategies that would account for their success.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Grapefruit</th>
<th>Oranges</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Good</td>
<td>33</td>
<td>10</td>
<td>43</td>
</tr>
<tr>
<td>Intermediate</td>
<td>23</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>Substandard</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Poor</td>
<td>15</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>Not Rated</td>
<td>10</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>28</td>
<td>118</td>
</tr>
</tbody>
</table>

Twenty-six (22%) of the 118 blocks were classified as Intermediate in performance. In these blocks, the managers estimated that about 9% of the trees were declining with a range of 0 to 40%. Our data collection methods did not indicate whether the declining trees were spatially clustered or were randomly distributed within blocks. Discussions with the managers, however, indicated that the declining trees generally were clustered and the most commonly observed characteristic was a lack of vigor (70%). We did not ask the managers to clarify whether the lack of vigor was a characteristic of young trees, or was associated with tree maturity and the onset of decline.

Thirty (25%) of the 118 blocks included in the survey were rated Substandard or Poor. In these blocks, the minimum level of tree decline was 25%, but 21 blocks had tree decline estimates of 80 to 100%. Therefore, the blocks rated Substandard and Poor were generally those which had tree decline throughout the block.

**Tree Age vs. Economic Longevity of Trees on Swingle Citrumelo.** Grapefruit is the dominant citrus crop in the Indian River area. The survey included three times the number of grapefruit as orange blocks. Sixty-two (53%) of the 118 blocks included trees that were more than 15 years old at the time of the survey and had been planted in 1989 or earlier; 99 (84%) of the blocks included trees that were 12 years old or more and were planted in 1992 or earlier. These blocks of trees were old enough to have expressed any lack of suitability for the site conditions. Of the remaining 19 (16%) blocks surveyed, 17 of those expressed symptoms of decline prior to 12 years after planting indicating that the trees in those blocks were poorly suited to the site conditions. No planting date was recorded for two blocks.

The average reported performance of all trees 15 years old or more was 3.1 on our rating scale of Excellent (5) to Poor (1). For all trees less than 15 years old, the average reported performance was 2.8. This difference in average rating is probably not meaningful, thus, suggesting that grower concerns about “older” versus current sources of Swingle seeds or other propagation materials may not be justified. The trees 15 or more years old on Swingle citrumelo rootstock were not obviously better in terms of overall performance than more recent plantings.

We visited several sites where young trees were removed because of their poor condition but there were no sites where trees had reached 15 years of age or more and then removed. In our other studies, we did not find any blocks that apparently began to decline among trees 15 years old. We did encounter blocks of older trees in poor condition, but the managers indicated they had been in poor condition for many years and were being maintained for various reasons not related to good commercial production. We identified 14 blocks where
the trees were removed prematurely. Without exception, the managers of those blocks indicated the trees were between 4 to 9 years old when any decline started.

**Soils and Tree Decline.** Our major hypothesis was that some soils will produce a high incidence of tree decline whereas other soils will induce little decline. Although we have not used a statistical test to compare soils and tree performance, we found common characteristics among soils identified in the USDA-NRCS soil surveys in their relationship to tree performance.

In the 49 blocks which were rated Good to Excellent, there was a small group of soils common to 44 of those blocks: Alfisols—Riviera fine sand, Pineda fine sand, or Malabar fine sand, or Spodosols—Oldsmar fine sand or Wabasso fine sand. Swingle citrumelo is well-adapted to Wabasso soil (Castle et al., 2002). Malabar and Oldsmar fine sand are less common in the Indian River region. They are typical of the soils of Southwest Florida and are generally well-suited to Swingle citrumelo in that region.

In the 26 blocks that were rated Intermediate in performance, the relationship between soils and tree performance was less clear. There were 12 soil series present in those blocks, and not one soil or group of soils was common to all blocks. Many managers of these Intermediate blocks commented that the tree performance may have been influenced by other factors such as site wetness, high salinity irrigation water, or a general lack of care. In some instances, a change in grove management practices reportedly improved tree performance.

A small number of soils were common in 23 of the 30 blocks where tree performance was rated Poor or Substandard. Winder loamy sand and Winder sand, depressional and Alfisols generally found in landscape depressions, were present in 15 of these blocks. Winder series is common in the Indian River region and previously accounted for ca. 30% of the soils planted with citrus in St. Lucie County (Boman, 1987). Other common soils were Chobee loamy sand, a Mollisol, and Riviera fine or Riviera sand, depressional. It was apparent that these soils, typically found in landscape depressions, were poor locations for tree survival on Swingle citrumelo.

The weak performance of trees on Swingle citrumelo was consistently associated with specific soil series with only a few exceptions. One instance was a series of blocks planted with trees on either Swingle citrumelo or Carrizo citrange rootstocks growing in Wabasso fine sand located in Martin County. Although Wabasso fine sand is a Spodosol, a soil series well-suited to Swingle citrumelo (Castle et al., 2002), in each block there appeared to be a circular depression in the center where the trees declined regardless of the rootstock. It was unclear whether the circular area was a landscape depression, or was related to land management and bedding. Tree behavior in these blocks was consistent with what we observed in other landscape depressions. These areas within the blocks were the only instances where ‘Hamlin’ orange trees on Swingle citrumelo failed on Wabasso fine sand.

Another exceptional instance was a location in the Fort Pierce area where large grapefruit trees were growing in Winder soil in a grove of single-row beds. This was one of only two locations from the survey that had single-row beds. Most groves in the Indian River area were either originally developed with two-row beds or were converted to two-row beds. It is possible that with single-row beds, the hydrology of the site and the beds of Winder soil had been modified in a manner to allow the successful use of Swingle citrumelo (Boman, 1987).

**Tree Performance and Physiographic Region.** We previously reported that the performance of trees on Swingle citrumelo was related to certain soil and site physical characteristics (Bauer et al., 2004; Castle et al., 2002). The general results from this study confirmed those reports and broadened the scope of observations. Our survey showed that over 40% of the blocks studied were rated Excellent or Good. Therefore, despite the tarnished reputation of Swingle citrumelo in the Indian River region, there were locations where Swingle citrumelo was an excellent rootstock in terms of longevity and horticultural performance.

The behavior of trees on Swingle citrumelo can also be explained on the basis of the three physiographic areas that form the Indian River region and the associated soils (Fig. 1; NRCS, 1987). These areas have similar physical (surface) features, but differ in their formation so the soils are different. The Atlantic Coastal Ridge includes relic beach ridges that were formed by wind and wave action. This is a low elevation ridge that parallels the east coast of Florida and extends north to Georgia. The soils of the Atlantic Coastal Ridge are dominated by quartz sand with little evidence of profile development. These soils frequently have been used for urban development, and are primarily of the Entisols order.

The Eastern Valley lies to the west of the Atlantic Coastal Ridge. As the name indicates, this is an elongated low area between uplands that can be described as a regional trough most of which is less than 25 ft above sea level. The Eastern Valley is essentially a large landscape depression bordered by the Atlantic Coastal Ridge to the east and the Osceola Plain to the west. This area is the heart of the Indian River citrus industry where sour orange historically was the rootstock of choice on heavy textured soils. The heavy textured soils remain, but sour orange is no longer an option. The soils of the Eastern Valley are primarily of the Alfisol order that have a sandy surface, loamy subsoil, and are poorly or very poorly drained. Winder sand depressional, and Riviera sand depressional are commonplace in this portion of the survey area.

![Fig. 1. Physiography of the Indian River area. USDA-NRCS, 1987.](image-url)
A minor physiographic feature within the Eastern Valley is the Ten Mile Ridge, an intermittently occurring, less pronounced ridge than the Atlantic Coastal ridge and that ranges from about 25 to 35 ft above sea level. The soils of the Ten Mile Ridge are sandy, with a dark colored, sandy subsoil underlain by loamy material. These soils are primarily Spodosols. There are few citrus groves located on this ridge. Apparently when the citrus industry developed, these soils were poorly suited to the flood irrigation which was common in that era.

The Osceola Plain makes up the western part of the Indian River area. It begins at the western edge of the St. Johns Marsh in Indian River County at an elevation of about 25 ft above sea level and then rises gradually and flattens out to become the Talbot Terrace. Elevation mostly ranges from about 30 ft to 60 ft above sea level. The sites where these soils occur are nearly level and the soils are sandy, with a dark sandy subsoil, typical of the Spodosols order. Common soil series are Wabasso and Oldsmar fine sand.

Other soils found in the western portion of the survey area are Malabar and Basinger fine sand, an Alfisol and Entisol, respectively. Most of the successful plantings of Swingle citrumelo we observed were on these soils and located in the eastern edge of the Osceola Plain. Citrus groves in this part of the Indian River region were developed in the 1980s and 1990s. It was apparent that the likelihood of success with Swingle citrumelo rootstock in the western portion of the region was high, where the soils had a larger depth to restrictive layers, and sandier textures in the upper profile. Tree failure on Swingle citrumelo was the norm in the lower elevation Eastern Valley, where depressional soils are typified by loamy sand texture and shallow restrictive layers.

Conclusions

Our survey and follow-up site visits confirmed and expanded our understanding of soils as they affect the performance of trees on Swingle citrumelo. In general, suitable soils were those of the Spodosol order such as Wabasso and Oldsmar fine sands and some soil series of the Alfisol order. Unsuitable soils were Winder loamy sand (Alfisol) and Chobee loamy sand (Mollisol) especially when they were located in depressional landscape positions. Planting trees on Swingle in the most desirable soils can lead to long, productive lives that exceed 15 years.

The association of soils with tree behavior has a regional application. As the urban population of Florida’s East Coast continues to increase, the citrus industry will respond by either becoming smaller or moving to other locations. Many of the areas where urban expansion is taking place are within the areas where citrus production once dominated. This urban expansion is primarily in the areas east and immediately west of the Ten Mile Ridge. A consequence of this urban development is that most of the areas dominated by depressional soils, those soils where Swingle citrumelo performed poorly, will no longer be in citrus production. However, replanting of citrus groves or new development of citrus groves will certainly occur in inland areas, particularly in the physiographic area identified as the Osceola Plain. This change in the geographic location of citrus groves bodes well for the use of Swingle citrumelo in future plantings.

Literature Cited