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2022–2023 Florida Citrus Production Guide: Grove Planning and Establishment[1]

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Main points:

- Plan all aspects of a new planting in coordination with your management program.
- Prepare soil and irrigation/fertigation infrastructure before planting.
- Use only good-quality plant material for planting.
- Careful planning prior to grove establishment will result in higher productivity and profitability.

"It's complicated."

Every choice in grove management affects other aspects of management, and many of these decisions must be made even before the grove is planted. For instance, decisions on planting density will have to consider the rootstock and the scion variety, because plant vigor will determine how quickly the space between plants will be filled. Because these choices are irreversible for the lifetime of the planting, each of them should be considered together, fitting each piece while considering the whole puzzle. This chapter addresses the most important decisions that should be made before and immediately after planting, and it refers to other chapters with more detailed information on specific management topics. The most important factors before planting fall into (1) site selection and (2) grove planning and preparation. Planting and early tree care are also essential to long-term grove success. Coordinated planning of all aspects of grove establishment and careful planting establishment can set you up for success and reduced frustrations in the future.

Site Selection

Every potential site has some challenges when establishing a new grove. In this section, we will discuss the most important factors to consider when selecting a site, including pest and disease history, soil type, and quality of available water for irrigation.

Pest and Disease History

Soilborne pests tend to persist over many years. Make sure you know whether the site has a history of phytophthora or Diaprepes root weevil. Poorly drained soils are more likely to have phytophthora, even if there are no records for the site. When sites are available that do not have histories of these problems, it is better to choose those sites. If you cannot choose another site, we will discuss measures to manage sites with a history of soilborne pests or diseases in the site preparation section.

Management of neighboring groves must also be considered because it can greatly affect disease pressure, especially from HLB. If neighboring groves are managed poorly, high psyllid populations will likely be present in your grove at most times during the year. Having no citrus nearby or

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having well-managed groves with active psyllid management is better.

Soil Fertility

Several soil characteristics affect soil fertility. These include pH, organic matter, and cation exchange capacity. Although most native Florida soils used for citrus plantings historically had a low pH in the upper 6 inches, at present most have a high pH. This is because most irrigation water is alkaline and raises the pH over time, leading to high pH in soils that have been in irrigated crop production. The optimum pH of soil and irrigation water is between 6.0 and 6.5.

Cation exchange capacity (CEC) is a measure of how well the soil holds most mineral nutrients. Most soils used for citrus production in Florida are sandy and have a very low CEC, usually between 0 and 2 (meq per 100 g soil). Below we will discuss approaches to managing low-CEC soils. Soil organic matter affects both nutrient- and moisture-holding properties of the soil. Most soils in Florida's citrus production areas have low organic matter (between 0% and 1%). A higher content of soil organic matter is generally preferred, because in most cases it will lead to higher CEC and water-holding capacity.

Soil Moisture

It can be difficult to achieve a happy medium of soil moisture in Florida soils. Upper layers of sand drain rapidly after rain or irrigation, leading to water deficits. However, high water tables or clay pans with poor drainage may result in waterlogging in the deeper layers of the soil. Waterlogging reduces the amount of oxygen that is available for root respiration and therefore inhibits root growth. In addition, growth of harmful microbes may occur in this oxygen-limited environment. If these conditions last for longer than 72 hours, root death is likely to occur. Root injury and death also open up infection sites for soilborne pathogens, such as phytophthora, which can further reduce root growth. Information on the history of flooding in the selected site will help assess whether waterlogging is likely to occur. In flood-prone regions, it is imperative to raise beds and establish a drainage system consisting of furrows, ditches, or tile drains.

Water Access and Quality

Access to water for irrigation is essential for citrus production in Florida. The site must have permits for well or surface-water pumps. Additionally, pump volume capacity must meet the maximum volume needed for the planting. The irrigation management chapter of this guide provides more information on determining the volume of water needed to irrigate the area supplied by the available pumps. Irrigation output capacity is especially important in areas where irrigation is used for freeze protection. If sufficient water volumes cannot be delivered during the freeze, then the system will fail. Consider the available infrastructure when choosing the site.

The quality of the water available for irrigation is as important as the available quantity. The best-quality water should not be alkaline nor contain high levels of bicarbonates. The specific concentration at which bicarbonates begin to affect citrus root growth is not known, but lower concentrations should be preferred over higher concentrations. Some evidence suggests that concentrations higher than 100 ppm of bicarbonates will negatively affect root growth. Any grower using nonsurface irrigation water should consider approaches to remediate bicarbonate levels.

Weather—Freeze Risk

Although freezes do not occur often in Florida, if they do, they can result in great economic losses and set a grove back by years in terms of production. The risk of freezing temperatures is the major reason for the expansion of citrus production areas southward since their initial establishment in northern Florida. The history of freezes is a good way of understanding the relative future risk of a freeze event a particular location. Most freezes in Florida are advective, meaning they result from cold air that moves in fronts from the north. These freezes pose regional risks, though the risk is higher farther north. Sites close to a large body of water may have some relief from an advective freeze if they are on the leeward side, because the water will warm the cold air as it crosses. However, some freeze events are convective, which means that they result from warm air dissipating upward as colder air settles. In a convective freeze, topography makes all the difference. Lower-lying areas between hills are more likely to accumulate cold air in frost pockets and are therefore more prone to freezes than sites that are elevated above their surroundings. Especially in northern production areas, frost pockets should be anticipated and adequately prepared for to avoid major crop losses. The risk of freezing should be considered when choosing the planting site, as well as when choosing rootstock and scion varieties and irrigation systems. See chapter 21, *Citrus Cold Protection*, for more details.

Grove Planning and Preparation

No site is perfect. In this section, we discuss how to overcome challenges presented by a selected site and approaches to reduce risks and improve productivity.

Grove Design

Before the site is prepared and the irrigation system is installed, you should consider tree spacing and orientation, because they can greatly affect profitability of a planting. Sunlight is the source of energy for tree and fruit growth; therefore, a grove should be designed so that the tree canopies capture sunlight most efficiently. Tree spacing should be based on the expected vigor of the scion/rootstock combination and the expected lifespan of the grove. Tree rows oriented north to south will maximize sunlight interception. However, row orientation may also depend on the row length and the direction of water drainage. A good grove design results in healthier, more productive trees.

Spacing between rows is a question of infrastructure. Rows need to allow enough space for a tractor to pass through without harming the trees when they are mature. Typically, row spacing is 18–22 feet. This allows enough space for an 8-foot-wide tractor to pass between trees with 10–14 foot canopy widths. The between-row spacing should be as narrow as your equipment allows. Anything wider than necessary will result in fewer plants per acre and thus fewer boxes of fruit per acre. Within rows, growers typically plant 8–12 feet apart. A spacing of 18 feet between rows and 8 feet within rows allows for 302 trees per acre, whereas a spacing of 22 feet between rows and 12 feet within rows only allows for 165 trees per acre. Within this range, climate, soil, scion variety, influence of rootstock on tree vigor, and expected disease pressure should be considered. Though there are few studies comparing planting densities with currently planted varieties in Florida, these studies have indicated that higher-density plantings achieve higher yields in the first 6 years of a planting under HLB pressure. In general, groves planted at higher density provide earlier returns than groves planted at lower densities, though they yield less on a per-tree basis at maturity and may require pruning. Because the expected life span of a tree is considerably shorter under the present endemic conditions of HLB, in combination with reduced yields of infected trees over time, maximizing yield during the early production years is essential. For a detailed assessment of the economics of planting density, see chapter 13, *Planting New Citrus Groves in Florida in the Era of Citrus Greening*.

Pest History

It is best to avoid sites that have a history of Diaprepesroot weevil or phytophthora. If this is not possible, take measures to minimize the effects of this pest-disease complex. Generally, phytophthora problems are intensified in poorly drained soils. Therefore, improving drainage will reduce disease pressure (see “Soil Moisture,” below). If the selected site has a history of phytophthora or Diaprepes root weevil, choosing the proper rootstock is essential. Several suitable rootstock options are available; see the Rootstock Selection Guide (https://crec.ifas.ufl.edu/extension/citrus_rootstock/templates/guide/explore.html) for more information.

Soil Fertility

One of the major fertility challenges in Florida citrus soils is high pH. Adjustment of the pH to the optimal range of 6.0–6.5 is recommended, because at a higher pH, availability of some nutrients is limited. However, soils that have high pH will tend to be high for a long time. Therefore, if the pH of the planting begins high, you should consider planting with one of the few rootstocks that tolerate high pH.

Florida citrus soils often require adjustment prior to planting. Our soils often have high pH accompanied by low nutrient-holding capacity. Preplanting applications of acidifying fertilizers, such as ammonium sulfate, can help lower the soil pH. Additionally, acid injection systems to acidify irrigation water should be considered. For more information, see chapter 15, *Irrigation Management of Citrus Trees*, and chapter 16, *Nutrition Management for Citrus Trees*.

In addition to pH adjustment, preplant practices that increase or preserve soil organic matter can improve soil fertility during establishment. These practices include the planting of cover crops and using minimal tillage to prepare the ground for planting, if additional shaping such as bedding is not required. Although costly, additions of composted materials increase soil fertility and therefore tree growth and productivity of newly planted trees, because they help maintain a balanced pH and improve nutrient-holding capacity. For further information about cover crops, SARE offers a free, well-documented cover crop manual for download (https://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition).

Soil Moisture

Excessive soil moisture can be more damaging to citrus trees than drought. More than 3 days of root zone flooding will cause severe damage to the roots, followed by tree decline and possible death of trees. Sites in the southern and coastal areas of the state referred to as flatwoods are poorly drained and therefore more prone to flooding than other parts of the state. To improve drainage in poorly drained areas, trees are usually planted on double-row raised beds. The crown of raised beds should be 3–4 feet above the bottom of the furrow. Drainage systems consist of water furrows, ditches, tile drains if needed, and a perimeter ditch to remove excess water. The drainage system in the flatwoods should be designed to remove approximately 4 inches of water per day. Drainage is usually adequate in the sandy soils of the central Florida ridge, and these groves usually do not require bedding or additional drainage measures.

Because of seasonal prolonged periods without adequate rainfall, in combination with the predominantly sandy soils in Florida's citrus production areas, installation of an irrigation system is required prior to planting. Microirrigation, including low-volume emitters such as drippers or microsprinklers, is preferred over other systems because it is more cost-effective and water-use efficient than traditional sprinkler systems. Microirrigation systems are easily automated, operate at lower pressures, and hence use less energy. Microsprinkler systems can be engineered to offer some degree of cold protection by installing one emitter per tree and using additional "spaghetti" tubing to hang the emitter in the lower canopy when there is threat of a freeze. Compared to overhead irrigation, microirrigation also reduces incidence of diseases that thrive in a moist environment by not wetting the canopy.

The goal of designing an irrigation system is to apply the water uniformly across the grove, improve water-use efficiency, and minimize water losses to evaporation, runoff, or drainage below the root zone. Uniform application means that each tree receives the same amount of water. Water-use efficiency means that the plants receive just enough water to grow optimally. This will also minimize nutrient leaching. When designing an irrigation system to optimize water-use efficiency, emitter type and strategies to schedule and monitor irrigation need to be considered. For details, see chapter 15, *Irrigation Management of Citrus Trees*.

Nutrient management should also be considered when selecting an irrigation system. Injection systems can allow you to acidify the soil through acid injection or to fertilize through the irrigation system ("fertigation"). There are other options to reduce soil pH, including acid-forming fertilizers and elemental sulfur. However, for sites with high soil and water pH, an injection system may result in a rapid drop in pH. Injection systems should be installed before planting.

Water Supply

When planning for adequate supply of water, well capacity and permits for any additional wells need to be considered. Well capacity should be calculated for the maximum volume needed, whether for cold protection or for irrigation. In the dry season, calculations need to include the estimated volume of water lost to total daily evapotranspiration of the crop per acre. For cold protection, calculations need to include the maximum volume needed to ensure the crop remains above freezing temperature. See chapter 15, *Irrigation Management of Citrus Trees*, and chapter 21, *Citrus Cold Protection*, for how to calculate these values. It is important to conduct these calculations before designing the irrigation system to avoid a situation where the system is not capable of delivering the amount of water needed to keep trees alive and productive.

Variety Selection

Both scion and rootstock selection should consider soil type, expected disease pressure, and desired planting density. Choosing the rootstock that is best adapted to the conditions of the soil in the selected site is essential for maximum productivity. In addition, rootstock will influence tree size, fruit quality, and yield. If you intend to have a high-density planting, small-to-mid-size-inducing rootstocks should be preferred over more vigorous rootstocks. Small-to-mid-size-inducing rootstocks should also be preferred if fruit quality is of concern. Similarly, vigorous scion varieties such as Sugar Belle are not well suited to high-density planting. Vigorous varieties will generally require more pruning, especially when planted at a higher density. For more information, see chapter 12, *Rootstock and Scion Selection*.

Planting

Sourcing High-Quality Trees

High-quality nursery trees are essential for maximum productivity. Citrus growers should purchase only from certified nurseries to obtain healthy, uniform, and true-to-type trees. Healthy trees should have retained the majority of their foliage and have a well-developed root system. Roots should not be pot-bound. Trees should be of good vigor with a mature woody stem (larger than ⅜" in diameter) to ensure survival and rapid growth after planting. Trees with mature flush are preferred over trees with tender new flush, because the new flush may compete with roots for available resources after growth. A good sign of tree health is how long the leaves have remained on the tree; the lower in the canopy the leaves have held, the more likely the plant has not had a debilitating stress while in the nursery.

The traditional method of rootstock propagation is by seed. Where the seed supply does not meet the demand for superior rootstocks for replanting, propagation by other methods (tissue culture or cuttings) is necessary. A case in point is US-942, which, due to high demand, was propagated predominantly by tissue culture during production years 2018–19 and 2019–20. Moreover, some recently released rootstock cultivars (US-1279, US-1281, US-1282, US SuperSour 1) do not produce true-to-type plants and cannot be propagated from seeds.

Tissue culture and cutting-propagated rootstocks lack the typical taproot system of seed-propagated rootstocks. Instead, they have an adventitious-type root system with multiple smaller-diameter roots arising from the base of the stem. There have been concerns that the different root systems of non-seed-propagated rootstocks could render the grafted tree inferior in growth and survival. However, ongoing field trials at different commercial production sites have thus far observed no difference in growth among trees on rootstocks propagated by seed, cutting, or tissue culture. Furthermore, excavation studies demonstrated that any initial differences in root architecture disappear during the early years of field growth. The taproot of seed-propagated rootstocks ceases to grow after field planting and is replaced by lateral roots, which anchor the tree in the ground. Most of the root system was limited to the upper 2 feet of the soil regardless of the propagation method. For more information on rootstock propagation, see chapter 6 of the *Citrus Nursery Production Guide* (https://edis.ifas.ufl.edu/hs1329).

Planting Day

Young citrus trees can be planted during most times of the year. However, in regions where there is potential for freezing temperatures, planting should be delayed until the spring. Ideally, trees should be planted on the same day they are received. Under no circumstances should the roots be allowed to dry out. To minimize root desiccation and damage, trees should be kept shaded and moist until they are planted. Trees should be removed from the container, and roots should be inspected. If circling roots are not removed, they will continue circling and restrict growth and therefore productivity of the tree. Thus, pot-bound roots should be removed or untangled prior to planting. If roots are moderately pot-bound, use a clean and sharp knife to make several vertical slashes about one-inch deep through the root ball to encourage new root growth. These slashes will also allow the roots to interface more closely with the soil in the planting hole. If planting severely pot-bound plants cannot be avoided, it is advisable to cut off the outer ½" of the root ball. Alternatively, some of the outer roots may be exposed by pulling them so they protrude from the root ball and extend into the soil in which the tree is planted. If roots are left in a pot-bound state, trees will not grow quickly, and growth may be hampered for the life of the tree. Trees with irregular root systems should not be planted, because this indicates other problems, such as phytophthora. For more information, refer to chapter 18, *Root Health Management*.

Other Details to Consider at Planting

Plastic tree tags from nurseries may girdle a tree if they remain on the trunk and become buried in the soil during planting. Remove tree tags or ensure they remain aboveground, where they will usually deteriorate over time and not girdle the tree. Tree damage can also occur from metal tree stakes. Close contact of stakes with the tree trunk can lead to injury and pathogen infection and therefore restrict tree growth.

Caring for Young Trees

Because of Florida's sandy soils, high temperatures, and frequent rainfall, young tree care requires regular fertilization, insect and disease management, and weed control. The primary objective during the first few years is rapid development of the tree canopy. Young trees are more sensitive and more attractive to pests than mature trees due to high levels of vegetative growth. Monitoring for insect pests and diseases in new plantings is essential, and adequate control is imperative. Weed management is especially important in newly established groves to reduce competition and ensure rapid tree growth. Application rates of crop protection chemicals need to be adjusted based on the size of the trees. Proper irrigation and nutrition are also critical factors to ensure rapid growth of young trees. Minor selective pruning (especially of water sprouts) can be beneficial during the first two years to develop good canopy architecture. The goal of such pruning should be to develop a canopy that allows light penetration into the center of the canopy.

Weed Control

Weeds compete with young citrus trees for water, nutrients, soil-applied pesticides, and sunlight, and they should be controlled both before planting and during the early years of growth. If herbicides with residual activity are used prior to planting, they should be applied at least 30 days in advance of planting to avoid negative impacts on the young trees. Herbicides should always be applied at recommended rates, which are lower for young trees. Not all herbicides are suitable for young trees; be sure to read labels carefully for restrictions. To minimize herbicide contact to young trees, using tree wraps is advisable. When using wraps, be sure to monitor the space between trunk and wrap for ants or other pests that may damage the tree. For more information, refer to chapter 44, *Weeds*.

Suckering

Rootstock sprouts, called "suckers," should be removed during the growing season before the sprouts become large and compete with the scion shoots. Young trees require regular sprout removal. Tree wraps usually reduce the need for removal.

Irrigation and Drainage

Because of their smaller root systems, young citrus trees require frequent but moderate irrigation for survival and proper growth. Irrigation systems should be in place before planting. Trees should be monitored frequently to be certain they are receiving sufficient but not excessive amounts of water. For more information, refer to chapter 15, *Irrigation Management of Citrus Trees*.

Fertilization

Regular fertilization of young trees is imperative to promote vigorous vegetative growth that rapidly produces a canopy with high fruit-bearing capacity. Applying fertilizer in several small doses is more efficient than applying fertilizer in few large doses because it ensures constant nutrient availability and reduces losses due to leaching. Frequent application of water-soluble fertilizers with irrigation water (fertigation) or use of controlled-release fertilizers can greatly increase nutrient-use efficiency. The needed quantities of water and fertilizers increase each year as the trees grow and should be based on tree size and canopy density. Great care must be taken to ensure that proper rates of fertilizer materials are dispensed to prevent nutritional deficiencies or toxicities. It is not recommended to place granular fertilizer in the planting hole, because direct contact with the roots may burn them and cause root deformations. For more information, refer to chapter 16, *Nutrition Management of Citrus Trees*.

Pest Control

Because young trees flush more frequently than mature trees, they are more attractive and sensitive to pests. Therefore, special care is needed to control Asian citrus psyllids and leafminers to reduce leaf damage, severity of citrus canker, and incidence of HLB. Maintaining young trees free of citrus canker and HLB is of utmost importance, because the trees that become infected during the early years will never become productive. Relying solely on foliar-applied contact insecticides for young trees is not a good strategy. Recently, noninsecticidal approaches, such as the use of kaolin particle films or individual-tree pest-exclusion nets have been developed. For more information on management of citrus psyllids and leafminers, refer to the pest management sections in this guide. Under the current HLB-endemic conditions in Florida, trees are very likely to become infected, but any practice that prevents or delays infection will improve productivity and higher economic returns in the long term.