Chapter 20

Horticultural practices

Fernando Alferez

University of Florida, Institute of Food and Agricultural Sciences, Southwest Florida Research and Education Center, Immokalee, FL, United States

Grove management starts with planning of the planting site, and by comprehending every operation until harvesting time in order to achieve the best marketable fruit yield and quality. It includes horticultural practices such as grove establishment, irrigation, nutrition, canopy management, and grove protection. Importantly, fruit quality starts in the grove. In this chapter we are focusing on grove planning with special focus on tree spacing, canopy management, and tree size control, and crop load management from a horticultural point of view.

20.1 Grove planning and tree spacing

Good grove design and management has, among others, the goal of providing a canopy structure able to capture optimum light intensity and minimize competition from neighboring plants. It is well known that for a given cultivar and environment combination, an optimum planting density exists for maximizing yields (Schumann et al., 2012). In planning a citrus grove, attention must be paid to site selection, choosing an adequate variety (scion) and rootstock combination to better adapt to soil characteristics and environmental conditions, and determining the correct tree spacing.

20.1.1 Site selection

According to Futch (1992), several factors determine the suitability of a site for citrus production, among others, well drained and fertile soil and location as it relates to extreme climate exposure, with susceptibility to freeze damage being the most important consideration. In this regard, topography is also a factor to consider, since during radiational freezes cold air settles in the lowest area, resulting in temperatures a few degrees lower than that in slightly higher surrounding areas, whereas during freezes with strong northerly winds, groves on exposed northern slopes and atop small ridges may be subjected to colder temperatures than those occurring on southern slopes (Sauls, 2008).

In general, an ideal citrus grove has good drainage, balanced soil pH, and access to sufficient good quality water for irrigation. The optimum pH of the irrigation water ranges between 6.0 and 6.5. In high-pH soils, a pH-tolerant rootstock variety is recommended (pH sensitivity: Swingle > Carrizo > Sour orange >Cleopatra). The best quality water should not be high in bicarbonates and salt levels (Zekri et al., 2017). Alkalinity caused by carbonate ($CO_3^{=}$), bicarbonate (HCO_3^{-}), and hydroxyl (OH^-) anions is detrimental to HLB (Huanglongbing)-affected trees as it decreases nutrient uptake and root longevity. In the cases of soils high in bicarbonates, lowering of soil pH through the acidification of irrigation water has proven to be a strategy that releases Ca and Mg from bicarbonate and increases the availability of soil Mn, Zn, and Fe for root uptake (Graham and Morgan, 2015).

20.1.2 Variety and rootstock selection

There are other chapters in this book specific to rootstock and scion selection (see Chapters 5 and 6). However, it is worth mentioning that in order to select the right rootstock, it is important to consider previous and accumulated experience, field and research data, and rootstock-scion compatibility (Castle and Futch, 2015). According to Castle (2010), nowadays breeding citrus rootstocks places emphasis on reducing tree size beyond what is currently possible among commercial rootstocks. In any case, it is desirable for the industry to have different choices to select the adequate rootstock that matches the grove's space needs. Thus, size-controlling rootstocks are important for higher density orchards, and rootstocks that induce scion precocity will allow significant cropping to begin early. Newly produced rootstocks should lead to excellent yields of

The Genus Citrus. https://doi.org/10.1016/B978-0-12-812163-4.00020-6

high-quality fruit and possess other key traits, such as disease tolerance, to be successful. This is especially important under HLB and other biotic and abiotic threats.

20.1.3 Tree spacing

Historically, according to Hutton (1989) worldwide tendencies in land management involve, and are influenced by the following aspects:

(1) Reduced availability of suitable citrus land, with a consequent development of poor soil types which influence tree growth rate and ultimately size and productivity.
(2) Increasing land values and taxes.
(3) Modification of zoning laws affecting the agriculture.
(4) Tree losses from freezes, diseases, and declines.
(5) Increased expenditures for equipment, energy, irrigation systems, and labor.

These factors are increasingly important, as reviewed by Nawaz et al. (2010). To remain profitable, citrus production must use resources more efficiently, and this can be achieved with adequate planning that considers tree spacing as a fundamental characteristic of the grove.

Tree spacing is an important factor determining profitability of a grove. Since sunlight is the source of energy for tree and fruit growth, grove design must address the arrangement of tree canopies to capture irradiance efficiently. Tree rows are typically oriented north to south for maximum sunlight interception. However, row orientation may also depend on the row length and water drainage direction at the site (Zekri et al., 2017). Tree spacing should be based on the vigor of the scion-rootstock combination and the expected life of the grove. The ability of citrus to adapt to a wide range of spacing is well known. In this regard, tree vigor is of fundamental importance in determining tree spacing, density, and pruning regime. Trees of low vigor will never fill their allocated space, preventing generation of maximum economic returns if planted in a wide plantation frame. On the other hand, placing vigorous trees in small spaces will result in poor production and will carry management problems (Wheaton et al., 1995). Tree spacing affects root densities, which may be related to water use. In general, in healthy citrus trees, higher tree densities result in higher root densities (Kaufmann et al., 1972; Castle, 1980).

Tree spacing widely affects the yield and quality of citrus fruit. According to Whitney et al. (1991) citrus fruit yields per unit of land area are related to tree spacing in the early bearing years (Boswell et al., 1975; Phillips, 1974; Wheaton et al., 1986). However, as the trees grow and compete, fruit yields per unit land area become independent of tree spacing, and may even decline at the closer spacings (Boswell et al., 1975). Tree spacing is an increasingly important consideration in citrus grove management due to increasing operating costs and less economic returns to the grower, as well as disease pressure that reduces yield and quality. Generally, closely planted groves provide greater and earlier returns but with a demand for precise management; operations such as spray coverage and harvesting are facilitated at higher density plantings (Phillips, 1978; Zekri, 2000). Higher density plantings require hedging and topping to maintain good light interception. In mature citrus groves that are not hedged regularly, insufficient light and increased shading promote a thin canopy and reduction in fruiting on the lower parts of the tree (Rouse et al., 2006). Factors that affect light interception in a mature grove include width of the drive middle, foliage wall angle (hedging angle), tree height, and row orientation.

With HLB pressure more and more prevalent worldwide, grove management, including site planning and tree spacing, is rapidly evolving toward higher density plantings. The concept of high-density plantings is not new in citrus (see Tucker and Wheaton, 1978, for a comprehensive review), but in the last years the trend toward higher density plantings has increased in search of faster economic returns under HLB pressure. Higher density plantings are an essential component of newer production systems such as CUPS (citrus under protective screen) aimed at excluding the Asian citrus psyllid (*Diaphorina citri*) and therefore HLB. In this case, planting densities may range from 871 to 1361 trees per acre and involve intensive hydroponics with daily or hourly delivery of nutrients by drip fertigation (Schumann et al., 2017).

20.2 Irrigation and water management planning

Irrigation strategies should allow growers to maintain or increase crop production without exhausting water resources. By selecting a proper irrigation scheduling method and application time, water use efficiency could be increased. This is especially important in groves affected by HLB, since water stress can produce a deleterious change in physiological activity of growth and production of citrus trees. It is recommended that for HLB-affected trees, irrigation frequency should be increased and irrigation amounts should be decreased to minimize water stress from drought stress or water shortage, while ensuring optimal water availability in the root zone at all times. It is recommended that growers maintain soil moisture in the root zone (top 3 ft. for Ridge and 18 in. for flatwood soils, in Florida for example) using soil moisture sensors or irrigation apps (Kadyampakeni et al., 2014; Migliaccio et al., 2016).

20.2.1 Water management

In poorly drained soils, control of high water tables and rapid removal of excess surface water from rainfall are essential for citrus production (Chapters 13 and 14). Soils with poor drainage are not adequate for citrus plantation as excess water supply is not properly evacuated. Drainage systems generally include beds, water furrows, lateral ditches, collector ditches, and may include perimeter ditches and discharge pumps. Drainage water from several lateral ditches usually is accumulated in collector ditches and conveyed off-site. This may be achieved by gravity or by discharge pumps. The size of the collector ditches and related pumping facilities depend on factors such as size of the area being served, soils, bed and water furrow design, and slope of ditches (Boman et al., 2018).

20.3 Canopy management and tree size control

Tree canopy and bearing volume are two important factors in fruit production and fruit quality. Generally, citrus trees with larger canopy volumes produce more fruit than smaller canopy trees (Vashisth et al., 2017). Tree size control through canopy management of citrus trees is essential to maintain and improve tree health and increase productivity and fruit quality. In addition, from a managerial perspective, it allows better efficiency while performing regular operations in the grove, since machinery can operate faster and chemical application can better reach targeted areas of the trees.

Canopy management mostly involves pruning operations. Pruning is one of the oldest horticultural practices. It changes the form and growth of a tree. In general, the pruning process has the following characteristics:

(1) Adjusts tree shape and the canopy's ratio of framework to fruit-bearing shell.
(2) Alters the shoot-root ratio.
(3) Changes the carbohydrate status of the tree (Boswell and Cole, 1978a).

When considering a citrus tree canopy, trees typically have 3–5 growth flushes a year, although this depends on growing conditions, i.e., management practices and geographical area. In general, the outer 90 cm of the spherical shaped citrus tree canopy produces most of the fruit. It is estimated that 90% of the solar radiation is absorbed by this outer 90 cm of canopy. When trees are small or in a narrow hedgerow, the total canopy may be considered to be productive (Rouse et al., 2006). However, when trees are large, the inner nonproductive part (scaffold limbs and branches inside the outer 90-cm shell) can be a major component of the total canopy volume. In every flushing period, new flushes add on established flushes, resulting in a drift of the young bearing wood to the outside of the tree canopy (Hardy, 2004). This results in larger trees with increased shading inside the canopy resulting in most of the fruit being carried on the tops and outside of trees. In general, through pruning we are able to remove weak branches and rejuvenate trees, reduce shading while improving the light interception, improve air circulation through the canopy, reduce pest and disease pressure, enhance tree performance, alleviate alternate bearing, increase fruit size and improve fruit quality, and facilitate harvesting.

The type of production will determine the type of pruning to be adopted. There are great differences in the way that tree canopies are managed depending on geographical area (i.e., Mediterranean, milder climates, or subtropical and tropical climates) and type of the fruit produced (fresh fruit or processing fruit varieties). In general, a massive production aimed at processing fruit for juice extraction demands mechanical topping, skirting, and hedging the trees with the objective of inducing lateral secondary branching while facilitating grove operations. In general, hedging down the tree row needs to maintain 8-ft width for passage of equipment, while efficiency of machinery is enhanced with longer tree rows, and turn space is needed at end of rows to accommodate large machines (Rouse and Futch, 2004). This affects also the grove design, as mentioned above. In contrast, high-quality fruit for fresh market demands more specialized manual pruning, with the goal of achieving better fruit coloration and absence of peel blemishes while facilitating manual, careful harvesting by the piece.

20.3.1 Mechanical pruning cuts

This topic has been extensively reviewed elsewhere (Rouse et al., 2006; Zekri, 2015; Vashisth et al., 2017). There exist three types of basic mechanical cuts: hedging, topping, and skirting, which are performed with special machinery and constitute important cultural grove practices. In general, tree response to these depends on several factors including variety, rootstock, tree age, growing conditions, time of pruning, and production practices. Main characteristics and uses of these mechanical pruning cuts are explained below.

20.3.1.1 Hedging

Hedging is cutting back the sides of trees to prevent or alleviate crowding (Fig. 20.1A). Hedging produces numerous cut wood surfaces along the side of the tree canopy from which new sprouts arise and eventually develop into a wall of new foliage (Vashisth et al., 2017). Middles (alleys) between tree rows should be sufficiently wide to accommodate grove equipment and provide adequate light access to the sides of the trees. Middles are usually hedged to a width of 7–8 ft. in Florida, but vary depending on original grove design, scion variety, rootstock, and equipment used in all production practices. Hedging is usually done at an angle, with the boom tilted inward toward the treetops so that the hedged row middles are wider at the bottom than at the top. This angled hedging allows more light to reach the lower skirts of the tree (Vashisth et al., 2017). Furthermore, to be more effective hedging is started before the canopy gets overgrown, and branches targeted are below 0.13″–0.25″ in diameter. Cutting these branches induces new flushing of fruit-bearing shoots (Fig. 20.1B and C).

20.3.1.2 Topping

Topping is the most invigorating form of pruning. For this reason, if done at the wrong time it can result in excessive upright vegetative growth, which causes shading and uses the tree's water and nutrient reserves (Krajewski, 2002; Hardy, 2004). Topping involves cutting off vegetation in the top of the tree, and ideally is performed before trees become excessively tall. No studies have shown an increase in yield due to topping, however, fruit quality is improved and fruit size increases, while management and harvesting costs are reduced (Vashisth et al., 2017). Trees can be flat-topped or roof-topped (topped at angles) (Rouse et al., 2006). Some common topping heights are 10–12 ft. at the shoulder and 13–14 ft. at the peak. As a general rule, topping heights are two times the width of the row middle (Vashisth, 2018).

FIG. 20.1 Mechanical hedging: (A) hedging of a high-density row planting of Valencia trees on the dwarfing rootstock Flying Dragon in southwest Florida in February, (B) massive lateral new flushing in early April after hedging, and (C) details of a pruned lateral branch showing new flushes with bearing capacity.

According to Wheaton (1986, 1997) topping and hedging can be scheduled to reduce crop load during heavy crop years. These operations are usually performed in winter or the early spring before flowering occurs if there is certainty that the coming crop load will be excessive. Alternatively, the decision is made after flowering and fruit set is largely completed. The benefits of reducing crop load are greater the earlier in the season it is done. Thus, it is important to complete the hedging and/or topping operations as soon as possible after crop load is estimated.

20.3.1.3 Skirting

Skirting raises tree skirts. This allows movement of herbicide booms, and mechanical harvesting and other equipment. Fruit and limbs near the ground are often damaged by the passage of such equipment and by herbicide spray and fertilizer contact. Skirting allows uniform distribution of granular fertilizers, good water coverage by microsprinkler irrigation systems, and more uniform herbicide application under tree canopies. Skirting facilitates the inspection and repair of microirrigation systems and reduces the incidence of Phytophthora foot rot and brown rot as it allows good air circulation (Zekri, 2015). In addition, since herbicide booms do not make contact with low hanging foliage and fruit, the chance for spread of canker is reduced (Rouse et al., 2006). Data from a 5-year study showed that average yields were not affected by skirting. In contrast, although fruit from unskirted trees had juice quality equivalent to other fruits on the tree, the fruit had increased blemishes and were smaller. Skirted trees had reduced yield the following year, but rebounded with yields above unskirted trees (Whitney et al., 2003). The current machinery available for mechanical harvesting makes skirting necessary for building a tree that facilitates the operations of this kind of massive harvester.

20.3.2 Manual pruning

Manual pruning involves several practices that comprise all stages of tree development, from young tree formation to maintenance pruning of bearing trees, and rejuvenation pruning of old trees. In the following, these aspects are explained:

20.3.2.1 Young tree formation

The main goal is to identify and preserve branches which will make good future scaffold limbs (those well orientated/angled) and to remove unwanted branches (those poorly orientated/angled) which will have an adverse effect on tree development and production (Taverner et al., 2011). Sometimes, selecting ideal scaffold branches present problems in the grove. For example, regrowth after pruning is unpredictable, and branches, if bent by their own weight, can provoke a shift in dominance. These facts force a careful follow up of the grove after selective formation pruning of young trees (Medina-Urrutia et al., 2002).

20.3.2.2 Young tree training

This type of pruning is performed in the first years (2–6 years, depending on the regions) after the scaffold branches have been established, and is aimed at maintaining the already selected scaffold branches by selectively pruning misplaced new growth such as water sprouts or gourmands. This has to be performed annually and involves no more than 10% of the canopy volume in order to avoid induction of excessive vegetative growth that results in yield reduction (Medina-Urrutia et al., 2002; Zaragoza et al., 2003).

20.3.2.3 Clearing internal canopy

This pruning eliminates vertical branches in the interior of the canopy and is performed mostly in adult trees. These usually vigorous branches do not bear any fruit, and reduce internal air circulation and light penetration (Curtí-Díaz et al., 2000). The removal of this type of branch induces better fruit coloration and reduces peel blemishes caused by wind (wind scars), as well to minimize associated disease problems. It may involve removal of up to 50% of the canopy in some cases.

20.3.2.4 Rejuvenating pruning

In older or poorly managed trees, this type of severe pruning will shape again the tree with newly selected scaffold branches. However, in subtropical areas this type of pruning may delay the new production by 3 years (Kretchman and Jutras, 1962; Kretchman and Krezdorn, 1962; Lewis et al., 1963). This practice is usually performed to remediate trees declining due to age, presence of diseases and pests in the soil, or root loss. However, if scaffold and secondary branches are healthy, this type of pruning does not improve the tree (Boswell and Cole, 1978b).

20.3.3 Effects of pruning on tree physiology

In general, tree response to pruning depends on several factors including variety, rootstock, tree age, growing conditions, timing and type of pruning, and production practices. Pruning affects physiology of citrus trees in several ways, which include changing branch dominance by affecting the number and disposition of buds in the tree canopy (Krajewski and Krajewski, 2011), changing canopy lighting (Krajewski and Pittaway, 2000), and altering air circulation. It also has a clear effect on fruit quality (Krajewski and Krajewski, 2011). According to Tucker et al. (1991), the removal of the terminal bud destroys apical dominance so one or several lateral buds will commence to grow, leading to new branching. Apical dominance explains many of the growth characteristics of trees and their responses to pruning. Severe pruning if performed in late spring or summer may induce only vegetative growth, diminishing fruit production (Boswell and Cole, 1978a; Tucker et al., 1991).

Light penetration is a very important factor for fruit production and quality. In some varieties such as grapefruit, light intensity inside the canopy can be as low as 2% of total sun irradiance if the trees were not pruned (Fischler et al., 1983). According to Krajewski and Pittaway (2000), of all cultural practices, only pruning and training can optimize light distribution and sap flow to fruits. Indeed, in well-managed groves correct pruning increases fruit quality and yield (Bevington et al., 2002). Pruning may affect nitrogen (N) requirements. If N is applied after a severe pruning, there may be excessive vegetative growth and low-quality fruit. In contrast, if pruning is light, N requirements are not affected (Tucker et al., 1991).

Pruning may also have deleterious effects on the tree, affecting fruit production. The inadequate pruning of healthy, mature citrus trees can reduce yields in proportion to the amount of foliage removed, and can delay fruiting of young, nonbearing trees as well (Vashisth et al., 2017). In general, the disadvantages are: (1) reduction in fruit yield when pruning is severe in young nonbearing trees and (2) reduction in stored reserves, including foliage stored carbohydrates and minerals such as Ca and N, and to a lesser extent K, Mg, P, and Na (Calabrese and Pino, 1992). In addition, severe hedging or topping of citrus trees during the winter can reduce cold hardiness because trees with exposed internal scaffold wood and new tender growth are susceptible to cold injury (Zekri, 2015). Other problems associated with these practices when not performed routinely are that long intervals between prunings increase the cost of the operation due to heavy cutting and more brush disposal (Zekri, 2015).

20.3.4 Other considerations

Pruning may affect disease incidence, and at the same time, can be used as a disease management tool in areas where citrus canker, citrus black spot, and HLB, among others, are present. Pruning results in vegetative regrowth that must be carefully protected from all diseases and pests, including vectors transmitting these diseases that feed on new flushes (Krajewski and Krajewski, 2011). Attention to the management of insects that feed on new foliar flush growth has increased as a result of the establishment of invasive plant diseases associated with insects that develop exclusively on these new flushes. Citrus can be monitored to identify peak periods of flush abundance to time insecticide applications for these insects (Hall and Albrigo, 2007). On the other hand, it is recommended to avoid pruning and generating vegetative regrowth at any time when activity of leaf pests such as aphids, thrips, psyllids, and lepidoptera larvae is high. Citrus leaf miner feeding activity aggravates severity of canker (Gottwald et al., 2002) and psyllid-feeding activity hastens spread of HLB (Catling, 1969; Gottwald et al., 2007).

20.4 Crop load management

For satisfactory management of groves, a regular production through the seasons is desirable. Alternate bearing is a major problem in citrus production worldwide, especially with mandarin cultivars (Wheaton, 1992). Alternate bearing trees produce a heavy (on) crop followed by a light (off) crop. The impact of alternate bearing on fruit size and quality for fresh market fruit (Chapter 11) is a major factor affecting profitability. Alternate bearing is a common phenomenon in many-seeded citrus cultivars. In these cultivars, high yields are followed by extremely low yields and vice versa. Lack of flowering reduces the following season's yield, and this is the cause of high flower intensity and subsequent yield (Monselise and Goldschmidt, 1982). Also, the cultural practice of holding fruit on the tree to extend the commercial harvest period during an on-crop year exacerbates alternate bearing (Verreyne and Lovatt, 2009).

Carbohydrate availability coupled with hormonal balance in the fruit determine fruit set and development. In alternate bearing sweet orange Salustiana, the accumulation of reserves is inversely related to crop load (Monerri et al., 2011), and changes in carbohydrate reserves during the year reflect variations in supply and demand. Fruiting trees accumulate most fixed carbon in fruits, while no accumulation is observed in roots before harvest. In the no-fruiting trees, however, most

TABLE 20.1 Plant growth regulator general uses.

Variety	Growth regulator	Time of application	Effect
Sweet orange, Temple, grapefruit	2,4-D	November–December	Reduction in preharvest fruit drop
Navel orange	2,4-D	6–8 weeks after bloom	Reduction of June drop
Tangerine and Murcott	NAA	Mid May	Fruit thinning
Seedless grapefruit	GA_3	November–January	Delay of peel senescence process and peel color development in mature-green fruit
Tangelos	GA_3	Full bloom	Improvement of fruit set
Minneola tangelo	GA_3	Early December	Delay of stem-end rind breakdown
Valencia orange	Homobrassinolides	After June drop	Better fruit growth, color development and retention

fixed carbon is transported to roots and utilized in growth processes, and after December, stored as reserves. Reserve carbohydrate accumulation in leaves starts by early December, and the levels in leaves are, until bud sprouting, the same in both the "on" and "off" trees. The heavy flower formation which follows an "off" year causes the rapid mobilization of the stored reserves, which are exhausted at full bloom (reviewed by Nebauer et al., 2014).

Endogenous hormonal levels play a major role in determining fruit set in citrus; this topic has been extensively researched and reviewed elsewhere (Talón et al., 1990, 1992, 1999; Mesejo et al., 2016; see also Chapter 11). In general, exogenous applications of gibberellic acid increase the sink capacity of the fruit (Agustí et al., 1982), and branch girdling enhances carbohydrate availability (Wallerstein et al., 1978; Goldschmidt et al., 1985). The former cannot be adopted in many cases since some varieties are insensitive to gibberellins, whereas the latter can be used always in healthy trees.

Reducing the number of fruit (fruit thinning), manually or with chemical substances, is one of the most common techniques to increase fruit size. Manual thinning is more efficient during physiological drop (Zaragoza et al., 1992). In this case, however, the high number of fruitlets make it economically not viable. Thinning may also reduce alternate bearing (Jones et al., 1977; Monselise et al., 1981) and tree collapse in years "on" (Monselise and Goldschmidt, 1982; Chapman, 1984).

Chemical thinning can be used as well for regulating fruit number and size (El-Otmani et al., 2000). Substances such as naphtalenic acid, ethephon, and ethylclozate if applied at the cell division stage can induce fruitlet abscission, and effectively reduce fruit crop load. These treatments, however, lose efficacy after fruit set, if applied during the cell elongation phase (Agustí et al., 1995). Chemical thinning has more effect on smaller fruitlets that will produce fruit of smaller size (Kamuro and Hirai, 1981). For this reason, eliminating these smaller fruits at a stage when the fruitlets are responsive to the chemicals applied increases average fruit weight (Agustí and Almela, 1984).

Table 20.1 summarizes the applications of plant growth regulators as spray treatments. The table is a general summary of documented effects regardless of geographical/climatic aspects of the citrus-growing region.

References

Agustí, M., Almela, V., 1984. Mejora de la calidad del fruto de la mandarina Satsuma. Bco. De Santander, Madrid, España, ISBN: 84-398-1798-3.

Agustí, M., García-Marí, F., Guardiola, J.L., 1982. Gibberellic acid and fruit set in sweet orange. Sci. Hortic. 17, 257–264.

Agustí, M., El-Otmani, M., Aznar, M., Juan, M., Almela, V., 1995. Effect of 3,5,6-trichloro-2-pyridyloxyacetic acid on 'Clementine' early fruitlet development and on fruit size at maturity. J. Hortic. Sci. 70, 955–962.

Bevington, K.B., Falivene, S., Moulds, G., Krajewski, A.J., 2002. Pruning *Citrus* for Export Fruit Size. CMDG Final Report Project 50, New South Wales Dept. of Agric., Australia.

Boman, B., Wilson, C., Jennings, M., Shukla, S., 2018. Detention/Retention for *Citrus* Stormwater Management. EDIS Circular 1405. Agricultural and Biological Engineering Department, UF/IFAS Extension.

Boswell, S.B., Cole, L.A., 1978a. Pruning citrus in California: a review of origins and history. Citrograph 63 (4), 80–84.

Boswell, S.B., Cole, L.A., 1978b. Pruning citrus in California: a review of origins and history. Citrograph 63 (5), 109–113.

Boswell, S.B., McCarty, C.D., Hench, K.W., Lewis, L.N., 1975. Effect of tree density on the first ten years of growth and production of 'Washington' navel orange trees. J. Amer. Soc. Hort. Sci. 100 (4), 370–373.

Calabrese, F., Pino, M., 1992. Pruning and mineral losses from mandarin orchards in Sicily. Proc. Int. Soc. Citriculture 2, 690–692.

Castle, W.S., 1980. Fibrous root distribution of 'Pineapple' orange trees on rough lemon rootstock at three tree spacings. J. Amer. Soc. Hort. Sci. 105 (3), 478–480.
Castle, W.S., 2010. A career perspective on citrus rootstocks, their development, and commercialization. Hortic. Sci. 45, 11–15.
Castle, W.S., Futch, S.H., 2015. Choose the Right Rootstock. EDIS HS932. Horticultural Sciences Department, UF/IFAS Extension.
Catling, H.D., 1969. The bionomics of the South African citrus psylla, Trioza erytheae (Del Guercio) (Homoptera: Psyllidae). 1. The influence of the flushing rhythm ofcitrus and factors that regulate flushing. J. Ent. Soc. S. Africa 32, 191–208.
Chapman, J.C., 1984. Ethephon as a fruit thinning agent for 'Murcott' mandarins. Sci. Hortic. 24, 135–141.
Curtí-Díaz, S., Loredo–Salazar, X., Díaz-Zorrilla, D., Sandoval-Rincón, J.A., Hernández-Hernández, J., 2000. Tecnología para producir limón Persa. INIFAP. CIRGOC-Campo Experimental Ixtacuaco. Libro técnico # 8. 145 p.
El-Otmani, M., Coggins Jr., C.W., Agustí, M., Lovatt, C.L., 2000. Plant growth regulators in citriculture: world current uses. Crit. Rev. Plant Sci. 19, 395–447.
Fischler, M., Goldschmidt, E.E., Monselise, S.P., 1983. Leaf area and fruit size on girdled grapefruit branches. J. Amer. Soc. Hort. Sci. 108 (2), 218–221.
Futch, S.H., 1992. Site Selection. Fact Sheet HS-141. Horticultural Sciences Department, UF/IFAS Extension.
Goldschmidt, E.E., Aschkenazi, N., Herzano, Y., Schaffer, A., Monselise, S.P., 1985. A role of carbohydrate levels in the control of flowering in citrus. Sci. Hortic. 26, 159–166.
Gottwald, T.R., Graham, J.H., Schubert, T.S., 2002. *Citrus* canker: the pathogen and its impact. Plant Health Prog. https://doi.org/10.1094/PHP-2002-0812-01-RV (Online).
Gottwald, T.R., da Graça, J.V., Bassanezi, R.B., 2007. *Citrus* Huanglongbing: the pathogen and its impact. Plant Health Prog. https://doi.org/10.1094/PHP-2007-0906-01-RV (Online).
Graham, J.H., Morgan, K., 2015. Managing excessive bicarbonates with acidification. Citrus Industry (May 2015).
Hall, D.G., Albrigo, L.G., 2007. Estimating the relative abundance of flush shoots in citrus with implications on monitoring insects associated with flush. Hortic. Sci. 42, 364–368.
Hardy, S., 2004. Growing Lemons in Australia. A Production Manual. NSW Department of Primary Industries, ISBN: 0-7347-1611-7.
Hutton, R.J., 1989. The influence of tree size control and plant density on citrus productivity. Symposium on physiology of productivity of subtropical and tropical tree fruits. Acta Hortic. 175, 12–17.
Jones, W.W., Coggins Jr., C.W., Embleton, T.W., 1977. Growth regulators and alternance bearing. Proc. Int. Soc. Citriculture 2, 657–660.
Kadyampakeni, D.M., Morgan, K.T., Schumann, A.W., Nkedi-Kizza, P., 2014. Effect of irrigation pattern and timing on root density of young citrus trees infected with Huanglongbing disease. Hort. Tech. 24 (2), 209–221.
Kamuro, Y., Hirai, K., 1981. Physiological activity of Ethylchlozate. Fruit thinning and maturity accelerating effects for citrus. Proc. Int. Soc. Citriculture 1, 260–263.
Kaufmann, M.R., Boswell, S.B., Lewis, L.N., 1972. Effect of tree spacing on root distribution of 9-year-old 'Washington' navel orange. J. Amer. Soc. Hort. Sci. 97 (2), 204–206.
Krajewski, A., 2002. Pruning for Improving Quality in *Citrus*. Fruit Doctors.
Krajewski, A.J., Krajewski, A.J., 2011. Canopy management of sweet orange, grapefruit, lemon, lime and mandarin trees in the tropics: principles, practices and commercial experiences. In: Proc. Ist IS on Trop. Hort. Ed.: N. Benkeblia, Acta Hort. 894, ISHS 2011.
Krajewski, A.J., Pittaway, T., 2000. Manipulation of citrus flowering and fruiting by pruning. Proc. Int. Soc. Citriculture 357–360.
Kretchman, D.W., Jutras, P.J., 1962. The influence of pruning on size and quality of Florida grapefruit. Proc. Fla. Sta. Hort. Soc. 35–45.
Kretchman, D.W., Krezdorn, A.H., 1962. Recent developments in pruning citrus. Citrus Industry 43 (1), 6–7. 13–16.
Lewis, L.N., McCarty, C.D., Moore, P.W., 1963. Effects of skeletonizacion on rejuvenation and production of declining orange trees. Am. Soc. Horticult. Sci. 83, 295–299.
Medina-Urrutia, V.M., Robles-González, M.M., Becerra-Rodríguez, S., Orozco-Romero, J., Orozco-Santos, M., Garza-López, J.G., Ovando-Cruz, M.E., Chavez-Contreras, X., Felix-Castro, F.A., 2002. El cultivo del limón Mexicano. INIFAP. Libro Técnico Num. 1 México. 204 p.
Mesejo, C., Yuste, R., Reiga, C., Martínez-Fuentes, A., Iglesias, D.J., Munoz-Fambuena, N., Bermejo, A., Antonietta Germanà, M., Primo-Millo, E., Agustí, M., 2016. Gibberellin reactivates and maintains ovary-wall cell division causingfruit set in parthenocarpic *Citrus* species. Plant Sci. 247, 13–24.
Migliaccio, K.W., Morgan, K.T., Vellidis, G., Zotarelli, L., Fraisse, C., Zurweller, B.A., Andreis, J.H., Crane, J.H., Rowland, D.L., 2016. Smartphone apps for irrigation scheduling. Trans. ASABE 59 (1), 291–301.
Monerri, C., Fortunato-Almeida, A., Molina, R.V., Nebauer, S.G., García-Luis, A., Guardiola, J.L., 2011. Relation of carbohydrate reserves with the forthcoming crop, flower formation and photosynthetic rate, in the alternate bearing 'Salustiana' sweet orange (*Citrus sinensis* L.). Sci. Hortic. 129, 71–78.
Monselise, S.P., Goldschmidt, E.E., 1982. Alternating bearing in fruit trees. Hortic. Rev. 4, 128–173.
Monselise, S.P., Goldschmidt, E.E., Golomb, A., 1981. Alternate bearing in citrus and ways of control. Proc. Int. Soc. Citriculture 1, 232–242.
Nawaz, M.A., Afzal, M., Maqbool, M., Hussain, Z., Ashraf, T., Iftikhar, Y., 2010. The productivity and quality of citrus fruits as influenced by tree spacing. Int. J. Agric. Appl. Sci. 2, 32–35.
Nebauer, S.G., Renau-Morata, B., Lluch, Y., Baroja-Fernandez, E., Pozueta-Romero, J., Molina, R.-V., 2014. Influence of crop load on the expression patterns of starch metabolism genes in alternate-bearing citrus trees. Plant Physiol. Biochem. 80, 105–113.
Phillips, R.L., 1974. Performance of 'Pineapple' orange at three tree spacings. Proc. Fla. State Hort. Soc. 87, 81–84.
Phillips, R.L., 1978. *Citrus* tree spacing and size control. In: Proc. Int. Soc. Citriculture, pp. 319–324.
Rouse, R., Futch, S., 2004. Start Now to Design *Citrus* Groves for Mechanical Harvesting. EDIS HS974. Horticultural Sciences Department, UF/IFAS Extension.

Rouse, R., Parsons, L., Wheaton, A., 2006. Hedging, topping and skirting trees in the citrus canker era. Citrus Industry (December 2006).

Sauls, J.W., 2008. *Citrus* Orchard Establishment. Texas Agri Life Extension Service.

Schumann, A., Hostler, K., Waldo, L., 2012. Advanced citrus production systems-grove designs for higher efficiencies. Citrus Industry (September 2012).

Schumann, A., Singerman, A., Wright, A.L., Ferrarezi, R.S., 2017. *Citrus* under Protective Screen (CUPS) Production Systems. EDIS HS1304. Horticultural Sciences Department, UF/IFAS Extension.

Talón, M., Hedden, P., Primo-Millo, E., 1990. Gibberellins in *Citrus sinensis*: a comparison between seeded and seedless varieties. J. Plant Growth Regul. 9, 201–206.

Talón, M., Zacarías, L., Primo-Millo, E., 1992. Gibberellins and parthenocarpic ability in developing ovaries of seedless mandarins. Plant Physiol. 99, 1575–1581.

Talón, M., Juan, M., Soler, J., Agustí, M., Primo-Millo, E., 1999. Criterios de racionalización de las aplicaciones de ácido giberélico para mejorar el cuajado de los frutos cítricos. Levante Agrícola 347, 128–133.

Taverner, P., Hardiyanto, A., Gunner, L., Shepherd, K., Morey, P., Andri, K.B., Ratule, T., Dewayani, W., Murdolelono, B., 2011. Market Development for *Citrus* From Eastern Indonesia. Australian Center for Agricultural Research, Canberra, Australia, ISBN: 978-1-921738-91-3.

Tucker, D.P.H., Wheaton, T.A., 1978. Trends in higher density plantings. Proc. Fla. State Hort. Soc. 91, 36–40.

Tucker, D.P.H., Wheaton, T.A., Muraro, R.P., 1991. *Citrus* Tree Spacing and Pruning. Florida Cooperative Extension Services. IFAS-University of Florida. SP. 74. 15 p.

Vashisth, T., Zekri, M., Alferez, F., 2017. Canopy Management of *Citrus* Trees. EDIS HS1303. Horticultural Sciences Department, UF/IFAS Extension.

Verreyne, J.S., Lovatt, C.J., 2009. The effect of crop load on budbreak influences return bloom in alternate bearing 'pixie' mandarin. J. Amer. Soc. Hort. Sci. 134 (3), 299–307.

Wallerstein, I., Goren, R., Monselise, S.P., 1978. Rapid and slow translocation of 14C-sucrose and 14C-assimilates in *Citrus* and Phaseolus with special reference to ringing effect. J. Hortic. Sci. 53, 203–208.

Wheaton, T.A., 1986. Alternate bearing. In: *Citrus* Flowering, Fruit Set, and Development. University of Florida Citrus Short Course, pp. 67–72.

Wheaton, T.A., 1992. Alternate bearing of citrus. Proc. Int. Seminar Citriculture 1, 224–228.

Wheaton, T.A., 1997. Alternate bearing of *Citrus* in Florida. In: *Citrus* Flowering and Fruiting Short Course, pp. 87–92.

Wheaton, T.A., Whitney, J.D., Castle, W.S., Tucker, D.P.H., 1986. Tree spacing and rootstock affect growth, yield, fruit quality, and freeze damage of young 'Hamlin' and 'Valencia' orange trees. Proc. Fla. State Hort. Soc. 99, 29–32.

Wheaton, T.A., Whitney, J.D., Castle, W.S., Muraro, R.P., Browning, H., Tucker, D.P.H., 1995. Tree vigor important in citrus tree spacing and topping. Proc. Fla. State Hort. Soc. 108, 63–69.

Whitney, J.D., Elezaby, A., Castle, W.S., Wheaton, T.A., Littell, R.C., 1991. *Citrus* tree spacing effects on soil water use, root density, and fruit yield. Trans. ASAE 34, 129–134.

Whitney, J.D., Wheaton, T.A., Castle, W.S., Tucker, D.P.H., 2003. Tree skirting effects on yield and quality of Valencia oranges. Proc. Fla. State Hort. Soc. 116, 236–239.

Zaragoza, S., Trenor, I., Alonso, E., Primo-Millo, E., Agustí, M., 1992. Treatments to increase the final fruit size on Satsuma 'Clausellina'. Proc. Int. Soc. Citriculture 2, 725–728.

Zaragoza, S., Trenor, I., Medina, A., 2003. Influence of manual pruning on citrus fruit quality and production. Proc. Int. Soc. Citriculture I, 513–514.

Zekri, M., 2000. Evaluation of orange trees budded on several rootstocks and planted at high density on flat woods soil. Proc. Fla. State Hort. Soc. 113, 119–123.

Zekri, M., 2015. Mechanical Pruning of *Citrus* Trees. EDIS HS1267. Horticultural Sciences Department, UF/IFAS Extension.

Zekri, M., Albrecht, U., Vincent, C., Vashisth, T., 2017. Grove Planning and Establishment. EDIS HS1302. Horticultural Sciences Department, UF/IFAS Extension.