Increasing yield through high-density plantings

By Rhuanito Ferrarezi, Alan Wright and Arnold Schumann

High-density plantings have been tested worldwide in advanced citrus production systems (ACPS) to increase efficiency of water, fertilizer and light, and to maximize yield per area. After the onset of huanglongbing (HLB) in Florida, canopy growth reduced drastically due to negative impacts on plant health, creating the need for new plant spacing recommendations for increased yield.

Since the most common tree densities were established for healthy trees, the use of narrower spacing between and within rows has become necessary to convert biomass into fruit more efficiently. Closer tree spacing is key to increasing yield per acre and profitability. However, as indicated by Pete Spyke, Bill Castle and Ed Stover (http://citrusindustry.net/2018/07/31/the-sweet-spot), finding the adequate plant spacing is the key. Rootstock choice also plays an important role since rootstocks induce or control tree growth.

This article describes the most recent high-density planting studies focused on staggered planting in a diamond set at the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Indian River Research and Education Center (IRREC). The article also revisits the ACPS research conducted by the UF/IFAS Citrus Research and Education Center (CREC) from 2008 to 2014.

IRREC ORANGE RESEARCH

Since 2013, researchers have conducted a series of studies to evaluate the effect of planting densities in round orange and grapefruit in the Indian River Citrus District.

Valencia round orange trees on Kuharske rootstock were planted in September 2013 to evaluate the combination of tree density, fertilization method and irrigation systems in tree growth and fruit yield. Three treatments were tested in a randomized complete block design with eight replications:

1. STD_dry_MS: standard tree spacing (12.5 by 23.5 feet, 145 trees per acre) + controlled release fertilizer (Harrell's 18-3-20) applied thrice a year at 200 pounds nitrogen per acre per year + one microsprinkler per tree [16.7 gallons per hour (gph) at 20 pounds per square inch (psi)]
2. HDS_fert_MS: high-density staggered spacing in diamond set [(9 by 5 by 3 feet) by 20 feet, 386 trees per acre] + water-soluble fertilizer (Agrolution pHLow 15-11-31 + 0.75 magnesium) applied weekly through fertigation at 200 pounds nitrogen per acre per year + one

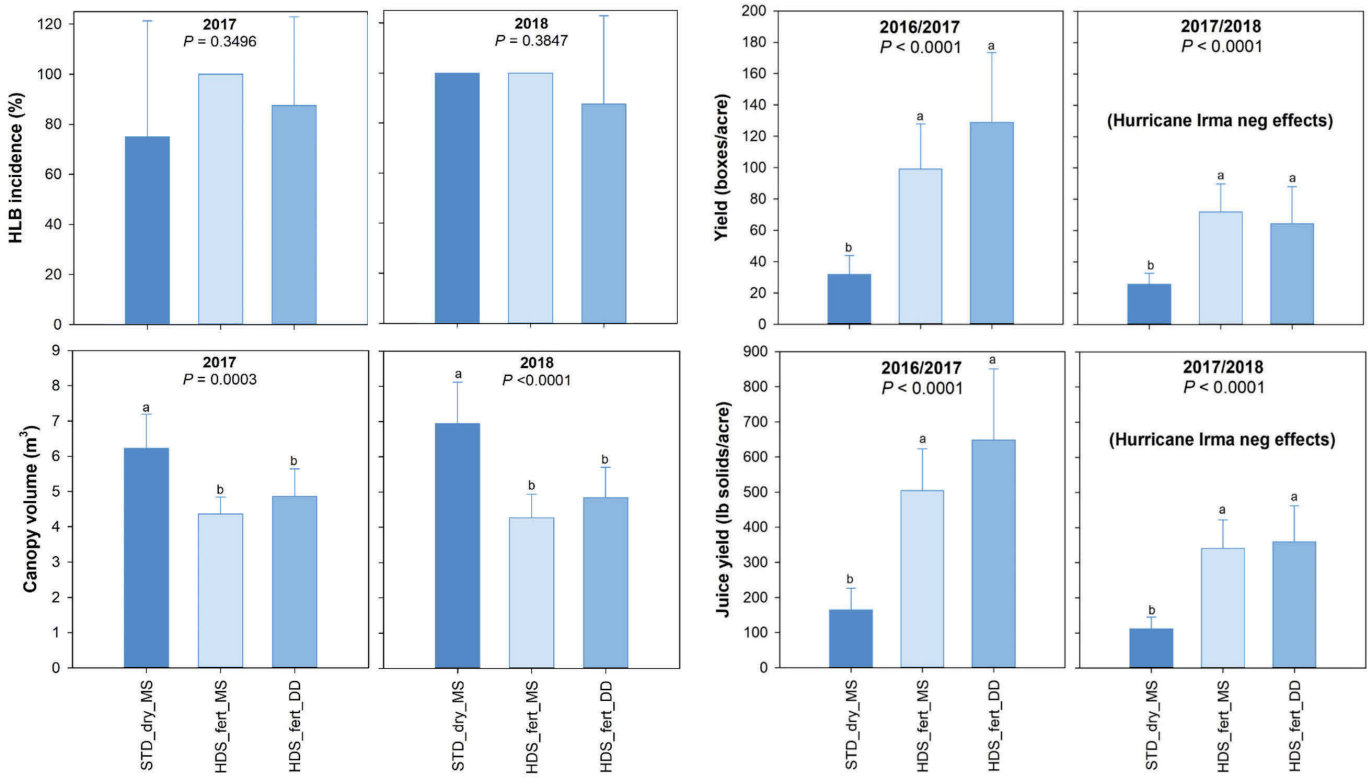


Figure 1. HLB disease incidence, canopy volume, fruit yield and pound solids per acre of Valencia on Kuharske planted at the UF/IFAS IRREC in September 2013. STD = standard spacing, HDS = high-density staggered spacing, dry = dry granular control release fertilizer, fert = fertigation, MS = microsprinkler and DD = double drip irrigation.

microsprinkler per two trees (16.7 gph at 20 psi)

3. HDS_fert_DD: high-density, staggered spacing in diamond set + fertigation + drip irrigation [two driplines per row (0.58 gph at 10 psi) at 12-inch spacing]

HLB incidence increased through time and reached 100 percent within four years after planting (Figure 1, page 8). Canopy volume per tree was larger in the treatment with lower density (145 trees/acre) in comparison to high-density staggered plantings at 386 trees per acre, irrespective of the irrigation system used. Staggered, higher plant density resulted in four times the fruit yield per acre in 2016–17 and three times as much in 2017–18 (Figure 1, page 8). Another result of this treatment was higher quality fruit, producing greater than 3 times soluble solids per area. This represents an important advantage to the juice-processing industry and indicates the long-term benefits of high-density designs in the Indian River.

However, labor cost, weed control and long-term growth effects of staggered high-density plantings still need to be determined before commercial recommendation. Staggered planting does require more hand weeding or spot spraying in cases where the spray boom cannot reach.

IRREC GRAPEFRUIT RESEARCH

Ray Ruby grapefruit trees on Kuharske were also planted in September 2013 to evaluate the effect of different tree spacing (standard and high density) on fruit yield and quality in the Indian River. Researchers tested three plant density treatments in a randomized complete block design with eight replications. All treatments received controlled release fertilizer (Harrell's 16-3-20):

1. SR/LD: single-row, low-density tree spacing (15 by 23 feet, 119 trees per acre) + one microsprinkler per tree (10.7 gph at 20 psi)
2. SR/HD: single-row, high-density tree spacing (10 by 23 feet, 173 trees per acre) + one microsprinkler per tree (10.7 gph at 20 psi)
3. DR/HD: double-row staggered in diamond set, high-density tree spacing [(9 by 5 by 3 feet) by 20 feet, 393 trees per acre) + one microsprinkler per two trees (10.7 gph at 20 psi)

HLB disease incidence reached 100 percent in grapefruit within four years after planting (Figure 2). Staggered, higher-density plantings resulted in lower canopy volume in comparison to single-row plantings. However, fruit yield was 40 percent greater in two consecutive years (including the year Hurricane Irma caused major fruit drop), indicating the potential of high-density plantings to increase yield and representing an important advantage to the fresh industry (Figure 2).

High-density plantings increased fruit yield and quality in young groves under the same fertilizer source (controlled release) and irrigation (microsprinkler), representing an important advance to grapefruit production systems. However, high weed pressure, increased labor costs for weeding and effect on plant growth over time still need to be determined before commercial recommendation.

ADVANCED CITRUS PRODUCTION SYSTEM STUDY

An open hydroponics, high-density Hamlin orange experiment was established in 14 acres of commercial grove (Gapway Groves, Auburndale) during 2008. This ACPS project was funded by the Citrus Research and Development Foundation (CRDF) to evaluate improved citrus establishment and growing methods to survive HLB-endemic conditions in Florida. The main treatments of the replicated experiment included two rootstocks (Swingle and C35), three planting

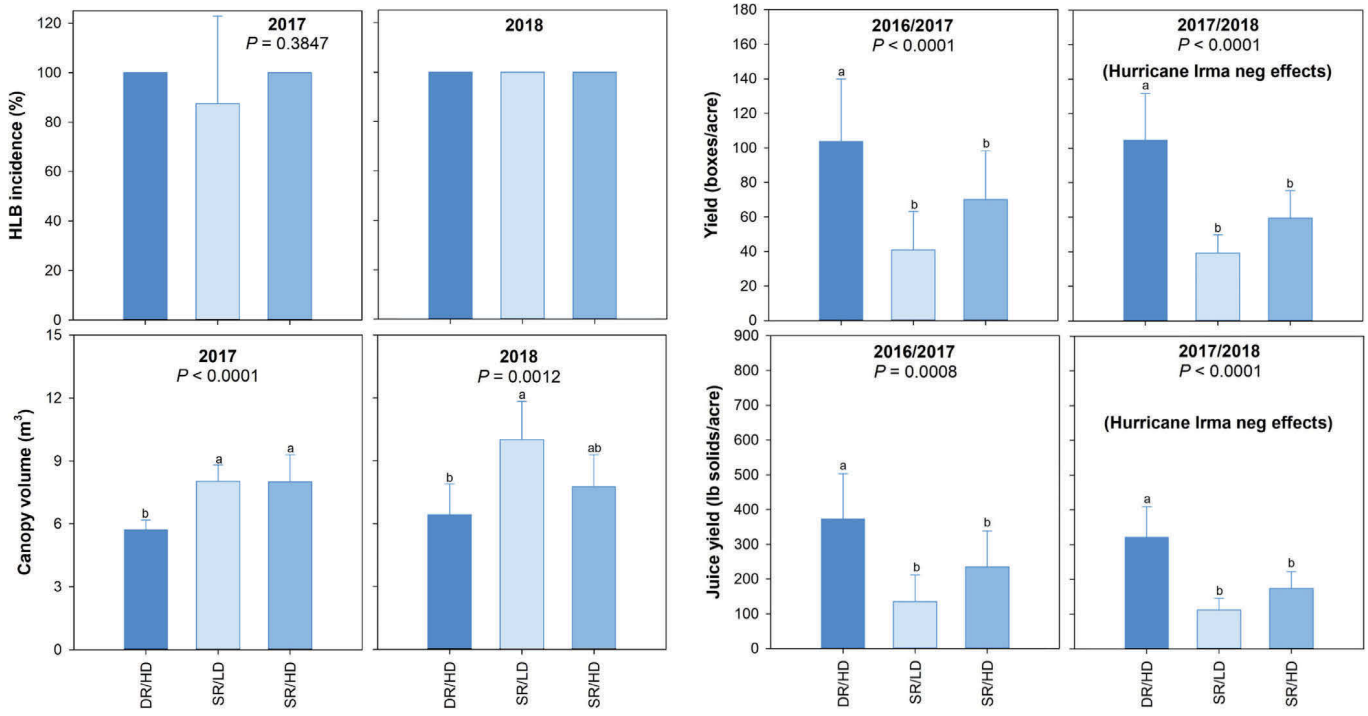
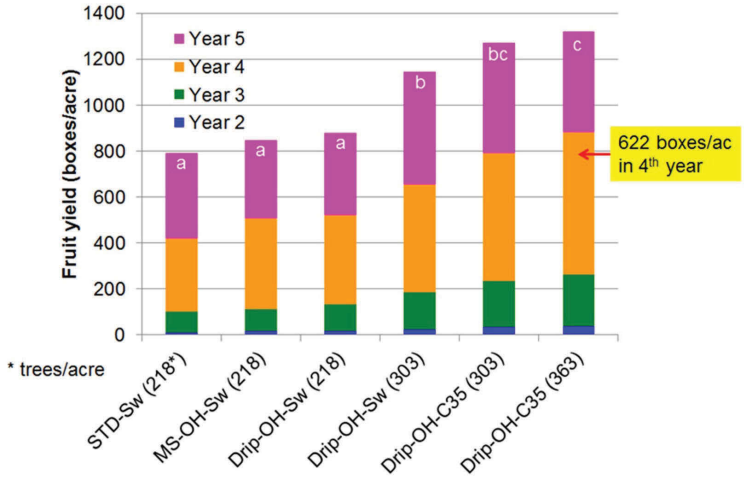


Figure 2. HLB incidence, canopy volume, fruit yield and pound solids per acre of Ray Ruby grapefruit on Kuharske planted at the UF/IFAS IRREC in September 2013. SR/LD = single-row, low-density planting, SR/HD = single-row, high-density planting and DR/HD = double-row staggered in diamond set, high-density planting.



Legend of treatment labels:

(1) STD-Sw (218) = standard control, 10' x 20' planting density (218 trees/acre), Swingle rootstock, IFAS-recommended dry soluble fertilization and grower-scheduled irrigation with microsprinklers

(2) MS-OH-Sw (218) = Advanced daily hydroponics fertigation using microsprinklers, 218 trees/acre, Swingle rootstock

(3) Drip-OH-Sw (218) = same as (2) but with two drip emitters /tree instead of microsprinklers

(4) Drip-OH-Sw (303) = same as (3) but with 8' x 18' planting density (303 trees/acre)

(5) Drip-OH-C35 (303) = same as (4) but with the C35 rootstock

(6) Drip-OH-C35 (363) = same as (5) but with 8' x 15' planting density (363 trees/acre)

Figure 3. Cumulative fruit yields for the Hamlin orange ACPS experiment in Auburndale, Florida. Treatment yields identified with different letters (a-c) are significantly different from each other.

densities (218, 303 and 363 trees per acre), two sources of fertilizer (liquid fertigation and dry soluble) and two types of irrigation (drip and microsprinkler).

The experiment control was designed to represent common baseline grower practices at the time (treatment 1: Swingle, microsprinkler, dry soluble fertilizer and 218 trees per acre). Details are provided in Figure 3, which summarizes four years of fruit yield.

Increasingly, intensive production practices (treatments 2 to 6) cost more than the standard grower control, but important yield increments were recorded for each additional enhancement. As shown in Figure 3, statistically significant yield increments were achieved for increases in planting density.

C35 improved fruit yield compared to Swingle rootstock. As expected, when both planting density and rootstock were changed (363 trees per acre and C35, treatment 6), the best yields were obtained, and were significantly higher than yields in the 303 trees per acre on Swingle (treatment 4). Fertigation produced small, nonsignificant yield increments compared to standard dry soluble fertilizer. Likewise, yield increases for drip irrigation versus microsprinkler were nonsignificant.

Despite not all treatment effects producing significant yield increments, it is important to note that an ACPS uses additive layers of technology to produce a hybrid system with significantly enhanced cumulative yields. By year 5, the cumulative yield increase of the best treatment (6) over the control (1) was about 550 boxes per acre. The changed technologies that made the yield increases possible were 145 additional trees per acre, a different rootstock (C35) and the use of daily drip fertigation by open hydroponics.

The change in technology often seems simpler than it is in practice. For example, there are additional "hidden costs" associated with managing a higher-density grove. These include the need for smaller farm machinery, possible difficulties during harvesting, longer distances to travel while spraying or fertilizing (resulting in higher machinery costs and labor time), and the inability to protect drip-irrigated groves during freeze events. However, in this era of endemic HLB, newly planted trees are partially stunted by the time they reach productive age, and using all the ACPS technologies mentioned above makes perfect sense to boost establishment growth, overall health, vigor and fruit yields.

TAKE-HOME MESSAGES

Selecting the best tree spacing is probably the most important of many factors that will influence the performance and profitability of a new grove. In Florida, the situations which could influence tree spacing include HLB-affected trees, the possibility of tolerant rootstock/scion combinations, intensive fertilization programs using fertigation or controlled release products, intensive foliar nutrition, anti-insect protective tree bags, trees grown in citrus under protective screen, citrus established with drip fertigation and reflective mulch, and citrus planted in staggered diamond-set rows.

When a grove matures, a planting density that is too high could be just as detrimental as one that is too low. If the chosen higher planting density can be calculated to offset most of the losses of canopy growth expected due to HLB, then that density is likely to succeed and not become problematic as the grove matures.

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