Effect of planting density and enhanced nutrition on grapefruit

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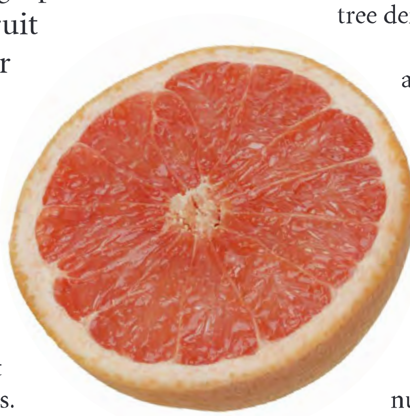
The Indian River District is the world's premier grapefruit production region due to a warm, ocean-facing humid climate and Flatwoods soils. The geographical location leads to the production of fruit with thin rinds and exceptional juice and color that has been a high-value export delicacy in Europe and Asia. However, destructive hurricanes and huanglongbing (HLB) disease have been severely harming the grapefruit industry since 2004 (Figure 1).



MANAGEMENT METHODS

HLB-affected citrus trees show severe leaf nutrient deficiencies such as magnesium, iron, manganese and zinc that are clear symptoms of inadequate nutrition. This is a direct result of HLB's effects on plant physiology and reduction in root volume. With fibrous root loss, trees have poor nutrient uptake from the soil. It is well known that small doses and frequent application (spoon-feeding) of liquid or controlled-release fertilizer (CRF) result in higher sweet orange yields.

HLB-affected citrus trees have smaller canopy volumes and lower fruit yield. Despite the reduced productivity, growers have increased production costs to control the HLB disease insect vector, the Asian citrus psyllid, and the bacteria causing the disease, *Candidatus* Liberibacter asiaticus. The lower yield per tree and the increase in production costs have influenced grower decisions to increase tree density to get early returns on investment and stay in business.

In the Indian River District, a region well-known for poorly drained soils with low water- and nutrient-holding capacities, grapefruit is cultivated in raised beds due to high water tables (Figure 2A, page 19). Adjusting density in single-row plantings is challenging because it requires changing the raised bed width, which increases production costs quite drastically. Staggered planting in a diamond set is a potential solution for those limitations since the original bed width can still be used while increasing the tree density (Figure 2B, page 19).

There is limited information available about the effects of CRF and tree spacing on grapefruit tree health, fruit yield and fruit quality in the Indian River District. This article describes the responses of 1) soil application of fertilizer blends with different sources and rates of macronutrients and micronutrients and 2) use of higher density tree planting for greater fruit yield and fruit quality. Tree growth, nutrient content and fruit size were also measured but not reported.

TREATMENTS TESTED

The treatment combinations of two fertilizer blends and three planting densities were tested for two seasons (2017–18 and 2018–19) at

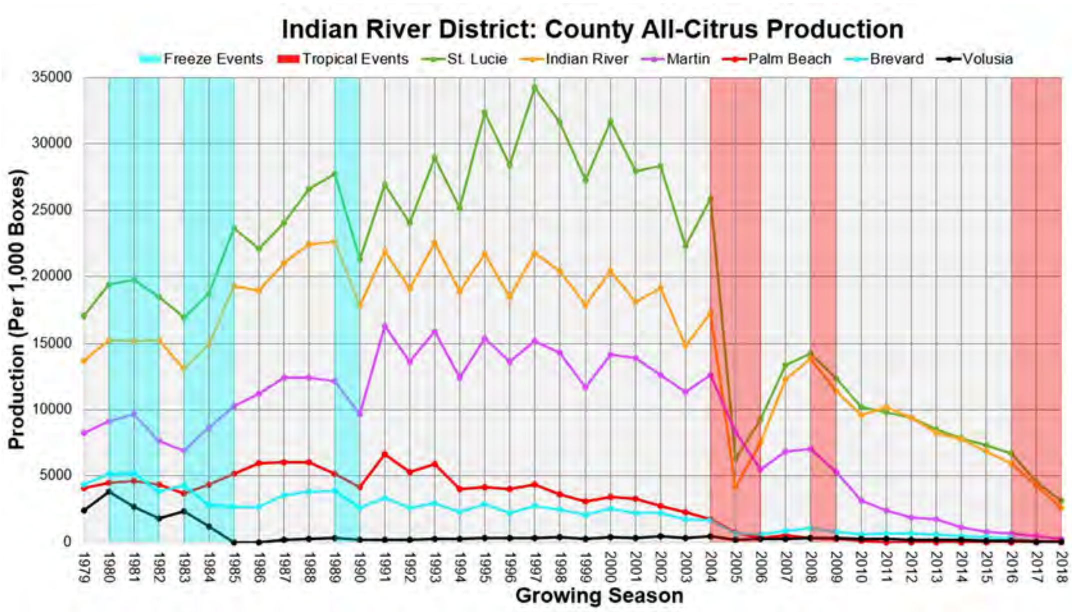


Figure 1. Citrus production in the Indian River District over the last 40 years.

Source: Ferrarezi et al., 2019, https://doi.org/10.1002/wea.3512

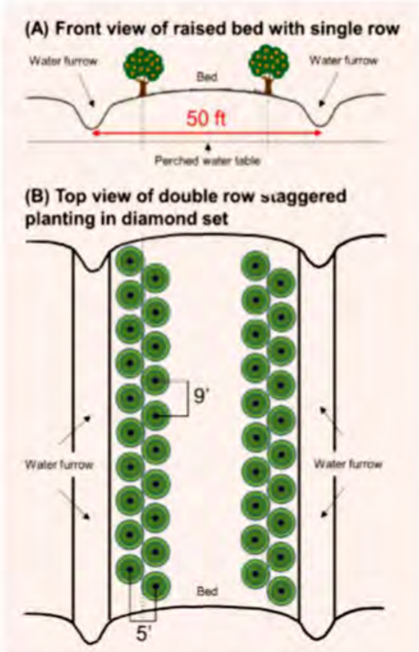


Figure 2. (A) Raised bed used for citrus production in the Indian River District. (B) Experimental setting with a high-density double row staggered in diamond set (393 trees/acre).

the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Indian River Research and Education Center (IRREC) in Fort Pierce (Table 1, page 20). Treatments were applied in February, July and October on young Ray Ruby grapefruit on Kuharske rootstock planted in September 2013. The trial was designed as a randomized complete block with four replications.

STUDY FINDINGS

Trees have been infected with HLB since 2016, and the tested treatments did not change the disease status of Ray Ruby grapefruit on Kuharske rootstock (Table 2, page 21). The application of 12-3-9 fertilizer and the increased planting densities decreased trunk diameter and canopy volume, while the increase in planting densities also decreased yield per tree and total number of fruit. We obtained higher fruit yield (104.7 boxes/acre in 2017–18 and 72.3 boxes/acre in 2018–19), soluble solids content or Brix (8.1 percent in 2017–18) and acidity (1.2 g/100 mL in 2018–19) with 393 trees/acre (Table 2).

Fruit yield is low because trees are still young. Hurricane Irma impacted the tree performance and caused large fruit drop, and the rootstock used

Table 1. Treatment combinations tested for two seasons (2017–18 and 2018–19) at the UF/IFAS Indian River Research and Education Center in Fort Pierce

	Planting Densities		
	119 trees/acre (low-density single row spacing at 15 x 23 feet)	173 trees/acre (high-density single row spacing at 10 x 23 feet)	393 trees/acre (high-density double row staggered in diamond set at [(9 x 5 x 3) x 20 feet]
Fertilizer Programs	16-3-20 controlled-release fertilizer (CRF) (16N-1.31P-16.6K) with 81 percent nitrogen and 50 percent potassium as CRF with iron as chelates and all other micronutrients as sulfates at 1x the UF/IFAS recommendations		
	12-3-9 CRF (12N-1.31P-7.47K) with 100 percent nitrogen, 100 percent phosphorus and 95 percent potassium as CRF with iron as chelates and all other micronutrients as sulfur-coated products at 2x the UF/IFAS recommendations		

induces low yields in the Indian River.

The 12-3-9 blend with micronutrients as sulfur-coated products at 2x the UF/IFAS recommendations resulted in higher leaf calcium, sulfur and manganese and higher soil manganese. The 16-3-20 blend with micronutrients as sulfates at 1x the UF/IFAS recommendations resulted in higher leaf phosphorus, potassium, calcium, sulfur and boron and higher soil pH, magnesium and boron.

Results indicate no effect yet of enhanced nutrition with micronutrients as sulfur-coated products at 2x the UF/IFAS recommendations on grapefruit with HLB disease over a period of two years. The possible effect over time is still unknown.

Fertilization with balanced nitrogen and potassium rates is key for maximizing grapefruit yield and quality. Higher tree density plantings at 393 trees/acre increased fruit yield by approximately 2.5x. More research is needed to study long-term effects, the influence of other rootstocks and scion varieties, and different plant-density combinations.

UF/IFAS researchers are also conducting a similar study evaluating planting density, CRF applied in ground and supplemental foliar nutrition with increased rates of boron, manganese and zinc. Foliar nutrient application is vital for perennial crops when nutrient demand is high and soil supply is not enough to match uptake. Preliminary results indicate that supplemental foliar micronutrient application more than 1.5x the UF/IFAS recommendation is negative to grapefruit yield and total number of fruit.

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Table 2. Cycle threshold (Ct) value of *Candidatus* Liberibacter asiaticus DNA, fruit yield, soluble solids and acidity of young Ray Ruby grapefruit on Kuharske rootstock trees planted in September 2013 under different fertilizer programs and plant density spacing

Treatments	Ct Value		Fruit Yield (Boxes per Acre)		Soluble Solids Content or Brix (percent)		Acidity (g/100 ml)	
	2017	2018	2017	2018	2017	2018	2017	2018
Fertilizer								
16-3-20*	25.4	25.4	77.3 A	43.0	8.0 A	8.0	1.1	1.0
12-3-9**	26.0	24.7	58.6 B	52.2	7.6 B	8.1	1.0	1.1
Plant Density (Trees/Acre)								
119	27.7	25.1	39.7 C	27.8 B	7.7 B	7.6	1.1	1.0 B
173	23.9	25.3	59.4 B	42.7 AB	7.8 AB	8.0	1.0	1.0 B
393	25.6	24.8	104.7 A	72.3 A	8.1 A	8.6	1.0	1.2 A

* 16-3-20 controlled-release fertilizer (CRF) (16N-1.31P-16.6K) with 81 percent nitrogen and 50 percent potassium as CRF with iron as chelate/humate/sulcrate and all other micronutrients as sulfates at 1x the UF/IFAS recommendations

** 12-3-9 CRF (12N-1.31P-7.47K) with 100 percent nitrogen,100 percent phosphorus and 95 percent potassium as CRF with iron as chelates and all other micronutrients as sulfur-coated products at 2x the UF/IFAS recommendations.

Means with different letters are significantly different from each other.

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