Figure 1. A Valencia/sour orange trial planted in 2013 compares different injection methods and oxytetracycline rates.

Research update on oxytetracycline injection for HLB management

By Ute Albrecht

The German scientist Paul Ehrlich pioneered the research for "magic bullets" — chemicals that could kill a microorganism but did not harm the patient. He also coined the term "chemotherapy" and paved the way for developing synthetic drugs.

The first synthetic antibiotic (the first sulfa-type antibiotic) to successfully treat human bacterial diseases without major side effects was available in 1935. The first natural antibiotic, penicillin, was not available until the 1940s, even though it was discovered in 1928. Around the same time, other natural antibiotics were discovered, including streptomycin and oxytetracycline. This began the golden era of antibiotics. These molecules were indeed magical as they cured previously incurable bacterial diseases and wound infections, saving countless lives.

Antibiotics were approved for use in agriculture in the 1950s and have been employed extensively since, especially in livestock production. In comparison, the amount of antibiotics used in plant agriculture represents less than 1%. Currently, streptomycin and oxytetracycline are the most dominant antibiotics used in crop production. They are usually applied by spray.

Huanglongbing (HLB), or citrus greening, is an especially difficult to cure bacterial disease. This is because the bacteria reside in the vascular system (i.e., the phloem) and inhabit all tree organs, including the leaves, fruit, twigs, trunk and roots. Foliar sprays of antibiotics are not effective against

the HLB-associated bacteria since they do not penetrate the leaf cuticle easily.

One way to deliver pesticides directly into the tree vascular system (i.e., the xylem) is by trunk injection. If mobile and formulated properly, injected pesticides are then transported throughout the tree with the transpiration stream and may also enter the phloem where the HLB bacteria reside.

ONGOING STUDIES

The plant physiology program at the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Southwest Florida Research and Education Center (SWFREC) in Immokalee has conducted numerous field studies since 2020. These studies found that oxytetracycline (OTC) formulated for injection can reduce fruit drop, increase fruit yield and improve fruit quality significantly. The positive effects were particularly striking in younger trees.

The trees in ongoing trials are all sweet orange. These trials have several objectives. They include a comparison of the injection method that has been used in past research studies and the method recommended on the label that was approved in October 2022. Different rates of OTC, different months of injection and other factors are also being investigated.

Oxytetracycline formulated for injection can reduce fruit drop, increase fruit yield and improve fruit quality significantly.

The results from these studies have been consistently positive so far. Yield increases of 30% or higher were routinely observed, along with significant increases (10% to 20%) in juice Brix, fruit size and coloration after one injection. However, results are variable among trees and even

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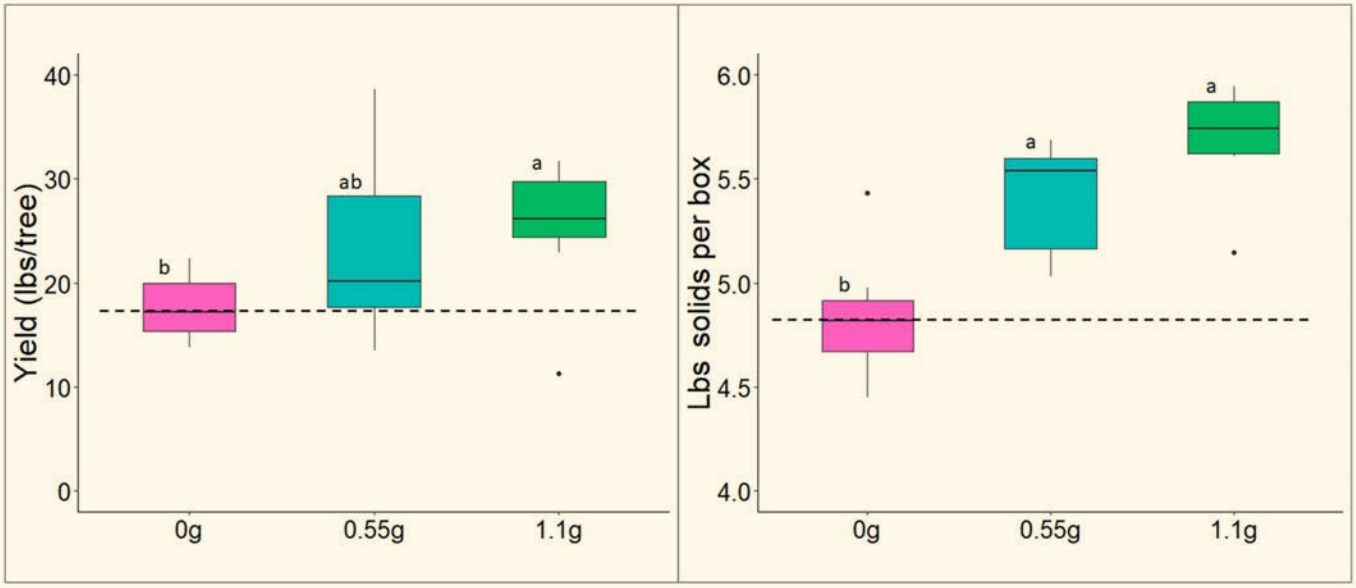

Figure 2. Valencia/sour orange yield and pounds solids were recorded after injecting 0.55 or 1.1 grams of oxytetracycline per tree using the FlexInject method.

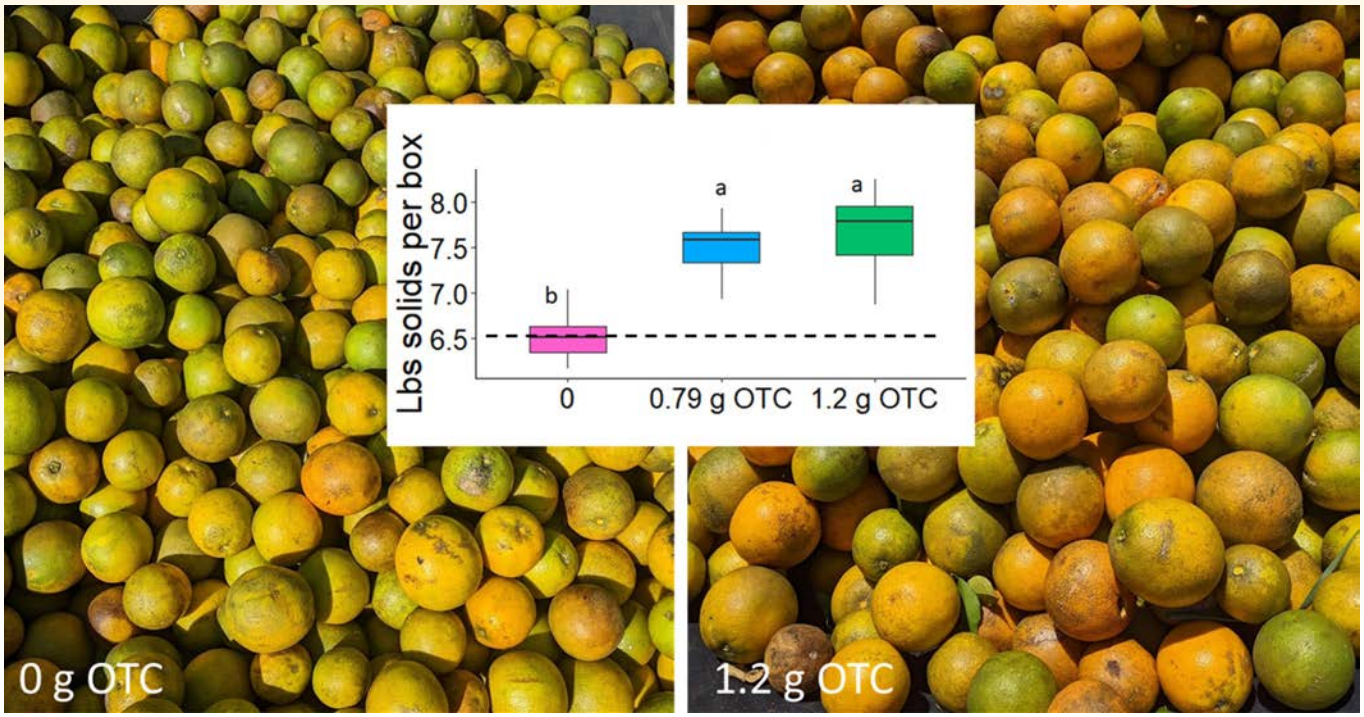

Figure 3. Harvested fruit from injected trees have more pounds solids and are larger and better colored. The Chemjet method was used in this Valencia/Carrizo trial in Southwest Florida.

between different parts of the canopy within the same tree. Tree age and location-specific factors also influence trial outcomes.

In a trial near Fort Pierce, Florida, 9-year-old Valencia/sour orange trees were injected using Chemjet tree injectors (spring-loaded syringes) or FlexInject injectors (Figure 1, page 8). Two different rates were compared: 0.55 grams OTC or 1.1 grams OTC per tree. When using the FlexInjects, a volume of 100 milliliters was injected on one side of the rootstock trunk. When using the Chemjets, a volume of 20 milliliters each was injected on two opposite sides of the scion trunk (40 milliliters total).

Injections were conducted in June. Fruit quality was determined in the last week of March 2023. Fruit were harvested in the first week of April 2023. Researchers measured increases in yield of up to 70% (Figure 2) using either method. A slightly lower yield was measured when the lower rate (0.55 grams/tree) was applied using the FlexInject method. The juice Brix or pounds solids was improved by 10% to 18%, regardless of the injection method. Although not statistically significant, there was a trend for the higher rate to induce more pounds solids.

In a trial in Southwest Florida near Felda, 8-year-old Valencia/Carrizo trees were injected either in April or June using either 0.79 or 1.2 grams of OTC per tree. All trees were injected using the Chemjet method. In this trial, the yield was improved by up to 50%, but the higher rate (1.2 grams)

was no better than the lower rate (0.79 grams), and it did not matter if the trees had been injected in April or in June. The pounds solids were improved by 15% to 18%, regardless of the rate and the month of injection. Fruit size, weight and color also improved (Figure 3, page 10).

In a trial with 4-year-old Valencia/X639 trees, the yield was positively correlated with the rate of injected OTC (0.15 to 0.75 grams per tree). Fruit yield was generally not affected by the month of injection (May or August). However, fruit were larger when trees were injected in May, and juice Brix was higher when trees were injected in August. Increasing the fruit maturation time (harvesting later) will likely increase the quality of the larger fruit. More experiments are being conducted to determine the best time for injections to maximize their efficacy.

OTHER OBSERVATIONS

To delineate the distribution pattern of injected materials, a pink dye (acid fuchsin) was injected into the trunk of mature citrus trees. After injection, the dye usually assumes a spiral pattern on its way into the canopy. A spiral ascent increases the chance for a uniform distribution.

Some leaves turned deeply pink within a few hours after injection, while others were speckled (resembling the "leaf bronzing" observed by some growers after OTC injection). Some leaves remained undyed. These dye studies demonstrate that not all parts of a tree may receive the same amount of injected material. This explains the often-varying responses to OTC injections in different parts of the canopy within the same tree.

New field trials have been initiated to compare different OTC rates and different months of injection in 18-year-old Valencia and Hamlin trees. Injection studies using three rootstock trials containing 8-year-old trees are also in progress.

One aspect of these studies is the comparison of rootstock and scion trunk injections. It was found the uptake rate is mostly influenced by the time of injection and the environmental conditions, but not by the injection location. Generally, the uptake rate is fastest during mid-to-late morning, under sunny conditions and when trees have been watered well. One probable advantage of injecting into the rootstock is that the OTC has more time to disperse within the trunk before reaching the canopy, increasing the likelihood of a uniform distribution.

Positive effects have consistently been observed after injecting OTC into HLB-affected citrus trees. But there is still much to learn. UF/IFAS will continue to provide new information from ongoing studies as soon as it is available.

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