The potential of thermotherapy in combating HLB

By Reza Ehsani, José I. Reyes De Corcuera and Lav Khot

Thermal treatment of trees or "thermotherapy" has been used for decades in small potted trees to kill micro-organisms and insects. A recent study published in *Phytopathology* showed that thermotherapy under a controlled greenhouse environment reduced HLB bacteria in seedlings and promoted healthy growth. Researchers and growers have taken this concept to the field on a small scale. By covering single trees with translucent plastic, tree canopies can be exposed to elevated temperatures. Thermal treatment of citrus trees in a grove is challenging because

- the critical temperature and time to kill HLB bacteria in the tree under field conditions is unknown,
- adoption by the industry will depend on the ability to treat numerous trees in a short period of time,
- higher temperatures that occur at the top of enclosed structures injure the top of the canopy, and
- the root system will escape the imposed heat treatment and will provide inoculum to re-infect the canopy.

Our team at the University of Florida's Citrus Research and Education Center (CREC), U.S. Department of Agriculture scientists in Fort Pierce and other scientists around the world are exploring thermotherapy to mitigate the effect of HLB on citrus trees. A key question that our research team is addressing is whether the level of HLB bacteria can be reduced to sustain the productivity of citrus trees in the short term until the ultimate solution is found.

The exact mechanism by which heat treatment kills the HLB bacteria is not known. Two mechanisms are possible: either directly killing it by heat or indirectly by activating a virus inside the bacteria. To apply thermotherapy in the field, it is critical to know the critical temperature and duration of exposure required to significantly reduce the microbial population without damaging the tree.

Figure 1. *An HLB-infected tree with heat treatment enclosure. The tree was fully covered during the thermotherapy process.*

SOLAR RADIATION SYSTEM

In 2012, we developed a prototype of a mobile system that used solar radiation to heat-treat HLB-infected trees in an orange grove. Within a plot of diseased trees, we covered only the trees that showed the most prominent HLB symptoms. Heat treatments are most effectively done from May to September when there is enough solar radiation to bring the canopy temperature to an ideal level. During these months, trees are acclimated to hot weather and can better tolerate thermotherapy.

We selected trees approximately 7 feet in height at the CREC groves in Lake Alfred that had visual HLB symptoms. Valencia trees were covered with translucent plastic (Figure 1), one tree per day, for a 5-hour heating period. In July of 2012, the temperature inside the enclosure reached 45°C (113°F) or higher for at least 4 hours. Temperatures of 50°C (122°F) or higher were recorded at a height of about 7 feet in April of 2013; the treated trees looked healthier than the surrounding untreated trees (Figure 2, see page 8). The trees shown in Figure 2 had HLB-symptoms and looked very similar to each other in May 2012, before the thermal treatment. Because of more cloud cover and cooler weather in late-summer (September of 2012), temperatures inside the enclosures did not reach 45°C (113°F) for as long as those treated in mid-summer. Trees treated in late-summer did not appear to be as healthy as the trees treated in mid-summer, but appeared healthier than infected untreated trees, suggesting that thermotherapy was effective in mitigating HLB symtoms.

YIELD AND JUICE QUALITY

Data from the April 2013 harvest

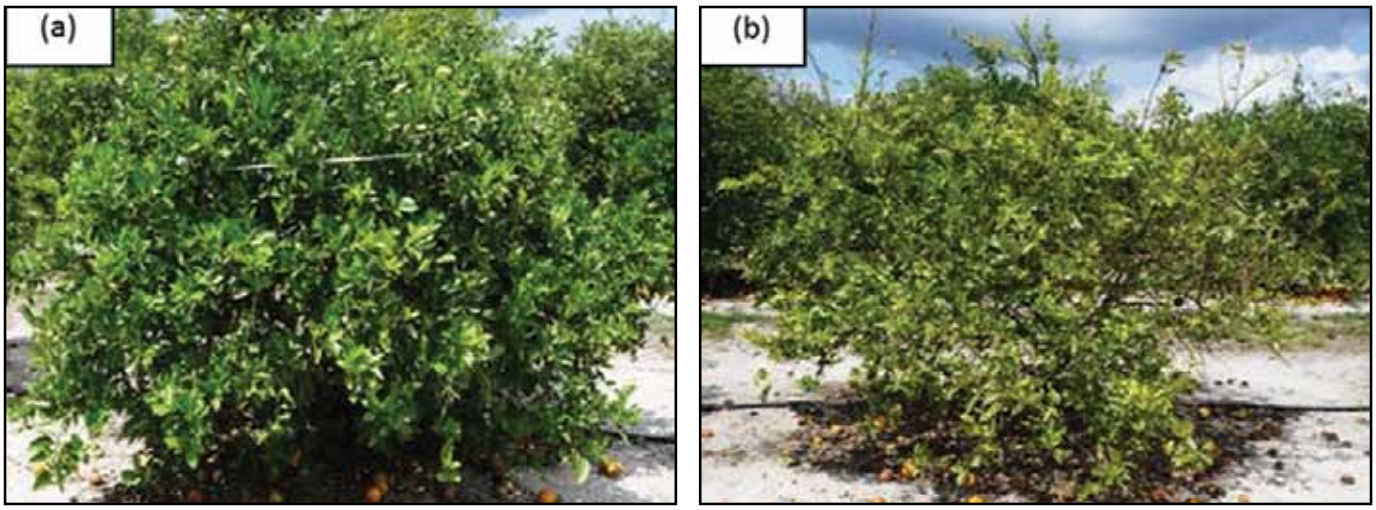

Figure 2. *Symptomatic mid-summer treated (a) [treatment date: July 10, 2012] and untreated (b) citrus canopies nine months after thermotherapy.*

showed that fruit yield (Figure 3) and juice quality from mid-summer treated trees were not different from that of apparently healthy control trees. Also, mid-summer treated trees had numerically higher yield than trees treated in late summer. Healthy control trees had the same mean soluble solids content (SSC) of 12.0 °Brix as trees that were treated in mid-summer. In contrast, untreated HLB symptomatic trees treated in late summer had a mean SSC of 11.3 and 11.0 °Brix, respectively. Significant fruit drop occurred in all trees, regardless of heat treatment.

Thermotherapy using a plastic tarp was relatively slow and weather dependent. Although healthier trees resulted from thermal treatment above 45°C (113°F) for four hours, it took two to three hours to reach that temperature under the most favorable conditions, particularly at the interior and lower sections of the enclosure. In one instance, when temperatures were low and conditions were windy, temperatures inside the enclosure varied by 13°C (55°F).

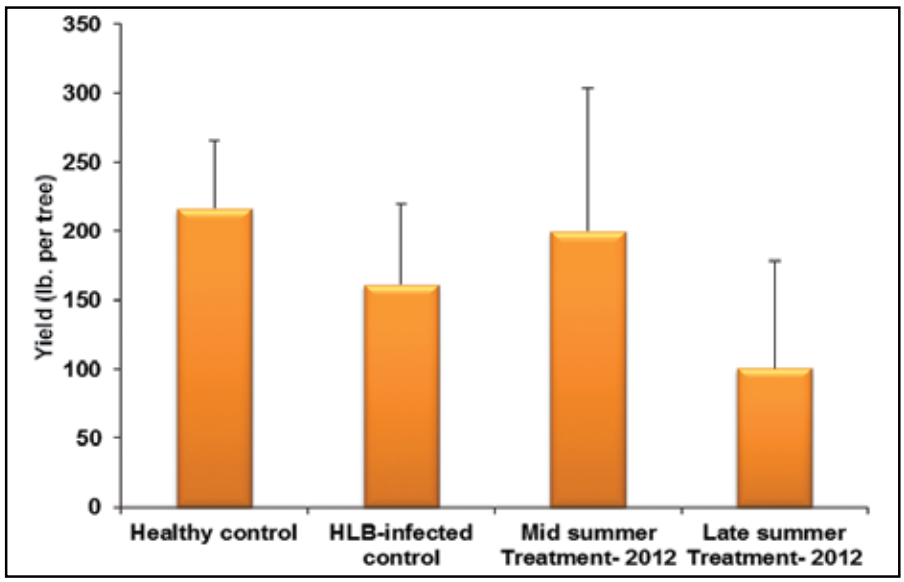

Figure 3. *April 2013 fruit yield (lb. per tree) for thermally treated and control Valencia orange trees.*

IMPROVEMENTS COMING

Control over the rate of heating in the enclosure and a method to achieve uniform temperature distribution is needed. A cloudy or rainy day in summer could significantly drop the temperature, thereby changing the effectiveness of thermotherapy. In our ongoing experiments, we are developing a rapid heating and circulation system to deliver uniform heat treatment to trees in an enclosure. Optimizing the temperature and time to treat the trees efficiently remains the next challenge. Would a tree survive if the temperature was raised and the time needed to reduce the bacterial population was reduced to seconds or minutes? That is the type of question that we will address this summer with the second year of our Citrus Research and Development Foundation-funded grant. Our future work will focus on critical time-temperature treatments and automating the process of applying temperature treatments rapidly to field trees.

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