Tenting and supplementary heat for thermotherapy of HLB trees

By Reza Ehsani and Cininta Pertiwi

Thermotherapy or heat treatment has begun to gain traction among citrus growers as a viable temporary alternative to sustain life of HLB-affected trees. There are several studies showing the effectiveness of thermotherapy for treatment of HLB-affected trees going back to 1965. All the previous studies tested thermotherapy for HLB within a laboratory scale. These studies utilized different means to provide heat to the plant such as solar radiation, hot water, hot water vapor and temperature-controlled growth chambers. The temperature of the medium is being controlled to reach the intended temperature.

EFFORTS USING TENTING

The simple principle of using solar radiation to heat-treat the trees, which involves low investment requiring only an enclosure or tent to cover the tree, is indeed an option in Florida. Tenting is currently the most common approach for applying thermotherapy for HLB in groves. There are several ways in which the tent can be developed. It can be built by covering a rigid frame with greenhouse plastic or heavy-duty tarp. The tent can also be in the form of a simple, large plastic bag covering a tree or multiple trees. Figure 1a shows tenting of a citrus tree covered with a 6 millimeter, green-tint polyethylene bag.

Two major issues with tenting are the lack of control on the amount and duration of heat treatment and the lack of uniformity of heat distribution. Usually the top of the tree gets hotter as the heat rises. Trees that are tented usually have dead top branches due to excessive heat. Also, variation in day-to-day temperature makes it difficult to get consistent results. The best way to maintain consistent results is to monitor the temperature of at least one of the tented trees. To get the benefit from tenting, the temperature inside the tent should reach and stay above 130°F for two hours, and the temperature should not exceed 140°F for more than 15 minutes. Extended amount of exposure to temperatures above 140°F results in significant leaf loss, which can delay the recovery of the trees, or it could kill them.

BENEFITS OF SUPPLEMENTARY HEAT

Several benefits of using supplementary heat rather than solar heat include uniformity and better temperature control. Uniformity means that the heat throughout the canopy is evenly distributed. Better control means that there is more

Figure 1: An example of a tenting treatment on small trees using a polyethylene bag. (a) A tree covered with a 6 millimeter, green-tint polyethylene bag. (b) A recovering tree after being treated two weeks prior for two hours maintained at 54°C (130°F).

Table 1: Advantages and disadvantages of using tenting, steam, dry hot air supplementary heat for in-field thermotherapy.

	Tenting	Supplementary Heat Sources	
		Steam	Dry Hot Air
Pros	▪ Very simple to apply ▪ Minimal equipment required ▪ Less financial investment than the other heat sources ▪ Good for small-scale treatment (10 – 20 trees)	▪ Fastest and most noticeable difference ▪ Less susceptible to weather variability ▪ Temperature and heating time can be controlled by the operator ▪ Temperature below the bark increases rapidly (only in a matter of seconds)	▪ Requires less time than tenting ▪ Temperature can be monitored and controlled ▪ A cheaper technology than using steam heat
Cons	▪ Requires a lengthy amount of time to raise the temperature of the tree (several hours to several days) ▪ Difficult to control and maintain the intended temperature ▪ Effectiveness is weather dependent	▪ Requires the most financial investment for the equipment and steam generator	▪ Although noticeably lower than tenting, the time needed to heat the trees to the required temperature is still lengthy (30 mins to several hours) ▪ The cost for an air heater is significant

freedom in determining and maintaining the temperature surrounding the canopy.

Weather variability becomes less of an issue compared to relying on the sun. It also provides the option of treating trees throughout the year rather than just the summer months.

Various sources of supplementary heat provide different heating results. Two sources that have been explored are dry hot air and steam. There may also be potential in using vaporized hot water as the heat source. Table 1 (page 8) provides comparisons between tenting with two supplementary heat sources — dry hot air and steam — for in-field thermotherapy use.

EFFORTS USING DRY HOT AIR

Using dry hot air for thermotherapy in the field is a good alternative to tenting when more control of the temperature is needed. With the ability to control and monitor the temperature under the tent, the treatment duration can be reduced dramatically compared to solar tenting. The method requires an air heater to be attached to the tent or enclosure. Efforts using dry hot air have included two types of air heaters — an infrared heater and a portable diesel, indirect forced hot air heater (Figure 2).

Experiments using dry hot air have shown that maintaining the air temperature under the tent at 55°C (131°F) for one hour is sufficient for the treatment. Higher temperatures such as 60°C (140°F) have shown to be harmful to the tree while lower temperatures of 45°C (113°F) and 50°C (122°F) did not show significant differences from untreated trees. Compared to the other combinations, this temperature/duration produced the highest fruit set, the largest fruit size and the largest leaves. After two years, the treatment of 55°C (131°F) for one hour produced the highest average yield value, which was significantly higher than the yield of HLB-affected trees that were not treated.

CURRENT FOCUS ON USING STEAM

Although dry hot air is a good option as supplementary heat, the thermotherapy team at the Citrus Research and Education Center is currently focused mainly on steam. Steam has the following advantages for use as the source of supplementary heat for HLB thermotherapy.

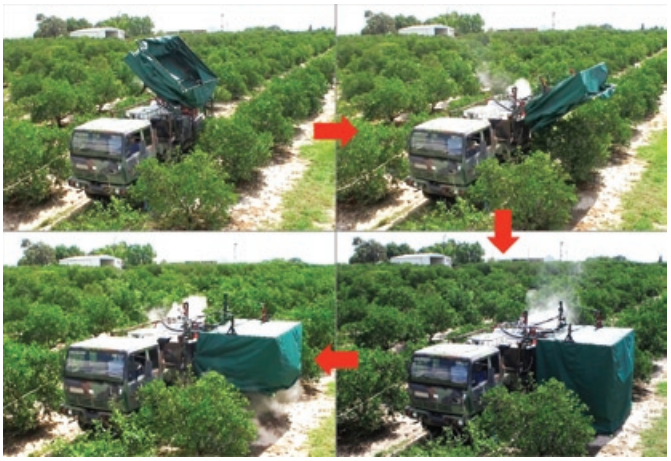
1) With steam, the temperature below the bark of the tree rises noticeably faster than using other sources of supplementary heat. This is important since the phloem layer that harbors the HLB bacterium is located just below the bark.

FAR LEFT: Figure 2: In-field thermotherapy using dry hot air as the heat source. An example of a system using a portable forced air heater to blow hot air into the enclosure.

LEFT: Figure 3: A system for in-field thermotherapy using steam as the heat source and a "goat" truck to mount the mechanical enclosure covering and steaming mechanism.

BELOW: Figure 4: A system for in-field thermotherapy using steam as the heat source mounted on a 5-ton surplus military truck (M1078).

FAR BELOW: Figure 5: Recovery progression of a tree after being treated with dry hot air thermotherapy.



2) Since steam requires only a matter of seconds to heat a tree, it is likely to have the most potential for continuous treatment of multiple trees in a large-scale commercial grove.

The team has developed steaming systems for thermotherapy of single trees in the field. Examples are shown in figures 3 and 4. The systems include a mechanically controlled enclosure which descends to cover the entire tree canopy. A steam generator, together with a water tank, is mounted on the bed of a truck. Steam from

the steam generator is then blown into the enclosure.

WHAT TO EXPECT

Results from applying thermotherapy are not instantly visible. It is common for some leaves to defoliate after a treatment. Within two weeks to one month, new flush will begin to appear replacing the fallen leaves. At this point, removing small dead branches will be beneficial. Figure 5 (page 10) shows the recovery progression of a tree after it was treated using dry hot air. It should also be noted that with appearance of new flush, it is very important to have a good psyllid and leafminer control program in place; otherwise the benefit of heat treatment will be minimal, and the chance of reinfection will significantly increase since new flush will attract psyllids to heat-treated trees.

ONGOING IMPROVEMENTS

The use of supplementary heat in thermotherapy, particularly steam, is still in the experimental stages, although it does seem to show promising results. There are still several issues that need to be addressed as improvements to the technique are continually being made.

- **Variability in the results between trees treated with the same temperature/duration combination.** These may be caused by factors such as the health of the tree itself and also its resistance to heat. It seems trees at an early stage of infection respond better to heat treatment.
- **Improving uniformity of the system.** Although it is easier to provide a uniform heat distribution with the use of steam, there have been results where only parts of the tree are heated.
- **Younger trees respond better and behave differently than older trees after being steamed**. This will also need further investigation.
- **Thermotherapy of both the tree canopy and the roots** might provide a more comprehensive treatment for the entire tree and may reduce chances of reinfection by bacteria harbored in roots.
- **Quantifying the level of the HLB-causing bacteria, *Candidatus Liberibacter asiaticus*, in the tree before and after steam treatment.** This information is critical to determine several factors, such as whether heat treatment causes significant reductions in bacterial levels in the trees, whether the treatment proves economically useful as an HLB management tool and how long before retreatment might be needed.

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