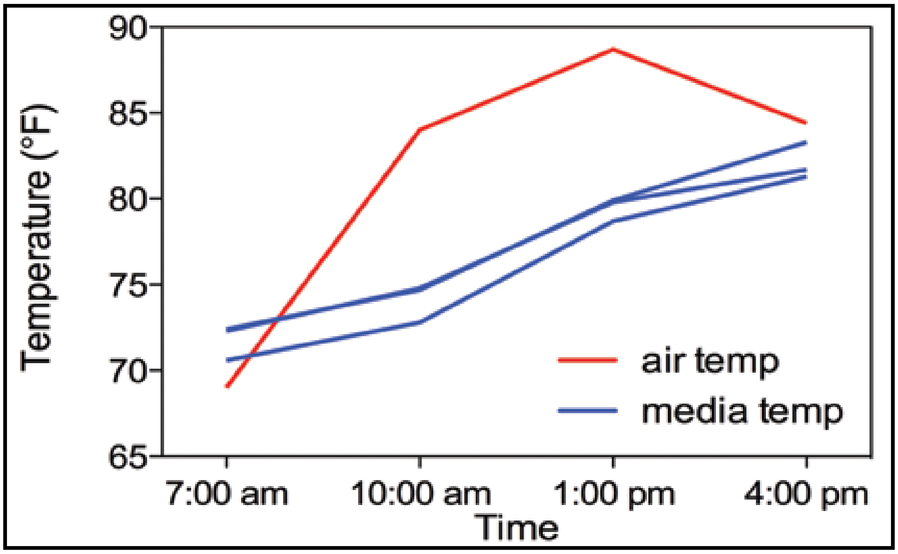

Figure 1. *The average daily temperature changes for air and container media (recorded at three different points within the nursery) during December 2008 in a Florida citrus nursery.*

The importance of maintaining root temperatures during the winter in Florida citrus nurseries

By Tim Spann

It is easy to recognize that air temperature is important for plant growth. The simple observation of temperate-zone trees that stop growing and go dormant in the fall tells us that. However, we don't often consider the temperature of the hidden half of a tree — the root system that resides below ground — and how that may impact growth.

In Florida, soil temperature, and thus root temperature, is usually not of major concern because the ground is well insulated, and our air temperatures do not drop low enough for long enough periods to cause severe drops in soil temperature. In nurseries, however, where trees are grown in containers suspended in air, it is very important to consider root temperatures. In this article, the importance of root temperature will be discussed in terms of the physiological responses of citrus trees to changes in root temperature and the effects on tree growth.

To the author's knowledge, no specific studies have been conducted to demonstrate the effects of different root temperatures on tree growth under today's Florida citrus nursery conditions. However, a fair amount of data from field studies exists, and observations made by researchers and nurserymen alike suggest that there's no reason to believe that citrus in containers will respond differently to changes in root temperature than field-grown trees.

ROOT FUNCTION IN RELATION TO TEMPERATURE

In a study conducted in the early 1980s, University of Florida professor Bill Castle and his graduate student, Ken Bevington, measured soil temperature over a 1-year period for Valencia trees on Carrizo and rough lemon rootstocks, and compared this to the patterns of root and shoot growth. They found that the overall seasonal pattern of root growth was significantly correlated with soil temperature. Specifically, the greatest root growth occurred at soil temperatures above approximately 81° F, and root growth was limited at soil temperatures below about 72° F.

Also in some work from the 1980s, University of Florida professor Jim Syvertsen measured the root conductivity of rough lemon, sour orange, Carrizo and Cleopatra mandarin trees at different soil temperatures. Root conductivity is a measure of the root system's ability to take up or conduct water. He found that for all four rootstocks there was a linear decrease in root conductivity from 86° F to 60° F.

WHY DOES THIS MATTER?

We all understand the importance of root growth for water and nutrient uptake. The more roots a tree has, the more resources (water and nutrients) it can acquire and the faster it will grow. In the case of temperate-zone tree crops, the root temperature is not usually an issue because as soil temperatures cool in the fall, so does air temperature, and both limit growth. However, in Florida citrus nurseries, that is not the case.

The graph in Figure 1 (page 14) shows the daily container media temperature changes (blue lines) recorded at three different locations within a Florida citrus nursery and the daily air temperature changes averaged over one month (December 2008). This graph demonstrates the long lag between air and container media temperature. In fact, container media temperature never rises as high as the air temperature. This is because air is a very poor conductor of heat, and the containers filled with moist potting media have a relatively large thermal mass (i.e., they are well-insulated). With the exception of containers near the edge of a bench that may receive direct sunlight to warm them, most containers in the nursery will follow this pattern.

From these data, it is clear that the tree roots experienced very few hours above the 81° F threshold for maximum growth. If these trees were newly transplanted liners, one could imagine it would take them longer to root into the new containers and reach budding size than if the container media temperatures were warmer.

The slower growth that can occur in response to cool root temperatures as depicted in Figure 1 is the result of different physiological interactions within. Root conductivity decreases as temperature decreases. Thus, at the same soil moisture content, a tree with cool roots will be able to take up less water over a given period of time than one with warm roots. And, by extension, nutrient uptake will also be lower, which could lead to wasted fertilizer that ultimately increases production costs.

Under the conditions shown in Figure 1, the trees will likely become drought stressed as well. The warm air temperatures will drive transpiration, but the cool roots may not be able to conduct enough water to the top of the tree, even under well-watered conditions, and water deficits within the tree can occur – especially on succulent new growth. This in turn will result in slower growth since canopy development (i.e., shoot and leaf growth) is the most sensitive process to moderate water stress. Under this scenario, it would actually be more beneficial to vent the greenhouse early to prevent air temperature from rising too high, thus avoiding the induced water deficit.

THE SOLUTION

Essentially, there is no easy solution to the issue of cool root temperatures. There are many different options that could be used to heat the greenhouse and, in turn, the roots. Since there is clearly not a great need to add additional heat to the air, an under-bench heating system would probably be the most efficient. This would place the heat closest to where it is needed, helping to maximize efficiency. As mentioned above, the other strategy is to keep the air temperature more in balance with root temperature by venting the greenhouse early.

Before a decision can be made as to which strategy is best, some research should be conducted to determine the exact responses of nursery trees to cool root temperatures and to high air-to-root temperature differences. This information could then be used to make an economic assessment of the benefits of supplemental root-zone heating. While there's little doubt that increasing root temperature would be beneficial, the cost of achieving it may outweigh the growth benefits.

Tim Spann is an assistant professor at the University of Florida-IFAS' Citrus Research and Education Center, Lake Alfred.