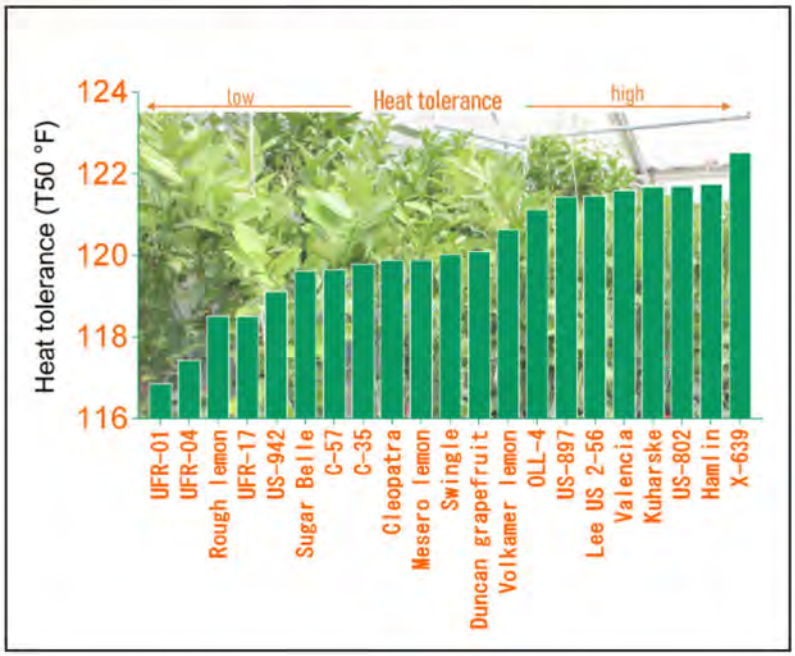
High summer temperatures take a toll on trees

By Anirban Guha and Christopher Vincent

A quick body temperature test is common these days before entering many workplaces, hospitals and clinics due to the ongoing COVID-19 pandemic. The purpose is to screen people for fevers, usually with a non-contact infrared thermometer. Measurement of plant body temperatures also has become common for many field crops, not to screen for infectious diseases, but to assess seasonal heat impacts on plants.

Citrus growers can improve growth and yield by managing canopy temperature. It may surprise you to learn that citrus trees often behave as megatherms, which means their leaf temperature often rises well above air temperature during summer days. Even citrus fruits can heat up, leading to fruit sunburn.



Many citrus varieties have a high heat-tolerance threshold. But citrus restricts carbon fixation and rapidly switches to strong photoprotection sensing unfavorable temperature, even if the threshold temperature is not reached.

Florida is known for its heat, especially in summer. Last year, the highest summer temperature recorded in Central Florida was 99 degrees. Previous researchers found that temperatures higher than 86 progressively harm citrus photosynthetic performance. This condition is probably common in Florida, given that it consistently experiences much higher summer temperatures. Due to megathermy behavior, citrus trees often experience much higher temperatures in their leaves than in the air.

LOOKING AT LEAVES

In the past two years, during peak summer conditions in Central Florida, University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) researchers investigated the leaf temperature dynamics of different citrus varieties, both in the field and in greenhouse settings. Fine wire thermocouples were used to monitor leaf temperature for several days in an experimental grove of well-irrigated Hamlin orange trees grafted on Swingle citrumelo rootstock.

On sunny summer days when the mean midday air temperature reached 95.8 degrees, citrus leaves heated almost 12 degrees higher, escalating to 107.5 degrees. Sunlit citrus leaves stayed several degrees warmer than the air during the day and cooled down to air temperature only at night. Possible reasons for this megathermy are insufficient leaf cooling due to stomatal closure, low transpiration and restricted flow of water from roots to the canopy.

ADVERSE EFFECTS

Plants' photosynthetic machinery, metabolic activities and enzyme functions are sensitive to temperature. As leaf temperature increases above the optimum temperature (approximately 86 degrees for citrus), plants become more vulnerable to oxidative stress, heat injury and tissue necrosis. This results in reduced growth and yield and sometimes poor fruit and juice quality. Megathermy makes citrus prone to all these problems, which could be further accentuated by recent warming trends and heatwaves.

A recent National Oceanic and Atmospheric Administration report says that Florida currently has an average of 25 extreme heat days each year. This number is expected to increase in the long term.

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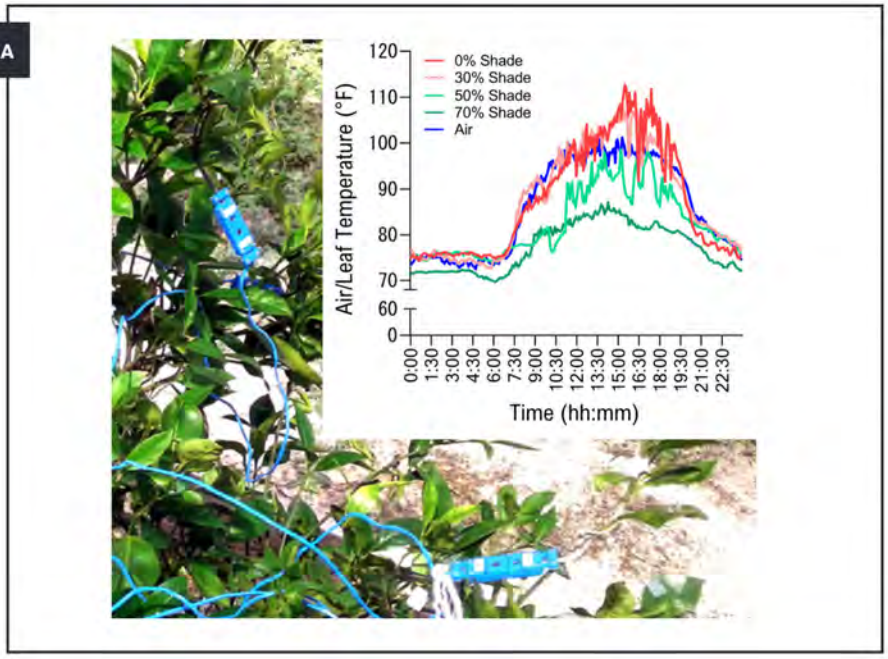
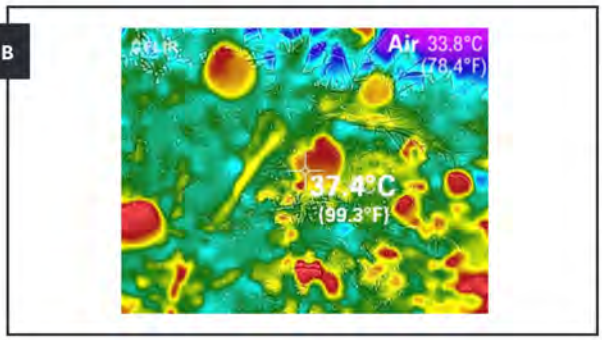
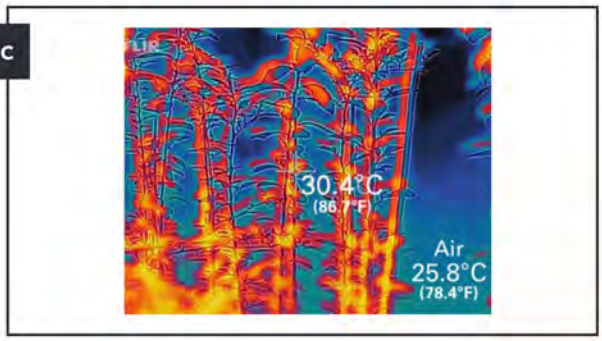
TESTING HEAT TOLERANCE

To see how typical Florida conditions affect citrus, what the trees' physiological limits are, and whether they can increase their heat tolerance as the weather heats up, UF/IFAS researchers screened 22 citrus varieties for photosynthetic heat tolerance. They used a technique called chlorophyll fluorescence that helps observe when photosynthetic structures begin to break down.

Though citrus exhibits megathermy, the good news is that many popular citrus varieties were found to have a high heat-tolerance capacity to counter seasonal summer warming and megathermy, tolerating temperatures up to 116.8 to 122.52 degrees. In the study, some of the popular scion







Megathermy in citrus can constrict carbon dioxide fixation, fruit yield and quality in Florida's summer conditions. A: Fine wire thermocouples tracked leaf temperature of Hamlin orange trees. Daytime temperature (inset) in non-shaded and mildly shaded canopy leaves peaked much above air temperature, whereas 50% and 70% shaded canopy leaves stayed much cooler. Infrared thermal images show daytime megathermy behavior of maturing citrus fruit in the field (B) and in young plants inside a greenhouse (C).

varieties like Hamlin and Valencia, as well as some rootstock varieties, ranked higher in heat tolerance. Varieties like Sugar Belle and Duncan grapefruit were somewhat sensitive to heat.

To learn whether citrus could enhance its heat tolerance when experiencing a minor heatwave, researchers exposed different citrus varieties (Swingle, Kuharske, US-897, C-57 and rough lemon) to progressively increasing temperature regimes. Trees were exposed from 77 to 97 degrees (day-time temperatures) over consecutive weeks and periodically tested for heat tolerance.

PLAYING DEFENSE

None of the varieties showed increased heat tolerance in response to high temperatures. Also, rather than enhancing leaves' heat tolerance capacity in response to increased temperatures, citrus leaves protected themselves in ways that also reduced photosynthesis. This protective, low-photosynthesis mode remained even after the ambient temperature came back down to 77 degrees. Citrus plants that could pull out of this defensive mode quickly would have much higher photosynthesis under typical Florida conditions.

Citrus greening, otherwise known as huanglongbing (HLB), has been putting a squeeze on Florida's citrus industry. Once infected with the disease, citrus trees keep suffering from imbalanced source-sink dynamics and stack excessive sugars in leaves. The excessive sugars in HLB-affected leaves could induce stomatal closure, leading to low transpiration and less cooling of the leaves. Florida's high temperatures and sunlight further escalate the temperature of HLB-affected leaves that are already in a warmer state.

LESS STRESS

UF/IFAS experiments show that sensing unfavorable temperature, citrus rapidly switches gears from a productive mode to a strong protection mode, but the reverse seems to be a time-consuming process. Therefore, maintaining a cooler and less stressful environment is advantageous for citrus leaf physiology to facilitate more photosynthesis, high fruit yield and quality.

HLB-affected Hamlin orange trees growing under different permanent shade conditions are being studied. In 50% and 70% shaded trees, the leaves can stay cooler by between 8 and 16 degrees during hot and sunny summer days than leaves of trees fully exposed to sun. The cooler canopy leaves also show higher photosynthetic performance during peak summer months. In addition, higher fruit yields and better juice quality were recorded in shaded citrus trees.

This research illustrates why maintaining a low-stress growing environment is crucial for citrus physiology and yield, especially in HLB conditions. For example, partial shading or a cooler, low-light environment can mitigate both HLB and high-temperature induced stress. An investigation is warranted for developing low-cost horticultural strategies for shading commercial citrus groves. One research need raised by this study will be developing and identifying varieties that have low heat-stress memory and are quicker in stress recovery.

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