Freeze protection principles

By Gary K. England and W. Chris Oswalt

No matter where citrus is produced in Florida, at times growers will have to consider protecting their trees from the effects of cold fronts and freezing temperatures. Freeze protection methods typically are placed in two categories: passive and active.

Passive freeze protection methods are those that require little to no actions just prior to or during a freeze event. These passive freeze protection tactics include avoidance of planting in low "cold pockets," designing the grove to enhance "cold air drainage" away from the citrus grove, establishment of windbreaks to reduce the potential of damage from evaporative cooling during advective (windy) freeze events, and the selection of cold-tolerant rootstocks. They are initiated prior to grove establishment. Other passive cold protection tactics are maintaining a weed-free or closely mowed grove floor, providing adequate nutrition to the trees and maintaining adequate soil moisture.

Use of under-canopy microsprinkler irrigation for freeze protection.
Photo courtesy of Tim Hurner

Active freeze protection tactics include utilization of tree wraps or soil banking of young trees, wind machines and under-canopy microsprinkler irrigation systems.

Tree wraps or soil banks to a height of 12 to 18 inches can reduce the rate of temperature fall in young citrus tree trunks, protecting the covered portion of the tree.

Wind machines are exclusively utilized during radiation (low/no-wind) freeze events where a temperature inversion occurs, resulting in much colder air settling close to the ground. Wind machines will mix the warmer air above with the colder air at the surface to raise the average temperature near the ground.

Microsprinkler irrigation protects citrus trees with the sensible heat added by the temperature of the well water (typically 68°F) and also the heat of fusion released during the transformation of water to ice. During radiation freezes, water applied through microsprinklers can raise the humidity level in the grove and thus slow temperature fall. Ice formed during a freeze releases heat to the grove environment and also helps insulate cold-susceptible plant parts that are encased in ice.

THE CHALLENGE OF MICROSPRINKLERS

The introduction of wind during a freeze event can make cold protection with microsprinklers challenging. Wind will increase evaporative cooling potential, thus taking heat out of the system. It takes approximately seven times the volume of water freezing to add the same amount of heat to the system that is lost due to evaporative cooling of the same volume of water.

If there is a windy freeze and the irrigation system cannot provide enough water volume to overcome evaporative cooling, temperatures in the grove can actually drop below the ambient air temperature, potentially to the wet bulb temperature.

To efficiently protect citrus groves from the effects of freezing temperatures, it is important that growers understand the active and passive tactics being utilized and the resources available to assist in the decision-making process.

FIRST STEP: DETERMINE CRITICAL TEMPERATURE

The first step in protecting your citrus from freezing temperatures is to understand what is the critical temperature or the temperature where serious damage to plant tissue will occur. Once you know the critical temperature, you can utilize forecast information to determine if an approaching cold air mass may result in local temperatures that approach or go below your critical temperature.

A means to estimate a critical temperature for use in implementing your freeze protection program is the "citrus leaf freezing temperature" or threshold temperature at which sampled citrus leaves collected weekly during November to March from selected groves are damaged. This is a value that typically becomes lower as the temperatures drop from the fall into the winter months. Thanks to a project funded by the Southwest Florida Water Management District, citrus leaf freezing temperatures (CLFT) for various scion/rootstock combinations in several central and north central Florida groves are updated through the winter on the Florida Automated Weather Network (FAWN) website (http://fawn.ifas.ufl.edu) under the "Tools" tab.

As average air temperatures fall into the winter, citrus trees slow down or enter a phase of quiescence. During this period, cold hardiness or acclimation typically increases due to chemical changes and reduction of moisture content in the leaves. Generally, non-acclimated mature citrus leaves can tolerate temperatures down to 24°F with little damage, while young tender flush can be affected at 31°F.

As trees become more acclimated with cooler temperatures as the winter progresses, values for CLFT can also change. Typically, CLFT will range between 16°F to 24°F, with reports as low as 14°F. Acclimation of citrus tissue can be affected by several factors, including scion/rootstock combination, nutritional status, crop load and moisture stress. If citrus trees are exposed to prolonged warmer-than-usual periods during the winter, acclimation can be reduced, making them more sensitive to cold.

TOOLS FOR FREEZE PROTECTION DECISIONS

Once you have determined a critical temperature for your grove, there are other resources available on FAWN to monitor freezing air masses prior to them entering your region, and as they enter your region, aiding in your decision-making process. The FAWN "Cold Protection Toolkit" on the Tools tab is the location of resources such as Evaporative Cooling Potential, Interactive Map with NWS Pinpoint Forecasts, Forecast Tracker, Minimum Overnight Temperature prediction and Wet Bulb Based Irrigation Cutoff Temperature.

As discussed earlier, windy freezes enhance the chance of evaporative cooling occurring, potentially leading to significant crop damage. We mentioned that as long as the irrigation system supplies enough water that freezes compared to the amount evaporating, effects from evaporative cooling should be minimal. During freezes, as the temperature decreases and/or wind increases, the amount of water necessary to properly freeze protect your crop increases significantly. The Evaporative Cooling Potential tool demonstrates the probability of evaporative cooling given the temperature, dewpoint temperature and wind conditions at FAWN stations, and the critical temperature you have determined for your grove. Knowing the capabilities of your irrigation system and evaluating the evaporative cooling potential will assist in deciding the potential risk involved in utilizing irrigation to protect your crop.

The Interactive Map with National Weather Service (NWS) Pinpoint Forecast tool allows you to determine the forecast for a point that may not be near a FAWN station. This forecast takes historical data from many NWS Fruit Frost Stations (FFS) that were located throughout important citrus production regions of the state and correlates them with fixed NWS stations. Current temperature forecasts for NWS stations, taking historical FFS data into account, allow for an extrapolation for a Pinpoint Forecast. It must be noted that geography of your site should be considered when utilizing Pinpoint Forecasts, especially when you are expecting a radiation freeze event.

The Forecast Tracker tool allows you to track the NWS forecast compared to actual temperatures at FAWN stations in real time. This allows growers to evaluate variance from the forecast, if any, to determine if temperatures will be significantly different from forecasts and thus result in a need to readjust their freeze protection plan for a particular event.

The Minimum Overnight Temperature tool takes the air and dewpoint temperatures at sunset for each FAWN station, utilizing a forecast method called the Brunt Equation to predict the morning low. This tool is more accurate for a radiation freeze when there is little to no wind at sunset (ie: the cold air mass has "settled" over the region, with no reinforcing freezing air masses moving in). You can take readings at your grove and enter them into the tool to calculate a predicted low for your location.

Having discussed evaporative cooling potential, it is important to determine when to turn your irrigation system off after a freeze event. The Wet Bulb Based Irrigation Cutoff Temperature Tool compares the wet-bulb temperature at FAWN stations and your critical temperature to determine when the system can be safely turned off. Wet-bulb temperature is the temperature that a wetted plant surface could drop to due to evaporative cooling. If conditions favoring evaporative cooling are present, the wet-bulb temperature can be significantly lower than ambient temperature. Under radiational freeze conditions, leaves on the outer edge of the citrus tree canopy that are exposed to the sky can be colder than leaves within the canopy due to radiational cooling. When the wet-bulb temperature is higher than your critical temperature, then the risk of damage from evaporative cooling is diminished.

Another resource available from FAWN, for a fee, is the Freeze Alert Tool. As a subscriber, you will receive a text message when your critical temperature is reached at the nearest FAWN station. Instructions on signing up for the Freeze Alert Tool are on the FAWN website.

Knowing the critical temperature of your citrus trees and utilizing FAWN tools in your cold protection decision-making process can enhance your probability of avoiding serious crop damage in all but the most extreme freeze events. An efficient freeze protection program will not only provide the benefit of crop protection, but also allow you to save money and a very valuable natural resource — water — by only utilizing irrigation systems for freeze protection when absolutely necessary.

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