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2022–2023 Florida Citrus Production Guide: Citrus Cold Protection[1]

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No other single factor has affected the historical distribution of Florida citrus more than freezing temperatures. Since the introduction of citrus by the Spanish in the 1500s, freezing temperatures have dictated where the citrus production areas in Florida are located.

Early citrus production in Florida relied on principles of passive cold protection practices to mitigate the effects of freezing temperatures. Passive principles of cold protection are decisions made prior to planting the citrus trees. Site selection, horticultural selections, and cultural practices are considered passive methods. These practices are those that do not require the grower to actively participate in cold protection of citrus during a freeze event.

Passive Methods of Cold Protection

Traditionally, site selection decisions that would result in a higher level of protection from cold would include planting on higher-elevation ground to better facilitate cold-air drainage; selecting areas on the south and southwest sides of lakes or large bodies of water, because they are warmer during freeze events; and planting in close proximity to natural windbreaks to reduce wind speeds, helping retain natural heat stored in the grove. Geographically, areas farther south along the Florida peninsula are warmer than locations in north Florida. Soil texture can also affect minimum temperatures and citrus freeze damage in a given grove. For example, white-colored sand-sink soils are significantly colder on a given freeze night than other soil types.

Horticultural selection of citrus rootstocks and varieties can influence the susceptibility of trees to freeze damage. Citrus rootstock selection can often result in success or failure of a citrus grove in a particular geographical location. Generally, the more vigorous the rootstock, the more susceptible the tree will be to freeze damage. Rough lemon, Volkamer lemon, and Carrizo citrange are vigorous rootstocks and are more sensitive to freezing temperatures. Cleopatra mandarin and Swingle citrumelo are considered slower growing and therefore more cold tolerant. During the freezes of the 1980s, it was not unusual for rough lemon groves to be killed while groves on sour orange grown beside them would recover from the same damage. That said, if the minimum temperatures reach a critical threshold for long enough, no rootstock is resistant to freeze damage, as was observed in 1980's freeze in north and central Florida. The selection of citrus varieties used in a particular grove location should be influenced by the probability of freezing temperatures. Mandarin or tangerine trees are considered more cold tolerant than orange trees, and orange trees are considered more cold tolerant than grapefruit trees. The time of fruit maturity can also have an effect on the profitability of a particular grove, depending on the probability of freezing temperatures. Early-maturing varieties that can be harvested before freezing temperatures may result

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in growers making a profit in areas where later-maturing varieties would receive fruit damage. The crop load on trees during the winter can influence cold tolerance. Pineapple oranges and Murcott tangerines with excessive crop loads ("on" years) have been shown to be more susceptible to freeze damage.

Cultural practices can also provide some degree of cold protection. Practices such as increasing soil moisture during the day prior to the freeze can increase the thermal conductivity of the soil, allowing for this stored heat to be released overnight. In addition, during the winter, tree water status should be maintained at levels that reduce fruit drop and prevent water stress without stimulating vegetative growth. Citrus trees under drought stress are also more susceptible to freeze damage. Row-middle management in the form of low-growing turf or clean row-middle management (by discing or by trunk-to-trunk herbicide application) can increase the solar interception of the soil and allow storing heat during the day. Tall-growing weeds in row middles reduce the soil solar interception and may create cold-air dams that impede the drainage of cold air from a grove. Nutritional status of the citrus tree can affect the susceptibility to freeze damage. No single nutritional element will affect the cold hardiness of citrus trees, although excessive nutrition and nutritional deficiencies can lead to an increase in freeze susceptibility.

Active Methods of Cold Protection

Passive cultural practices can only provide a certain level of protection. Active cultural practices are used by growers during a freeze to reduce the freeze damage to citrus trees. During the 1900s, a number of these active cold-protection practices were used by growers to reduce freeze damage to citrus trees. These practices included heating, wind machines, low-volume irrigation, and tree wraps for young citrus trees.

Heating a citrus grove involves the use of grove heaters burning fossil fuel to prevent temperatures from reaching a critical temperature. Heating is very effective in protecting trees and fruit from freeze damage. Years ago, this was one of the more common methods to protect citrus trees and fruit. Depending on the grove, usually 35 to 40 heaters per acre were used. These heaters would burn about 1 gallon of fuel oil per hour. This type of system is quite labor-intensive and expensive due to the initial cost annually associated with setting out and picking up the heaters at the end of the winter. Additionally, refueling and lighting heaters before and during freeze events and the need for in-field refueling during a freeze adds to these costs. Moreover, there were also environmental concerns, such as fuel spills in and around the heaters. These problems, along with fuel costs and the fuel shortage of the 1970s, have resulted in the disuse of grove heaters in Florida citrus.

Wind machines are used extensively in "cold pockets," depressed areas of elevation in the "ridge" production region where dense cold air drains on radiation freeze nights. One wind machine will protect about 10 grove acres if ideally located. Wind machines need the development of a strong temperature-inversion reversal at the height of the machine (about 30 feet above the ground) in order to be effective. Temperature inversions develop only during radiation-type freeze events. Cold air at the surface cools and displaces warmer air to levels above the ground where the warmer air is mixed by the wind machine, increasing grove temperature to an average of the volume of air mixed. The development of inversions can be monitored with the Florida Automated Weather Network (FAWN) tower locations by looking at the difference between 2-foot and 30-foot temperatures. FAWN data can be accessed at https://fawn.ifas.ufl.edu.

Low-volume microsprinkler irrigation is the most widely used method in the Florida citrus industry to protect citrus trees from freezing temperatures. Early attempts in 1962 to use overhead irrigation for freeze protection resulted in widespread damage to trees due to insufficient volumes of water being applied. This resulted in growers being reluctant to use irrigation for cold protection until the early to mid-1980s. Widespread use of microsprinklers in the early 1980s allowed growers to apply sufficient volumes of water directly under and on the lower portions of citrus trees, resulting in protection of these trees from freeze damage. Irrigation used for freeze protection is based on a few simple principles. First, the sensible heat of water that is released when water hits the tree is beneficial. This sensible heat is due in large part to the actual temperature of well water (about 68°F). There may also be some additional benefit if irrigation can cause the development of fog in the grove, which in turn will reduce the rate of temperature fall during the night (this is highly dependent on the dew point temperature). Secondly, the process of water turning to ice (called the latent heat of fusion) releases additional heat to the grove microclimate. The formation of ice also helps in insulating plant tissues above critical temperatures. Current recommendations call for application rates of 2000 gallons per acre per hour to protect trees from freezing temperatures. During radiation freezes, water applied under the canopy of citrus trees modifies the tree microclimate, resulting in limited protection of the tree and fruit from freeze damage. This modification of the tree microclimate decreases with height above the irrigation source. Generally, irrigation under mature trees will provide little protection of fruit on the exterior canopy of the tree, but it may limit damage to fruit located closer to the microsprinkler. During advective freezes, mature trees may not typically benefit from irrigation, but this would be highly dependent on evaporative cooling and the amount of irrigation heat removed from the grove due to increased wind speeds. Microsprinklers can provide excellent protection of young citrus trees from such freeze damage. Microsprinklers should be located on the north or northwest sides of the tree no further away than 2 to 3 feet. This will allow winds during an advective freeze to blow water at the tree. The type and pattern of emitter used is critical. Emitters should be the fan type, with either a 90° or 180° pattern applying a uniform distribution of water at the tree. This condition should provide for excellent protection of young citrus trees. Another version of this system would involve elevating 360° fan-type microsprinklers on PVC stakes, 24 to 36 inches in length, in the center (2 to 4 inches from the trunk) of young trees. The emitter tubing should be wrapped around the PVC stake to keep ice formation from pulling down the elevated emitter. This system has been shown to provide additional protection to greater heights in young citrus trees. Before making a decision on using irrigation for cold protection, a grower must understand some of the potential issues. Low-volume irrigation works as long as the heat added to the grove (sensible heat and the heat of fusion) is greater than what is lost. Heat losses from a grove when using irrigation will generally come from evaporative cooling. This process occurs when the dew point is low and evaporation of water exceeds that of ice formation. It takes 7.5 gallons of water freezing to equal the heat lost in one gallon of water evaporating. This demonstrates the importance of knowing the effects of dew point and wind speed on the effectiveness of low-volume irrigation. Another consideration is the power source of the irrigation system. Growers using electricity to power their irrigation systems should exercise caution. In past freezes, rolling power outages during peak demand have resulted in damage to citrus groves due to inadequate irrigation caused by ice plugging up emitters. Growers in this situation need to evaluate contingency plans for backup power sources. Growers also need to determine a critical temperature start time of microirrigation for cold protection. The start time needs to be prior to any formation of ice in the irrigation tubing; otherwise, the freeze protection could be compromised.

Tree wraps are used to protect the trunk and bud union of young citrus trees recently planted in the grove. The effectiveness of tree wraps is directly related to the insulating properties of the wrap used. Tree wraps are designed to reduce the rate of temperature fall around the trunk of young citrus trees. This reduction in the rate of temperature drop allows for critical temperatures to be reached after sunrise, past the time of minimum temperature. A number of tree wraps are available on the market today. Research has shown that some very poor insulating wraps can cause temperatures under the wrap to be lower than air temperature. Care should be used when determining if the tree wrap chosen will provide for adequate protection of the tree trunk. Tree wraps with good insulating properties have been demonstrated to be quite effective, yet most growers have tended to rely solely on irrigation for freeze protection in the past 20 years. Young citrus trees are more susceptible to freezing temperatures than mature trees, and wraps could be an attractive alternative to entire-grove irrigation when protection is needed for only young trees.

To summarize, there are a number of citrus cold-protection practices or decisions growers can make to ensure the success of a grove in surviving freezing temperatures. Some of these would be done prior to planting, but there are additional practices that can be deployed in an established grove.