COLD HARDINESS AND COLD PROTECTION

By Mongi Zekri

Both citrus fruit and foliage can be damaged if temperature falls below freezing for a prolonged period. However, weather conditions prior to cold temperature, duration of cold, position of the tree in the grove or yard, maturity of the fruit, and health and age of the tree can affect tree and fruit hardiness.

Citrons, Tahiti and Mexican limes are the most sensitive. True lemons are slightly more cold hardy, followed by grapefruit, tangelo, limequat, sweet orange, most mandarins and kumquat. Leaves of kumquats are hardy to 20_F.

The majority of sweet oranges are hardy to 26-27_F. Thin-skinned, small-sized fruit or fruit held toward the outside of the canopy are usually more sensitive to cold. Fruit that is mature or close to maturity and has high sugar content can withstand more cold than immature fruit.

Trees are more cold hardy when exposed to cooler temperature over several weeks prior to freezes. Sudden cold snaps can be particularly damaging to citrus. Cold tolerance develops most readily when trees are not flushing. Warm temperatures at any time during the winter may cause citrus trees to resume growth and reduce their cold tolerance.

Ice formation in citrus tissues - not low temperature - kills or damages citrus trees and fruit. One hour below 28_F may kill tender growth and citrus flowers. New flush growth and bloom buds will experience minimal damage at 28_F when exposed for 30 minutes, but will be killed at 26_F for the same period of time. Fruit damage occurs when the temperature falls below 28_F for at least four hours. Frozen fruit can be salvaged for juice.

Mature citrus leaves can generally withstand four hours of 23-24_F with minimal damage. Four hours at 20_F can kill 3/8-inch or smaller wood and temperatures below 28_F for 12 continuous hours may kill larger limbs and possibly the entire tree.

WATER FOR COLD PROTECTION

A clean, hard-packed surface intercepts and stores more solar radiation during the day and releases more heat at night than a surface covered with vegetation or a newly tilled area. Addition of water to the cleanly cultivated area prior to a freeze further improves heat accumulation during the day. Therefore, keep the area around the trees free of weeds and apply water to the soil prior to cold weather.

Water should also be pumped high in the ditches the day before and during the time of freezing weather. But water has to be removed within two to three days after the freeze to avoid root damage.

As the water cools, it releases heat, increasing air temperature around the trees. Young trees are more vulnerable to cold damage. It is more of a problem in open, solid-set plantings than resets in mature groves.

Minimum-reading thermometers should be installed in the coldest locations of the groves. They should be placed at a height of 42 inches on a stand sheltered at the top and facing north.

Use of microsprinklers for cold protection is very important. Turn on the water early when the air temperature reaches 36_F. Remember that in cold pockets, the ground surface can be below 32_F when it is 36_F at the thermometer location.

You have to keep running the system all night. The irrigation system can be turned off in the morning when the air temperature rises to 40_F.

Microsprinkler emitters should be placed on the upwind (northwest) side one to two feet from the tree. As long as the water is constantly being changed to ice, the temperature of the ice-water mixture will remain at 32_F. Use a 90-180 degree spray pattern, which concentrates the water on the trunk and lower limbs of the tree.

As a means of cold protection, overhead, high-volume sprinklers have been used successfully in citrus nurseries and low-volume microsprinklers have been used to protect young trees in groves. However, success can vary with the type of system, application rates, type of freeze (advective vs. radiative), and severity of the freeze.

TYPES OF FREEZES

An advective or windy freeze occurs when a cold air mass moves into an area bringing freezing temperatures. A radiation frost occurs when a clear sky and calm conditions allow an inversion to develop and temperatures near the surface drop below freezing. Inversion occurs on a clear night during which heat continues to radiate out into the space. The temperature drops significantly and cool air collects at the surface. The temperature increases with altitude (height), which is the inverse of normal conditions.

Water protects young trees by transferring heat to the tree and the environment. The heat is provided from two sources, sensible heat and the latent heat of fusion. Most irrigation water comes out of the ground at 68_ to 72_F, depending on the depth of the well. In fact, some artesian wells may provide water of 80_F or more.

As the water is sprayed into the air, it releases this stored (sensible) heat. However, by the time the water reaches the tree it has lost most of its energy, particularly for low volume microsprinkler systems. Consequently, the major source of heat from irrigation is provided when the water changes to ice (latent heat of fusion). As long as water is constantly changing to ice the temperature of the ice-water mixture will remain at 32_F. The higher the rate of water application to a given area, the greater is the amount of heat energy that is applied.

The major problems in the use of irrigation for cold protection occur when inadequate amounts of water are applied or under windy (advective) conditions. Evaporative cooling, which removes 7.5 times the energy added by heat of fusion, may cause severe reductions in temperature under windy conditions, particularly when inadequate amounts of water are used. It should be kept in mind that most irrigation systems will not protect the upper portion of tree canopies. Because water can provide protection in one situation and cause damage in another, it is important to know what principles are involved and understand the dew point and what can happen when using water during a freeze.

DEW POINT

The dew point is the temperature at which dew begins to form or the temperature at which water vapor condenses to liquid water. It is also the temperature at which air reaches water vapor saturation. A common example of condensation is the water that forms on the outside of a glass of ice water. This happens because the temperature of the glass surface is lower than the dew point temperature of the ambient air in the room. Hence, some of the water vapor in the surrounding air condenses on the outside of the cold glass.

When referring to cold protection, the dew point is one of the better ways to describe the humidity or amount of water vapor in the air. When the dew point is below 32_F, it is often called the frost point because frost can form when the temperature is below freezing.

The dew point is important on freeze nights because water vapor in the air can slow the rate of temperature fall. With a relatively high dew point on a cool night, radiant heat losses from a grove are reduced, and the temperature may be expected to fall slowly. But if the dew point is quite low, the temperature may be expected to fall rapidly.

Water vapor absorbs infrared radiation. Water droplets or fog are an even more effective radiation absorber than water vapor. Hence, fog can reduce the rate of temperature drop on a frost night. Dew point temperatures are commonly higher on the coasts than they are inland. In addition to affecting the rate of radiation loss, the dew point is often a "basement" temperature, and the air temperature will not go much below it unless drier air moves in. The reason for this is that when dew condenses or ice forms, heat is given off.

A sling psychrometer is a convenient portable gauge for measuring relative humidity and dew point. It is an important tool to determine when to stop irrigating during freezing conditions. This instrument compares the temperatures of a dry bulb thermometer and a wet bulb thermometer. The psychrometer is spun around rapidly for a few minutes and readings are taken for the dry and wet bulb temperatures. The scale on the back of the unit and the chart that comes with the unit allow deriving the dew point and relative humidity. In the morning, when the temperature warms up, it is not necessary to wait until the ice has melted before turning off the system. When the wet bulb temperature is above 33¯ or when the air temperature is 40¯, the system can be turned off safely.

EMITTER PLACEMENT

It is generally advisable to place the emitter northwest of the tree, approximately one to two feet away from the trunk. Emitters should be attached to risers for greatest tree trunk protection. Improper placement or inadequate spray coverage will greatly lessen the effectiveness of the irrigation. A 90¯ to 180¯ spray pattern, which concentrates the water on the trunk and lower limbs gives cold protection superior to a 360¯ pattern. Inverted cone sprinklers positioned above the wrap in the tree also give adequate protection.

The volume of water applied depends on the amount of cold protection required. Generally, 10 gallons per hour (gph) applied directly to the trunk in a 90_ pattern will provide adequate cold protection during most freezes.

It is very important to know the critical temperature at which freezes can damage the grown crop. Minimum-temperature-indicating thermometers are not expensive and are a wise investment for any grower concerned with freeze/frost protection. Several thermometers should be placed in several blocks. Placement and number of thermometers should depend on the area and grower's interest. Some factors to be considered include elevation, scion/rootstock cultivars, tree size and irrigation systems. Some growers place one thermometer in the coldest spot and organize their protection strategy around the worst possible case. This is acceptable, but most of the area will receive more protection than it needs, which will waste water and fuel and cost the grower money.

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