Frost Control for Almonds— Fans, Polymer Products, Water & Air

By: Cecilia Parsons | Associate Editor

Like in citrus, just raising the orchard temperature two degrees can make a difference in protecting an almond crop from a freeze.

Dormant almond trees can tolerate freezing temperatures, but once buds begin to swell, the harm caused by late winter/early spring freeze increases. Significant crop loss can occur from petal fall to early nutlet development when temperatures fall below 26 degrees F. Management strategies that can raise orchard temperatures by just two degrees can save much of the crop.

Research done by University of California (UC) bio-meteorologist Richard Snyder and Cooperative Extension (UCCE) advisor Joe Connell shows that minimum temperature, length of time at that temperature, the presence of ice-nucleation active bacteria and frost hardiness of the variety all determine the possibility of ice forming inside the plant tissue and causing damage.

Snyder said that early defoliation of trees in the fall due to water stress or insect damage the previous fall increases susceptibility of almond buds to frost damage. Trees need adequate irrigation and pest management to allow them to store carbohydrates. That supply helps the trees withstand freezing temperatures.

In a severe freeze event, ice forms on plant surfaces due to the presence of ice-nucleation—active bacteria on the surface. The ice forms inside the plant tissue, but outside of the plant cells. Freezing injury happens to buds, flowers and nuts when ice forms, the cells dehydrate and the cell walls are damaged.

Advection and Radiation

There are two types of freeze events: advection and radiation. Advection is when cold air moves in and replaces warmer air. The type of event is characterized by low humidity, no inversion layer and windy conditions. There are few effective protection measures against an advection frost. Radiation frosts are more common in almond production areas. They occur due to a net loss of radiant energy. Inversion layers aloft are found with radiation frosts and the stronger the inversion the better most frost protection strategies will work.

Injury from freezing temperatures is due to net heat loss from an orchard. There are four mechanisms that transfer heat in or out of an orchard: radiation, conduction, convection and latent heat. All orchard protection methods use one or more of these to reduce heat loss or replace heat.

Radiation is energy emitted from any source that has a measurable temperature. Orchard floors radiate heat, and the larger the area, the more heat is lost. Air, which contains heat, also radiates energy in both upward and downward directions.

Convection

Convection occurs when heated air becomes less dense and rises. Similarly, cold air is more dense than warm air and sinks. On frost nights, cold-air drainage occurs because the cold, dense air flows downhill much like water.

Orchard heaters, wind machines and helicopters used force

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convection to move warmer air aloft down to the trees.

Conduction transfers heat through the soil and is an important factor in orchard protection. Soil heat storage can be maximized by maintaining soil moisture near field capacity, especially following a dry winter.

Latent heat is an important factor in any frost protection plan that involves water. Dew or frost formation on almond buds, flowers, or small nuts actually protects against damage. Dew or frost formation releases latent heat to the plant parts and air. This heat slows or stops temperature drop. When no dew or frost forms (that is, when the dew point is low), damage is more likely.

Frost protection methods seek to reduce heat loss, redistribute heat, or add heat to an orchard. In all cases, the idea is to balance the net heat loss. This can be accomplished by reducing the upward radiation, enhancing heat conduction in soil, improving air convection, or increasing downward radiation.

Passive Frost Protection

Freeze protection strategies begin with site selection for an almond orchard. If the site has low places where cold air flows, additional protection measures will be necessary. Planting on slopes where cold air can drain away is recommended. In existing orchards, identifying the cold spots is part of the protection strategy.

Planting on north facing slopes, can also delay bloom until after freezes are likely to occur. Any structures or vegetation that diverts cold air into an orchard site increases freeze potential. These can also be used to block the downward movement of cold air away from the site.

Soil water content affects thermal conductivity and heat content of soils. Heat is transferred daily into and out of the top foot of soil. When the soil is wet, the heat transfer and storage improves and more heat is stored during daylight hours for release at night. Snyder's research showed that wetting the top foot of soil aids in heat transfer when the soil is dry prior to frost season.

How soon the soil should be wetted prior to a forecasted freeze also depends on the type of soil. Clays are better at storing heat than sandier soils.

Using Water to Raise Orchard Temperatures

Managing soil moisture and ground cover can help reduce frost damage in a radiation freeze event. Heat is retained in moist soil and radiates upward during cold nights. Ground covers, if left unmowed, can pull the moisture out, but prevent it from rising.

A few days advance warning of a freeze event can help when using micro sprinklers or solid set sprinklers for frost

Continued on Page 72

Continued from Page 71

protection. If soil surface is already wet, using flood or drip irrigation will not provide adequate protection. Once the surface water freezes, no heat is released. Drip lines may also freeze. With micro sprinklers, heat is released off the water. Snyder and Connell's research found that targeted amounts of water should be 30-40 gallons per minute per acre.

Determining the right time to initiate wetting the soil and turning off the sprinklers is important.

Sprinklers should be started and stopped when the wet-bulb temperature is above the critical damage temperature. When a sprinkler system is first started, the air temperature in the orchard will fall to the wet-bulb temperature. This initial drop in temperature will be followed by an increase as water freezes on the ground and plant parts and heat is released. Sprinklers should not be turned off until the wet-bulb temperature is above 32 degrees F.

Snyder explained that the wet-bulb temperature can be measured directly with a psychrometer or it can be determined from the dew point and air temperature.

Wind Machines are Another Option

Wind machines are another option in freeze damage prevention in almonds. Although they are not common in most almond production areas, wind machines can protect the crop by raising orchard temperatures above critical points. Wind machines work by pulling down the warmer air aloft and moving air to prevent pooling of cold air. By providing air movement across a plant surface, super cooling is prevented. Damage occurs with loss of air movement. Wind machines do not create wind chill.

Shawn Miller of Orchard-Rite Wind Machines said their new designs give growers more options in freeze protection. These include an automatic system that starts, warms up, throttles up, throttles down, cools down and shuts off based on pre-set temperatures. They also allow for remote monitoring and management via the Internet and a mobile device.

Other new options in wind machine design are custom and tilt heads to protect crops on uneven terrain, covering areas that normally would require two machines.

Other Protection Options

Two newer freeze damage protection measures include polymers applied to plants and cold air drains.

Cold air drains are a mechanical means of warming the air in an orchard. These machines work best in site specific areas—low areas where cold air pools. The cold air is expelled upward by the drain and it mixes with warmer air aloft. It's ability to raise orchard temperatures depends on the strength of the inversion layer.

These portable machines were designed in the late 1990s and have mainly been used in in vineyards planted on hilly terrain.

The Australian company AgroBest developed a seaweed based product for frost protection. It's potassium additive provides protection to the plant within 6 hours of application, and the seaweed will continue protection after 36 hours to keep plants protected for a period of 10-12 days. The company states that the product will provide approximately 2-3 degrees of extra frost tolerance.

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