

FROST PROTECTION: TIPS AND TECHNIQUES

Kathy Demchak, Department of Horticulture, Pennsylvania State University



Damage from freezes and frost is of concern from bud break in the spring through flowering and fruit set. The blossoms are tender and are the plant part most commonly damaged by low temperatures. Since loss of the blossoms means a loss of fruit for the year, frost protection is of great concern.

Critical Temperatures for Frost Damage

Damage occurs when water in the plants' cells freezes, thus causing the cells or cell parts to rupture. The temperature at which this occurs depends on the water content and concentration of water vs. solutes in the plant tissue. Therefore, the temperature at which damage occurs varies with the crop and growth stage. Table 1 lists commonly-accepted critical temperatures for strawberry and blueberry blossoms at different stages of bud development. These values are not absolute, and within reason, it is better to err on the side of safety when protecting crops from frost damage.

Table 1. Critical temperatures (degrees F) for cold damage of flower buds based on stage of development. Note with blueberries, there is considerable variability in temperatures at which damage was reported for these growth stages.

Strawberries	Critical temp.	Blueberries	Critical temp.
Bud emergence	10	Bud swell	15-20
Tight bud	22	Tight cluster	18-23
"Popcorn"	26	Separate flowers visible	22-25
Open blossom	30	Late closed blossom	25-26
Green fruit	28	Open blossom	27
		Petal fall	28

Sources: *Strawberry Critical Temperatures* - K. Perry and B.C. Poling, North Carolina State Univ.; and Richard Funt, Ohio State Univ.; *Blueberry Critical Temperatures* - Fruit Crop Advisory Team Alert, Vol. 18, No. 3. "Protecting Blueberries from Frost", E. Hanson and M. Longstroth, Michigan State Univ.

Types of Frosts and Freezes

Radiant frosts and freezes occur on calm, clear nights with no cloud cover. Heat is lost from the soil and plants, and radiates back to the sky. *Advectional freezes*, sometimes called windborne freezes, are caused when a cold air mass moves into the region accompanied by with a lot of wind. It is difficult to protect against this type of freeze.

Environmental Factors Affecting Frost Occurrence and Protection

Air temperature is the measurement used for initiating or stopping frost control practices, and can be taken with either a dry-bulb or wet-bulb thermometer. *Dry-bulb temperatures* are the type commonly referenced in literature and in weather forecasts. *Wet-bulb temperatures* are obtained from a thermometer that is covered with a wet wick. Air is moved over the bulb causing evaporative cooling to occur. The wet-bulb temperature is useful because it essentially is what the plant temperature will be once the irrigation is started and evaporative cooling has taken place.

Wind speeds of more than a few miles per hour can make frost protection difficult, especially in an advective freeze. Light breezes, however, tend to mix the air and can increase temperatures at ground level in the case of radiational frosts. Temperatures tend to be more uniform even across a distance of miles when windy conditions exist.

The *dew point* is the temperature at which the relative humidity reaches 100% as the air cools. At this point, water vapor in the air condenses into fog or dew, which gives off heat, slowing the temperature drop. The risk of having a frost becomes greater as the dew point becomes lower. If the dew point is below freezing, so that condensation and heat release does not take place until below freezing, temperatures can drop to damaging levels extremely rapidly. In this case, the white crystals typically seen in a frost or freeze may not form, a condition sometimes referred to as a "black frost".

Relative humidity is the amount of moisture contained in the air relative to the maximum amount that could be held. It changes with temperature and can change quickly with the air mass.

Site-Specific Effects on Frosts/Freeze Occurrence

Site selection is the most important step for frost or freeze protection of a small fruit crop. The best site is one downwind from or closely surrounded by a large body of water. Topography also affects frost occurrence. Cold air is heavier than warm air, and therefore flows downhill. Temperatures are often higher at the tops of slopes, while cold air which collects in the lower areas (frost pockets) is often 4° to 5°F lower. Southern slopes are generally warmer than those facing north, but plants on Southern slopes will also come out of dormancy earlier, possibly negating this benefit in many instances.

Soil moisture has an effect. Moist soil holds more heat and radiates heat back to the environment for a longer time than dry soil. If the soil is dry, plantings should be irrigated a day or two ahead of an expected cold snap to allow time for heat to be captured.

Soil texture and compaction are also factors, as heavier soils with more clay retain heat better than sandy soils. Sandy soils are also often lighter in color and hence tend to reflect more sunlight, rather than absorbing it in the form of heat.

Ground cover affects the amount of heat absorbed by and released from the soil. A bare, undisturbed moist soil with no ground cover can release enough heat to raise the temperature 2 to 3 degrees in the plant canopy as compared to a sod-, grass-, or straw mulch-covered soil.

Methods for Protecting Plants from Frosts and Freezes

Floating row covers are useful especially for small acreages of low-growing crops or when water for overhead irrigation is not available. The amount of frost protection obtained varies with the weight and fiber arrangement of the row cover. Usually the amount of protection increases with the weight, though differences in texture make this correlation less than perfect. Row covers weighing 0.6 ounces per square yard typically can give 2° or 3°F protection during a radiational frost, while nursery foam covers or a double layer of row covers can give more than 10°F of protection. Weather conditions prior to the frost affect the amount of protection obtained from row covers, since little or no heat may accumulate under the row cover on cloudy windy days. When row covers are used for frost protection, they should be pulled over the crop during mid-afternoon to allow heating to take place. Row covers can also be used in conjunction with sprinkler irrigation on top of the row cover. Row covers used in this way typically cut the amount of overhead irrigation needed for frost protection by about 50% on average.

Heating or burning is an old method of frost protection, but is not practical for low-growing small fruit crops like strawberries, and is infrequently used. However, if fires or heaters are used, several small ones are better than one large one.

Wind machines work if a temperature inversion occurs (warm air present above a cold layer) and if there is no wind as with radiant-type freezes. They mix the air by pulling down the warm air from above to replace the colder air trapped near the soil surface. They only provide a few degrees of protection, and therefore are sufficient protection primarily for crops that bloom relatively late when frosts are usually less severe.

Sprinkler irrigation works well on all small fruit crops, but needs to be used carefully. Because sprinkler irrigation use can result in the application of large volumes of water to the crop, use should be delayed until greater than 10% of the blossoms are in danger of being damaged. This does not necessarily mean that 10% of the blossoms are open. Sprinkler irrigation for frost protection works because water gives off heat when it changes from a liquid to a solid (i.e., freezes). Frost protection using irrigation works only if the system is fully functional prior to the frost event, so test it to ensure it works.

A common recommendation is to start the system when the temperature at plant level falls to 4°F above the critical temperature (for example, 34°F for open strawberry blossoms). If the dew point is below freezing, irrigation must be started at a higher temperature. Under conditions with wind or low humidity, damage can occur when the air temperature is several degrees above the freezing point because of evaporative cooling. Because of this, the wet bulb temperature is often a better indication of when the irrigation system should be used rather than dry bulb

(standard) temperature. Irrigation should be operating by the time the wet bulb temperature equals the critical temperature.

Most overhead sprinkler systems are designed to deliver 0.1 to 0.2 acre-inches of water per hour and are useful for radiant freeze or frost protection when wind speeds are light and temperatures are not below the mid-twenties. Microsprinklers provide more uniform distribution than those having larger droplets and/or those covering a larger area. However, the rate at which water freezes depends on several environmental factors, including air temperature, humidity, and wind speed. When breezy conditions (5 mph) are forecast overnight, water supply lines should be moved closer together. At 5-10 mph, protection will be spotty. When wind speeds exceed 10 mph, the risks for crop damage from evaporative cooling may outweigh the potential benefits.

Overhead irrigation pipes and sprinklers can be set up on row covers, and irrigation started after the temperature under the row covers drops near the critical temperature. This is the safest way to protect crops in the case of advective freezes, and greatly reduces the amount of water used regardless of the type of frost event. Because of the necessity of and time required for removing and re-applying the row covers (they can just be gathered into the row middles in which the irrigation pipes are located), this method is best suited for small acreage plantings. Be sure to uncover the plants as early in the day as possible so that drying of the foliage and pollination can take place.

Taking Temperature Measurements: Accurately Depicting Crop Conditions

Temperature sensors must be calibrated to be sure the temperature you are reading is correct. Calibrate them by immersing the sensor in a water and crushed ice slurry, gently stirred, which will be at 32°F. Note that with liquid-in-glass min-max thermometers, the top of the thermometer needs to be immersed. Adjust subsequent readings accordingly.

With low-growing plants such as strawberries, the coldest temperature in a field is often near the surface where the strawberry plants grow. Readings should be made at the plant canopy level. In blueberry plantings, several measurements should be taken at different places in the field at the various heights of the plant canopy.

Liquid-in-glass thermometers, usually relatively inexpensive in price, can vary in their readings. However, they usually vary less than dial thermometers, and are a good value. *Thermocouple thermometers* are generally capable of measuring a wide range of temperatures, and have a very good percentage accuracy, such as being within plus or minus 0.05% of the temperatures in their ranges. Because the range can be huge, the accuracy may still only be one or two degrees. The thermocouple probes themselves are quite cheap, but the device to which they connect that produces the readable output can be pricey. *Thermistor thermometers* are probably the best option for accuracy, as they are designed to read a relatively narrow temperature range, and have a good percentage accuracy. There are models that will be accurate to within plus or minus 0.5 degrees F with prices in the moderate range. Calibration is still recommended.

Digital readouts give the impression that, because the reading can be noted to the closest tenth or hundredth of a degree, the device must be accurate. This is not necessarily the case. The reading may be very exact, but also very wrong. Accuracy is how correct the device is. For example, a certain digital thermometer may be advertised as having a resolution of 0.1 degrees, but an accuracy of + or - 2 degrees. Accuracy is the important figure. Sometimes you'll see a notation that a thermometer is accurate to a certain percentage within its range. As an example, if the device is listed as being accurate to within 0.5% in its range, and its range is -60° to 140°F, it would be accurate to within 0.5% of this 200 degree range, or, to within plus or minus 1 degree of any temperature read between -60° and 140°F. This does not mean that it is accurate to within 0.5% of any given temperature.

Electronic devices and plug-in probes offer some useful advantages over standard thermometers. For example, if a probe is positioned under a row cover with connecting wires outside of the row cover, the temperature under the row cover can be measured easily. Also, even once irrigation is turned on, the temperature in the field can be monitored. Note that with some electronic devices, the number display is not meant to withstand temperatures below freezing, so the display could "black out" when you need it the most! So, use the display portion in the field only when obtaining the reading.

Frost alarms and alerts are especially valuable if your field is further than walking distance away from where you live. Once the temperature drops to a certain point, the alarm either sounds a buzzer, calls you on the phone, or flashes a light, depending on the model. If you get a model that calls you, it will likely need to be located where

there is access to a phone line. A recent addition to frost protection gadgetry is a device that flashes a light that is color-coded to the temperature. This means that it is possible to track the temperature in your field from indoors, or monitor fields in several locations at one time.

(Reprinted from: New York Berry News, [Vol. 6 No. 4, April 23, 2007](#). Originally printed in: [The Penn State Vegetable and Small Fruit Gazette, Vol. 11 NO. 4, April 2007](#).)