Protecting Blueberries from Freezes in Florida

P.M. Lyrene and J.G. Williamson

Dormancy and Cold Hardiness

Most temperate zone plants, including blueberry, enter a dormant period during late fall and winter characterized by no growth and greatly reduced metabolic activity of above ground parts. This dormant condition is a defense mechanism which enables plants to survive cold. The development of dormancy and cold hardiness is a gradual process which begins in late fall or early winter in Florida. In response to shorter days and lower temperatures during the fall, growth of blueberry plants slows, dormancy begins to develop, and cold hardiness increases. Even before cold temperatures occur, blueberries develop a certain amount of cold hardiness. Exposure to cool temperatures greatly accelerates dormancy development and increases cold hardiness. Later in the winter, as temperatures continue to drop, cold hardiness continues to increase. Fully dormant blueberry plants are quite cold hardy and seldom suffer serious damage from cold weather in Florida.

Once fully dormant, a blueberry plant must be exposed to a period of cool temperatures before it will break dormancy and grow normally the following spring. This is a result of its chilling requirement. Each cultivar has its own characteristic chilling requirement. The amount of chilling that blueberry plants receive in Florida varies considerably from year to year. Temperatures needed to satisfy the chilling requirement are generally considered to be between 32°F and 45°F. However, keeping track of chill hours is more complicated than merely recording the number of hours between 32°F and 45°F. Exposure to one hour of temperatures either slightly above or below the optimum chilling temperature can result in some chill accumulation. The farther from the optimum temperature, the smaller the fraction. At temperatures below freezing, no chilling accumulation occurs. Loss of accumulated chilling can occur with exposure to very warm temperatures. Temperatures between 32°F and 45°F appear to be most effective at satisfying the chilling requirement of blueberries, but temperatures between 45°F and 55°F contribute something to chilling and temperatures above 70°F between mid-November and mid-February probably negate some chilling.

Another factor which can affect chill accumulation in blueberries is the presence of leaves during chilling. Blueberry plants in Florida often retain some of their leaves throughout much of the winter, especially in southern Florida. These plants...
of wind and freezing temperatures is the hardest situation to combat when cold protecting blueberries.

Radiation freezes occur on clear, cold nights when there is little or no wind. Heat is radiated from the Earth to the open sky. Under these conditions, large temperature differences can develop over short distances due to differences in elevation. Hilltops may be 5 to 10 degrees F warmer than low ground at the same latitude. Hilltops in the northern part of peninsular Florida may be warmer than cold pockets 200 miles farther south. Traditionally, Florida blueberry farms have been planted on low, cold land because soils there are high in organic matter. There is increasing interest in planting blueberries on high ridge land, circumventing the soil problem either by growing plants in pine bark, or by adding enough peat to the soil to obtain good growth.

**Pruning**

If done at the right time of the year, pruning can delay flowering by 1 to 2 weeks. Growers who often lose their crops in freezes can delay flowering by pruning immediately after harvest and providing conditions that promote vegetative growth during summer and fall. Flower buds produced on vigorous shoots that result from pruning in late May and early June will mature later in the fall and flower later the following spring.

**Freeze Protection Methods**

Overhead irrigation systems, designed for freeze protection with diesel, rather than electric, pumps are the most widely used and practical method of reducing blueberry fruit losses to freezes in Florida (Fig. 1). Large volumes of water must be pumped to get good protection. The number of gallons per minute needed to protect one acre depends on the temperature, wind speed, relative humidity, and the design of the system. Table 1 adapted from Gerber and Martsolf (Circular 287, Florida Agricultural Extension Service) attempts to describe the relationships between minimum temperature/windspeed combinations and water application rates needed for protection during a freeze. However, this table does not consider the water vapor content of the air. With unusually dry air, higher water application rates will be needed than indicated by the table. In Alachua county, blueberry crops have occasionally been lost between February 20 and March 20, even in fields protected with overhead irrigation at a rate of 0.2 inches per hour. Temperatures of 26°F combined with 15 mph winds and low humidities exceed the protection capabilities of such a system, even though the same amount of water would protect flowers down to 18°F with no wind.

![Figure 1. Blueberry field protected with overhead irrigation during a freeze.](image)

Some growers have designed systems that can be quickly altered to deliver 0.4 inch of water per hour by changing riser heads. A practical system might be able to deliver 0.25 inch per hour over 10 acres or 0.4 inch per hour over 6 acres. In most years, the entire 10 acres could be protected. In years with severe late freezes, 4 acres could be allowed to freeze so that the other 6 acres could be given maximum protection. Before installing an irrigation system, seek advice from an irrigation specialist.
Best use of an irrigation system for freeze protection requires experience and close attention to the weather. Blueberry flowers and fruit will not freeze if temperatures in a weather bureau shelter located alongside the plants at the same height as the flowers stay 32 degrees F or above. Frost on the grass between the rows does not necessarily mean that flowers are damaged since on humid nights, frost can form when temperatures in the weather shelter are as high as 36 degrees F. With a clear sky and no wind, a thermometer placed open to the sky will read about 2°F colder than the same thermometer at the same height in a weather shelter. By placing several thermometers throughout a blueberry field, one can learn a lot about the temperature distribution patterns in that field during radiation freezes.

If or when to turn on the irrigation system during a cold night can sometimes be difficult decisions to make. The answer depends on such factors as the capabilities of the irrigation system, state of development of the crop, relative humidity, temperature, and wind speed. Some of these factors can not be predicted with certainty. The following guidelines should be helpful in most but not necessarily in every situation. First, the system should not be used on nights where the temperature-wind combination produces conditions more extreme than the system was designed to handle. Refer to a reliable forecast and Table 1 to determine whether or not the system should be used.

Calm Nights

If there is no wind predicted and a decision is made to run the system, it is usually turned on when a thermometer, hung under the open sky from a bare branch in the coldest part of the field reaches 32°F. However, if the dew point temperature is below 25°F, the system should be turned on at 34°F, which will probably be only about half an hour before the temperature reaches 32°F. The temperature has a great tendency to fall to within 1 degree of the dew point on clear, calm nights. If the dew point is 26°F or lower and frost forms on flowers or berries, they will be killed. If the dew point temperature is 30°F or above and frost forms on flowers or berries, they may not be damaged. During the morning following the freeze, if there is no wind and the sun is shining brightly, the irrigation can be turned off when icicles are falling rapidly from the plants and have been falling for more than half an hour. Never turn off the irrigation before icicles are falling no matter what the temperature. If the dew point temperature is below 20°F, continue running irrigation until the shaded air temperature rises to 40°F. If it is windy and the dew point is 26°F or below, do not turn off the irrigation until most of the icicles have fallen.

Windy Nights

For windy freezes, the decisions about whether or not to run irrigation become complicated. Table 1 provides guidelines for determining the amount of water required to protect fruit at various temperature/wind speed combinations. However, the values in Table 1 assume normal relative humidity. If relative humidity is very low, as sometimes happens when a cold dry air mass moves into Florida, the values in Table 1 may underestimate the amount of water needed for adequate freeze protection. Paying attention to the dew point temperatures during various nights of freeze protection will help take the mystery out of why crops are sometimes saved when it seemed too cold and windy and why crops may be lost when it seemed they should have been saved.

Overhead Irrigation the Afternoon or Evening Before a Freeze

Experienced fruit growers have long known that irrigating their fields the afternoon before an expected freeze can sometimes reduce the damage caused by the freeze. There are four situations in which this practice is potentially useful to blueberry growers.

First Situation

It is a calm afternoon, and minimum temperatures are forecast to be on the borderline between damaging and safe. A wet ground may allow
the grower to avoid having to turn on the system during the night. In such situations, even minimum overhead irrigation during the night should be effective in preventing damage, but there are disadvantages to irrigating on frost nights, and being able to avoid a run is highly desirable. If the temperature does become critical during the night, a wet ground will reduce the probability that damage will occur before the system is turned on.

Second Situation

The dew point is low and the wind speed is expected to be erratic during the night. Or, temperatures are expected to fall to or below the damaging point with light winds, with a rising wind expected later in the night. Even though a rising wind in the night is frequently bringing in colder, drier air behind a secondary cold front, the effect may be to raise the temperature of the blueberry flowers, as cold surface air is mixed with warmer air above the inversion and the wind raises the flower temperature to the temperature of the surrounding air. On some occasions, growers may be able to protect the crop with overhead irrigation before the wind increases, but lose the crop due to evaporative cooling after the wind begins. On the other hand, dry plants might have survived the cold wind without damage, but could not survive the lower temperatures that occurred before the wind broke the inversion. On some such nights, fields that have been thoroughly wet late in the afternoon before the freeze have escaped damage because a higher temperature was maintained before the wind began, whereas crops were lost in dry fields that were not irrigated at all and in fields in which irrigation was run throughout the night.

Third Situation

The grower lacks sufficient pumping capacity to protect the entire acreage against a freeze of the expected severity. A decision is made to change the sprinkler heads to a larger orifice diameter in half of the field and close off the valve to the other half. It may be possible to reduce damage in the half that cannot be irrigated during the night by thoroughly wetting the soil during the afternoon before the freeze.

Fourth Situation

This may be the most common situation in which growers could improve their crops by adopting a practice that is seldom being used at present. Frequently, during January and early February, after blueberry flower buds have begun to swell in response to warm periods in the winter, a freeze will occur in which the dew point is so low, the air so cold, and the probability of some wind during the night so high that no experienced grower would choose to run the irrigation at night for fear of causing massive damage from evaporative cooling, frozen emitters, broken branches, and uprooted plants. Furthermore, many of the flower buds may still be quite dormant, and will survive if nothing is done. Frequently, in late January, the flower buds may show a wide range of developmental stages. For example, 20% of the buds might be killed if the temperature falls to 24°F, an additional 20% will be killed if it falls to 21°F, an additional 20% will be killed at 18°F, and 20% would survive 16°F. A low-risk strategy for the grower would be to thoroughly wet the ground the afternoon before freezing temperatures began, with the goal of raising minimum temperatures in the field by two or three degrees and reducing the fraction of the crop lost. Because fruit prices are often higher in years with light crops, and because blueberry plants can sometimes partially compensate losses in fruit number by increasing fruit size, saving part of the crop could be quite rewarding for the grower.

Alternative Freeze Protection Methods

Wind machines and helicopters have been used to some extent to protect blueberry crops from freezes in Florida. Both are based on the fact that on clear calm nights a strong temperature inversion develops, in which temperatures within 6 feet of the ground may become much colder than temperatures 50 to 100 feet above the ground. By mixing these air layers, wind can raise the temperature near the ground by about 4°F, the exact amount varying with the strength of the temperature inversion and the effectiveness of the air mixing. On nights with wind, wind machines and helicopters cannot warm an orchard because no temperature inversion develops.
Many windy freezes occur in Florida during January and February which usually coincides with the southern highbush bloom period.

A single wind machine will normally provide a maximum heating of about 5°F over an area of about 10 acres. The cost of installing and maintaining a wind machine is fairly high, but the cost of running one is comparatively low, about eight gallons of gasoline per hour. A single helicopter can provide a similar degree of heating over an area of about 40 acres, so long as it is constantly flying. A problem with helicopters, apart from their high cost, is how to keep them continuously in the air on freeze nights. Scheduling problems, pilot fatigue, mechanical breakdowns, and the need to refuel can interrupt service. Wind machines are commonly used in some fruit producing areas of the World. They are seldom used on blueberries in Florida but might be practical at the south end of the production area in Florida.

Orchard heaters, which burn fuel oil, were widely used to protect citrus trees from freezing before fuel prices became prohibitive. They are also effective, but expensive, in protecting blueberry crops. On a still night, 24 grove heaters per acre will heat a citrus grove by about 5°F. These heaters burn a gallon of fuel per hour and fuel costs can be over $300 per acre for a single night. High fuel costs have prevented widespread use of grove heaters for freeze protection in Florida blueberries.
### Table 1. Suggested overhead irrigation application rates for cold protection of blueberries under different wind and temperature conditions.

<table>
<thead>
<tr>
<th>Minimum Temperature Expected</th>
<th>Wind Speed in M.P.H.</th>
<th>Application Rate (inches/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 to 1</td>
<td>2 to 4</td>
</tr>
<tr>
<td>27 °F</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>26 °F</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>24 °F</td>
<td>0.10</td>
<td>0.16</td>
</tr>
<tr>
<td>22 °F</td>
<td>0.12</td>
<td>0.24</td>
</tr>
<tr>
<td>20 °F</td>
<td>0.16</td>
<td>0.3</td>
</tr>
<tr>
<td>18 °F</td>
<td>0.20</td>
<td>0.4</td>
</tr>
<tr>
<td>15 °F</td>
<td>0.26</td>
<td>0.5</td>
</tr>
</tbody>
</table>

¹ Dry air accompanied by wind will require higher application rates than indicated for a given temperature/wind speed combination. From Gerber and Martsolf, Extension Circular 287, Florida Agricultural Extension Service.