

## GUIDE TO DECIDING WHEN TO START AND STOP IRRIGATION FOR FROST PROTECTION OF FRUIT CROPS

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The decisions of when to turn an irrigation system on and off for frost protection are complex and difficult. This guide presents a procedure to follow in making these decisions.

This guide is based on the assumption that you have completed certain tasks prior to the night of the decision making. These tasks encompass important planning decisions that are made well ahead of the frost season. The tasks are stated here very simply, but this is certainly not meant to imply that they are not critical in this process; it has been done merely to limit the scope of this article. For more information on the tasks leading up to the actual frost night, request Horticulture Information Leaflet No. 705, titled "Frost/Freeze Protection for Horticultural Crops," from your County Extension Center, or retrieve it from the World Wide Webathttp://www2.ncsu.edu/ ncsu/cals/hort sci/comm/weather.html. You can also borrow the 13-minute video, titled "Overhead Irrigation for Frost Protection," from your County Extension Center.

Prior to the night you make the decisions of when to turn on and when to turn off your irrigation system, make sure of the following.

 You know the critical temperature of the blossoms at the current stages of development (see Table 1 for examples).

- The air- and/or blossom-temperature monitoring equipment has been set up and checked, i.e., thermometers/sensors calibrated.
- The irrigation system has been set up and checked.
- The application rates that can be provided are known, and an estimate of the rate that will be required on this particular night has been made (Table 2).
- You know that your system can provide this rate! [If it cannot, it is better not to turn the system on at all! Irrigation for frost protection is one method that can do more damage than not doing anything if it is not properly carried out.]
- You know the forecast of the minimum air temperature, wind speed, and dewpoint.

## Deciding When to Turn On and Temperature Monitoring

When your frost alarm or alarm clock has awakened you, begin checking temperatures (blossom temperatures are preferred over air temperatures) at each place you have a sensor. Do this every 15 to 30 minutes. Record the observations. It is best to graph the temperature (x-axis) versus time (y-axis). This graph will show you the cooling rate. Early in the process, this can be used to estimate when you will likely have to turn the system on. Later, close to sunrise, it may tell you that the critical temperature will not be reached, and you can go back to bed.

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Table 1. Critical temperature at which 90% bud/blossom kill occurs for several development stages for several North Carolina fruit crops.

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Fruit Crop	Bud/Blossom Stage of Development	Critical Temp. °F 90% bud/ blossom kill	Critical Temp. °F 50% bud/ blossom kill			
Apple	Silver tip Green tip Half-inch green Tight cluster First pink Full pink First bloom Full bloom Post bloom	2 10 15 21 24 25 25 25 25				
Blueberry	Flowers protruding from bud Corollas at half full length Full bloom Right after corolla drop	20 26 27 28				
Grape	Dormant enlarged Dormant swollen Shoot burst First Second		7 26 28 28.5 29			
Peach	First swell Calyx green Calyx red First pink First bloom Full bloom Post bloom	1 5 9 15 21 24 25				
Straw- berry	Bud Popcorn blossom Full bloom	24 28 30				

Table 2. Required irrigation rates, in/hr, for a critical temperature of 28°F and relative humidity of about 70%.

Air Temp.ºF	Wind Speed, mph			
	0-1	2-4	5-8	9-14
27	0.10	0.11	0.14	0.16
26	0.10	0.13	0.16	0.17
25	0.10	0.14	0.18	0.21
22	0.10	0.18	0.24	0.29
20	0.11	0.21	0.28	0.34
18	0.12	0.23	0.31	0.38
16	0.13	0.26	0.35	0.43

<sup>\*</sup> If wind speeds are above 15 mph, it is unlikely irrigation for frost protection will be successful.

Continue monitoring the temperatures until your predetermined turn-on temperature has been reached. This turn-on temperature will vary according to the wind speed and dewpoint and whether you are monitoring air or blossom temperatures. If the cooling rate is less than 2°F per hour and the dewpoint is in the mid to upper 20s, then a safe turn-on temperature is 32°F (air temperature) or 31°F (blossom temperature). If the cooling rate is greater than 2°F per hour and the dewpoint is in the teens, a safe turn-on temperature is 34°F (air temperature) or 32 to 33°F (blossom temperature). However, this information must be integrated with the estimate of the required rate for the worst conditions expected during the night.

If your system will not be able to meet this rate, it will do no good to turn on and protect earlier in the night. In this case, you will protect the blossoms for awhile, but when the atmospheric conditions surpass the ability of your irrigation to protect, you will be cooling the crop to a lower temperature than it would have reached had you done nothing! Also, keep in mind that the ice coating on the blossoms does nothing to protect them. Rather, it is the continuous process of ice making that releases heat and thereby provides protection. If ice making stops or is occurring too fast [this traps air bubbles in the ice and gives it a milky appearance], the process is not protecting.

## Deciding when to turn off.

This decision is as difficult as that for starting. When the crop is receiving direct rays from the sun, it is safe to turn the system off. The radiant heat from the sun will warm the blossoms very rapidly. If you are monitoring blossom temperatures, you will see this and feel very comfortable knowing they are safely above the critical temperature when you turn off.

However, if you are monitoring air temperatures, you will not see this. The air temperatures will warm more slowly than the blossoms, because the air is warmed indirectly, i.e., the radiant heat from the sun heats the surface and solid objects which in turn transfer heat to the air by conduction and convection. For more information on this, request Horticulture Information Leaflet No. 705, titled "Frost/Freeze Protection for Horticultural Crops," from your County Extension Center, or retrieve it from the World Wide Web at http://www2.ncsu.edu/ncsu/cals/hort\_sci/comm/weather.html.

If you make your decision based on air temperature, you will likely turn off much later than is desirable. In most cases, this will not be harmful, but it will use more water than is necessary and may jeopardize the number of nights in a row your water supply will support protection. In a few cases, when the wind picks up briskly as the sun rises, the irrigation may switch from mostly freezing — and

thereby heating — to mostly evaporating and thereby cooling! This will inhibit the ice from melting and can erroneously lead you to think you must keep irrigating late into the morning! In such cases, it is safe to turn the system off when the sun is directly on the blossoms. The wind alone will inhibit the ice from melting, so you may be concerned when it doesn't melt as quickly as usual. However, as long as the sun is directly on the blossoms, they will be warmand remain above the critical temperature.

## References

Several references are available for North Carolina climate data. It is convenient to have these references on hand to access climate data quickly. References available from the NCSU Department of Agricultural Communications, Box 7603, Raleigh, NC 27695-7603 (919-515-3173) include the following:

- Weather and Climate in North Carolina, AG-375 (\$2.50)
- Risk of Frost and Freeze Damage for North Carolina Fruit Crops, AG-403 (free)
- Low-Temperature Probability Data for North Carolina, AG-403S (\$3.00)
- Growing Degree Days in North Carolina, AG-236 (free)
- Probabilities of Dry Periods in North Carolina, AG-411 (\$2.00)