RAIN BIRD®

TECH TIP

Frost Protection By Sprinkling

Utilizing Impact Sprinklers for Frost Protection:

Application of water by sprinklers to protect crops from radiation frost damage is utilized on thousands of acres where adequate water is available. Radiation frosts may occur on clear, calm nights, usually following the passage of a cold front in the previous twenty-four to forty-eight hours. The term "radiation frost" is used to differentiate it from "wind-borne freeze" which describes a below-freezing air mass moving through the area.

Water offers an economical, pollution-free method of frost protection if a grower has a sprinkler system. The heat released for frost protection, when water is applied through sprinklers, depends upon the temperature of the water applied and the amount of water which is converted to ice. When water cools to 32° F, one BTU per degree per pound of water is released to the atmosphere. When 32° water is changed to 32° ice, 144 BTU per pound is released. This is termed heat of fusion.

The significance of these figures may be seen from the following calculations:

Heat Released by Water Cooling From 62° to 32° F

0.01 acre-inch per hour releases 68,000 BTU/hour
0.05 acre-inch per hour releases 340,000 BTU/hour
0.10 acre-inch per hour releases 680,000 BTU/hour

Heat Released by Changing From 32° Water to 32° Ice

0.01 acre-inch per hour releases 360,000 BTU/hour
0.05 acre-inch per hour releases 1,630,000 BTU/hour

Heat Released by 0.10 Acre-Inch of 62° F Water, of Which Half or 0.05 Acre-Inch Freezes

680,000 + 1,630,000
= 2,310,000 BTU/hour

For comparison, the heat released by 20 return stack heaters, each burning 3/4 gallon of fuel oil per hour = 2,250,000 BTU/hour

Two methods of sprinkler frost protection are utilized:

Undertree Protection
Overhead Protection

Each method has its place and its limitations.

Undertree Protection:

Under tree protection is used mainly in deciduous trees, in areas where low dewpoints do not generally occur. Where low dewpoint or high evaporation potential situations occur, under tree frost protection is not recommended. It may in fact be detrimental because of super-cooling due to the evaporation which takes place under those conditions. The latent heat of vaporization is over 7 times the heat of fusion, and this causes the cooling to take place. This means that in order to maintain a temperature, 7 times as much water must be freezing as is evaporating. The lower the dewpoint, the greater the potential for evaporation.

The amount of protection from an undertree system depends on the amount of water applied. An application of 40 gpm per acre will give a temperature increase of 4-5° F, if the dewpoint is above 32°. The temperature to which this will protect a crop depends upon the stage of growth and the sensitivity of the variety to frost damage. For example, most almonds will be damaged at 30° F during the milk or small nut stage. The same varieties will show about equal damage at 26° F in the full bloom stage and less damage in the pink stage. An application rate of 0.089 inches/hour or 40 gpm/acre is recommended for protection. More sprinklers per acre give better protection from a given quantity of water. For example, it is better to have 20 sprinklers per acre with 2 gpm each than to have 10 sprinklers per acre with 4 gpm each. Best results are obtained with pressures near the top of the recommended range for a sprinkler.

On most spring nights there is relatively little ice formed undertree to give heat for protection. The type of protection achieved must therefore be different from that of ice encasement (as in overhead protection). In the majority of cases, the trees are enveloped in rising columns of fog. The increased atmospheric moisture reduces the net outgoing radiation of ground surface heat, and keeps the temperature in a protected block from dropping as low as in an unprotected area. Higher rates of application are required on the borders of field, particularly on the upwind side.

Overhead Protection:

Overhead protection utilizes the heat of fusion to maintain a temperature of 31-32°F in the ice encased tissue of the plant. The degree of protection is greater than with undertree, but more water per acre is required. Ice is an excellent thermal conductor, so the temperature of the surface of the ice encasement is rapidly reflected at the plant tissue. Maintaining a temperature of 31-32°F at the ice surface depends upon supplying water to that surface at regular rapid intervals to maintain an ice/water interface there. As long as a film of water surrounds ice-coated vegetation, the temperature of the ice and vegetation cannot go below 32° F.

Therefore, the frequency of wetting and the speed of rotation of the sprinklers are of great importance in obtaining the maximum protection from the minimum amount of water. For example, with an application rate of 0.11 inch/hour (50.0 gpm per acre), with a wind 3.4 mph, an air temperature of 32° F, and a wet bulb temperature of 29° F, a leaf edge drops from 37° F to 29° F in about 50 seconds. It drops to 32° in about 25 seconds. Comparisons of 30 and 60 second rotation times show that from 29° down to 23° F, the equivalent protection can be obtained with 0.02 inches per hour less water with 30 second rotation time. This is a saving of 9 gpm per acre due to rotation time of 30 seconds, instead of 60 seconds.
Frost systems in grapes designed on 0.12 inches/hour (54.3 gpm/acre), utilizing the Rain Bird® 14V sprinklers (with a rotation time of 15 to 40 seconds) have protected down to 23° with dewpoints of 25° or higher. For each degree the dewpoint is below 25°, an additional 0.01 inch per head should be applied above the 0.12"/hour. For example, to protect 23 °F with a dewpoint of 22°, would require the application of 0.15 inch/per hour.

When a sprinkler system is first turned on, there is a reduction in temperature due to evaporative cooling. The magnitude of the drop depends upon the relative humidity of the air in the area to be protected. An indication of the potential temperature drop can be related to dewpoint in the area. Table 1 indicates turn on temperatures required for various dewpoints to prevent evaporative cooling to below 31° F.

TABLE 1

Dew point Temperature	Turn On Air Temperature At:
15°	39°
16°	39°
17°	38°
18°	38°
19°	37°
20°	37°
21°	37°
22°	36°
23°	36°
24°	35°
25°	35°
26°	34°
27°	34°
28°	33°

In the absence of dewpoint information, wet bulb temperature may be used to start the system. The system should be turned on at 32° F wet bulb temperature. It should not be turned off until the wet bulb temperature is at least 34° F, and higher if there is a wind blowing to cause evaporation.

Rain Bird Frost Protection Sprinklers: Specifications and Application Table

Model Series		M20	L20	14	20A	30PWH	30FH/30WH
Wedge Drive Model[1]	w/ Brass Bearing	M20VH	L20VH	14VH			
	w/ Plastic Bearing	M20VH-PM					
Spoon Drive Model	w/ Brass Bearing				20AH (alum)	30PWH	30FH/30WH
Trajectories [2]	w/0° Nozzle	40" (15°)	38" (13°)	72" (23°)	72"		(27°)
	w/3° Nozzle Up	---	30" (10°)	---	78"		---
	w/3° Nozzle Down	36" (12°)	24" (7°)	68" (20°)	66"		---
	w/L.A. Nozzle	---	---	---	36" (7°)		---
Crop Recommendations		Almonds Avocados Pistachios Walnuts	All stone fruits Apples Avocados Cherries Pears	Almonds Walnuts (on wide spacings) Vines	Apples Cherries	Strawberries Vegetables	Strawberries Vegetables

Recommendations: (A) Smaller Nozzles - use wedge drive for better rotation (B) Low Pressures - use wedge drive for better rotation, and use LPN nozzles for better break-up and distribution (C) Frost Protection - use wedge drive for faster rotation (A, B & C: see performance charts)

[1] Features patented sef-flushing, anti-jamming design. [2] Inches above nozzle and degrees from horizontal.

These models are suitable in all undertree, overtree, overvine and over row crop applications.

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