



# Agricultural Engineering

SW - 4

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## FROST PROTECTION WITH SPRINKLER IRRIGATION

Sprinkler irrigation can be used to provide frost protection for certain vegetables and small fruits, particularly strawberries. A properly designed and operated sprinkler irrigation system can provide frost protection for strawberries down to 22° F or lower. This protection can make the difference between a 90 percent crop and one that is 20 percent or less—or the difference between profit and failure.

### How Protection is Provided

Heat is applied in one way or another to change ice into water. Similarly, to change water into ice, heat is released. When an irrigation system is used for frost protection, water is sprayed almost continuously on the plants and soil. When the air temperature surrounding the plants drops below freezing, water starts to freeze on the plants.

The latent heat of water, released when the water freezes, is the principal factor involved in protecting the plant. One gallon of water at 32° F, changing into ice at 32° F, gives off approximately 1200 BTU's (British Thermal Units) of heat. Some of the heat released goes into the plant leaves and blossoms, some goes out into the air and some goes to the soil. The heat absorbed by the plant is enough to keep the plant above its freezing point, except when the air temperature is very low or when heat is removed rapidly by a cold wind. There is some transfer of heat because the water temperature is above freezing, but most of the protection comes as the water freezes and latent heat is released. The slush ice and the increased humidity also increase protection.

Water must be sprayed on plants continuously, or at frequent repeated intervals, such as when applied by a rapidly rotating sprinkler or oscillating pipe. This will provide enough heat to keep the plant from freezing. Ice may form on the plant to a thickness from 1/16 to 1/2 inch, depending on the duration and intensity of below freezing temperatures. Ice may not form when the frost is very light; temperatures will usually be 1-2° F below freezing before ice starts to form. When ice does form, water must be applied until air temperature is above 32° F and all ice is melted from the plants.

### When to Start System

A "test run" of the sprinkler irrigation system should be made before frost protection is needed. This will provide an opportunity to check out the system and insure that it will operate properly when needed. The amount of water applied should be checked by measuring its depth in cans placed between sprinklers. In

actual operation, the system should be started when the falling temperature reaches about 34°F. An accurately adjusted temperature alarm can be used to signal when the temperature reaches this point. Controls are available to automatically start and stop the system, though most operators will want to be on the job to make sure that everything is functioning properly.

### Application Rate

The rate of water application for frost protection depends on air temperature—as it drops, more water must be applied. The degree of crop frost protection available and the optimum sprinkling procedures to be used are a function of the crop's resistance to freezing, stage of growth, general weather conditions and the design and operation of the frost protection-irrigation system.

#### RECOMMENDED APPLICATION RATES FOR STRAWBERRIES

Air Temperature (F)	28	26	24	22
Application Rate (inches/hour)	0.08	0.10	0.125	0.20

#### GALLONS PER MINUTE REQUIRED FROM EACH SPRINKLER FOR DIFFERENT SPRINKLER SPACINGS AND APPLICATION RATES

Sprinkler Spacing (feet)	Number of Sprinklers per acre	Application Rate (inches per hour )						
		0.08	0.09	0.10	0.11	0.125	0.15	0.20
30 x 30	48	0.75	0.84	0.93	1.03	1.17	1.40	1.87
30 x 40	36	1.00	1.12	1.24	1.37	1.56	1.87	2.50
30 x 50	29	1.25	1.40	1.56	1.72	1.95	2.34	3.12
30 x 60	24	1.50	1.68	1.87	2.06	2.34	2.80	3.74
40 x 40	27	1.33	1.49	1.66	1.82	2.04	2.49	3.32
40 x 50	22	1.66	1.87	2.08	2.29	2.60	3.12	4.16
40 x 60	18	1.99	2.24	2.49	2.74	3.11	3.74	4.98
60 x 60	13	2.98	3.36	3.73	4.10	4.66	5.60	7.45

### Sprinklers For Frost Protection

Many of the two-nozzle sprinklers commonly used for irrigation apply more water than needed for frost protection. Single nozzle sprinklers designed for frost protection, with special bearings and low tension arm springs or speed washers for faster rotation, are available. Although definite recommendations on the optimum rotation speed needed for frost protection cannot be made until more research data is available, a speed of at least 1-2 revolutions per minute has been recommended as the minimum for adequate frost protection. Operating pressures in the high side of the specified pressure range for the sprinkler should be used to obtain both the good coverage and finer water droplets desirable for frost protection. Sprinklers spaced in a triangular pattern, rather than a rectangular or square one, provide more uniform coverage. Sprinkler performance charts should be used as a guide for selecting sprinklers.

### Amount of Water Needed

Applying 1/8 inch per hour (0.125) to 1 acre requires about 60 gallons of water per minute. Frost-protecting 5 acres then would require about 300 gallons per minute. If a pond or reservoir is to be used as the water supply, sufficient storage capacity must be available. For 5 acres at 1/8 inch application rate, 18,000 gallons of water per hour are needed. Assuming that the system may have to be operated continuously for 10 hours boosts that figure to 180,000 gallons. The reservoir must be able to supply water for two or three consecutive nights or be replenished during the day.

#### GALLONS PER MINUTE NEEDED FOR VARIOUS APPLICATION RATES FOR EACH ACRE TO BE FROST PROTECTED

Application Rate (inches/hour)	0.08	0.00	0.10	0.11	0.125	0.15	0.20
Gallons per minute per acre	39	43	48	53	60	73	97

Assistance on planning, designing and operating frost protection-irrigation systems can be obtained from county extension agents, engineers, irrigation equipment suppliers and the Soil Conservation Service.

Additional information on irrigation: Extension Circulars 414, 415, 416 and 417.

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