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Frost/Freeze Protection in Strawberries

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Even though the coldest part of the season has past, beware of temperature fluctuations during bloom that can plunge below freezing and damage emerging flowers. Strawberry crowns are fairly tolerant of low temperatures when fully dormant. However, as the plant awakens, re-hydrates tissues and begins to grow there is a concurrent loss of cold tolerance. Additionally, flower structures begin to emerge from the crown, which are sensitive to low temperatures, and will require some form of protection to avoid damage.

Not all frost/freeze events will be similar and strategies to protect your crop can be modified appropriately based on the weather conditions and stage of crop development. There are generally two types of freeze conditions strawberry plants will experience in the field, radiation and advective freezes. Radiation freezing results when heat from the atmosphere and ground is lost continuously to a cloudless sky on a cold, windless night. Advective freeze events occur when temperatures drop below freezing and are accompanied by high winds. The latter presents growers with a challenge in protecting the crop and alternative strategies are required if freeze damage is to be avoided.

Under radiational type freezes, overhead irrigation is the typical strategy employed for frost protection. Protection is provided to the emerging blossoms via the continual freezing of water on the plant. As water cools and freezes, two sources of heat are released, sensible heat and latent heat of fusion. Freezing of liquid water is an energy releasing processes and can generate up to 144 btu's for every pound of water frozen (latent heat of fusion).

A significantly less amount of heat is given to the environment by water cooling (sensible heat). Therefore, under conditions of radiational freezing, irrigating the fields and allowing the physical process of water freezing to occur on the plants can afford a great deal of protection and moderation of the temperature experienced by the blooms. For this method to be effective, uniform irrigation patterns and subsequent continuous freezing of water is required on the surface of the plant. Sprinkler heads spaced either 40' x 40' or 30' x 30' is optimum and uniformity of coverage is a function of sprinkler type and available water pressure. Traditional impacts require higher water pressure and can operate well at larger spacing. Wobblers can operate at lower pressures, have faster rotation compared to impacts but have a limited range and require closer spacing (30' x 30'). The key to successful frost protection is to optimize the irrigation layout to match the specifications of your system (i.e. proper spacing based on irrigation heads and water pressure provided by the pump).

A more challenging situation occurs when weather forecasts predict a large cold front with sub-freezing temperatures and high winds (advective freeze). Under these conditions it becomes increasingly difficult to provide your crop with the necessary conditions of uniform irrigation patterns and continual heat release. Protecting the strawberries using overhead irrigation can do more harm than good as uneven watering patterns and frequent freezing of the irrigation nozzles can lead to the crop experiencing colder temperatures than the ambient due to evaporative cooling. As water freezing is a heat releasing process, the opposite is true when liquid water becomes a gas (evaporative cooling). This can be the case even under freezing temperatures when frozen water can change phases directly from a solid to a gas (sublimation) during cold temperatures and high wind velocities.

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Some rules of thumb for frost protection during radiation freeze conditions have been presented through various extension outlets and will be re-emphasized. Things to keep in mind for effective crop protection is when to start irrigating, the proper volume of water to use and when to stop. Different plant tissues and stages of crop development have varying critical temperatures associated with them when damage is experienced (Table 1).

Table 1. Critical temperatures of strawberries at various stages of flower development

Stage of Development	**Critical Temp. (°F)**
Tight bud	22.0
"Popcorn"	26.5
Open blossom	30.0
Fruit	28.0

Source: Perry, K.B. and E.B. Poling. 1986. Field observation of frost injury in strawberry buds and blossoms, Advances in Strawberry Production 5:31-38.

The first step in beginning to prepare for a protection event is to know what stage of development the plants are and what the forecasted low is to determine what strategy is needed. When flower buds are still tucked into the crown and weather forecasts predict a low of 29°F then no protection will be needed. However, if a significant amount of flowers are open and forecasts are predicting lows in the mid 20's, the crop will certainly need protection and addressing when to turn the system on becomes the next consideration. As was mentioned, two opposing energy processes are influencing the temperature of the crop. The latent heat of fusion (water freezing) will release heat (approximately 144 btu's/lb of water), meanwhile evaporative cooling (absorbing approximately 1,044 btu's/lb of water) will absorb heat (energy) from the plant and lower plant tissues below the ambient. Therefore a problem arises important to the initial start-up of irrigation. That is, the first water to come into contact with our crop will actually cool tissues greatly due to evaporative cooling and plunge plant tissues several degrees below the ambient air temperature. As a result, overhead irrigation should be initiated when temperatures are a few degrees above the critical temperature for the structure you are trying to protect (i.e. open blooms, start at 340F under light wind) in order to compensate for the energy (heat) lost during evaporation. Table 2 shows some suggested precipitation rates under varying environmental conditions to ensure uniform ice formation.

Table 2. Irrigation rates, in/hr, for critical temp of 28°F and relative humidity of about 70%

	Wind Speed (mph)			
Min. Temp.(F)	**0-1 mph**	**2-4 mph**	**5-8 mph**	**9-14 mph**
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
15	0.13	0.26	0.35	0.43

Source: Perry, K. 1998. The strawberry grower. Vol. 5 No. 2.

An emerging area of research in frost/freeze protection deals with the use of floating row covers. Dr. Allen Straw, of the University of Tennessee, recently presented some preliminary data at the National Berry Growers meeting in Nashville looking at row covers used in conjunction with overhead irrigation for frost protection. Allen has shown that combining overhead irrigation with row covers can significantly moderate the plant canopy and keep temperatures substantially above the ambient. This method appears to be most useful during advective freeze conditions when protection from overhead irrigation is unpredictable and the use of row covers alone may not provide the needed protection.

Row covers have traditionally been used in strawberry plasticulture to 1) extend the fall season promoting additional branch crown development, 2) provide winter protection from cold temperatures and wind and 3) spring use for advancing flowering and early harvest. When temperatures are forecasted to be in the mid to low 20's during bloom, row covers alone have been thought to not provide adequate protection. The amount of cold protection provided by floating row covers is a function of its weight with the highest weight fabrics providing the most protection. Or is it? Allen's preliminary data indicated that using a double layer of 1 oz/sq yd cover provided adequate crop protection (30°F) when ambient temperatures went as low as 25°F and was more effective than using a single layer of 2 oz/sq yd cover. Charlie O'Dell also has some experience indicating that this double layer effect is not simply additive and may involve other 'insulating' effects. More research is needed into this area; however, these results are promising and could possibly result in conserving water during the spring season, decreasing early season flower loss and increasing the average hours of sleep for the farm manager. Research trials looking at the repeatability of this layer effect will help to provide a working set of protocols for the use of row covers as a possible alternative to traditional frost protection.

In order for any strategy to be effective, we need to be prepared and informed about the conditions affecting our location. Setup a weather station in the lowest section of the field wired to an alarm system to notify you when temperatures are approaching levels that will require action to be taken. Timely setup of irrigation pipes and preventive maintenance on critical equipment will help to ensure success when action is taken. And most of all, we have to deal with what Mother Nature throws at us. GOOD LUCK!

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