Frost/Freeze Protection in Strawberry

Jayesh B. Samtani, Small Fruit Extension Specialist, Hampton Roads AREC, School of Plant and Environmental Sciences

Even though the coldest part of the strawberry growing season has passed, beware of temperature fluctuations during bloom that can plunge below freezing and damage emerging flowers (Figure 1). 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. Strawberry crowns are fairly tolerant of low temperatures when dormant and can tolerate temperatures up to the lower teens (ºF). However, as the plant awakens in the spring season, tissues are rehydrated, and the plant begins to grow. There is a loss of cold tolerance with rehydration. Additionally, flower structures begin to emerge from the crown, and those are sensitive to low temperatures and will require some form of protection to avoid damage.

Figure 1. Open blossoms with black flower center (black eye) are an indication of frost injury on the plant. Those flowers with yellow centers on the open blossom are were not injured. Black eyed flowers are no longer viable and will not set fruit (Photo by J.B. Samtani)

There are generally two types of freeze conditions strawberry plants will experience in the field, *radiation* and *advective* freezes. *Radiation* freeze results when heat from the atmosphere and ground is lost continuously to a cloudless sky on a cold, low wind speed night. *Advective* freeze events occur when temperatures drop below freezing and are accompanied by high winds. The latter presents the growers with a challenge in protecting the crop and alternative strategies are needed if freeze damage on the strawberry plants is to be avoided.

Strawberry tolerance to low temperatures. Different plant tissues and stages of crop development have varying critical temperatures associated with them when damage is experienced (Table 1). The first step in frost/freeze protection event is to know what development stage the plants are at and what the forecasted low is, to determine which strategy is needed. When flower buds are still tucked into the crown (tight bud stage of development) 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.

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

Stage of Development	**Critical Temp. (°F)**
Tight bud	22.0
"Popcorn" (slightly opened bud)	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.

Crop protection strategies.
Floating row covers (Figure 2) have traditionally been used in strawberry plasticulture to 1) promote further branch crown development in the fall season 2) protect from cold temperatures and wind in the winter season and 3) advance flowering and early harvest in the spring season. In this article, we will focus on purpose 2 of utilizing row covers in strawberry production i.e., protection from cold temperatures.

Figure 2. Floating row covers in use in a strawberry field (*Photo by J.B. Samtani).*

A single cover of row cover (1 oz.) offers up to 3 to 4 ºF of cold protection. Thus when temperatures are forecasted to be in the mid to low 20's ºF during bloom, row covers alone will not provide adequate protection. Under radiation freezing with these temperatures, 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 the water cools and freezes, two sources of heat are released, at first, sensible heat and then later, latent heat of fusion. Sensible heat and latent heat are explained very well by North Carolina State University, North Carolina Climate Office web page and can be accessed at <https://climate.ncsu.edu/edu/Heat>. When water freezes into its solid form (ice), energy is released as the molecules are compacted giving off energy. This process can generate up to 144 BTU's for every pound of water frozen or 80 calories per gram of water frozen (latent heat of fusion). When the temperature of the water drops from higher temperature to lower temperature, a significantly less amount of heat is given to the environment by water cooling (sensible heat).

Radiation freeze.

In the event of a radiation freeze, irrigating the fields and allowing water to continuously freeze on the plant surface can offer protection and moderation of the temperature experienced by the blooms. For uniform irrigation patterns, sprinkler heads should be spaced either at 40' x 40' or 30' x 30'. Uniformity of coverage is also a function of sprinkler type and available water pressure. Traditional impact sprinklers require higher water pressure and can operate well at a larger spacing (40' x 40'). Wobblers can operate at lower water 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).

Advective freeze.

A more challenging situation occurs when weather forecasts predict a large cold front with sub-freezing temperatures and high winds (*advective freeze*). Row covers can cause damage to flowers or fruits under very windy conditions and would not work under these conditions. It also 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 due to high winds and frequent freezing of the irrigation nozzles due to sub-freezing temperatures can lead to the crop experiencing colder temperatures than the ambient due to evaporative cooling. During evaporative cooling, water changes into water vapor. Ice could also change directly to vapor (sublimation). Both sublimation and evaporative cooling will absorb energy and can result in cold injury to plants.

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 begin irrigation, the proper volume of water to use and when to stop. 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 that relates to the initial start-up of irrigation. The first water to come into contact with the 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 for frost protection should be initiated when temperatures are a few degrees above the critical temperature for the plant structure you are trying to protect (i.e., open blooms, start at 34 F 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 the 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.				

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.

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.

Current content has been adapted and modified from the Publication 2906-1386 'Frost/Freeze protection in Strawberries' authored by Jeremy A. Pattison. Original print appeared in Virginia Vegetable, Small Fruit and Specialty Crops – March-April 2005.

Additional resources for further reading. University of Illinois, Extension. Strawberries: covered and uncovered. <https://web.extension.illinois.edu/mms/downloads/68766.pdf>

Poling, B. 2005. Strawberry Plasticulure Advisory on Cold Protection. <https://www.ces.ncsu.edu/wp-content/uploads/2009/03/StrawberryPlasticulureAdvisoryApril1505.pdf?fwd=no>