9. Managing Cold Events During the Nine-Month Strawberry Plasticulture Production Cycle

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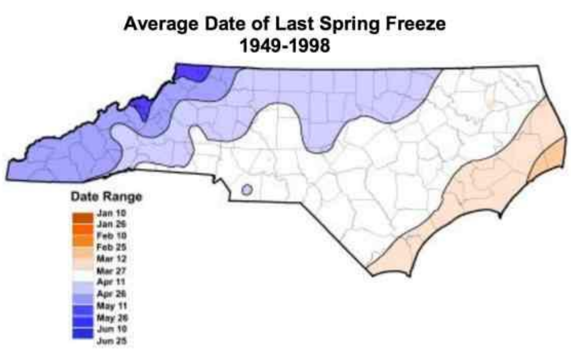
Strawberries are a very weather sensitive crop. Without climate modification strategies—including row covers, sprinkler irrigation, or both—to protect flower buds and blossoms from spring frosts and freezes, strawberry plasticulture would be marginally profitable in North Carolina's climate.

In the strawberry plasticulture growing system, it is not uncommon for strawberry blooms to appear two to three weeks before the *average date of the last spring freeze* in any given location in North Carolina (Fig. 9-1). Strawberry plasticulture growers should expect to frost protect for at least five to six spring frost events, as well as one or two hard freezes during the early bloom period (Fig. 9-1).

A



B

C

Fig. 9-1. Frost and freeze events: A. Average date of last spring freeze, 1949 to 1998 (Boyles, 2000). B. A hard freeze with temperatures in the upper teens and low 20s (°F) can cause extensive damage to newly opened blossoms—even with row cover protection! Open strawberry blossoms will be killed (brown at the center) or damaged at temperatures in the range of 28° to 30°F. C. In very cold and windy conditions, growers will sprinkle on top of row covers to achieve maximum cold protection.

Part 1. Importance of Crop Stage in the Selection of a Protection Method

It is very important to **carefully** consider your general crop stage before deciding on a cold protection strategy. For instance, if the crop has transitioned from winter *dormancy* to *new leaf* stage with emerged flower buds (Fig. 9-2), the safest way to protect the crop against a cold event in this pre-blossom stage is with a floating row cover.

Dormancy Period	Transition Period	New Leaf Growth Stage	New Leaf Growth Stage	New Leaf Growth Stage
Buds inside crown	Tight buds inside crown	Buds inside crown	Emerged buds	Popcorns/early season open blossoms
Hardy to 10 F	Hardy to mid-teens?	Hardy to upper teens	20 – 25 F critical temp	Could be hardy to 27-28 in dry air (low dewpoint

Fig. 9-2. Critical temperatures for cold injury by developmental stage. Open blossoms and "popcorn" stage blossoms (shown just below pencil) are the most susceptible to cold injury, and are generally damaged in the range of 28° to 30°F. However, in dry air conditions (low dew points), it is possible to see open blossoms and popcorns survive down to 27°F. Emerged flower buds (two buds are shown immediately above the pencil point) are generally tolerant to 20° to 22°F; nonemerged flower buds (at the new leaf growth stage) in late winter are hardy to the upper teens.

In the pre-blossom period, more severe cold events often occur in North Carolina, including wind-borne freezes as well as frost/freezes (Table 9-1).

Table 9-1. Frost, frost/freeze, and freeze terminology

Frost event	Wind Speed	Air Temperature (°F)
Frost	Below 5 mph	Above 32
Frost/freeze	5 – 10 mph	Below 32

Freeze	Above 10 mph	Below 32

Further terminology about cold events. Across North Carolina, the most common cold event is a *frost,* which is technically a *radiation* or *radiational frost*. There are two types of radiational frosts: *hoar frost* (white frost) and *black frost* (Perry, 1998, p. 147). Of the two types, hoar frosts are far more common.

Hoar frosts occur when atmospheric water vapor freezes in small crystals on solid surfaces. A hoar frost is also called a white frost. Tender plant parts such as an open strawberry blossom can be killed from exposure to a white frost. Frost formation triggers ice nucleation and possibly plant freezing, even though air temperatures at canopy level may be only slightly below 32 degrees F. For this reason, growers are encouraged to *closely* monitor their strawberry plantings for the formation of frost on the surface of weeds, on rolled up row covers, and on the strawberry canopy. For frost protection with sprinkler irrigation, plan to start irrigating *at the first appearance of frost ice crystals.*

Natural factors that will help keep ice crystals from forming include winds of greater than 5 mph. Cloud covers and potentially drier soil conditions (Sugar et al., 2003) are other natural factors that keep ice crystals from forming.

Black frost. Many growers are unfamiliar with *black frosts*. This may be partially due to the fact that they occur with considerably less frequency in strawberry plantings than *hoar frosts.* Another reason may be due to their "invisibility." Few or no ice crystals form on plant surfaces in a black frost because the lower atmosphere is essentially too dry. Thus, the grower who depends on seeing evidence of "frost" (ice crystals) before starting countermeasures (for frost protection), could potentially suffer catastrophic losses if the dew point temperature (*frost point*) is below the *critical temperature* of the open blossom.

Terminology confusion. Black frosts are strongly radiative events, yet they are very often referred to as a "dry freeze," even though technically, it is not a freeze. As meteorologist Perry cautions, "Although the terms frost and freeze are often interchanged, they describe two distinct phenomena" (personal communication, 1998).

In a black frost, air and plant temperatures will diverge! In addition to the fact that strawberry tissue temperatures may dip below a critical point in a black frost before you can see ice crystals, another very confusing aspect of this type of "invisible" frost is the phenomenon that the plant itself may become significantly colder at night than the surrounding air under the dry atmospheric conditions.

Freeze. When the National Weather Service (NWS) issues a warning for a *freeze*, this means that the potential exists for a very dangerous weather event with subfreezing temperatures and winds exceeding 10 mph. In contrast, "a *radiation frost* occurs when a clear sky and calm winds (< 5 mph) allow an inversion to develop and temperatures near the surface drop below freezing" (Perry, 1998, p. 147).

Prior to the Easter freeze of April 7 – 8 2007, windborne freezes in the strawberry bloom period in North Carolina were essentially unheard of! Sprinkler irrigation is also risky due to a phenomenon known as *evaporative cooling* under freezes, as noted in Table 9.2.

Frost/freeze. A *frost/freeze* combines characteristics of both a *radiational frost* and a *freeze.* As defined by the NWS, a *frost/freeze* warning indicates the potential for a cold event with winds of less than 10 mph and temperatures lower than 32^{o} F. Although the National Weather Service does not set an official lower limit for the wind speeds associated with a *frost/freeze,* it might be inferred that the winds associated with a *frost/freeze* are in the range of 5 to 10 mph. Note that Perry (1998) has defined a *radiation frost* event as having winds of less than 5 mph . As shown in Table 9-2, sprinkler systems can operate successfully in *radiative frosts* (*hoar frost* and *black frost),* but winds above 7 to 8 mph can be very problematic for sprinkler systems.

As Table 9-2 indicates, sprinkler irrigation alone is ineffective for *freeze* events. Under high wind conditions and low dew points, sprinkling can cause extensive crop loss. due to evaporative cooling heat losses.

Table 9-2. Relative effectiveness of row covers and sprinkling under different cold event scenarios

	Radiational	Radiational

Method	White (Hoar) Frost Temperature 28 to 36° F	Black Frost[1] Temperature Below 28° F	Frost/Freeze (winds 5 to to 10 mph)	Freeze (winds > 10 mph)
Row Cover (med)	***[2]	**	**[3]	*[3]
Row Cover & Sprinkling	na	***	***	**
Sprinkling Alone	***	***	*	0

[1] *Black frosts* are more damaging radiational events than a white (*hoar)* frost.
[2]*highly effective = ***; effective=**; limited effectiveness=*; ineffective=0; na=not applicable; na=not appropriate*
[3]*It is very difficult to assign an effectiveness rating for a medium weight row cover in either a frost/freeze or freeze without knowing the minimum temperature associated with the cold event.*

Fortunately, at the pre-blossom stage that normally occurs in early March, a single medium-weight row cover (Fig. 9-3) will provide all the protection needed—this crop stage can tolerate temperatures into the low 20s. A single 1.2 oz row cover can provide 6 to 8 degrees F protection (Fig. 9-3), which is adequate for this crop stage but not for the more tender open blossoms (critical temperature 28 to 30 degrees F).

For example, if the forecast is for a minimum air temperature of 16 degrees F, your crop is still in the pre-blossom stage. A single medium-weight row cover of 1.2 oz/sq yd should confer about 8 degrees F protection. Simply add this level of row cover protection (8 degrees F) to the minimum temperature forecast (16 degrees F), to determine if emerged flower buds will have adequate protection:

a. Row cover protection (8° F) + Minimum temperature (16° F) = 24° F.
b. Emerged flower buds should be tolerant to low 20s° F.
c. Conclusion: Buds beneath the cover should at 24° F, so a single, medium-weight row cover should be a satisfactory method of protection.

Row Cover Properties

	Light wt	Medium weight	Medium weight	Med. Heavy wt
Weight (sq yd)	0.6 oz	1.0 oz	1.2 oz	1.5 oz
(gsm)	20 grams	34 grams	40 grams	51 grams
Protection to:	27 F (-2.7)	24 F (-4.4)	22 F (-5.5)	20 F (-6.6)

Fig. 9-3. Row cover properties for light, medium, and medium-heavy weight row covers. The most popular row cover choice of strawberry plasticulture growers in the mid-South is the 1.2 oz/sq/yd cover. This cover can confer about 8° F protection and can be effective down to about 22° F. For an open blossom with a critical temperature in the range of 28° to 30°F, the 1.2 oz cover would provide adequate protection. In more extreme conditions, it may be necessary to supplement row cover protection with sprinkler irrigation. See "Sprinkling On Top of Row Covers" in **Part 2** of this chapter, **Understanding Sprinkler Irrigation**, for further information about this important procedure.

Comparing row covers to sprinkler irrigation during bloom stage. Clearly, row covers are the best cold protection option in the pre-blossom stage. But during bloom season, row covers and sprinkling are equally effective (Table 9-2) for a radiational white (hoar) frost, which is the most prevalent event during the bloom period in North Carolina.

In Fig. 9-4, you can see how row covers are applied in anticipation of a spring white (hoar) frost event with the crop in heavy bloom stage. For a typical white frost with minimum temperatures in the range of 27 to 32 degrees F, the 1.2 oz row cover provides more than adequate temperature protection as well as preventing "ice crystals" from forming in most blossoms.

Fig. 9-4. Applying floating row covers in late afternoon to protect strawberry blooms from an early morning frost event (photo courtesy of Wohletz Farms).

Specific disadvantages of row covers. Relative to sprinkler irrigation for blossom protection, *row covers do require a tremendous amount of labor and lead time for deployment.* For this and other reasons, many growers prefer sprinkler irrigation to row covers for frost protection at the strawberry crop bloom stage. Another reason why growers may prefer sprinkling in a heavier frost situation is that open blossoms in direct contact with a "frosted" row cover (a heavy frost will cause the covers to stiffen like cardboard) are often killed, and this type of "row cover" injury could affect up to 5% of the open blossoms. A third reason why many growers prefer sprinkling to row covers in the bloom season has to do with pollination. Though honeybees are not essential to pollination and fruit set, wind is critical (Fig. 9-5). And, when you leave row covers **on** the crop during bloom season, you are risking the possibility of getting some bumpy, malformed berries from blooms that are poorly pollinated. Even on a spring day with good breezes, relatively little air movement occurs beneath a row cover. Rains are another challenge for row cover use during bloom—once covers become wet, they cannot be handled again until they become dry, and this can further delay their removal during the bloom period. A final point in favor of sprinkler use during bloom has to do with rapidly changing weather systems in North Carolina during the spring. Very often, weather systems and forecasts do "turn on a dime." Growers without access to a sprinkling system face a considerable challenge to quickly procure a labor force and apply row covers because of a last minute forecast for frost that may or may not happen! Growers with an "easy on, easy off" sprinkler system can more easily respond to the rapidly changing weather conditions that typically occur in North Carolina in late March and April.

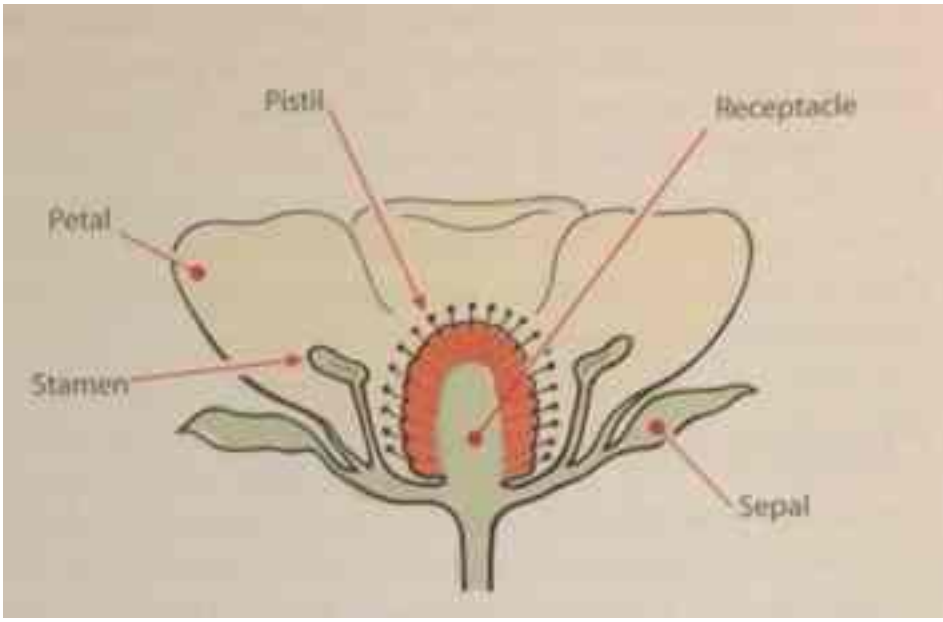


Fig. 9-5. When the pollen is released from the stamens, it is viable for two to three days. And, once the pollen is released, it is available for transfer to the pistil (female flower part). The pollen can be moved by wind, gravity, and insects to the stigma surfaces at the tips of the pistils. Though honeybees are not essential to pollination and fruit set, wind is critical. Self-pollination (by gravity) is not sufficient.

Row covers work best for extreme cold events in fall and winter. Row covers may not be as convenient or as effective as sprinkling during the bloom stage. But as discussed in an earlier section, row covers are the protection method of choice in the pre-blossom period (Fig. 9-4). We have also learned from experience that row covers can be very effective in extreme cold events that occur in fall and winter. Be aware, however, that row covers are *not* recommended for extended periods of use in the winter for milder plasticulture growing regions (Fig. 9-6). As the upper left photo in Fig. 9-6 indicates, the row cover is rolled up at a transition NC coastal plain/piedmont location. But for events like the arctic clipper that came through North Carolina on January 8, 2015, and dropped temperatures below 10 degrees F, these covers were definitely deployed before that event to protect the strawberry crowns from cold injury.

Fig. 9-6. Strawberry plasticulture developmental cycle from planting through harvest in a mild winter region: a transition NC piedmont and coastal plain location (Clayton Central Crops Research Station, Clayton, NC).

The strawberry plant's crown tissues are susceptible to cold injury during the winter months if minimum temperatures drop below 10 degrees F and into single digits, as they did in much of North Carolina in early January 2014 and 2015. Row covers can provide excellent cold protection against such extreme cold events. A longitudinal section of a healthy, noninjured Chandler crown is shown in Fig. 9-7 (far left)—this plant was exposed to a 7 degrees F arctic clipper on January 6, 2014 (Burlington, NC), and it had row cover protection (1.2 oz). In contrast, a dissected crown of a Chandler plant exposed to a wind-borne freeze event in early January 2015 without row cover protection is shown in Fig. 9-7 (center).

A B C

Fig. 9-7. Longitudinal cuts through Chandler plant crowns : A.This crown had row cover protection during a 7°F arctic clipper in early January. B. This crown did not have row cover protection. C. This crown was injured underneath a row cover because of poor plant hardening in the fall (this is nonrecoverable damage). Note the much darker appearance to the central pith tissue in the plant on far right. This plant also exhibits damage to the narrow *cambium layer* outside the pith.

Row covers ARE detrimental to plant hardening in the late fall. Regardless of whether strawberries are being grown in the plasticulture system in a mild winter region such as the NC coastal plain, Sandhills, and piedmont (Fig. 9-5), or a colder plasticulture region like western North Carolina (Fig. 9-7), one of the biggest mistakes a grower can make is leaving a row cover "on" in the late fall when the plant actually needs to be exposed to multiple nights of colder temperatures to become "hardened" for the colder winter season.

Fig. 9-8. Strawberry plasticulture developmental cycle from planting through harvest in a colder winter region such as in western North Carolina or in Maryland. In colder climates, transplanting of plugs normally takes place in September. The plants actively grow for about a month and a half. By mid-November, the plants need exposure to temperatures for several weeks to harden off before winter row covers (over-winter covers) are applied in mid-December, or later, depending on the year.

Unless a forecast occurs for an extreme cold event at any time in fall, row covers are not used during fall unless the producer is interested in "fall growth enhancement" for Camarosa in early November (covers are applied for the first two weeks of the month). This practice is ***not recommended*** for Chandler. If the covers remain on in late November to early December, plants will not properly acclimate (harden-off) for the winter season. An example of cold damage to nonhardened cut-off plants that were transplanted in mid-October and then covered with a row cover in November and December, is shown in Fig. 9-9.

Fig. 9-9. This California cut-off plant was transplanted in mid-October (Greensboro, NC), and had continuous row cover treatment from early November through December (2014). An arctic clipper occurred January 8, 2015 (minimum 5 to 7°F). The photo of a mildly injured crown was taken March 20, 2015. This plant will recover, as the cambium tissue is still healthy.

Fall season acclimation for the winter season. Various authorities have indicated that the strawberry plant must be exposed to a week or more of near freezing, or sub-freezing temperatures (in the mid-to-upper 20s) for "plant hardening" to begin (Shoemaker, 1978; Galletta and Bringhurst, 1990, p. 111). With the benefit of a few hard frosts in early November, it has been the author's experience that Chandler plants can tolerate minimum temperatures in the upper teens without visible damage to the canopy or crown tissues by mid- November. By the time autumn temperatures of 20 degrees F have been reached, plants are considered to have hardened (Galletta and Bringhurst, 1990). In North Carolina, the plant hardening process continues through December, with plants being able to tolerate temperatures down to 10 degrees F without injury by the end of December (see temperature information in Fig. 9-2).

Part 2. Principles and Practices of Cold Protection with Sprinkler Irrigation

The first part of this chapter has been written to share the author's more recent experiences and recommendations for using row covers to protect a strawberry plasticulture crop from cold damage in the fall, winter and spring. The information presented in this section is a review of the principles and practices associated with the use of sprinkler irrigation for managing cold events in the pre-blossom and blossom period. Much of this information appeared in the 2009 edition of the NCSA *Strawberry Plasticulture Guide* in the chapter "Irrigation for Frost Protection of Strawberries" that was reproduced with permission from a fact sheet published by the Ontario Ministry of Agriculture, Food, and Rural Affairs. The fact sheet is presented in its entirety below. It includes a sidebar that summarizes key points related to flower bud and blossom protection with sprinkler irrigation.

The following material is reproduced from: Fisher, P. and R. Shortt. 2009. Irrigation for frost protection of strawberries. ©Ontario Ministry of Agric., Food, and Rural Affairs, Guelph, Ontario. <http://www.omafra.gov.on.ca/english/crops/facts/frosprot_straw.pdf>

Note to Phil: Please flow in the 7-page PDF file provided for this chapter, with each page placed in as a graphic so it is distinguished from the text authored by Barclay Poling.

In Part 3 of this chapter, we discuss using sprinkler irrigation in conjunction with row covers for severe cold events that may occur in the pre-blossom or blossom period.

Part 3. Sprinkler Irrigation Use in Conjunction With Row Covers for Severe Cold Events

Fig. 9-10. This photo taken during Easter freeze 2007 showing sprinkling on top of row covers.

Background. The approach of sprinkling on top of row covers can save strawberry blossoms and buds from temperatures as low as the mid-teens. In 2007, because of a very warm March, the strawberry crop that year raced ahead in its development, and by April 7 – 8, 2007, the crop was in full bloom and highly susceptible to freeze injury. Low temperatures in the teens, along with high winds and very low dewpoints, made sprinkler irrigation alone a very dangerous procedure. And, some growers who tried to irrigate in the mountains actually killed their strawberry plants! With a forecast of temperatures in the teens, it was also apparent that a single medium weight row cover would not provide sufficient bloom protection.

Because of the extreme threat this freeze posed to the NC strawberry crop, NC Cooperative Extension advised growers to irrigate on top of the row covers. The idea was make an “ice blanket” to trap the ground heat in the early evening, and then to continue to run the sprinklers as long as possible so that blossom temperatures would stay above 28 degrees F. Even in situations where growers were unable to keep their sprinkler systems running all night, nearly all of the emerged flower buds were saved. With continuous wetting of the covers through the night and early morning, it was possible to save the popcorn and open blossom stages as well. By sprinkling over top of covers, you are effectively adding heat back into the *ice* *blanket system*. Without adding some heat back, it is quite possible that ice encased flower buds that have emerged from the crowns, and even some popcorns, will drop below what is called a critical temperature

Growers who applied this procedure successfully at Easter time in 2007 opened their markets on time and achieved nearly full production. Since 2007, the procedure of combining sprinkling with row covers has been reserved for the most severe cold events, such as the *black frost* of March 28 – 29, 2015, when row covers alone did not provide adequate blossom protection. It was possible to successfully use sprinkler irrigation in the *black frost* of March 28 – 29, but growers had to be sure to increase precipitation rates due to the extreme cold and record low dew points.

Figure 9-11. Row covers can work well under an arctic clipper freeze event for the protection of emerged flower buds, but row covers alone are likely to be inadequate for protecting open blossoms and popcorn stage blooms from minimum temperatures in the mid-to-upper teens.

Recommendations for Sprinkling on Top of Row Covers:

- This technique can be very successful in windborne freeze conditions, or conditions where the row cover blanket is not going to provide adequate protection.
- For the ice blanket approach to work, you need a reliable sprinkling system, and you also need a digital thermometer to closely monitor bloom and bud temperatures all through the night (Fig. 9-12, left). You really cannot tell if the sprinkling is helping or not without a digital thermometer and thermocouple wire that is inserted right into the blossom or bud (Fig. 9-12, right).

Fig. 9-12. Temperature readings: A. The temperature reading on a digital thermometer from this bloom can guide all of your critical decision-making when running sprinklers on top of covers. When the blossom stage gets below 28°F, there is a good chance the blossom will be killed if it is already encased in ice (in this photo the digital thermometer is still reading 29.6°F). The emerged flower buds may be killed in the mid-20s. B. By inserting the thermocouple wire into flower buds ahead of the cold event (during the prior day), you can personally monitor the actual blossom temperature at night under the covers.

- It is important to note that it is virtually impossible to determine the actual temperature of the blossom without using a digital thermometer that is connected to a thermocouple wire that has the very end of the thermocouple inserted directly into the receptacle tissue of the open blossom. About 1/3-inch of the thermocouple wire's Teflon coating must be peeled back so that the end of the thermocouple may be inserted in the blossom – the two wires should be twisted together (three to four twists) before inserting in the bloom.
- The relationship between air temperature and plant temperature is not constant (Nelson, 2012), and under dry atmospheric conditions the temperature of the bloom will be colder than the surrounding air. This instrument will eliminate the need to consult dew point temperatures (or wet bulb temperatures) for the purpose of estimating plant tissue temperatures.
- Make all of your start-up and shutdown decisions using the digital thermometer readings from at least several blossoms in the lowest part of the field.
- When atmospheric conditions are dry, it is a good precaution to start sprinkling on top of the row covers when the blossom temperature reaches 32 to 33 degrees F. You should not see ice forming right away by starting at a blossom temperature of 32 to 33 degrees F. It is better to waste some water than risk a lower start-up temperature that could produce a "cold jolt" at startup.
- After you start sprinkling on top of the row covers, you will actually see from your digital thermometer that the bud and blossom temperatures immediately "pop up" (usually to about 38 degrees F). The reason the temperature actually rises this much is because there is a lot of ground heat. When water freezes, a beneficial release of heat occurs (called *heat of fusion*). As long as you can keep sprinklers turning, you will be able to maintain temperatures of the floral tissues above their critical temperature.
- In case of serious winds, you will definitely need extra labor to work with you at night to knock ice off nozzles—you want to keep nozzles rotating all night. The problem with nozzles freezing up occurs in *frost/freeze* and *freeze* events; it should not be a problem with a *black frost* event.

- In case your pump fails, the author has seen growers come through these situations successfully as long as they are able to get their sprinklers "going again" within 1.5 to 2 hours. Keep monitoring bud and blossom temps with your digital thermometer to know how critical the patient may become.
- Keep running the water on the frozen row cover past sunrise, and never stop running it until the blossoms in coldest part of field are registering 32 degrees F. One of the reasons you need to have several blossoms for readings is that the thermocouple wire that was inserted into the blossom the previous day may slip out or lose good contact with the plant tissue.
- NC Cooperative Extension has a videos on digital thermometer use posted on the web: http://strawberries.ces.ncsu.edu/2009/12/mauris-sed-leo-aliquam-aliquam/

Resources for Frost/Freeze Protection

Information updated as of January 2015. The starred companies on this list are members of the NC Strawberry Association—we encourage you to support our members. Manufacturers listed also sell directly to growers or put you in contact with their local distributors. If you are not listed and would like to be, please contact NCSA.

Suppliers

Atmore Industries
Row cover manufacturer
(Gro-Guard UV)
115 Industrial Drive
Atmore, AL 36502
888-396-2566
bfarrai@frontiernet.net
www.flotecinc.com

****Agrifabrics, LLC***
Row covers (AGROFABRIC)
5905 Atlanta HWY, Suite 101
Alpharetta GA 30004770-663-7600
peter@agrofabric.com
www.agrofabric.com

AutoVerters
Row cover manufacturer (DuPont/Typar)
P.O. Box 850
Roanoke Rapids, NC 27870
252-537-0426
barbaradickens@autoverters.com
www. autoverters.com

****B. B. Hobbs, Inc.***
Sprinkler systems, digital thermometers, row covers
P.O. Box 1147
Darlington, SC 29540
843-395-2120, 800-597-8903
irrigate@bbhobbs.com
www.bbhobbs.com

Berry Hill Irrigation
Row covers (Atmore Gro-Guard,
Dupont Typar), hold-downs, row cover hoops, sprinkler systems
3744 Hwy 58
Buffalo Junction, VA 24529
434-374-5555, 800-345-3747
sales@berryhilldrip.com
www.berryhilldrip.com
803-730-6334

****Coor Farm Supply Service, Inc.***
Row covers (DuPont/ Typar and WinterBlanket) sprinkler systems, thermometers, frost alarms
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919-934-4573, 800-999-4573
mail@coorfarmsupply.com
www.coorfarmsupply.com

****Crop Tunnels***
High tunnels
334 Weeping Cherry
Columbia, SC 29212
803-730-6334
dlooney@jaderloon.com
www.croptunnels.com

Eastfield Farms/Peter Perina
Row cover hold-downs
P.O. Box 275
Mathews, VA 23109
804-725-3948

Fabrex Unlimited, Inc
Row Covers (Pro-Guard UV®)
24181 Hwy 49N
Richfield, NC 28137
Phone: 704-463-0406
orders@fabrexunlimited.com
www.fabrexunlimited.com

****Gra-Mac Irrigation***
Sprinkler systems

2310 NC Hwy 801 N.
Mocksville, NC, 27028
336-998-3232, 800-422-3560
gramacirr@yadtel.net
www.gramacirrigation.com

Haygrove Tunnels
Multi- and single-bay high tunnels
694 Kraybill Church Road
Mount Joy, PA 17552
866-HAYGROV
ralph.cramer@haygrove.com
www.haygrove.com

Irrigation Automation Systems Inc.
Automated frost/irrigation
monitoring systems
174 Main Street
Buzzards Bay, MA 02532
617-480-8717
kc7749@aol.com
www.iassys.com

J & M Industries
Row covers (Agribon; also woven and
needlepointcovers), loop hoops
300 Ponchatoula Pkwy.
Ponchatoula, LA 70454
800-989-1002, 985-974-6751
jgideon@jm-ind.com
www.jm-ind.com

Johnson & Company
Sprinkler systems
P. O. Box 122
Advance, NC 27006
800-222-2691, 336-998-5621
hrj@jc-irrigation.net
www.jc-irrigation.net

Omega Engineering
Digital thermometers, frost alarms
P.O. Box 4047
Stamford, CT 06907
800-848-4286 or 203-359-1660
sales@omega.com
www.omega.com

***Pro-Ag** 250 26th Street Drive SE
Hickory, NC 28601
sales@proagonline.com
Strickland Bros. Enterprises, Inc.
Row cover management equipment
3622 Wiggins Rd.
Spring Hope, NC 27882
252-230-0345
www.stricklandbros.com

**** TriEst Ag Group***
Row covers (AgroFabric, AtmoreGro-Guard. DuPont), frost
alarms, digital thermometers, hold downs)
P. O. Box 648
Greenville, NC 27835
800-637-9466
vlilley@triestag.com

Spectrum Technologies, Inc.
Digital thermometers, frost alarms
12360 South Industrial Dr., East
Plainfield, IL 60585
800-248-8873, 815-436-4440
info@specmeters.com
www.specmeters.com

Walker Bros, Inc.
Row covers (DuPont), high tunnels
105 Porchtown Rd.
Pittsgrove, NJ 08318
856-358-2548
scott@hightunnel.net
www.hightunnel.net

Information

Commercial Providers of Specialized Weather Forecasts—These vendors provide site-specific forecasts tailored to the specific needs of the user. They offer various methods of product delivery, including fax, email, Web, and satellite dish.

**** Strawberry Weather Advisories***
http://ncsu.edu/enterprises/strawberries/category/public-advisories/.
A public weather advisory service offered by Dr. Barclay Poling, Prof. Emeritus, NC State University.

AWIS Inc.—Agricultural Weather Information Service Inc.
P.O. Box 3267, Auburn, AL 36831,
888-798-9955, ext 1 or 334-826-2149
info@awis.com
www.awis.com

**** ZedX, Inc. (SkyBit)***
369 Rolling Ridge Drive
Bellefont, PA 16823
800-454-2266
info@skybit.com
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Row Covers—Do Strawberry Growers Need Them?

Improvements in manufacturing over the last 20 years have made available large covers that can be laid directly on plants. Normally, these covers are easy to use, lightweight and durable and can be easily applied over large areas by hand or with machinery.

Such covers can improve earliness, yield, and quality. More specifically to plasticulture strawberry growers, benefits lean towards over-wintering protection and late season frost/freeze protection or towards promoting fall growth of plants in colder climates.

These row covers are known as *spunbound* or *nonwoven fabrics* and are most commonly made of polypropylene or polyester. Such covers are manufactured by melting the appropriate plastic or combination of plastics and spraying fine filaments onto a belt, which conveys them to a bonding roller that presses and fuses them together where they touch. This process creates fabrics that are lightweight and durable.

The greatest benefits from the use of row covers are realized when they are fitted to one's individual strawberry production system. This requires giving consideration to one's geographical location, committing to proper management of the covers with regards to application and removal timing, and use of covers with overhead irrigation for late season freezes.

Strawberry growers in mild climates (NC coastal plain and piedmont) typically use row covers for late-season frost or freeze protection. Most growers in these regions view row covers as insurance policies; they may not be needed, but are invaluable when they are needed. When covers are used for only short periods such as this, their exposure to the elements (sun, wind, moisture) is greatly reduced; therefore, lightweight, less expensive row covers can be utilized. The benefits of lightweight covers (0.5 oz/yd^2) for freeze protection can be greatly enhanced when used in combination with overhead irrigation.

Growers in colder climates (mountains) should use row covers as part of their strawberry production system and should consider the heavier and better quality materials due to the length of time these materials will be exposed to the elements. It is possible for some growers to apply covers as early as December, leaving them on until late February. Also, temperatures in these areas have been known to dip low enough to cause plant mortality without the aid of row covers to protect and shield plant crowns. For these reasons, medium to heavy covers (1.0 oz/yd^2 to 1.25 oz/yd^2) should be considered; however, covers that are too heavy will cause excessive light reduction. Covers that block more than 50% of available light could actually slow growth and advancement of a strawberry crop.

The following reference chart gives the basic information needed for making good decisions when purchasing the right cover for your application.

Spunbonded Polypropylene

MANUFACTURE TYPE	PRODUCT INFO	Wgt Oz Sq Yd	STD/ SIZE Ft	APPLICATIONS	EST. $/ ACRE	COMMENTS
AgroFabric Pro 10 (light weight)	-spunbonded polypropylene -uv stabilized -air and water permeable -non abrasive, -one crop -glued seams, -transmits 90% light	0.3	8ft. To 17ft. widths -custom sizes available	-insect protection -seed germination	$400	-Not recommended for strawberry over-wintering or frost/freeze protection. -No heat buildup
AgroFabric Pro 17 **Gro-Guard GG20 and GG17** (light to medium wt.)	-spunbonded polypropylene -uv stabilized, -air and water permeable -one to two crops, -glued seams -transmits 85% light	0.5 0.55 0.6	83in. To 50ft. widths -custom sizes available	-frost protection, 2-5°F -higher daytime temp 8-10° -earlier/increased yields -extended growing season -reduced desiccation and winter kill	$600 – $700	-Not recommended for strawberry over-wintering because of lack of durability, although it can be used for late season freeze protection in combination with overhead irrigation.
AgroFabric Pro 30 **Agribon+ AG-30** **Gro-Guard UV GG34** (medium weight)	-spunbonded polypropylene -uv stabilized, -air and water permeable -high tear strength and edge tear resistance, double bonded glue seam, one to two crops, non abrasive -transmits 70% light, good microclimate	0.9 0.9 1	83in. To 50ft. widths -custom sizes available	-frost and freeze protection, 4-7° -over-wintering protection in moderate climates -higher daytime temp 10-15° -reduced desiccation and winter kill -improved yields and quality	$900 – $1,000 $1,100 – $1,200	-Recommended for over-wintering strawberries in moderate climates -Mechanically applicable -This weight is most favorable for much of the Carolinas, GA, VA and TN for over-wintering and late season frost/ freeze protection.
Typar T-518 (medium to heavy wt.)	-spunbonded polypropylene -uv stabilized, -air and water permeable -high tear strength and edge tear resistance, -three to five crops -transmits 70% light	1.5	83in. To 51ft. widths -custom sizes available	-freeze protection, 8-12°F -over-wintering protection in harsh cold climates -reduced desiccation and winter kill	$1,400 – $1,500	-Not recommended for over-wintering in mild to moderate climates due to heat Build-up and light reduction. -In most plasticulture strawberry crops this amount of light reduction would not be beneficial. -Could be used for late season freezes, but not recommended.
AgroFabric Pro 50 **Agribon+ AG-50** **Gro-Guard GG51** (heavy weight)	-spunbonded polypropylene	1.5	83in. to 51ft. widths Custom sizes available	-freeze protection, 8-12°F -over-wintering protection in harsh cold climates -reduced desiccation and winter kill	$1,400 – $1,500	-Not recommended for over-wintering in mild to moderate climates due to heat build-up and light reduction. -In most plasticulture strawberry crops this amount of light reduction would not be beneficial. -Could be used for late season freezes, but not recommended.
AgroFabric Pro 70 **Gro-Guard GG60** (extra heavy weight)	-spunbonded polypropylene -uv stabilized, -air and water permeable -high tear strength, multiple seasons -transmits 30% light	2	12ft. To 25ft. widths	-freeze protection, 12-14° F -used in harsh cold climates	$2,000	-Not recommended for over-wintering in mild/ moderate climates due to heat buildup and light reduction. -Could be used for late season freezes, but not recommended.

Spunbonded Polyester

Reemay 2006 (light to medium weight)	-spunbonded polyester -uv stabilized, -air and water permeable -one to two crops -transmits 85% light	0.6	67in. To 12ft.4in widths	-2-4° F frost protection -earlier/increased yields -extended growing season -reduced desiccation and winter kill	$1,300	-Not recommended for strawberry over-winter- ing because of durability but can be used for late season frost and freeze pro- tection when used with overhead irrigation.

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