

Strawberry Cold Protection 101



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Cold Protection: When?

Protection Methods

What to do after damage?

Cold Protection: When?



The injury potential of a strawberry plant depends on it's growth state!

Dormancy	Transition	New Leaf			Bloom
Buds inside crown	Buds inside crown	Buds inside crown	Emerged buds	Popcorn	Open Blossoms
Hardy to 10F	Hardy to mid-teens		20-25F	27-28F	30F

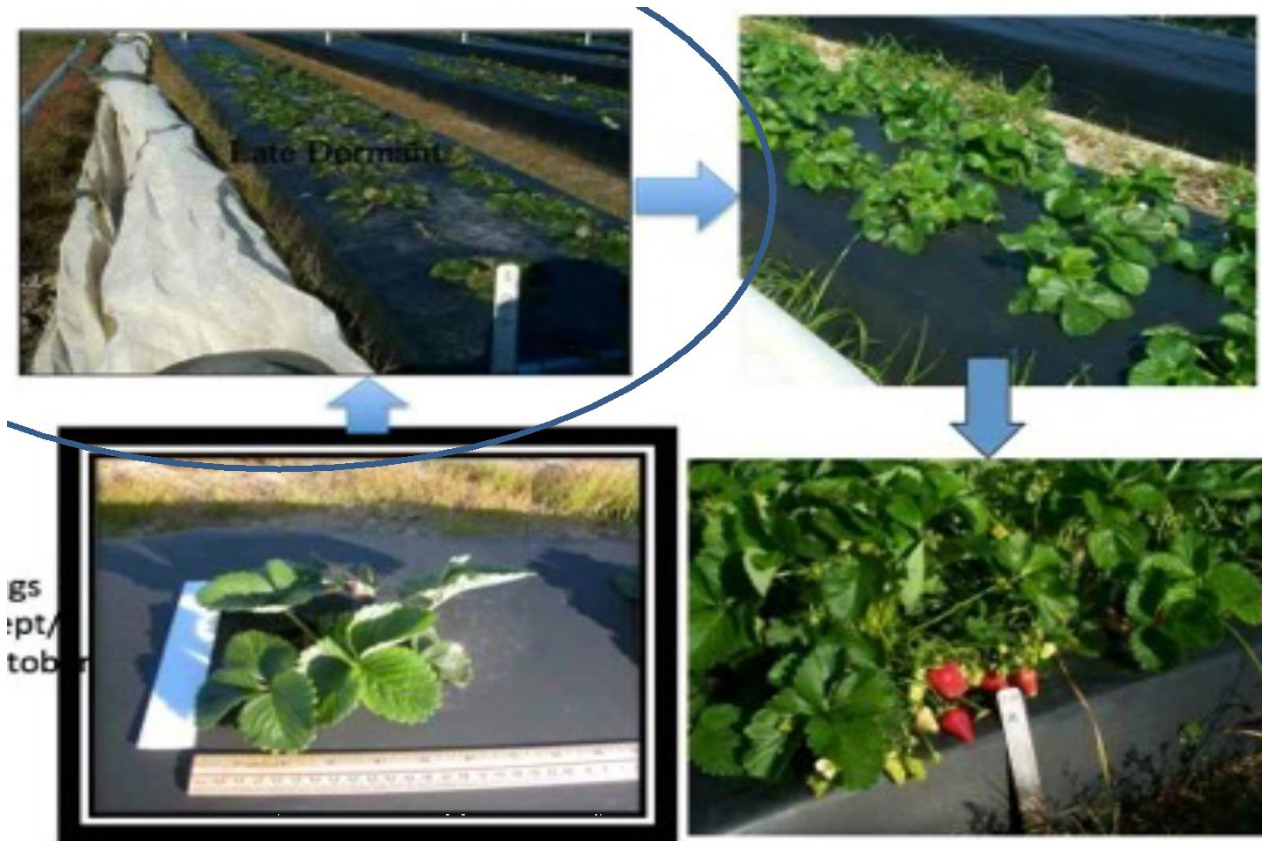
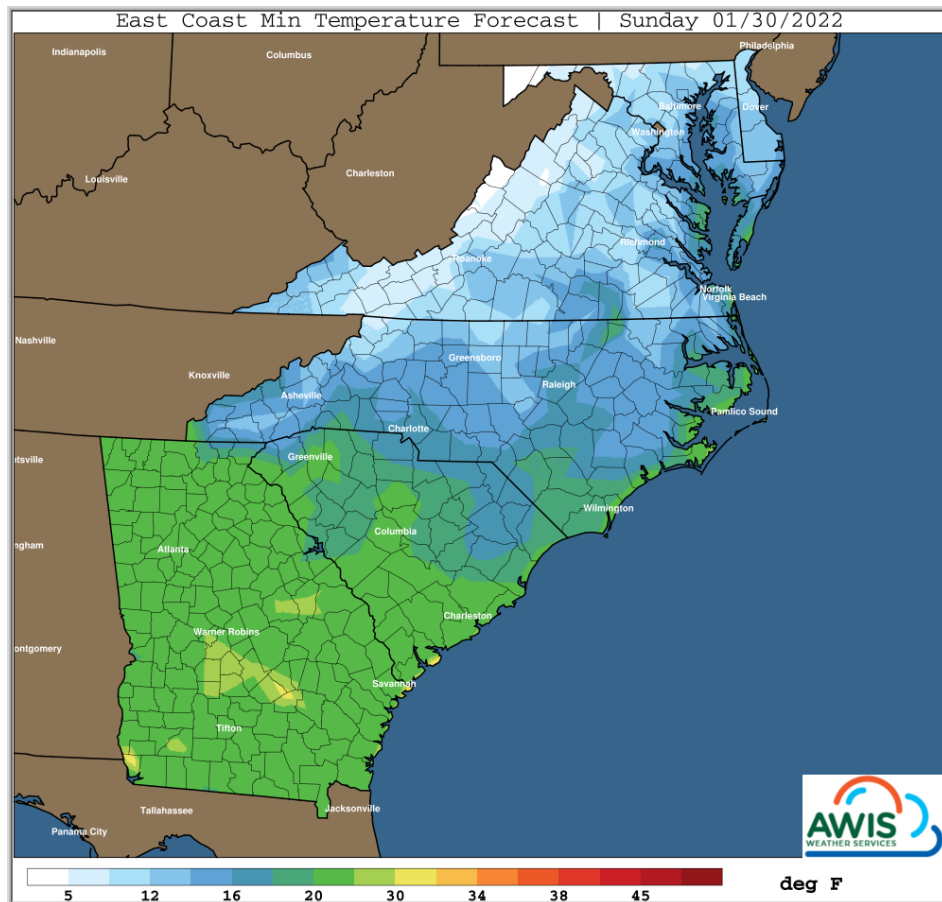


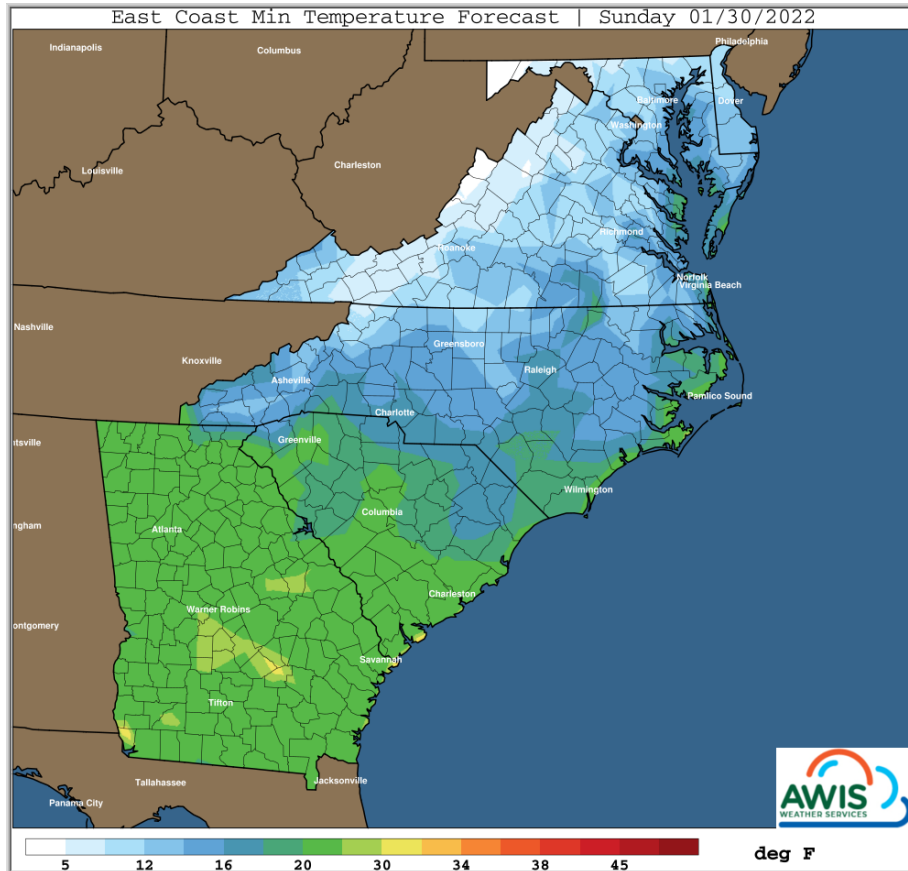
Photo courtesy: Barclay Poling



Photo courtesy: Barclay Poling

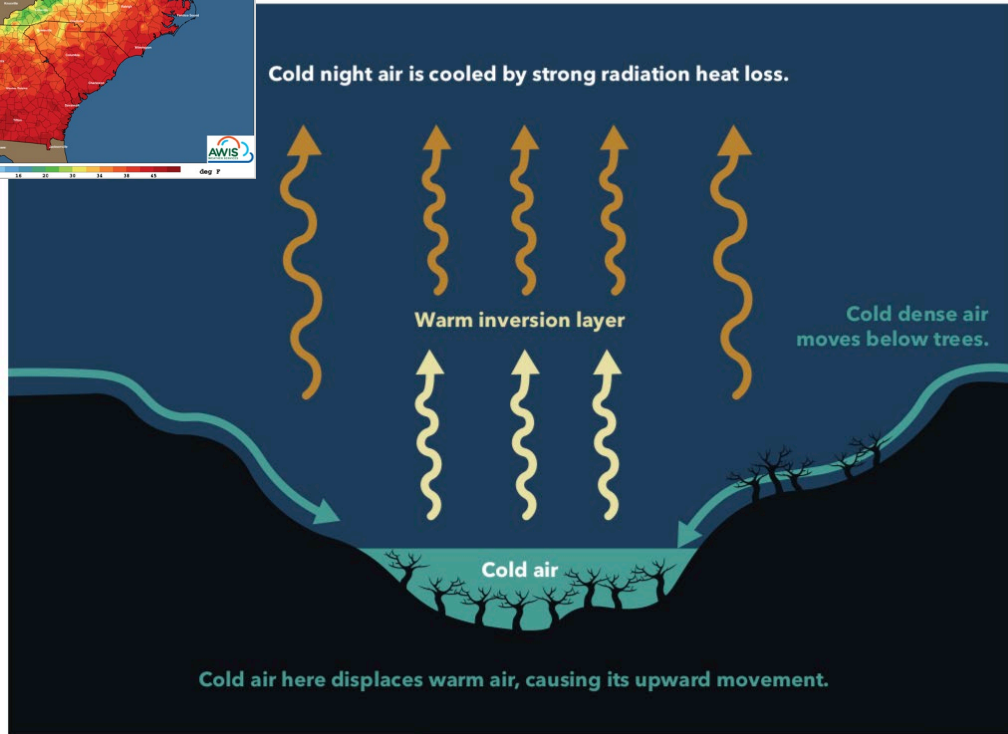
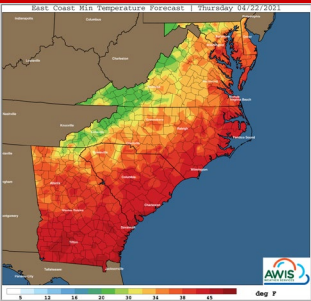
Frost vs. Freeze





Freezes:

- Advective (wind borne)
- Cold air moves into an area
- Temperatures below 32F
- Often wind speeds
- Often several days
- **Common in Winter**
- Dangerous in Spring
- Cold air layer: 500-5000 feet



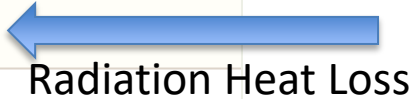
Frost Events

- 90% a radiation event
- Often an inversion event
- Temperatures at or above 32F
- The dew point is important
- **Dangerous and Common in Spring**
- Cold air layer: 30-200 feet

Terminology	Description	Management
HOAR FROST	<ul style="list-style-type: none"> Water crystals on plant parts Temperature around or above 32F Can cause injury 	<ul style="list-style-type: none"> Monitor closely weeds sprinkler irrigation or row covers
BLACK FROST	<ul style="list-style-type: none"> NO ice crystals ONLY temperatures at/near surface drop below 32F LOW wind LOW humidity 	<ul style="list-style-type: none"> Monitor forecast tools Row covers Additional Sprinkler possible
FREEZE	<ul style="list-style-type: none"> Usually long events (several days) Higher wind speeds Spring freeze in NC: April 7-8, 2007 	<ul style="list-style-type: none"> Can be devastating Row Covers!! Sprinkler may be risky
FROST/FREEZE	<ul style="list-style-type: none"> Combination of weather changes and radiation Usually not long events 	<ul style="list-style-type: none"> As long as winds < 8mph, sprinkler and/or row cover

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.

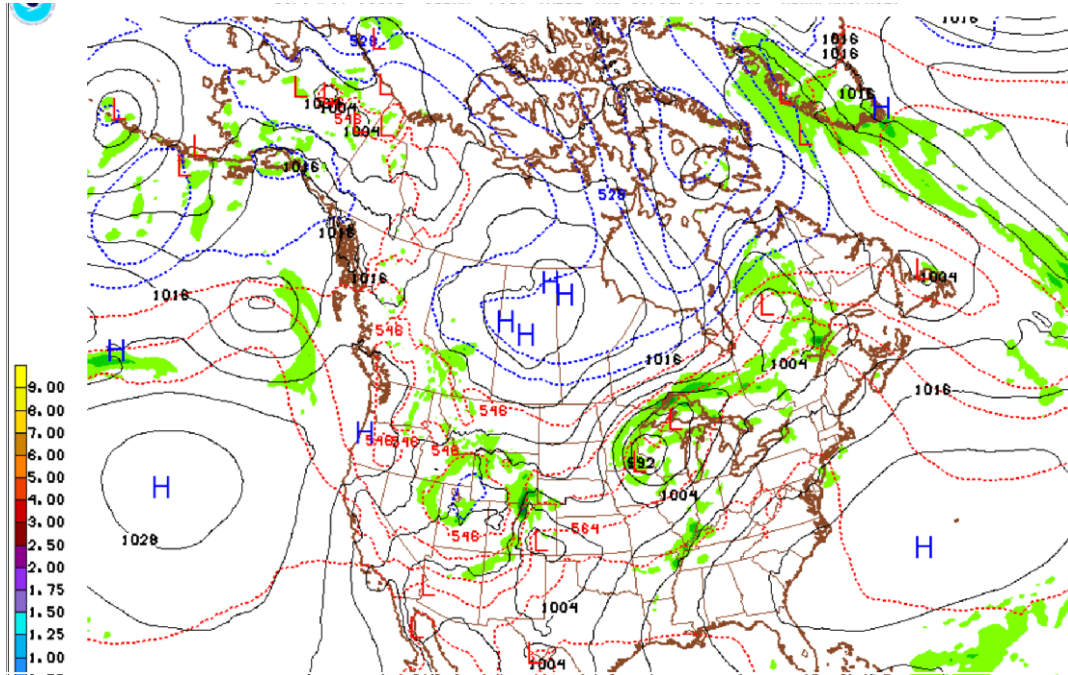
Take Home

Strawberries need to be protected against two types of cold events:

- DEC-FEB: **Crown protection** from freeze damage at temperature $< 10-15$ F.
- MAR-MAY: **Blossom protection** from frost events (at min temperatures between 32-40 F)
- MAR-MAY: Protection from frost/freeze events and rarely late spring freezes

Management Methods





How to diagnose the weather events

You need to know the kind of cold event that will confront you in the field!

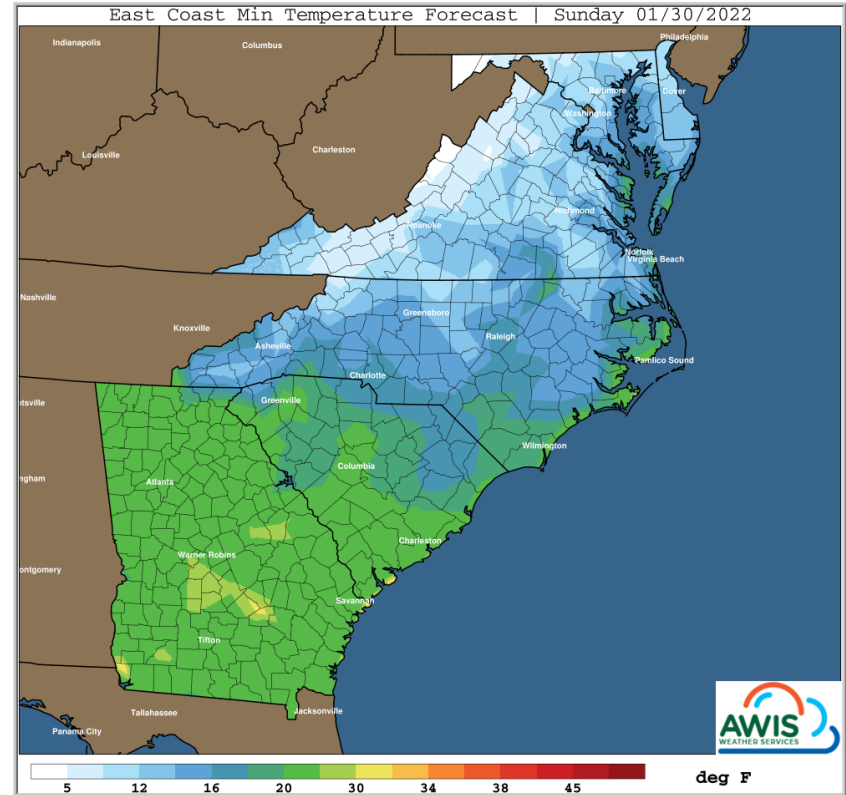
How to diagnose the weather

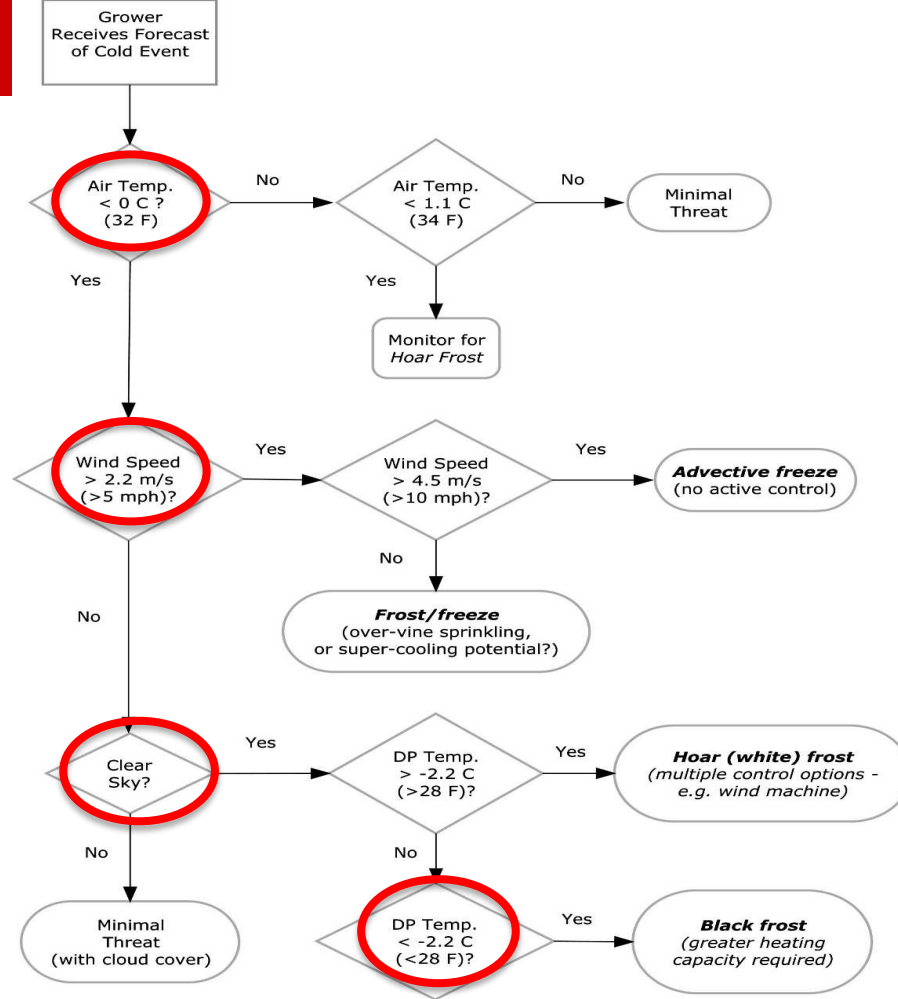
- First: Have a reliable, good weather forecasts
- Formulate an idea of which weather you will see
- **Observe 1-10 day weather forecasts**

A. Event Diagnosis

- Observe minimum temperature forecast → Frost/Freeze?
- Check for wind speeds → Frost/Freeze? Covers/Sprinklers?
- Evaluate atmospheric humidity with dew point temperature!

- Strawberry Portal Weather advisories!!!
- <https://strawberries.ces.ncsu.edu/>
- This is the region we cover.





At this point:
7-10 days ahead of time

Floating Row Covers



Winter



Spring

Function	Promote Plant development	Protection from lethal temperatures	Protection from Frost and Freezes
When?	Oct-Nov	Dec-Feb	Mar-May
Which Cover?	0.5-1 oz	1-1.5 oz	1-1.5 oz
Duration?	2-3 weeks max	Depending on temp.	Depending on dew point and cloud cover
Required Knowledge	GDD, Weather Forecast	Min Temp and Weather Forecast	Dew Point, Weather Forecast
Goal	Increase GDD	Protect crown from Cold Temp	Protect flower from Frost



Photo courtesy: Barclay Poling

Pros:

- Can be used in freeze AND frost
- Can be used to improve GDD
- Don't require night shifts
- Don require water



Cons:

- Labor intensive (Winter + Spring: probably 10-15 events)
- Disease and Pest Build-up under cover
- Don't work well when wet/rain
- Wind can be a problem
- Poor pollination can be a problem

Measure temperature under row covers!



During Winter!

- When plants are dormant, they can survive low temperatures
- Critical in most cases: <10-15 F air temperature

March 12, 2014
Davidson County, NC

New Leaf and
Emerged Flower
Buds – Some real
question on these
numbers



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)

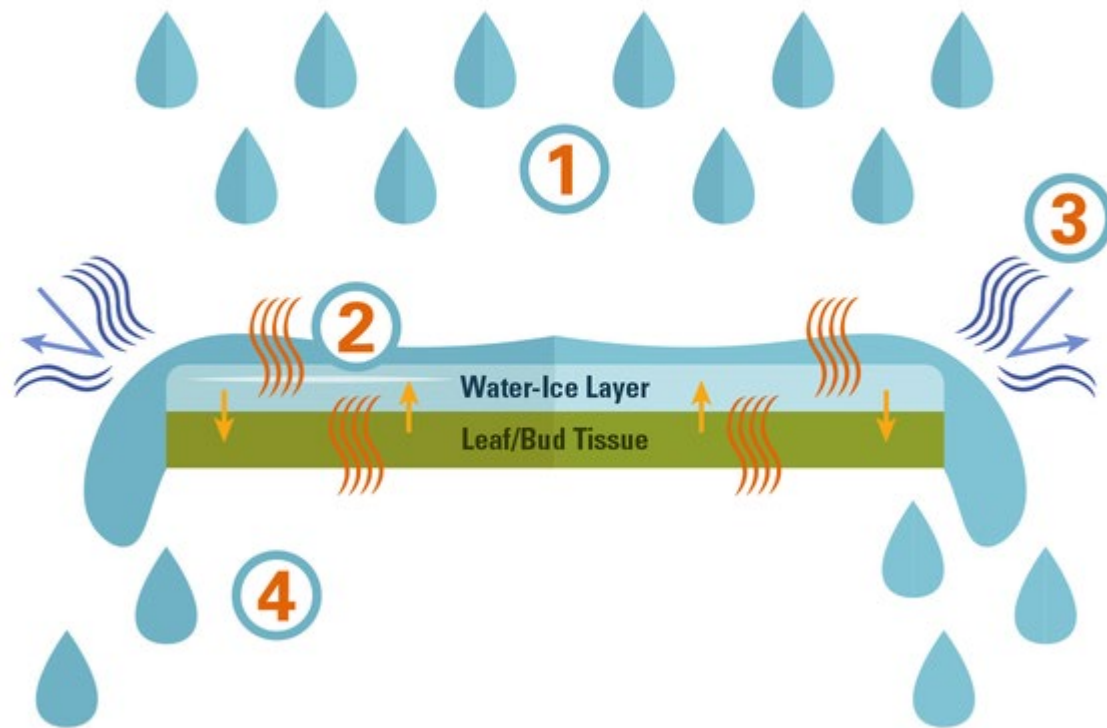
Chandler plants were exposed to mid-teens and emerged flower buds were alive

It is also relevant to point out, these Chandler plants did not have winter row covers!

Photo courtesy: Barclay Poling

Sprinkler Systems







HOW DOES IT WORK?

Phase change of water (liquid to solid) releases HEAT

- Freezing water to form ice gives off 80 calories per gram (latent heat of fusion = 80 calories of heat)
- This benefit occurs **ONLY** when humidity is high and water is not evaporating too rapidly – the ice stays **WET** all night, irrigation never stops



Damage would occur at 28 F, but as long as CLEAR ice is constantly forming, flowers and berries never fall below 32 F, even if air temperatures drop to low 20s.



What Happens when it DOESN'T WORK?

Evaporation (liquid to gas) = COOLING

- Evaporation of water takes up 600 calories per gram (NEGATIVE latent heat of vaporization = 600 calories of cooling)
- So, freeze protection fails in WIND-BORNE freezes where evaporation is excessive
- If too windy, ice is white rather than clear, indicating drying and evaporative cooling



Don't try it on windy nights!!

Requirement	Description
Rotation time < 30 sec	Mechanical arm; brake system that can adapt to changing water pressure
Uniformity in distribution and droplet size	Hybrid-systems designed to produce consistent coverage and droplets
Freeze tolerant	Spring and arm shielded from ice buildup
Low maintenance	Tool free replacement of sprinkler system. ACME threads need fewer turns.

Water Application (Inches/Acre/Hour)

Windspeed (mph)	27F	24F	20F	18F
0 – 1.2	0.1	0.1	0.16	0.2
1.2 – 3.6	0.1	0.16	0.3	0.4
3.6 – 8.6	0.1	0.3	0.6	0.7
8.6 – 11.8	0.1	0.4	0.8	1.0
11.8 – 21	0.2	0.8	-	-

But

- Application Inches/acre depend on nozzle size, not on water pressure!
- The more inches/acre, the more gallons of water you need.
- 9/64 nozzles deliver 0.12 inches/acre/hour
- **Require: 60 gallons of water per minute per acre**

So for example

- 1 acre, 9/64 nozzle, 12 hours of application

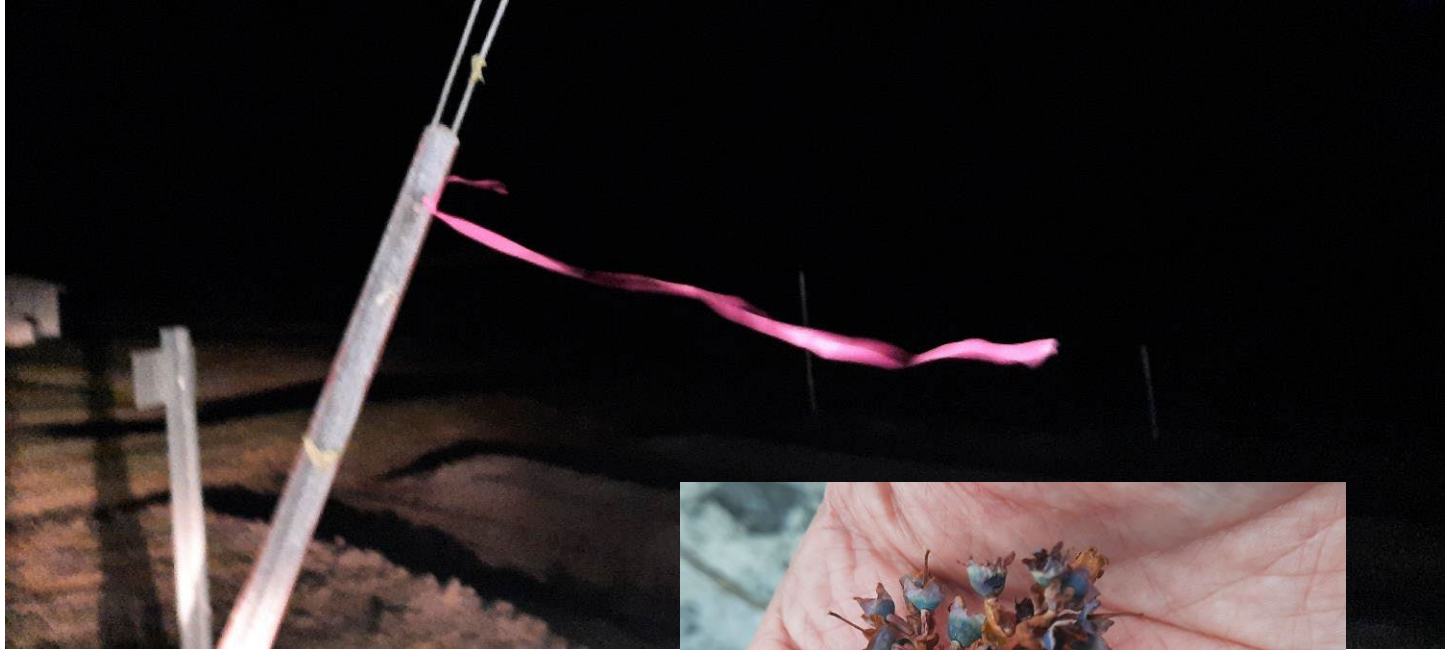
$$= 1 \text{ acre} * 60 \text{ gal} * 720 \text{ minutes} = \mathbf{43,200 \text{ gal/acre}}$$

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11.8 – 21	0.2	0.8	-	-

Which means

- Most cases: Sprinklers only work in low wind-speeds and in a temperature range of 24-32 F.
- If deployed at lower temperatures or higher wind speeds with the wrong nozzle: Can cause a lot of damage!!!



**Wind-borne freeze
13 March 2022
Blueberry damage**



Brown areas of freeze damage following irrigation on a windy night –



Not a “protectable” event – ~15.5 M lbs (-\$ 32.8 M)



Importance of Dew Point in Spring Frost

Dew Point

-1.1° C (30.2°F)

-1.7° C (28.9°F)

-2.8° C (26.9°F)

-3.8° C (25.2°F)

-4.4° C (24.1°F)

-5.5° C (22.1°F)

-6.7° C (19.9°F)

-8.3° C (17.1°F)

Suggested air temperature for sprinkler start

0° C (32.0°F)

0.5° C (32.9°F)

1.1° C (34.0°F)

1.6° C (34.9°F)

2.7° C (36.9°F)

3.3° C (37.9°F)

3.8° C (38.8°F)

4.4° C (39.9°F)



Pros:

- Not very labor intensive
- Can be used in most frost events



Cons:

- High water usage
- Complicated use
- Risk of causing damage
- Needs to run for a long time!
- Require maintenance
- Disease built up!
- Flooding of fields
- Food Safety!!

Integrated Responsibility

Single layer row covers are useful down to 24 F
but, “what if” the forecast is for “colder”

What do you do if you have soaked row covers and
there is a coincident cold event and they won't dry?

How do you handle a “black frost” vs. white frost

Several questions typically come up with
management of cold
events during bloom stage

Method	Hoar Frost	Black Frost	Frost/Freeze	Freeze
Row Cover	+++	++	++	+
Row Cover and Sprinkling	Not recommended	+++	+++	Windy, so not recommended
Sprinkler	+++	+++	+	Windy, so not recommended

Double Covering!

- Two row covers can add heat units!
- Drip tape can add a little bit heat.
- Frozen covers/soaking wet covers can be more damaging than protective

When to protect flowers?

- Usually at 10% bloom
- Not too early!
- Important: Once you start protecting: You are committed

Take-away

- Site Selection extremely important
- Sprinkler and Covers have Pros and Cons
- Try to have both in place

Damage? What now?



MOST VULNERABLE STAGE



Photo courtesy: Barclay Poling

Crown Damage in Winter



This is what you want to avoid in Winter

Assess through cutting
50-100 plants/acre

Canopy Damage in Winter



As long as the crowns are not damaged, you are fine.

Remove crisp leaves

Blossom Damage in Spring



- This is frost damage
- Avoid with abovementioned methods
- Once you start protecting, you are committed

Fruit Damage in Spring



G Johnson, University of Delaware

- Poor pollination through row-cover use
- Partially damage to flowers through frost.

Take Away

- Spring frost protection is crucial in many areas in the Southeast
- Don't start too early! Once you start protection, you are committed
- Use an integrated approach: Sprinkler and Rowcover

Black Frost!!!



Black Frost

- *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.

IF the dewpoint is low, don't wait to see ice crystals
Before starting frost protection – monitor temps & dewpoint

You need to be prepared to deal with all these!

Numerous frost events

Some possible frost/freezes?

Maybe even an advective freeze?

- NCSU Strawberry Portal: <https://strawberries.ces.ncsu.edu/>
- NCSU Diagnostic Key: <https://diagnosis.ces.ncsu.edu/strawberry/>
 - NC Strawberry Association: <https://ncstrawberry.com/>
- Strawberry School: <https://smallfruits.org/2021/02/southeastern-strawberry-school-webinar-series/>

Thank you to
Dr. Barclay Poling, Professor emeritus, NCSU
Flavor First LLC.

Thank You

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Strawberry Disease Management

Bill Cline, NCSU
Entomology and Plant Pathology
Horticultural Crops Research Station
Castle Hayne, NC



Anthracnose fruit rot



Sticky spores, dispersed by rain splashing or by handling plants (picking, culling infected fruit)

Firm, sunken lesions, often with gelatinous masses of orange spores on the surface



Managing Anthracnose Fruit Rot

- **Use Disease-Free Plants**
- **Use Resistant Cultivars – Sweet Charlie, others?**
- **Monitoring and sanitation; handle fruit/plants DRY**
- **Fungicides – most act as protectants**
 - **Switch (cyprodinil + fludioxonil)**
 - **Miravis Prime (pydiflumetofen + fludioxonil)**
 - **Strobilurins (Pristine, Merivon, Luna Sens.)**
 - **Captan, Thiram**



Gray mold (*Botrytis cinerea*)



Expect gray mold every year!



Managing Gray Mold (Botrytis)

- Cool season disease = early-season management
- Cultural – plant spacing, plant size, air movement
- Sanitation – removal of old dead leaves just prior to bloom may be helpful
- Fungicides --
 - Management of Botrytis crown rot (Rovral 1x)
 - Bloom sprays for fruit rot control
 - Fontelis, Merivon, Kenja, Scala, Elevate
 - Switch, Miravis Prime



Example of strategic rotational program for gray mold and anthracnose control

Low disease pressure (dry weather)

- Early season
 - Thiram
 - Polyoxin D (PhD or OSO)
- After bloom
 - Captan
 - Polyoxin D (PhD or OSO)

High disease pressure (rainy weather)

- Thiram or captan + Rovral (1x max before bloom)
- Thiram or captan + Kenja or Fontelis (3x max)
- Thiram or captan + Elevate (2x max)
- Miravis Prime (2x max)
- Inspire Super (4x max)
- Switch (2x max)

From 18Mar21 “Botrytis & Anthracnose Management”

Dr. Guido Schnabel, Clemson University

2021 Southeastern Strawberry School Webinar Series

<https://smallfruits.org/>



**Gray Mold
(*Botrytis*)**

**Anthracnose
(*Colletotrichum*)**

Elevate (17)
Kenja (7)
Fontelis (7)
Scala (9)
Rovral (2)
Luna Tranquility (7+9)

Switch (9+12)
Miravis Prime (7+12)
Pristine (7+11)
Merivon (7+11)
Inspire Super (3+9)
Luna Sensation (7+11)
Polyoxin D, Oso (19)
Captan (M04)
Thiram (M03)

Abound (11)
Cabrio (11)
Flint Extra (11)
Quadris Top (3+11)
Quilt Excel (3+11)

Mode of action
in parentheses ().

All products shown are rated “Good” to “Excellent”, see:
<https://smallfruits.org/files/2022/01/2022-Strawberry-IPM-Guide.pdf>



Thank You!

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