

# **Blueberry Freeze Protection**

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# "FREEZE" or "FROST"?

- The "FROSTED" object is below freezing (32°F) but MAY not be damaged.
- Damage to blueberry flowers and fruit occurs at ~ 28°F.
- There may or may not be ice crystals we call "FROST" on the bush at the critical 28°F.
- FROST indicates still air, no wind, <u>radiative</u> freeze



# **Blueberry freeze events in NC**

- Greatest threat in March, April and May (during and after bloom).
- Commercial fields are in low-elevation sites can be 8-10 degrees colder than predicted low temps.
- Overhead irrigation does NOT work very well on windy nights (advective freezes) in MARCH
- Overhead irrigation works GREAT to protect against radiation freezes in APRIL and MAY.

## **HOW DOES IT WORK?**

Phase change of water (liquid to solid) releases HEAT

- Freezing water to form ice <u>gives off</u> 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, <u>but as long as CLEAR ice is</u> <u>constantly forming</u>, 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 <u>takes up</u> 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 <u>white</u> <u>rather than clear</u>, indicating drying and evaporative cooling



Don't try it on windy nights!!

Impact-type sprinklers (usually brass) are used for overhead irrigation, Spring freeze protection and Summer evaporative cooling. 12 per acre @ 5-6 gallons per minute = ~ 68 gpm/Acre



Blueberry irrigation systems in southeastern NC rely on surface water from dug ponds. The water table is close to the surface, so for more water – dig a bigger pond.



# A single pump/pond combination may irrigate 25-30 acres in a typical system.





# How Much Water is Required?

Pumping capacity required (gallons per minute/Acre) for various precipitation rates (inches per hour).

Inches/Hr:	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20
<b>GPM/Acre:</b>	49.8	54.3	58.8	63.4	67.9	72.4	76.9	81.5	86.0	90.5

Source: Tyson, A. W., et al. Frost/freeze protection by sprinkler irrigation. http://www.smallfruits.org/Weather/frost\_freeze.htm



= standard blueberry rate in NC is approx 0.15 in/hr, 68 gal/min/A using 12 sprinklers per acre at 5-6 gpm each.

Precipitation rates (Inches/Hr) for selected nozzle capacity and sprinkler spacing.									
Sprinkler Spacing (ft.)	Gallons per minute/Sprinkler								
	2	3	4	5	6	8	10	12	15
30 x 30	.21	.32							
30 x 40	.16	.24	.32						
40 x 40		.18	.24	.30					
40 x 50		.14	.19	.24	.29				
40 x 70		.12	.16	.20	.24	.32			
50 x 50		.12	.15	.19	.23	.31			
50 x 60			.13	.16	.19	.26	.32		
60 x 60				.13	.16	.21	.27	.32	
60 x 70					.14	.18	.23	.28	.34

Source: Tyson, A. W., et al. Frost/freeze protection by sprinkler irrigation. http://www.smallfruits.org/Weather/frost\_freeze.htm

= standard blueberry rate in NC is approx 0.15 in/hr

Precipitation rates (inches per hour) for blueberry freeze protection at various temperatures and wind speeds. Shaded rates generally require a sprinkler spacing closer than 60x60 feet.

Min. Temp. °F	0-1	2-4	5-8
27	0.10	0.10	0.10
26	0.10	0.10	0.14
24	0.10	0.16	0.30
22	0.12	0.24	0.50
20	0.16	0.30	0.60
18	0.20	0.40	0.70
15	0.26	0.50	0.90

Wind Speed (mph)

Source: Gerber, J. F. and J. D. Martsolf. 1965. Protecting citrus from cold damage. Univ. Fla. Agr. Ext. Circ. 287.

NCSU Ideal Tract farm, April 19, 2001. Almost no damage occurred in fields with irrigation protection. Without irrigation many fields lost the entire crop.





# Cultivar Powderblue at harvest in July 2001, following a late spring (post-bloom) freeze event on April 19th.



Unprotected 19 Apr 01

Freeze protected 19 Apr 01

2007 "Easter Freeze"– Over half the NC blueberry crop was lost. Prior to the freeze, the crop was estimated at over 30 million lbs. Surviving production in 2007 was 14.8 Million lbs. Sites with three- to four-night capacity for overhead freeze protection irrigation, AND with minimum temps at 20°F or above were saved.



## Healthy berry with white ovules (left) versus freezedamaged. Note browning of ovules in the berry at right.



## Healthy undamaged flowers (left), cut open to show green ovary and style. Severely damaged flowers (right) are water-soaked after 48 hrs.



# Near-frozen berries may ripen yet have hollow, soft or corky internal damage (right).





## "frost rings" around the calyx that cause berries to split. Shown 48 hr (right) and 1 month later.



# Botrytis flower blight on 'Duke' following freeze injury



## **Blueberry growth stages**

Flower bud development				Leaf bud development			
Tight bud	Bud swell	Bud break	ak Tight Early cluster green tip		Late green tip	Shoot expansion	
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No visible swelling; bud scales completely closed.	Visible swelling of buds; scales separated. Can tolerate 10 to 15°F (-12 to -9°C).	Bud scales separated, tips of flowers visible. Can tolerate 15 to 20°F (-9 to -6°C).	Individual flowers distinguish- able. Can tolerate 20 to 25°F (-6 to -4°C).	1/16 to 3/16 inch (1 to 5 mm) of green leaf tissue visible; leaves still rolled up.	1/4 to 1/2 inch (6 to 13 mm) of green leaf tissue visible; leaves starting to unfold.	Shoots expanding and leaves enlarging.	

Schilder, et. al, 2004, 2008, 2015. A Pocket Guide for IPM Scouting in Highbush Blueberries. Michigan State Ext. Bull. E2928

## **Blueberry growth stages**

Flower development							
Early pink bud	Late pink bud	Early bloom	Full bloom	Petal fall			
Partly expanded flowers are readily visible and have separ- ated; corolla tubes (petals) short and closed. Can tolerate 23 to 25°F (-5 to -4°C).	Individual flowers fully developed and separated; corollas expanded but still closed. Can tolerate 24 to 27°F (-4 to -3°C).	Some corollas completely expanded and open; many flowers still closed. Can tolerate 25 to 28°F (-4 to -2°C).	Most flowers on the bush have opened and can tolerate 28°F (-2°C).	Corollas are falling off, revealing small green fruit; this is the stage most vulnerable to frost damage, which can occur at 32°F (0°C).			

Schilder, et. al, 2004, 2008, 2015. A Pocket Guide for IPM Scouting in Highbush Blueberries. Michigan State Ext. Bull. E2928

## **Blueberry growth stages**

Fruit development and postharvest							
Green fruit	Fruit coloring	~25% blue	~75% blue	Bud set for following year			
Berries are expanding; fruit may vary from small to large pea-size in the same cluster.	Weights and the series are changing from green to pink to blue.	First crop of berries is ripe and ready for harvest.	Berries are picked several times as they ripen. There may be 2 to 5 pickings. Berries may be hand- or machine harvested.	After harvest, the blueberry plant stores reserves and sets buds for next year's growth until leaf fall.			

Schilder, et. al, 2004, 2008, 2015. A Pocket Guide for IPM Scouting in Highbush Blueberries. Michigan State Ext. Bull. E2928



DAYS FNT-

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7:00 AM on Day 1 – the high is not quite overhead, some wind can be expected. As the high moves east, clockwise rotation brings cold air down ahead of the system, and warm air up from the south behind the system.

16

20















## **1. System Design Considerations**

- System that will provide at least 0.15" of water/acre/hour (68 gal/min).
- Maximum sprinkler spacing 63' (every 7<sup>th</sup> row with 9' rows) x 60' in the row.
- Sprinklers with 5/32" nozzles that will provide a wetted diameter circle greater than 90 ft.
- A low-pressure design and pump that will deliver at least 55 psi with less than 10% variation between sprinklers
- Pipe size based on flow rates at or below 5 ft/sec

## 1. (continued) -- Capacity and Water Requirements

- Water for more than one night of operation. Desirably 3 nights of 12 hours (31 hours from pond and 5 hours from a well).
- A well with the capacity for 5 hours of irrigation after 31 hours will provide 1.5" of water/week during drought.
- A well capacity of 4 gal/min/acre is needed.
- The 2007 Easter Freeze -- 4 of 5 consecutive nights in most blueberry fields!!

## **2.** Preparation the day before a freeze

- Run and check system, repeat if >1% clogs.
- Have rain suits, boots, high-intensity spotlights, wires to unclog sprinklers, <sup>1</sup>/<sub>2</sub>" wrench to remove nozzles, spare sprinklers.
- Check drainage around the field.
- Check shielded minimum thermometers.

# 3. Starting, Running and Stopping

- Only begin if <28° F is expected for highbush and southern highbush, <30° F for rabbiteye.</li>
- On a still night with high humidity, get pumps running by 33° F. With low humidity 36-38°.
- Thoroughly wet bushes, then reduce pressure to 40 psi. Increase pressure as temp. drops. Be up to 50 psi by 27° F and 55 psi by 25° F. As 20° F is approached use full pressure.
- Run until ice begins to melt and temperature goes above 40° F. Ice should slip freely on stems. If temperature rises slowly and wind begins, be sure ice does not freeze again.

# If not done properly, freeze protection irrigation can be more damaging than doing nothing

- Poor system design
- Too cold
- Too windy
- Started protecting too late
- Shut down too soon
- System failure
- Ran out of water



# Morning after a successful night of freeze protection. System paid for itself in a single night.





Blueberry Freeze Damage and Protection Measures <u>http://www.ces.ncsu.edu/depts/hort/hil/hil-201-e.html</u>