Blueberry II

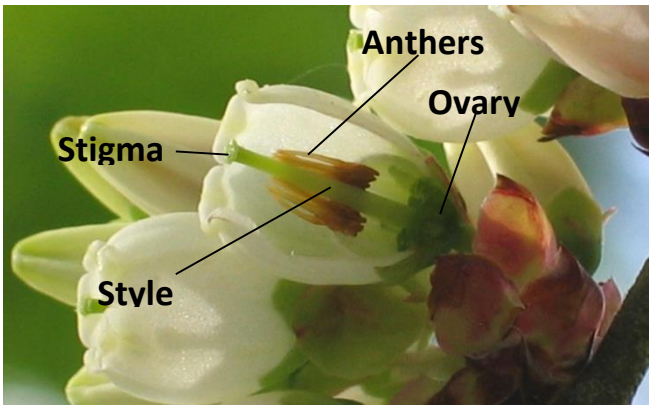
Where: Grand Gallery (main level) Room A & B
MI Recertification credits: 1 (1C, COMM CORE, PRIV CORE)
OH Recertification credits: 0.5 (presentations as marked)
CCA Credits: PM(0.5) CM(0.5)
Moderator: Steve Hunt, MSHS Trust Committee, Grand Junction, MI

2:00 pm	Optimizing Blueberry Fruit Set • Eric Hanson, Horticulture Dept., MSU
2:15 pm	Blueberry Disease Update (OH: 2B, 0.5 hr) • Bill Cline, Entomology and Plant Pathology Dept., North Carolina State Univ.
2:45 pm	What the USHBC Does for the United States Blueberry Industry • Chris Barnhill, USHBC rep. and blueberry grower, Ivanhoe, NC
3:15 pm	Updates from the Michigan Blueberry Commission and the Michigan Blueberry Advisory Council • Jake Clemons, Michigan Blueberry Commission,South Haven, MI • Creela Hamlin, Michigan Blueberry Advisory Committee, South Haven, MI
3:45 pm	Session Ends

Optimizing Blueberry Fruit Set

Eric Hanson, Department of Horticulture, MSU hansone@msu.edu

Fruit set is the percentage of flowers that result in a harvested fruit. Blueberries are actually efficient at the process compared to many fruit crops. Often 60-80% of blueberry flowers set fruit. The process starts with the transfer of pollen from the anthers to the stigma. The pollen then germinates like seeds and produces a pollen tube. Pollen tubes then grow down through the style to be base of the flower where the ovules are located. Genetic materials are transferred from the pollen tube to affect fertilization and produce a viable seed. Numerous pollen tubes need to reach ovules so that multiple seeds develop at the base of flowers. If adequate seeds are initiated, the corolla (petal) falls and the ovary at the base of the flower begins growing into a fruit. If no seeds or too few seeds are initiated, the ovary does not grow and eventually drops.



Blueberry flower parts shown with half of the corolla (petal) removed.

Fruit set can be low and greatly reduce yields. Low set is usually the result of weather during bloom that limits bee activity, freeze damage to flower parts, or lack of cross pollination in varieties that are not fully self-fruitful.

Poor pollination conditions. Honey bees do not work well when it is cold, rainy or very windy, so if these conditions persist during the bloom period, pollen transfer can be inadequate to provide high fruit set percentages. However, complete inhibition of pollinators is very rare because blueberries have developed a built-in insurance policy. Flowers on a bush open sequentially over an extended time so some flowers are open if conditions improve.

Cold injury. Flowers are susceptible to injury from sub-freezing temperatures, but each freeze event seems to be a little different. Flowers become progressively more susceptible to cold as they approach bloom. Depending on the stage of development, temperature and duration, wind, and humidity, cold can kill all or just some flower tissue. In some situations, the stigma and style is killed. This means that pollen tubes cannot reach the ovaries and accomplish fertilization. Other times, only the corollas (petals) are damaged, so pollination and fruit set can still occur even though the corollas are brown.

Self-fruitfulness. Self-unfruitful varieties set fruit readily with their own pollen, and include Bluecrop, Duke, Draper, Bluejay, and Rubel. Other varieties are considered partly self-fruitful, and include Aurora, Elliott, Legacy, Liberty, Jersey and Nelson. Some types are very unfruitful (Brigitta, Chippawa, Polaris). Poor fruit set can result if self-unfruitful or intermediately self-fruitful varieties are planted in large blocks where pollen from other varieties is not readily available.

Gibberellin (GA) to improve fruit set

GA is a growth regulator that is produced by blueberry seeds. In well pollinated berries, GA is abundant and promotes normal berry growth. Without pollination and abundant seeds, berries abort or do not size fully. When bee activity and pollination are limited by cold, rainy, and/or windy weather, GA applications can sometimes increase the average size and/or number of berries.

Several GA products are labeled for highbush blueberries but the rate or active ingredient is similar. Apply GA either in a single spray during bloom (80 grams active ingredient per acre) or as two sprays of 40 g; one during bloom and the second 10-14 days later. Higher spray volumes (40 to 100 gallons per acre) may improve coverage and effects. Slow-drying conditions such as at night also increase absorption. Spray water pH needs to be between 4.0 and 8.0.

When GA is beneficial, yield increases are usually in the modest (10-30% range) and sometimes hard to recognize by looking at bushes. Several years ago, we treated Jersey bushes at bloom or at bloom plus petal fall. The bloom + petal fall treatment resulted in a 25% yield increase over non-treated controls. In 2017, we treated Duke, Bluecrop and Draper plants at bloom or bloom + petal fall. The bloom + petal fall treatment increased fruit set and yield of Duke and Draper, but not Bluecrop. Yield increases were 80 and 98% for Duke and Draper, respectively. Why Bluecrop showed no response in not known, but untreated plants of Bluecrop had higher fruit set percentages than Duke or Draper, so pollination may not have been a limitation. GA treatments also reduced average berry weight of Duke and Draper. This may result from a heavier crop and inter-berry competition for carbohydrates, or retention of some berries with less seeds that do not size well.

When to use GA is hard to know. If weather is expected to be reasonable good for bee activity and the white corollas (petals) fall easily from the bushes, pollination is probably adequate and benefits from GA unlikely. Keep in mind that blueberries can bloom over a long time, and often only a couple days of good conditions is enough for adequate pollination. GA is most likely to pay for itself when weather during bloom is cold, rainy and/or windy. A clue that pollination was inadequate is that some corollas (petals) hang on the bush longer and turn red/purple before falling. The corollas of pollinated flowers drop readily while still white. Varieties with fruit set problems (Jersey, Coville, Earliblue, Berkeley, Blueray) are most likely to benefit from GA. Since GA does not always provide a benefit and effects can be subtle, always leave non-treated check rows to determine whether the treatment was worthwhile.

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Blueberry Disease Update and Observations in North Carolina

Bill Cline
Researcher and Extension Specialist
Entomology and Plant Pathology
North Carolina State University

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Outline of today's presentation

- **Overview of blueberries in NC**
- 2017 freeze experiences
- Focus on fungi
- NC spray tactics and timing
- Fungicides new and old
- Integrated approach to anthracnose (ripe rot) control
- Harvest and postharvest handling

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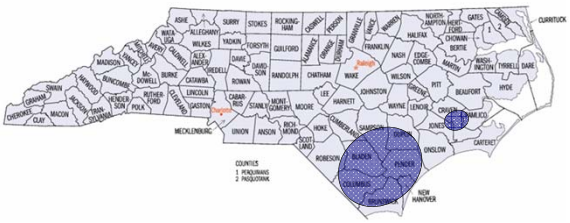
BLUEBERRIES IN NORTH CAROLINA

Home garden and pick-your-own plantings exist throughout the state, but our main commercial crop is harvested in southeastern NC (blue area) with an annual farm gate value of $78M (2015). Limited to unique, low pH sand-based organic soils (Leon, Lynn Haven series), or organic muck soils (i.e., Carolina Bays). Approx 10,000 acres total



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The best native NC blueberry soils are organic sands (>3% organic matter) with a water table within 12-24" of the surface; fields are not mulched but are bedded to improve aeration in the root zone.

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Field layout used in North Carolina (southern highbush)

- Nine to ten feet between rows
- Plants spaced 30 to 36 inches apart
- Generous turn radius at ends of rows
- Most fields are a single cultivar, no pollinator rows
- Rows bedded and drainage established prior to planting

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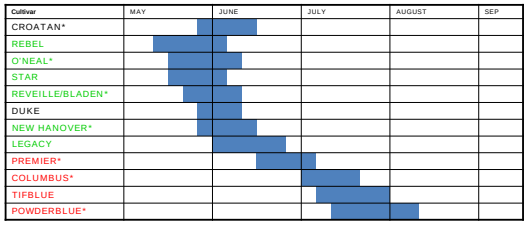
Blueberry harvest timing by cultivar in southeastern NC (*NCSU)



EARLY >>>MIDSEASON >>>LATE

HIGHBUSH SOUTHERN HIGHBUSH RABBITEYE

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FRESH price declines over time, so volume is stacked early in the season

Wk	1	2	3	4	5	6	7	8	9	10	11
	May (3 wks)			June				July			
$ per lb	2.46	2.4	2.1	1.89	1.74	1.57	1.45	1.38	1.36	1.45	1.44
% of total crop	10%	30%	17%	16%	10%	7%	3%	3%	2%	1%	<1%

Average NC fresh blueberry returns and volume 2008-2014

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Machine for Fresh (MFF) in NC

- Began 1990s with Reveille, Bladen, rabbiteyes
- Blowers, sorters (color & soft) critical to success
- Forced-air cooling (pre- & post-pack) is necessary
- Legacy, O'Neal & rabbiteyes
- Est. currently 50% hand, 30% MFF, 20% processed
- Usually start with hand harvest 1-2x
- Handle fruit dry

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2017 Freeze Experiences in NC

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Overhead irrigation is used for freeze protection, most with sprinkler spacing 60 x 60 ft delivering 0.15 inch/hr

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Typicall blueberry freeze events in NC

- In most years, the greatest threat in April and May (during and after bloom).
- Mostly radiation freeze events (center of high pressure system, no wind).
- Blueberries in NC are grown in low-elevation sites – fields can be 5-10 degrees colder than predicted low temps.

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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.

	Wind Speed (mph)		
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

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

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NON-typical freeze events in March 2017 in Eastern NC

- Warm winter, low-chill cultivars bloomed early
- Multiple wind-borne freezes
- Dewpoints in single digits
- Freezes lasting for more than 24 hrs
- Reported temps on some farms in low teens
- Conditions exceeded capacity of protection
- Protected and non-protected fields had similar damage
- 2017 crop reduced by 50% in NC

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Exobasidium Fruit and leaf spot – "Green spot" disease caused by *Exobasidium maculosum*

- A once-rare problem that is becoming more prevalent
- Grower discovery
- Spots initially thought to be stinkbug injury
- Identified as a fungus in NC in 1997

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Exobasidium symptoms on leaves (upper surface) 24 May in North Carolina

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Infected berries are highly visible in clear plastic clamshell containers, but it is nearly impossible to remove them all on the packing line!

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Why is this disease becoming more prevalent?

- Cultivar changes? Not likely, old cultivars (Croatan, Wolcott) were susceptible too…
- More irrigation, wetter, denser canopy?
- Loss of fungicides?
  - Benomyl (Benlate) 2001
  - Triforine (Funginex) 1996
  - Captafol (Difolatan) 1999

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Unsprayed vs Indar 2F @ 6 fl oz / A

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Unsprayed vs Indar 2F @ 6 fl oz / A

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Mummy Berry

- Can occur every year
- Overwinters on the ground
- Emerges each spring
- Two-stage disease
  - Primary leaf infection
  - Secondary fruit infection

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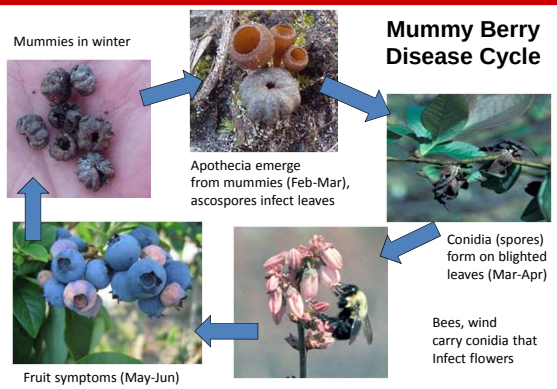
Mummy Berry Disease Cycle



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Green berries – cut to show infected (top) vs healthy (bottom)

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Mummy berry Control

- Control relies mostly on fungicides
- Loss of best product, triforine (Funginex)
- Spray timing critical budbreak through bloom
- Spray coverage critical – Ground application?
- Respray as new tissue emerges
- Shorter intervals –7-10 days?

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Other major fruit rots

- Colletotrichum ripe rot
- Alternaria
- Phomopsis
- Botrytis

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Botrytis flower blight

- Serious problem only one year out of five in NC.
- Usually with freeze damage followed by cool wet weather
- Fungicides are still effective, no resistance issues identified (yet) in blueberry in NC

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Botrytis flower blight on 'Duke' following freeze injury

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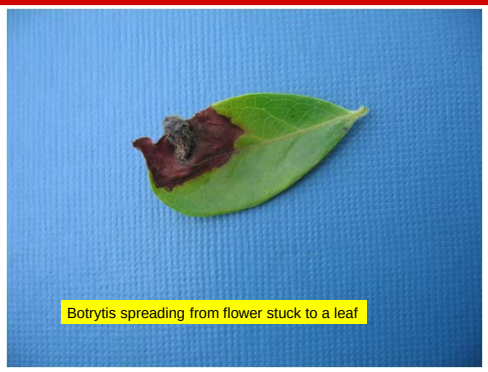

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Leaf spots, Rust

- Premature defoliation results in reduced flower bud set
- Reduced yields in the following year
- Loss of leaf photosynthetic capacity
- Managed with pre- and post-harvest fungicides and with mowing

Gloeosporium

Septoria

Rust

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Effect of leaf spots on leaf drop and flower bud formation

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Typical NC Fungicide Spray Timing on Blueberries (7-10 sprays)

Pre-harvest applications

- Feb 28 delayed dormant as needed for EXO
- March 15 bud break
- March 25 early bloom (2x?)
- April 5 Full bloom (most effective for fruit rots) (2x?)
- May 1 small green berry stage, for leaf spots

Post-harvest applications

- June 15 leaf spot spray
- July 1 leaf spot spray
- July 15 leaf spot spray (drop?)

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A word of caution --- blueberry flowers and fruit are sensitive to spray burn from surfactants and tank mixes, especially low-volume (concentrated) applications

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Injured "control" -- intentional surfactant damage at NCSU/HCRS, 29Apr08

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Fungicide without surfactant, 4x rate, no damage 29Apr08

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Aerially applied, tank mixed, with surfactant added!!

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Fungicides New and Old

- USDA/NASS surveys – most commonly used in NC are Captan and Indar (Fenbuconazole).
- Propiconazole popular ($) for leaf diseases
- Sulforix and lime-sulfur (calcium polysulfide) increasing in use in NC due to Exobasidium
- MANY new "- azole" products, most with similar activity, some with unique activity – more research needed
- Combination products becoming more prevalent
- Crop Safety should be biggest concern with any new product

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Ripe rot of blueberry causes decay of fruit in the field, and can also infect berries during handling

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Fresh-pack blueberry practices to reduce postharvest decay

- Select cultivars for disease resistance, firmness, dry stem scar
- Use fungicides as needed pre-harvest
- Timely, thorough harvest (every 4-7 days)
- Machine-pick for processing if overripe
- Handle berries dry when picking, sorting and packing fruit
- Cool packed berries to 33-34°F

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Select the Best Cultivars

- Good color
- Small, dry stem scar
- Firm
- Resistant to disease
- Good yield

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Use Fungicides as Needed

- Lime-sulfur for Exobasidium leaf and fruit spot (shown)
- Pre-bloom sprays for mummy berry
- Bloom sprays for fruit rots and mummy berry
- Sprays generally not needed after bloom for disease control

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Timely and Complete Harvest

- Pick every 4-7 days
- Harvest all ripe fruit on the bush
- Do not pick when wet – handle fruit dry
- Remove from the field as soon as possible
- Do not leave fruit in the sun

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Machine-Pick for Processing if Quality is not Suitable for Fresh Sales

- Over-the-row harvesters are used to pick berries destined for processed (frozen) markets
- Some harvesters are capable of picking berries for fresh sales

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Immediately after harvest, berries are quickly cooled by using forced-air fan systems to pull cold air across shallow trays of fruit.

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Sorting and Packing

- **Pre-cool berries prior to sorting**
- **Handle berries only when dry**
- **Sort to remove soft, green and decayed fruit**
- **Cool packed berries to 34ºF**

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Packed berries are held at 33-34 ºF during storage and transport

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The best management for pre- and post-harvest fruit rots is careful, timely picking and rapid cooling

- Highbush blueberries– pick every 3-7 days
- Rabbiteye blueberries –every 7-10 days
- Pick ALL ripe fruit at each harvest
- Sanitary handling – fruit is not washed
- Do not pick or handle fruit when it is WET!!
- Once harvested, shelf life is extended with forced-air cooling

Spores of pathogenic fungi that cause pre- and post-harvest fruit rots

Ripe rot (*Colletotrichum* sp.)

Alternaria rot (*Alternaria* sp.)

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Are there alternatives to post-harvest cooling?

Milholland, R. D. and Jones, R. K. 1972. Postharvest Decay of Highbush Blueberry Fruit in NC. Plant Disease Reporter 56:118-121

- *Alternaria* was found to be the primary blueberry postharvest rot organism in NC
- Fungicides, Hot Water Treatment, Clorox treatment NOT effective in reducing rots
- Postharvest cooling was VERY effective in reducing rots
- Cooling within 2 hr after harvest significantly better than 12 hr after harvest

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What does mechanical harvest do to fruit quality?

Mainland, C. M. et.al., 1975. The Effect of Mechanical Harvesting on Yield, Quality of Fruit and Bush Damage on Highbush Blueberry. J.A.S.H.S., 100:129-134

- Machine harvesting reduced yields of marketable fruit by 19% to 44%
- 10% to 30% softer than hand harvested fruit
- Machine harvested fruit developed 11% to 41% more decay after 7 d storage at 70ºF
- Sorting increased rots of mechanically harvested fruit by an additional 5% to 10%

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What are the effects of plant disease on shelf life?

Cappellini, R. A. et.al., 1982. Nature and Extent of Losses in Consumer-grade Samples of Blueberries in Greater New York. HortScience 17:55-56

- Consumer samples averaged 15.2% defective fruit during a two-yr study
- Fungal decay accounted for two-thirds of defective fruit

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What is the effect of ripeness and detachment scar on shelf life?

Ballinger, W. E. et.al., 1978. Postharvest Decay of Blueberries as Influenced by Stem Attachment and Ripeness. Plant Disease Reporter 62:316-319

- Just-ripe, stemless blueberries had 9 to 11 times as many rots as just-ripe berries <u>with stems still attached</u>
- Over-ripe, stemless blueberries had 2.3 to 3.2 times as many rots as over-ripe berries with stems still attached

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How does temperature affect post-harvest shelf life?

Ballinger, W. E. et.al., 1978. Relationship of Stage of Ripeness and Holding Temperature to Decay Development in Blueberries

- Berries held at 34, 50 or 70ºF. Only fruit held at 34ºF had good enough storage life to justify sorting by degree of ripeness

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What effects do fungicides have on postharvest Rots?

Ramsdell, D. C. 1994. Evaluation of Foliar Fungicides for Control of Post-Harvest Fruit Rots. Fungicide & Nematicide Tests 49:57-58

- Postharvest *Alternaria* rot of blueberry was not controlled by fungicides when berries were commercially handled; some fungicides made it worse
- Postharvest Anthracnose ripe rot of blueberry (*Colletotrichum* sp.) was reduced by all fungicides tested when berries were commercially handled

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What happens to shelf life when produce is mis-handled?

Mainland, C. M., 1995. Blueberry Handling, Packaging and Storage Studies. Proceedings of the North Carolina Blueberry Council 29th Annual Open House, p.7-10

- Drops of 0, 2, 4, 6 ft resulted in marketable percentages of 86, 67, 43, 31, respectively after 7 days at 70ºF
- Studies in Australia & US -- No detrimental effect if berries held for up to 8 hrs at 64ºF before cooling to ideal temperature

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What Happens When Berries are Handled Wet?

Cline, W. O. 1996. Postharvest Infection of Highbush Blueberries Following Contact with Infested Surfaces. HortScience 31:981-983

- Harvested every 7 days, only visibly healthy berries were used in the treatments
- Infested metal pan with either *Alternaria* or *Colletotrichum* by rolling sporulating fruit on the surface (5 s)
- Healthy berries rolled on infested pan (5 s)
- Wet surface vs Dry surface
- Rated after 7 days at 70ºF

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Percent rots occurring on the cultivar Bluechip (small dry stem scar) after 7 d at 70ºF

	No spores on surface		Inoculated surface	
	Ripe Rot	Alternaria	Ripe Rot	Alternaria
No Sorting	1.5	10	--	--
Sort Dry	2.1	9.1	3.6	10.3
Sort Wet	8.2	29.8	63.5	25.0

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Summary of Blueberry Handling Experiments

- Commercial handling infests berries with spores and increases the chance of decay
- Handle berries dry -- moisture is required for postharvest sporulation & infection
- Large/wet stem scars provide sufficient moisture for infection and thus increase rots
- Spores are always present in nature -- you must always cool to prevent mold

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