Controlling Summer Fruit Rots in Apples

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Outline: Fruit Rots That Appear During Summer and After Harvest

Summer fruit rots: Biology and management

- Black rot (*Botryosphaeria obtusa*)
- White rot (*Botryosphaeria dothidea*)
- Bitter rot (*Colletotrichum* sp.)

Storage-decays: Biology and management

- Diseases initiated in the field (all of the above) plus gray mold (*Botrytis cinerea*)
- Pathogens that attack after harvest:
  - Blue mold (*Penicillium expansum*)
  - Gray mold (*Botrytis cinerea*)

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Summer fruit rots: Black rot

Botryosphaeria obtusa, a fungus

- Endemic in most orchards.
- Can infect fruit during warm rains anytime from petal fall to harvest.
- Infections often remain quiescent until fruit begin to ripen.
- Decayed areas are firm and somewhat dry.
- Late-summer infections may appear as lenticel spots.

Summer fruit rots: Black rot

Botryosphaeria obtusa

- Also causes black rot cankers and frog-eye leaf spot.
- Leaf spot is found near fruitlet mummies.
- Leaf spots do not contribute to fruit rots.
- Cankers occurs mostly on dying or compro-mised wood colonized by internal fungi.

Black Rot & White Rot (*Botryosphaeria* sp.)

Fruitlet mummies left after thinning can provide inoculum.

Photos: Jim Schupp

Fruitlet mummies on Honeycrisp in winter

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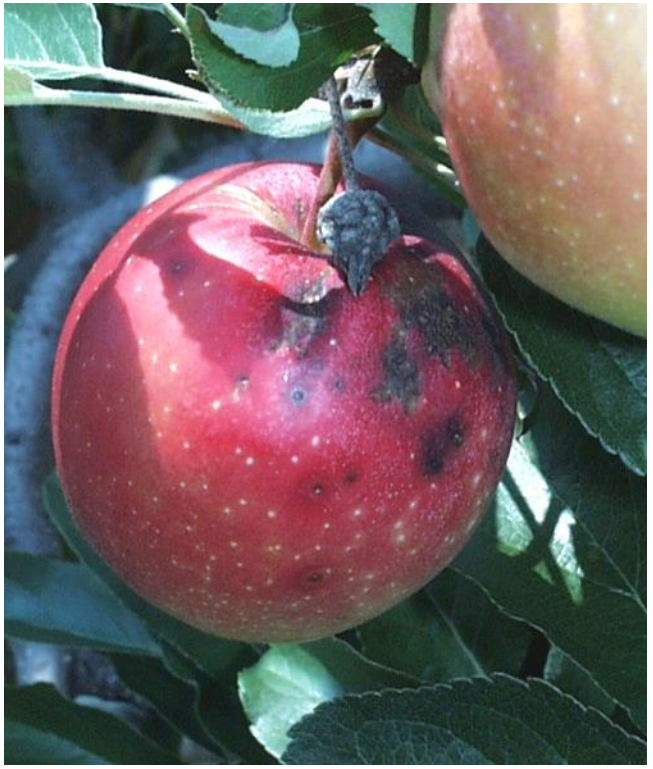
Black Rot & White Rot (*Botryosphaeria* sp.)

Inoculum from fruitlet mummies can cause lenticel infections during summer.

Braeburn

Gala



- Lenticel infections can progress into fruit decays in the field or during storage.

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Summer fruit rots: White Rot

Botryosphaeria dothidea, a fungus

- Endemic in most orchards.
- Infects fruit primarily during the heat of summer.
- Decayed areas in summer are softer (“sauce in a bag”) than black rot and may have irregular margins.
- Rots developing in autumn may look just like black rot and are firmer than in summer

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Summer fruit rots: White Rot

Botryosphaeria dothidea: Fungus

- Causes cankers on drought-stressed trees.
- Superficial cankers on older limbs cause flaky bark.
- Inoculum is always present in older trees.

Black Rot & White Rot (*Botryosphaeria* sp.)

Effective fungicides:

Topsin M (thiophanate-methyl)
- does not control bitter rot

Flint (trifloxystrobin) and other QoI inhibitors

Pristine (pyraclostrobin + boscalid)

Captan

NOTE: Mancozeb and DMI fungicides are weak or ineffective.

Fungicide timing

- Protection required from petal fall to harvest, but especially from mid-July through harvest
- Re-apply fungicides after >2 inches rain
- Maintain protection until harvest.

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Black Rot & White Rot (*Botryosphaeria* sp.)

Sprays that may increase black rot problems:

- Liquid-lime sulfur used during summer to control sooty blotch and flyspeck in organic orchards.
- High rates of oil (e.g. 1% oil) during summer.

Products/rates per 100 gal [z]	Royal Court at harvest 2010
Control	2.7 a[y]
Liquid Lime Sulfur 2 qt	21.0 b
Captan 16 oz/Prophyt	1.7 a

Treatments were applied 11 Jun, 2 and 27 Jul, 16 and 28 Aug.

Probably any sprayed product that causes even a very slight injury to the fruit epidermis has the potential to exacerbate fruit rot problems.

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Summer fruit rots: Bitter rot

Colletotrichum species: fungi

- Dark raised pustules in a light tan and slightly sunken lesion in dry weather.
- V-shaped area of decay in flesh.
- Characteristic orange sporulation in damp weather.
- Favored by **hot, humid weather** in mid to late summer.
- Can spread rapidly if fruit are not protected with fungicides.

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Bitter Rot

Inoculum to initiate fruit infections may come from:

- Dead wood in trees, **especially following fire blight**.
- Prunings left beneath trees.
- One of many wild hosts in hedgerows and woodlots.
- Rotted fruit left on the ground.

Bitter rot inoculum from other hosts

In one case, inoculum came from horse-chestnut (*Aesculus hippocastanum*) trees next to the orchard

Colletotricum infections on horse chestnut leaves (above), along with an apple from a nearby tree showing signs of bitter rot.

Bitter rot on hand-thinned fruit in New York's Champlain Valley provided inoculum for infecting ripening fruit still on the tree.

Photographed 3 August 2006

Another Honeycrisp issue:
Fruit are very susceptible to bitter rot

Infections may occur on only a few scattered fruit
or they may appear on
many fruit simultaneously.

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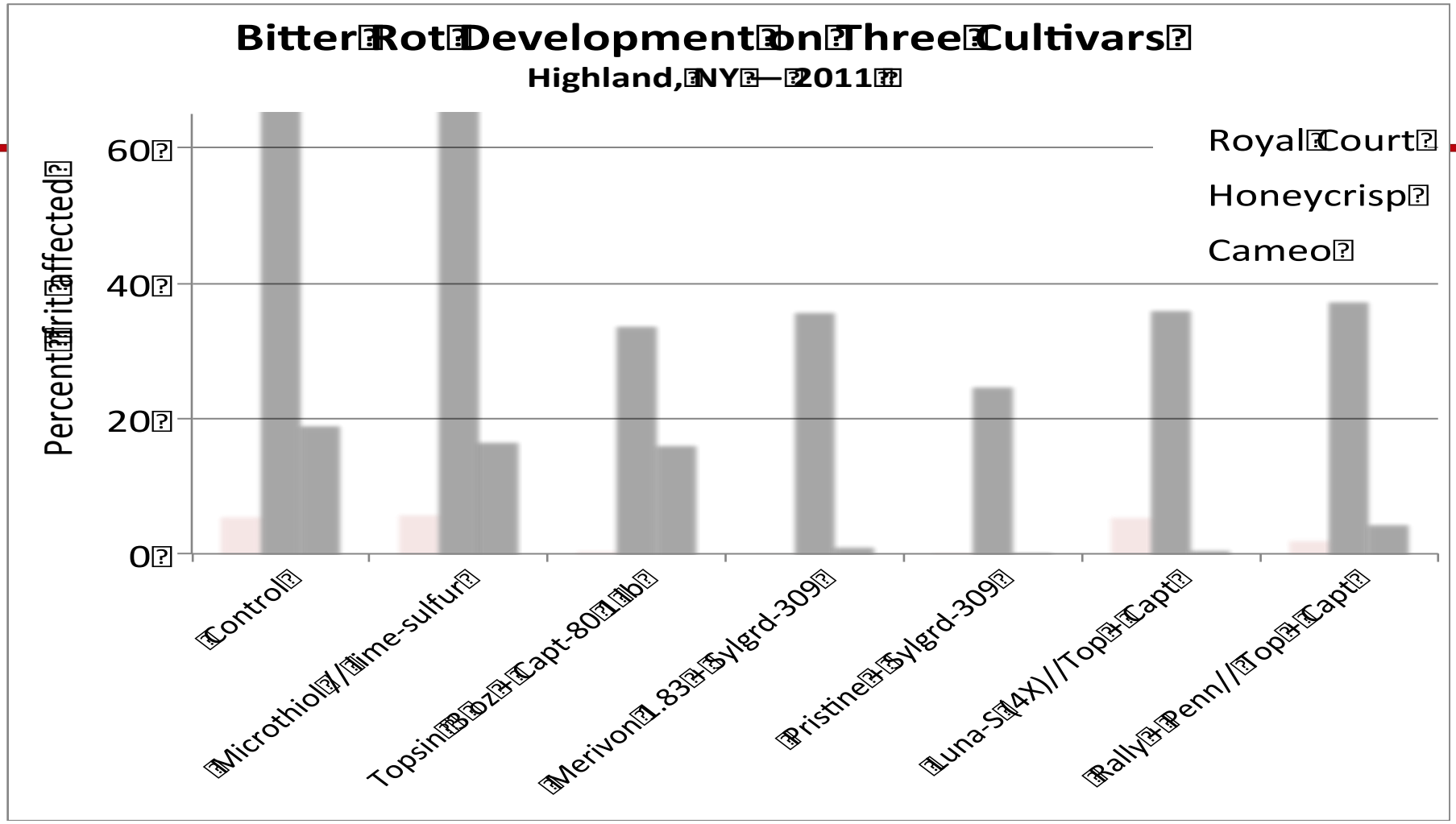
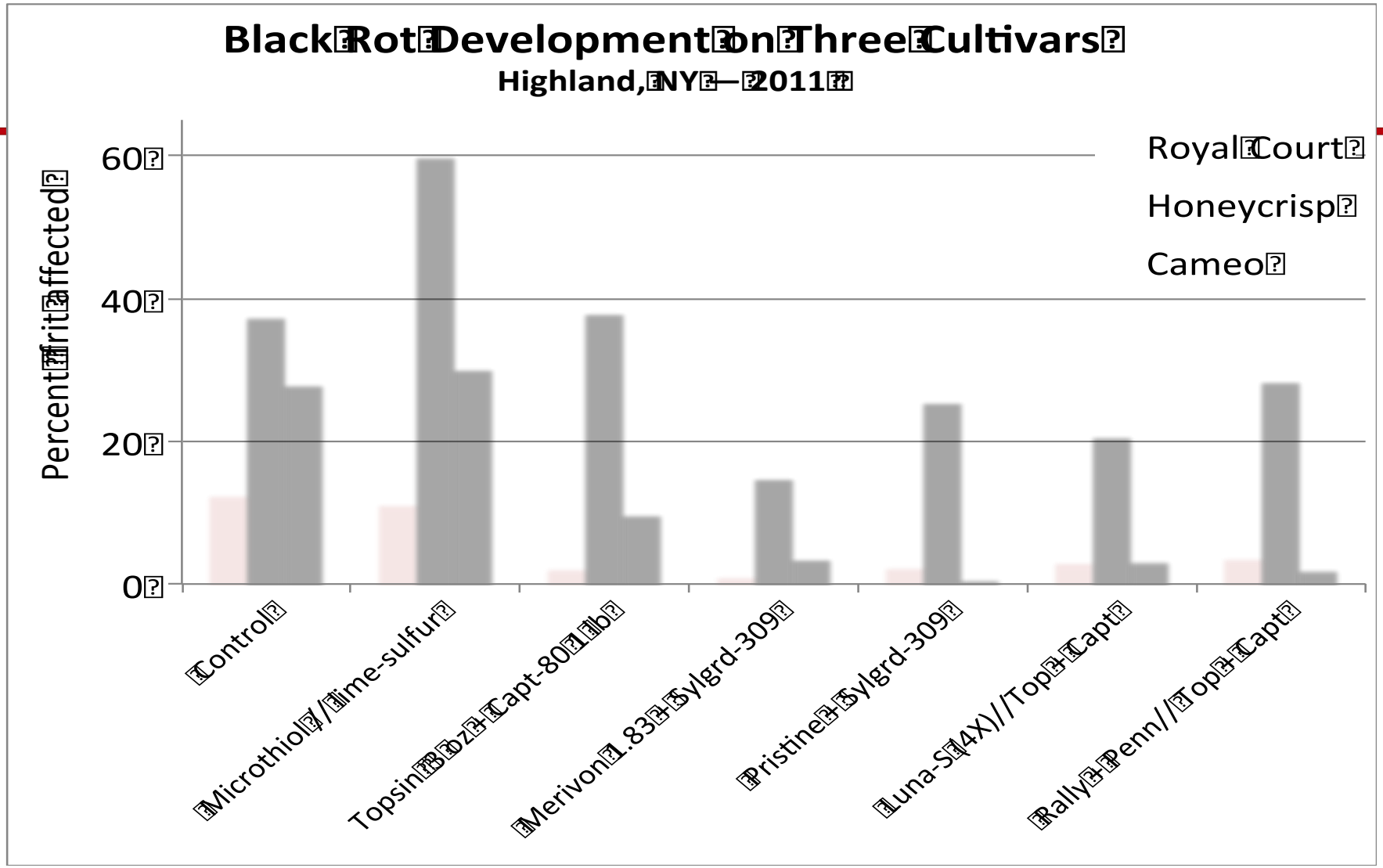
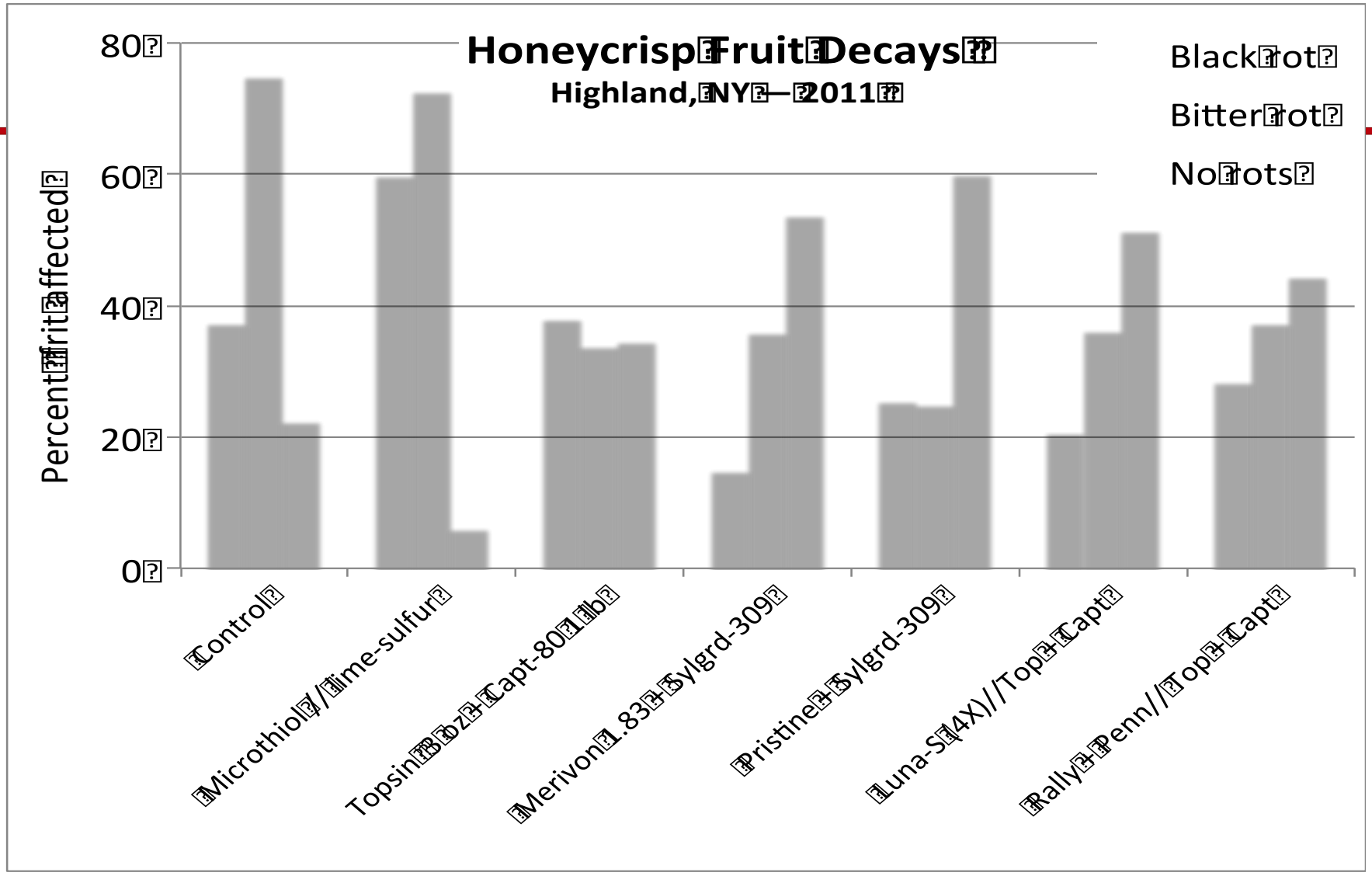


Results from a field trial at the Hudson Valley Lab in 2011:

- Much more bitter rot on HC than on other cultivars.
- None of the fungicides were very effective. WHY ??



Black rot was also more prevalent on Honeycrisp and also was not controlled very well with fungicide treatments.



Even the best treatment had only 60% of Honeycrisp fruit that were free of decay by 23 August. WHY ??

Treatments in the trial were applied on a tight schedule.

Fungicides, formulations, rates, and spray dates used in the 2011 trial at the Hudson Valley Lab.

Treatment and rate of formulated product per 100 gal of dilute spray[z]	5/20 PF	5/27 1C	6/14 2C	6/27 3C	7/11 4C	7/28 5C	8/17 6C	8/31 7C	9/14 8C[y]
Control..... --	--	--	--	--	--	--	--	--	
Microthiol Disperss 80WG 1.2 lb.....	X	X							
Millers Lime-Sulfur Sol'n 29% 1.33 q--	--		X	X	X	X	X	X	X
Penncozeb 75DF 1 lb/.....	X	X	TC[w]	TC	TC	TC	TC	TC	TC
Microthiol Disperss 1.2 lb	X	X							
Merivon 1.83 fl oz + Sylgrd 3.84 fl oz.....	RP	RP	X	X	X	X	X	X	X
Pristine 38WG 4.83 oz + Sylgard-309 3.84 fl oz.....	RP	RP	X	X	X	X	X	X	X
Luna Sensation 500SC 1.33 fl oz	RP	X	X	TC	TC	TC	TC/x[t]	X	X
Rally 40WSB 2 oz + Penncozeb 1 lb	RP	RP	TC	TC	TC	TC	TC/Pr[s]		
Pristine 4.83 oz ..... --		--	--	--	--	--		X	X

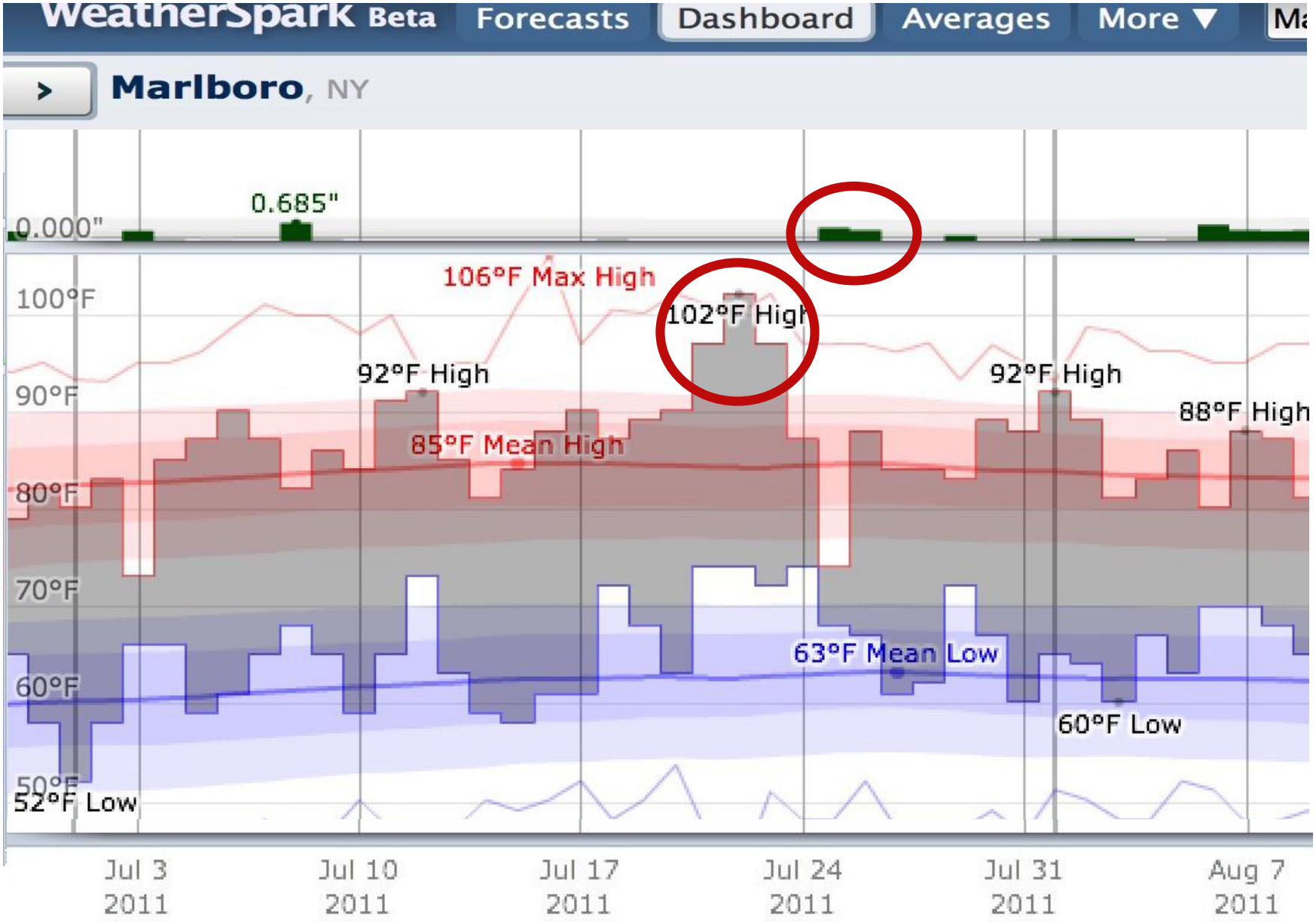
[x] X= product listed was applied.

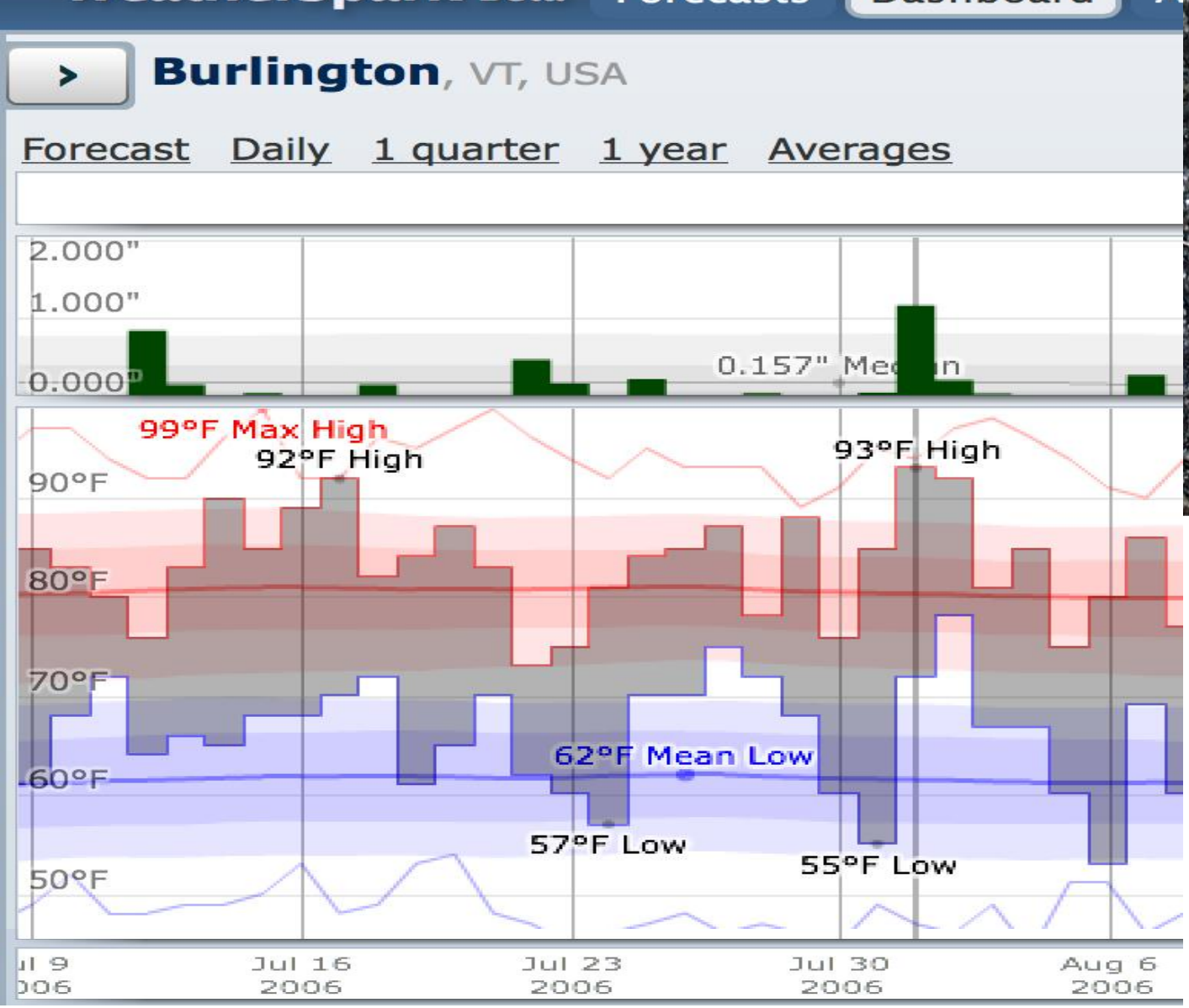
[w] TC= Topsin 3 oz/100 gal plus Captan 80W 1 lb/100 gal .

[v] P= Penncozeb 1 lb/100

[u] RP= Rally 2 oz/100 gal plus Penncozeb 1 lb/100 gal.

However, trees were water-stressed in July.





Bitter rot on hand-thinned fruit in New York's Champlain Valley provided inoculum for infecting ripening fruit still on the tree.

Photographed 3 August 2006

Some fruit showed heat injury after the July heat wave.

Heat injury is different from sunburn, although both may occur at the same time

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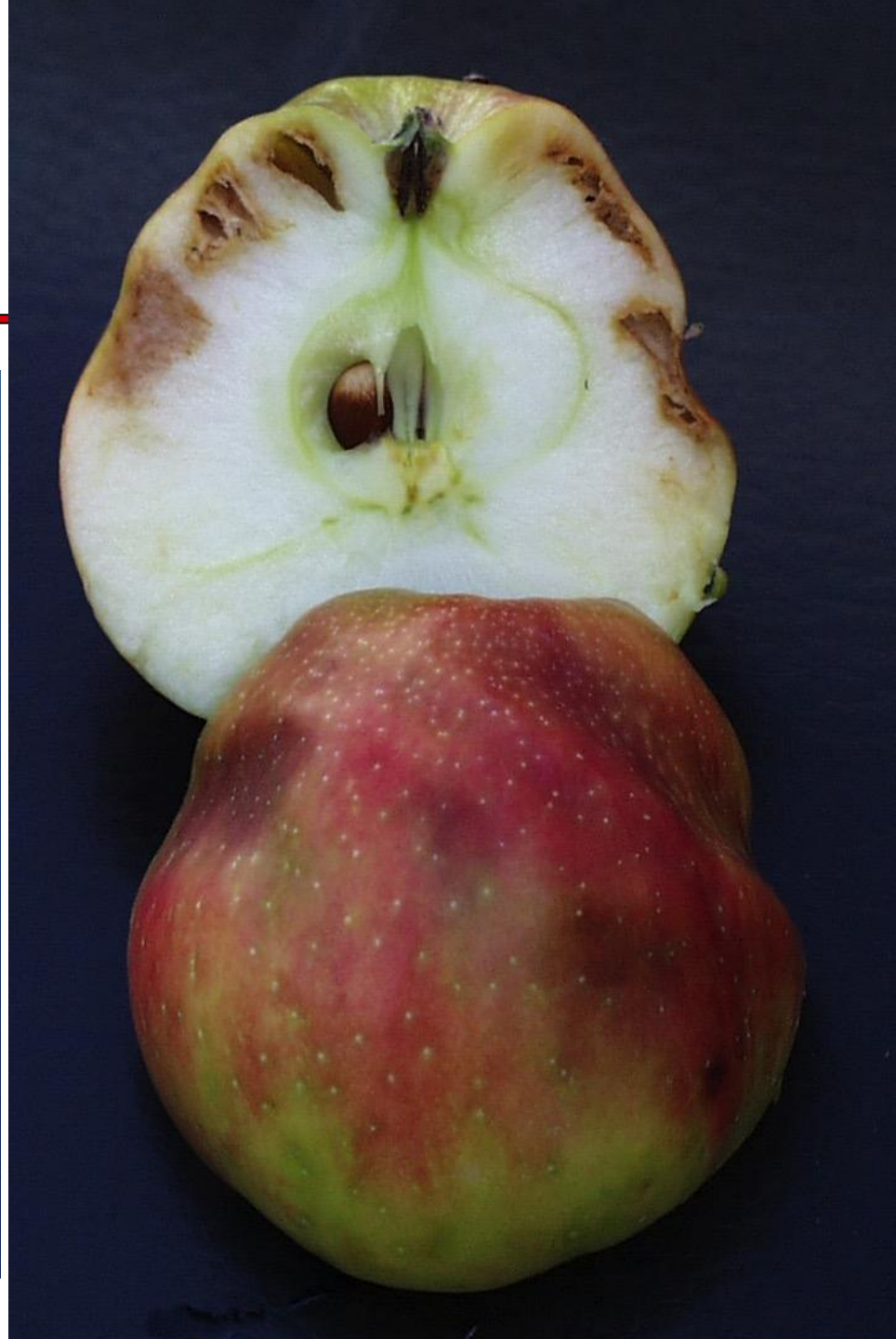
Tissue collapse on Honeycrisp as a result of heat injury



Heat injury: a predisposing factor for bitter rot?

Heat injury on Honeycrisp (below) is sometimes followed by extensive development of bitter rot (right):

Initial decays produce inoculum that generates additional infections.

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Heat injury: a predisposing factor for bitter rot?

Other evidence:

- The first bitter rot infections are usually on the sunny side of sun-exposed fruit.
- Fruit temperatures just beneath the skin can be 25-30 ° F higher than air temperatures.
- Trees under water stress will close stomata earlier under heat stress, thereby shutting down evaporative cooling and allowing more rapid heating of sun-exposed fruit.

Hypotheses that await testing:

- Localized heat stress may inactivate host defense mechanisms in the fruit, allowing initial bitter rot infections.
- Later, secondary infections do not require heat stress due to high inoculum levels generated by initial infections.

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Bitter rot management

Cultural:

- FACT: Remove dead wood during winter.
- FACT: Remove rotted fruit from under trees after harvest.
- CONSIDER: Irrigating to soil saturation ahead of heat waves.
- CONSIDER: Applying fresh fungicide ahead of predicted heat?
- CONSIDER: Avoiding calcium sprays just prior to predicted periods of high temperatures (> 90 F).
- CONSIDER: Overhead cooling, reflective coatings, hail nets?

Best fungicide options:

Captan: If fruit begin to show bitter rot, however, use full label rates applied at 10-14 day intervals, especially ahead of warm wet weather.

Flint, Pristine, Merivon: moderately effective, with less visible residue than high-rate captan, but must be applied with mid-rates of Captan under high disease pressure.

Other cautions for summer sprays:

Some sprays may cause lenticel damage:

- Spray materials may enter lenticels during preharvest sprays or postharvest treatment.
- Exposed cells are compromised and die during storage.

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Other cautions for summer sprays:

Minimize the potential for lenticel cracking:

- Avoid drought stress with irrigation when possible.
- Be cautious with spray mixtures (e.g., captan, calcium, foliar nutrients), especially when heavy rains follow drought conditions, thereby allowing rapid fruit sizing that often results in ruptured lenticels and subsequent penetration of sprays that kill cells beneath lenticels

Summer fruit rots appearing after harvest

Fruit infected shortly before harvest may develop decays during storage.

- *Botryosphaeria* and *Colletotrichum* sp. will not grow below 6 or 7 ° C, but harvested fruit that are cooled slowly may develop black rot or bitter rot during storage.
- Postharvest fungicide treatments will NOT prevent development of decays from infections that occurred in the field.
- Thus, prevention of postharvest decays by these pathogens is dependent on maintaining fungicide coverage throughout the growing season.

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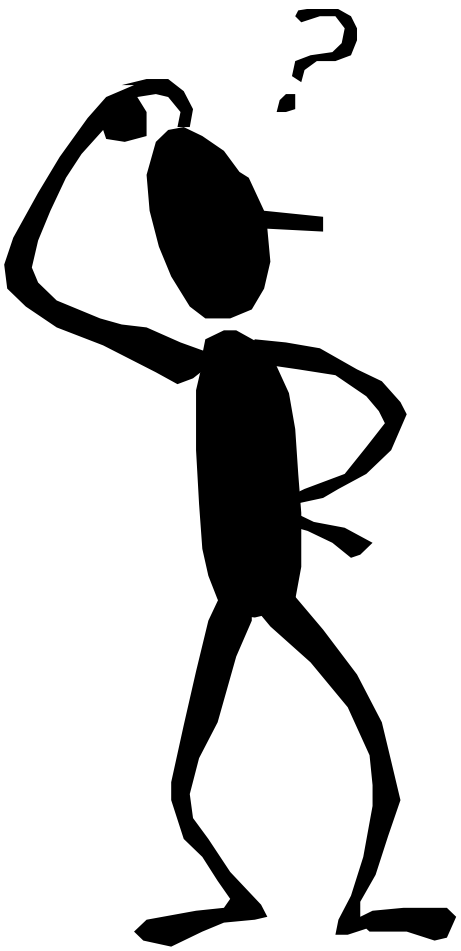

Questions ?

Gray Mold caused by *Botrytis cinerea*

- Symptoms: firm “baked apple” decay originating from the calyx end is seen after CA storage
- Fruit-to-fruit spread occurs in air storage, but does not seem to occur in CA storages.

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Gray mold caused by *Botrytis cinerea*

- Calyx-end decays may result from infections on dying petals that grow into the sepals at petal fall.
- Sepal infections remain quiescent until fruit begin to senesce in storage.
- Losses limited to fruit that receive no postharvest fungicide.
- Can invade fruit through wounds.

Controls:

- Perhaps via petal fall sprays that are active against *Botrytis*??
- Postharvest drenching or fogging.

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Postharvest rots: Penicillium blue mold

Disease cycle for *Penicillium expansum:*

- Decayed fruit produce spores.
- Spores contaminate and survive year-to-year on bins and in storage rooms.
- Spores are washed from bins into recycling drench solutions.
- Spores in drench solutions infect apple wounds if fruit are not protected with a postharvest fungicide.
- Spores in storage rooms get blown about during room filling.

Not easily controlled with preharvest sprays in climates with summer rainfall.

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Sources of *Penicillium* spores in the era of recycling drench treatments

Results from research in southeastern New York:

Comparison of inoculum sources	Numbers of *Penicillium* spores/bin:
Dirty bins (quantified all *Penicillium* sp.)	
3 yr, 5 different lots, 20-25 bins/lot	923,159,000
Orchard soils (based on 2.2 lb of soil/bin)	
3 yr, 12 managed orchards, 19 total tests	2,351,000
Apple fruit (assuming 2000 fruit/bin)	
1 yr, 4 orchards, 7 tests	11,186

Conclusions for fruit treated with recycling drenches:

1. Most inoculum recycles on bins.
2. Sanitizing bins should reduce disease pressure.

Considerations for sanitation

1. Clean first, then sanitize:
   - Sanitizers do not kill spores embedded in organic matter.
   - Thus, decayed or smashed fruit must be removed.

2. Three interacting factors affect sanitizer activity
   - Sanitizer concentration: limited by labels
   - Temperature: warmer is better
   - Exposure time: longer is better

IMPORTANT

For bins coming off of packing lines, low temperature will limit effectiveness of sanitizers unless exposure time is quite long (perhaps 10-15 min.).

Thus, there are no easy solutions for bin sanitizing.

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Sanitizers for fruit operations

1. For hard surfaces (bins, storage floors):
   - Quaternary ammonium is the standard (e.g., Deccosan 315): very effective if solution and bin surfaces are warm. **Beware of new EU residue limits for quats !!**
   - Sodium hypochlorite (chlorinated water): ineffective with exposures <15 min?
   - Peroxides (e.g., Stor-Ox): Will be effective if exposure time is adequate.
   - Fogging or foams can be used to extend exposure times and ensure effectiveness.
   - Steam: high fuel costs for cold bins, but is sometimes used for citrus.

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Postharvest rots: Penicillium blue mold

Tips for avoiding blue mold rot on Honeycrisp:

- Minimize puncture wounds (via stem clipping?)
- Sanitize bins and storage rooms that will be used to hold Honeycrisp.
- Manage storage and packing so as to avoid spore contamination from other sources.
- If possible, do not drench fruit after harvest.
- If fruit must be drenched, include Penbotec (pyrimethanil) or Scholar (fludioxonil)in the drench solution.

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