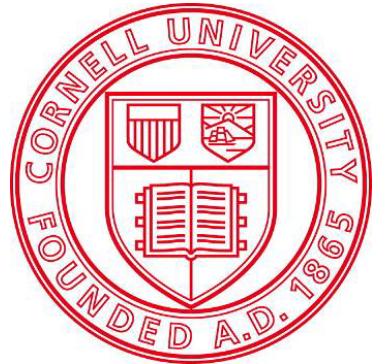


# Blueberry Disease Management Review

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***Cornell AgriTech***

***Plant Pathology and Plant-Microbe Biology Section***  
***School of Integrative Plant Science***  
***Cornell University***



**Cornell**  
**AgriTech**

New York State Agricultural  
Experiment Station





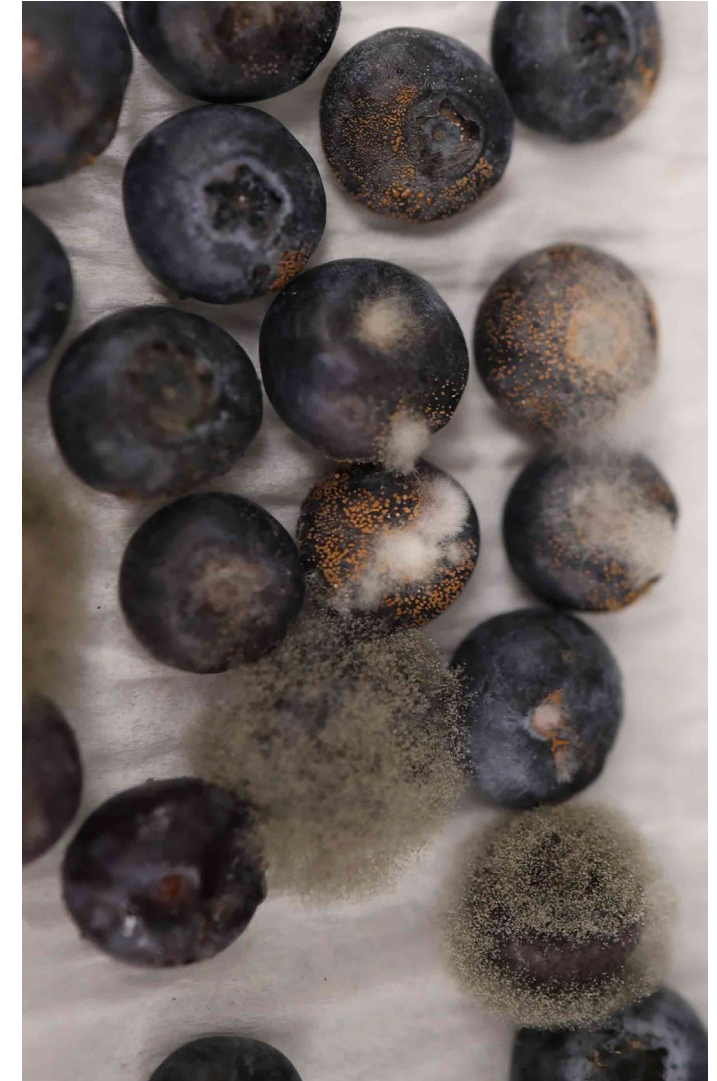
# Principles of Disease Management



# Key Diseases of Blueberries



# Blueberry Fungicide Evaluations





# Principles of Disease Management



# Key Diseases of Blueberries



# Blueberry Fungicide Evaluations





# Management Principles: Avoidance

- **Avoidance:** implement practices that help avoid disease
  - Select & prepare site to avoid pathogen presence, and minimize environmental factors favoring pathogen presence
  - Keep weeds out of the planting site (harbor inoculum)





# Management Principles: Avoidance

- **Avoid:** cultural practices that favor development of disease
  - Avoid overhead irrigation or excessive watering
  - Avoid excessive nitrogen fertilization
    - Succulent tissues encourage fruit rots, powdery mildews
    - Dense foliage/fruit clusters increase drying times & allow for fungal infection

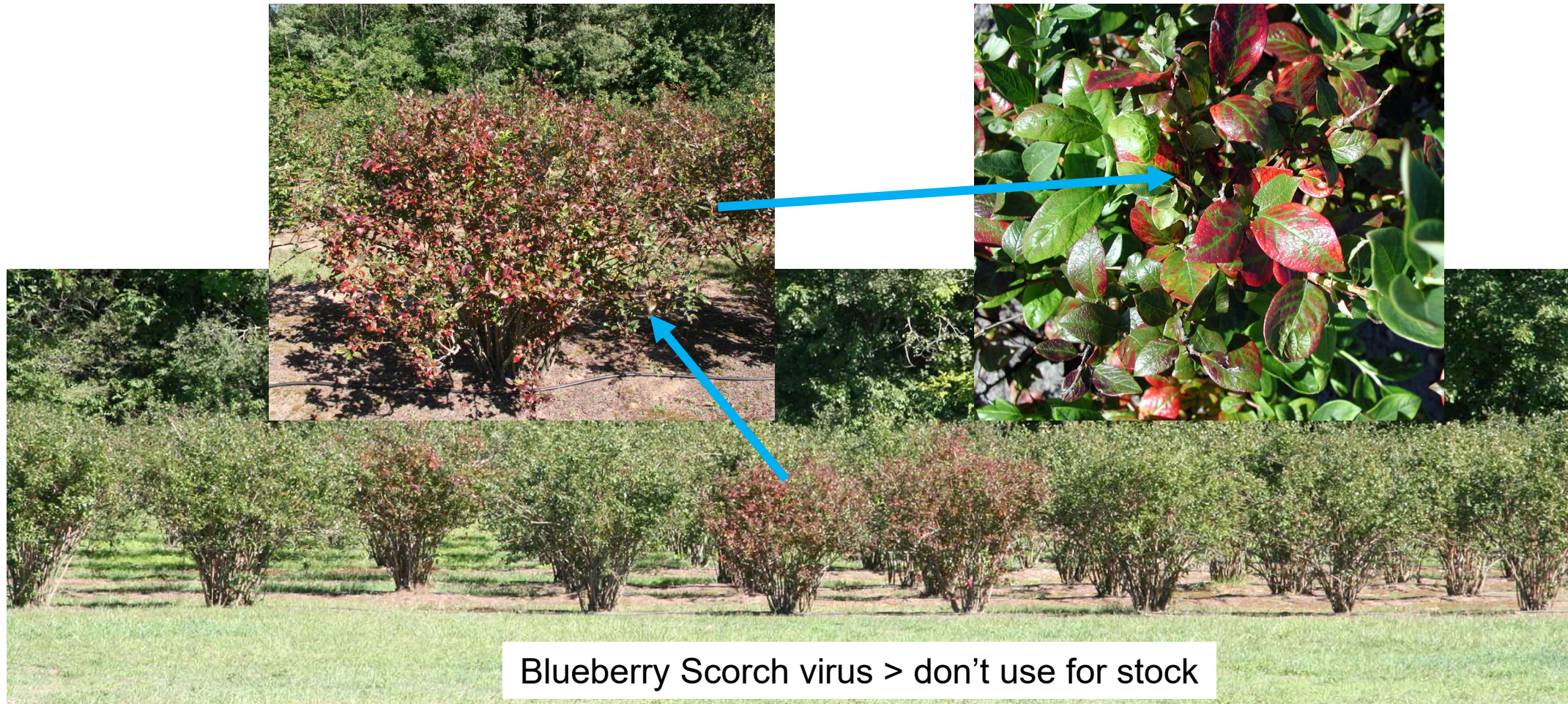


Blueberry Anthracnose



# Management Principles: Avoidance

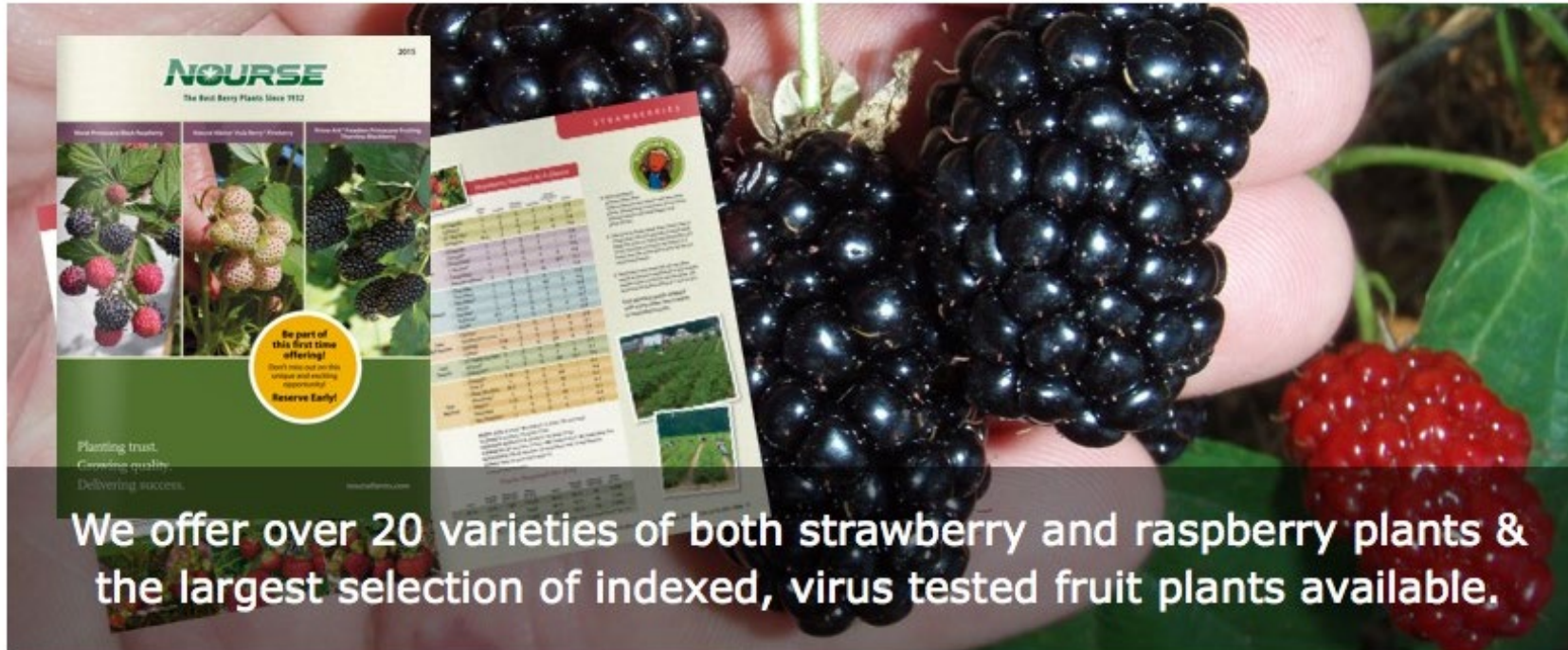
- **Avoid:** practices like propagating your own plants





# Managing Diseases (principles)

- **Avoid:** sources of disease
  - Prevent pathogen introduction by using certified disease-free planting stock (usually for viruses)



**NOURSE**  
The Best Berry Plants Since 1912

2015

Be part of this first time offering!  
Don't miss out on this unique and exciting opportunity!  
Reserve Early!

Planting trust.  
Caring for quality.  
Delivering success.

We offer over 20 varieties of both strawberry and raspberry plants & the largest selection of indexed, virus tested fruit plants available.



# Management Principles: Protection

- **Protect:** optimize plant or pot spacing to ensure good air circulation (drying of fruit, flowers, and leaves)
- Remove old plant material, prune, or weeds to increase air circulation – **air protects against disease?**



Excellent spacing and weed management



Needing Pruning and weed management



# Management Principles: Eradication

- **Eradicate** (pathogen destruction):
  - **Sanitation:** remove & destroy infected fruit or plants, leaf litter, and dead plant material
  - Reduce inoculum & spread of disease





# Biochemical management: (inc. fungicides)

- **Protect** plants from pathogen infection using biochemical agents
- **Eradicate** pathogens to stop disease & prevent invasion/symptom development





# Biochemical management: (inc. fungicides)

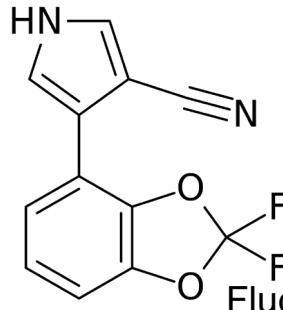
- **Protect** plants from pathogen infection using biochemical agents
- **Eradicate** pathogens to stop disease & prevent invasion/symptom development

KEEP OUT OF REACH OF CHILDREN

**MICROTHIOL**<sup>®</sup>

**DISPERSS**<sup>®</sup>

ACTIVE INGREDIENT: 800 g/kg SULPHUR in the form of a water dispersible granule



BAYER

**SCALA**<sup>®</sup> SC

Fungicide

Net Contents: 1/2 Gallon

For Use On: Almonds, Pistachios, Bulb Vegetables, Grapes, Lemons, Stone Fruits (Except Cherries), Pome Fruits, Potatoes and Other Tuberos and Corm Vegetables, Strawberries and Tomatoes

ACTIVE INGREDIENT: Pyrimethanil: 4,6-dimethyl-1H-phenyl-2-pyrimidinamine ..... 54.6%

OTHER INGREDIENTS: ..... 45.4%

Equivalent to 600 g/L or 5.0 lbs. TOTAL 100.0% of active ingredient per gallon.

EPA Reg. No. 264-788

Produced for: Bayer CropScience LP  
P.O. Box 12014, 2 T.W. Alexander Drive  
Research Triangle Park, North Carolina 27709  
©2012 Bayer CropScience

Product of Germany

**REGALIA**<sup>®</sup>

BIOFUNGICIDE

A plant extract to boost the plants' defense mechanisms to protect against certain fungal and bacterial diseases, and to improve plant health.

Active ingredient: Extract of *Reynoutria sachalinensis* ..... 5 %

Other ingredients: ..... 95 %

Total ..... 100 %

EPA Reg. No. 84059-3

GROUP **PS** FUNGICIDE

KEEP OUT OF REACH OF CHILDREN

**CAUTION**

**FIRST AID**

**IF SWALLOWED:** Call poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Do not give anything by mouth to an unconscious person.

**IF ON SKIN OR CLOTHING:** Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

**IF INHALED:** Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth if possible. Call a poison control center or doctor for further treatment advice.

**IF IN EYES:** Hold eyes open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or if going for treatment.

Produced for: Marrone Bio Innovations  
2121 Second St. Ste. B-107, Davis, CA 95618 USA  
info@marronebio.com

OCT 06 2014 Doc ID: 540222

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION  
BUREAU OF MATERIALS MANAGEMENT  
Pesticide Product Registration

**Badge X<sub>2</sub>**

DRY FLOWABLE

FUNGICIDE/BACTERICIDE FOR AGRICULTURAL USE

ACTIVE INGREDIENT:

Copper Chlorophenox CAS No. 1332-40-7*	23.82%
Copper hydroxide EPA No. 20427-99-2*	21.89%
OTHER INGREDIENTS: .....	54.29%
TOTAL:	100.00%

\*Metric Copper (Cu) Equivalent is 28% by weight

KEEP OUT OF REACH OF CHILDREN

**WARNING - AVISO**

See Attached Label (back) for Additional Precautions and Directions For Use

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label find someone to explain it to you in detail.)

FIRST AID	
<b>IF SWALLOWED:</b>	<ul style="list-style-type: none"> <li>Call a poison control center or doctor immediately for treatment advice.</li> <li>Have person sip a glass of water if unable to swallow.</li> <li>Do not induce vomiting unless told to do so by a poison control center or doctor.</li> <li>Do not give anything by mouth to an unconscious person.</li> </ul>
<b>IF IN EYES:</b>	<ul style="list-style-type: none"> <li>Hold eye open and rinse slowly and gently with water for 15 to 20 minutes.</li> <li>Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.</li> <li>Call a poison control center or doctor for treatment advice.</li> </ul>
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<b>IF INHALED:</b>	<ul style="list-style-type: none"> <li>Move person to fresh air.</li> <li>If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible.</li> <li>Call a poison control center or doctor for further treatment advice.</li> </ul>

NOTE TO PHYSICIAN: Possible mucosal damage may contraindicate use of gastric lavage.

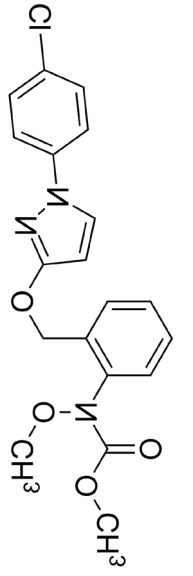
Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

\*You may also call 1-800-222-1222 for emergency medical treatment information.

For Chemical Emergency Spill/Leak/Fix Exposure or Accident Call CHEMTREC Day or Night  
Domestic: North America 800-424-9306 International 703-527-3893 (collect calls accepted)

EPA Registration No.: 80289-12 EPA Establishment No.: 79508-1A-1

FOR ORGANIC PRODUCTION



Pyraclostrobin



# Principles of Disease Management



# Key Diseases of Blueberries



# Blueberry Fungicide Evaluations





# *Phomopsis* Canker

(Early bloom to dormancy)

- *Pathogen: Phomopsis vaccinii*
- Symptoms - Twig blight
  - Rapid wilt and death of shoots (flagging)
  - Spreading reddish/brown lesions (tip to base)

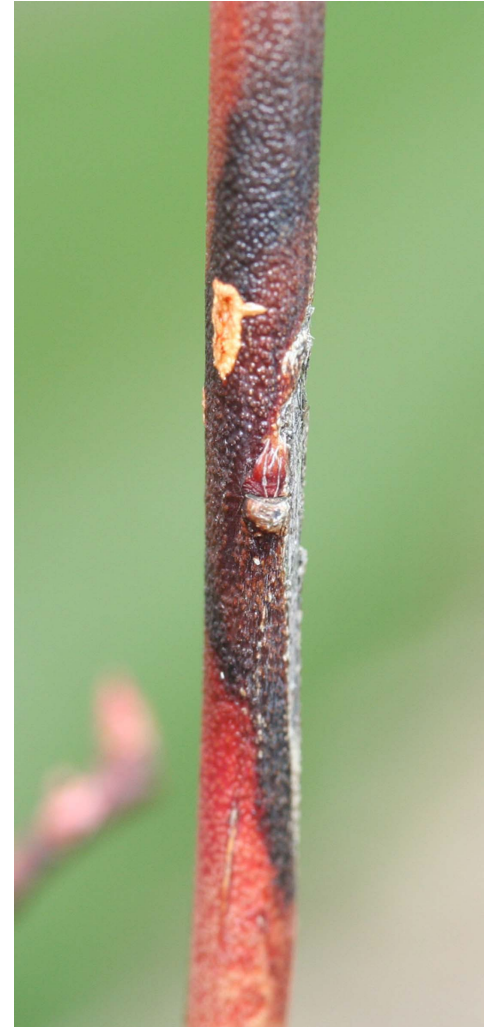




# *Phomopsis* Canker

(Early bloom to dormancy)

- *Pathogen: Phomopsis vaccinii*
  - Canker
    - Flattened/sunken discolored area at base of canes
  - Leaf spot & fruit rot
    - Mycelium (mold) present & Fruit burst easily

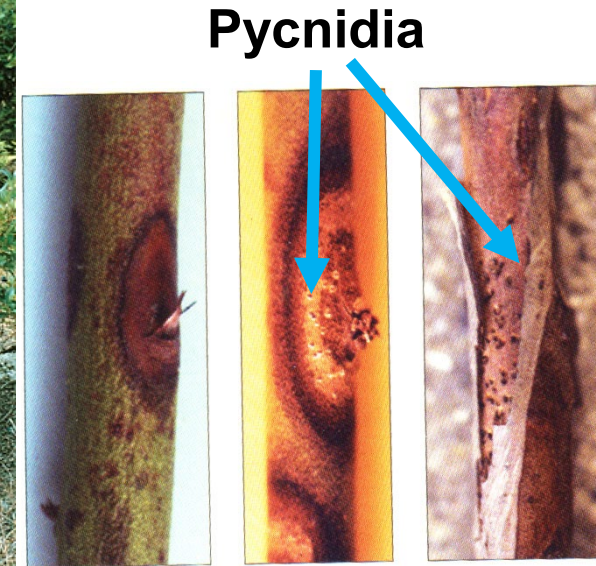




# Fusicoccum Canker

(Early bloom to dormancy)

- *Fusicoccum putrefaciens*
- Symptoms
  - Cane/shoot blight: Rapid wilt and death (flagging)
  - Cankers
    - Reddish/violet-brown lesions at round infected buds (bull's-eye appearance)
    - Expand yearly until girdling cane
    - Filled with tiny black pycnidia





# Botryosphaeria Canker/Blight

(Early bloom to dormancy)

- *Botryosphaeria corticis* & *B. dothidea*
- Symptoms (late spring)
  - Flagging of shoots
  - Stem blight: yellow > reddening > dry > blight of shoots





# Botryosphaeria Canker/Blight

- *Botryosphaeria corticis* & *B. dothidea*
- Symptoms (late spring)
  - Stem cankers: small red lesions on young tissue > lead to Large, dark deeply-cracked cankers
  - Infected wood brown-tan on one side of stem





# All Canker Diseases

- Management options
  - Prune and destroy infected and old growth
  - Remove dead canes to the crown
  - Avoid sites prone to spring frost
  - Fungicide applications
    - Delayed dormant application of copper/sulfur to reduce inoculum
    - Second sulfur application if high disease pressure last season





# Mummy berry

(Bud Break to Harvest)

- Pathogen: *Monilinia vaccinii-corymbosi*
- Symptoms - Shoot infection:
  - Early green tip to shoot expansion
  - Rapid blight of leaf clusters (strikes)
- Flower/fruit infection
  - Green fruit: white mycelium in locules
  - Mature fruit: grey to pinkish-tan rigid, but rubbery
  - Mummies (pseudosclerotia): Black spongy pumpkin-shaped fungal structures



Green fruit > Mature mummies





# Mummy berry

(Bud Break to Harvest)

- Management options
  - Remove and destroy mummies & ground cover like moss
  - Fungicide – green tip to petal fall
    - Applications of single-site fungicides to protect shoot & flowers
    - Sulfur and copper not effective > some biopesticides are effective



Severe shoot blight



# Mummy berry

(Bud Break to Harvest)

- Management options
  - Mulch planting - over ground cover - after mummy removal
  - Shallow cultivation between and under bushes at bud break
  - Cultivars w/ different flowering can escape infection

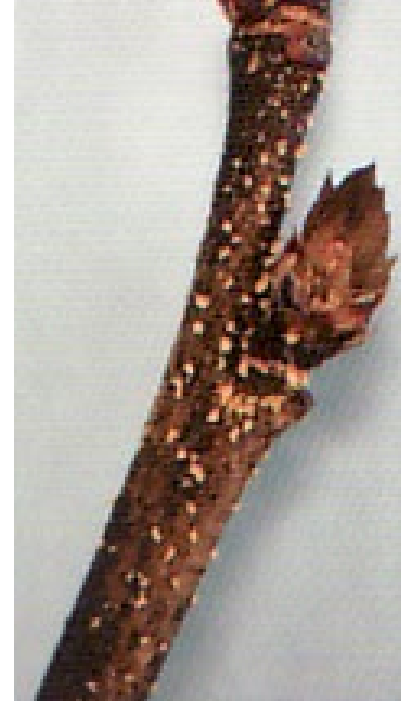




# Anthracnose

(Bud Break to Harvest)

- Pathogen: *Colletotrichum sp.*
- Symptoms
  - Cane and twig infection
    - Reddish brown lesions at buds
    - May girdle shoots
    - Severe infection → cane death
  - Fruit rot
    - Often latent infection (at bloom)
    - Sunken lesions & salmon-colored sporulation → appears during harvest





# Anthracnose

(Bud Break to Harvest)

- Management:
  - Use anthracnose free planting stock
  - Remove and destroy infected shoots
  - Promote air circulation to dry plants: Control weeds & widen plant spacing: Prune for an open canopy





# Anthracnose

(Bud Break to Harvest)

- Management:
  - Fungicide applications
    - Sulfur: at bud break reduce spore inoculum
    - Single-site fungicides: bloom through harvest during warm wet weather



At same timing as mummy berry applications



# Blueberry Brooms

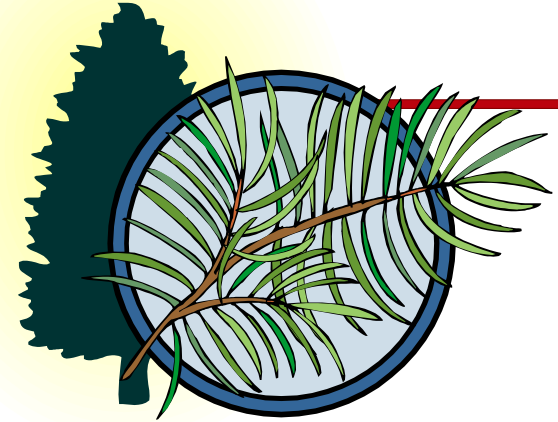
- *Pucciniastrum goeppertianum*
- Symptoms: numerous small swollen shoots emerging from lateral buds (broom-like)
- Impacts: Rare in NY & damage negligible unless infection severe





# Blueberry Brooms

- Disease cycle
  - Survival : overwinters on fir trees (*Abies* sp.)
  - Infection: sporulation on fir needles infects blueberry
- Management options
  - Eliminate firs near planting (300m)
  - Eliminate infected blueberries





# Principles of Disease Management



# Key Diseases of Blueberries



# Blueberry Fungicide Evaluations





# Viruses

- Viruses: abiotic infectious particles: nucleic acids and proteins that disrupt cellular physiology
- Virus problems look similar to subtle horticultural problems





# Viruses

- Virus infection upsets the plant physiology like a nutrient deficiency or toxicity
- Virus infections can be asymptomatic for many years until titers build sufficiently
- Asymptomatic infections are transmissible





# Tobacco and Tomato ringspot virus (ToRSV & TRSV)

- Symptoms: asymptomatic with consequences, and malformed leaves with chlorotic & necrotic spots
- It may take more than 10 years before symptoms become apparent
- Consequences: poor growth, poor or absent fruit production, plant death





# Tobacco and Tomato ringspot virus (ToRSV & TRSV)

- Vector: Dagger nematode
  - Thrives in sandier soils & doesn't move far (in./season)
  - Numerous weeds can host the nematode – widely distributed throughout a planting
- Management
  - Should remove and replant elsewhere with healthy stock
  - Plant to non-host or leave fallow





# Blueberry Scorch Virus (BIScV)

- Symptoms: Blight and necrosis of developing leaves and flowers during bloom (start brown, bleach gray)
- May look like frost injury and may kill young twigs
- Cultivar-specific chlorosis and marginal reddening patterns





# Blueberry Scorch Virus (BIScV)

- Consequences: poor growth, poor or absent fruit production, plant death
- Vector: Aphids
  - Quickly move throughout a planting, and to neighboring fields
  - Not more than 0.5 miles





# Blueberry Shock Ilarvirus (BIShV)

- Blight of flowers and developing leaves during bloom
- Second flush of growth in the summer and bushes look normal, but have no fruit
- Have symptoms for only 1-4 years and then infections become quiescent





# Blueberry Shock Ilarvirus (BIShV)

- Consequences: Bushes lose productivity, but can recover w/ good yields with nutrition
- Vector: Transmitted in pollen spread by bees.
  - Can quickly spread within a field and to neighboring fields
  - Quiescent infections are still transmissible





# Distinguishing viruses from other problems

---

1. Number of shoots and leaves expressing virus-like symptoms (when symptomatic, virus symptoms often systemic)
  - Don't be alarmed by a few crumbly berries, or oddly chlorotic leaves on a cane or bush
2. Intensity of virus-like symptoms
  - Although infected plants can be asymptomatic, poor fruit production, or lack thereof is not reason to suspect a virus



# Distinguishing viruses from other problems

## 3. Timing of symptom appearance

- Virus tissue titers during peak biomass production in spring - virus symptoms most apparent in spring
- Sudden appearance of bizarre symptoms - end of the summer during the beginning of senescence - not likely a virus

## 4. Symptom distribution

- Usually patchy distributions - due to restricted movement and habitation patterns of the virus vector
- Varieties vary in susceptibility and symptom expression - Uniform distribution across blocks and varieties are likely abiotic causes (like nutrition)



# How to avoid and get rid of viruses

---

- No chemical controls for viruses – best defense = avoid viruses
- Can scout and treat for vectors (aphids & nematodes)
- Purchase planting material from established nurseries with certification programs
- Once a plant has a virus it has it for life!
  - Don't just remove the symptomatic plants
  - Neighboring plants = infected, but asymptomatic
  - Important to remove the entire block or planting

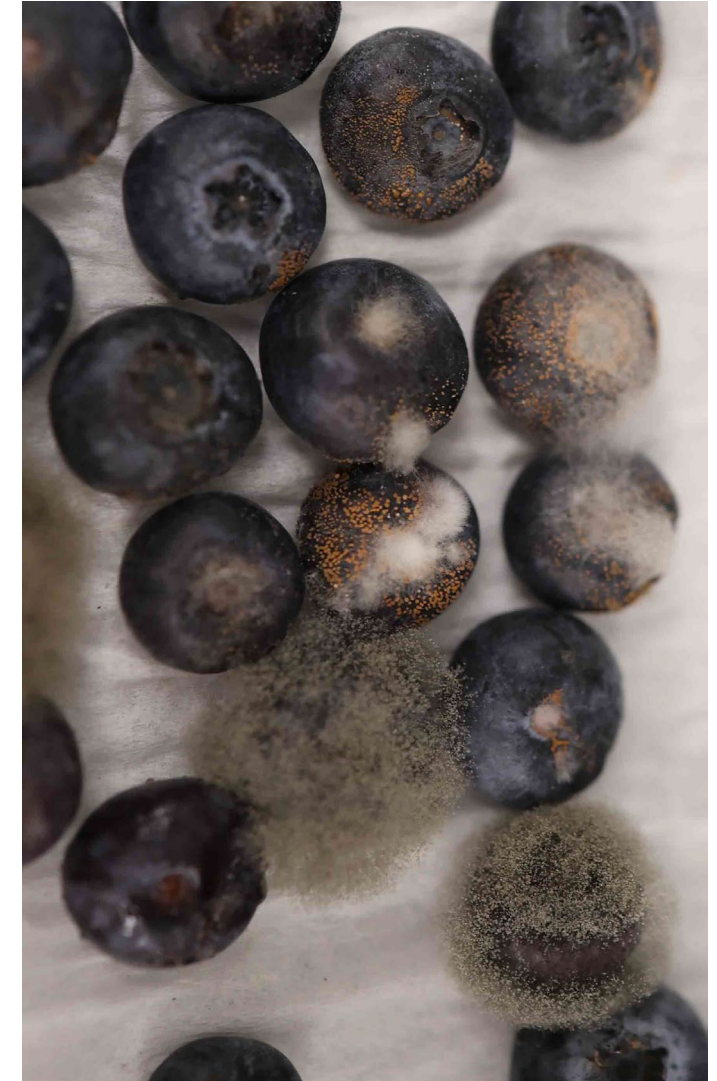
# Principles of Disease Management



# Key Diseases of Blueberries



# Blueberry Fungicide Evaluations





# Pre/post-harvest fruit rot trials

- ‘Blueray’ blueberries are treated with fungicides at harvest maturity in replicated plots

Product Evaluated	Rate	Fungicide or Biopesticide active ingredient	FRAC Group	Manufacturer
Scala SC	18 fl. oz./A	Pyrimethanil	9	Bayer CropScience
Elevate WG	24 oz./A	Fenhexamid	17	Arysta LifeScience
Switch	14 oz./A	Cyprodinil + Fludioxonil	9 + 12	Syngenta
Captan Gold 80 WDG	3.75 lb./A	Captan	M4	ADAMA
Organic JMS Stylet-Oil	9 qts./A	White Mineral Oil	NA	JMS Flower Farms
Pristine	23 oz./A	Pyraclostrobin + Boscalid	11 + 7	BASF
Merivon	11 fl. oz./A	Pyraclostrobin + Fluxapyroxad	11 + 7	BASF
DoubleNickel LC	6 qts./A	Bacillus amyloliquefaciens	NA	Certis USA
Serenade Opti	20 oz./A	Bac. subtilis QST 713	NA	Bayer CropScience
Scholar	32 fl oz./A	Fludioxonil	12	Syngenta
Inspire Super	20 fl. oz./A	Difenoconazole + Cyprodinil	3 + 9	Syngenta
Fontelis	24 fl. oz./A	Penthiopyrad	7	DuPont Crop Protection
Miravis	3.4 fl. oz./A	Pydiflumetofen	7	Syngenta
Cevya	3.0 fl. oz./A	Mefentrifluconazole	3	BASF
Aprovia	5.5 fl. oz./A	Benzovindiflupyr	7	Syngenta

# Pre/post-harvest fruit rot trials

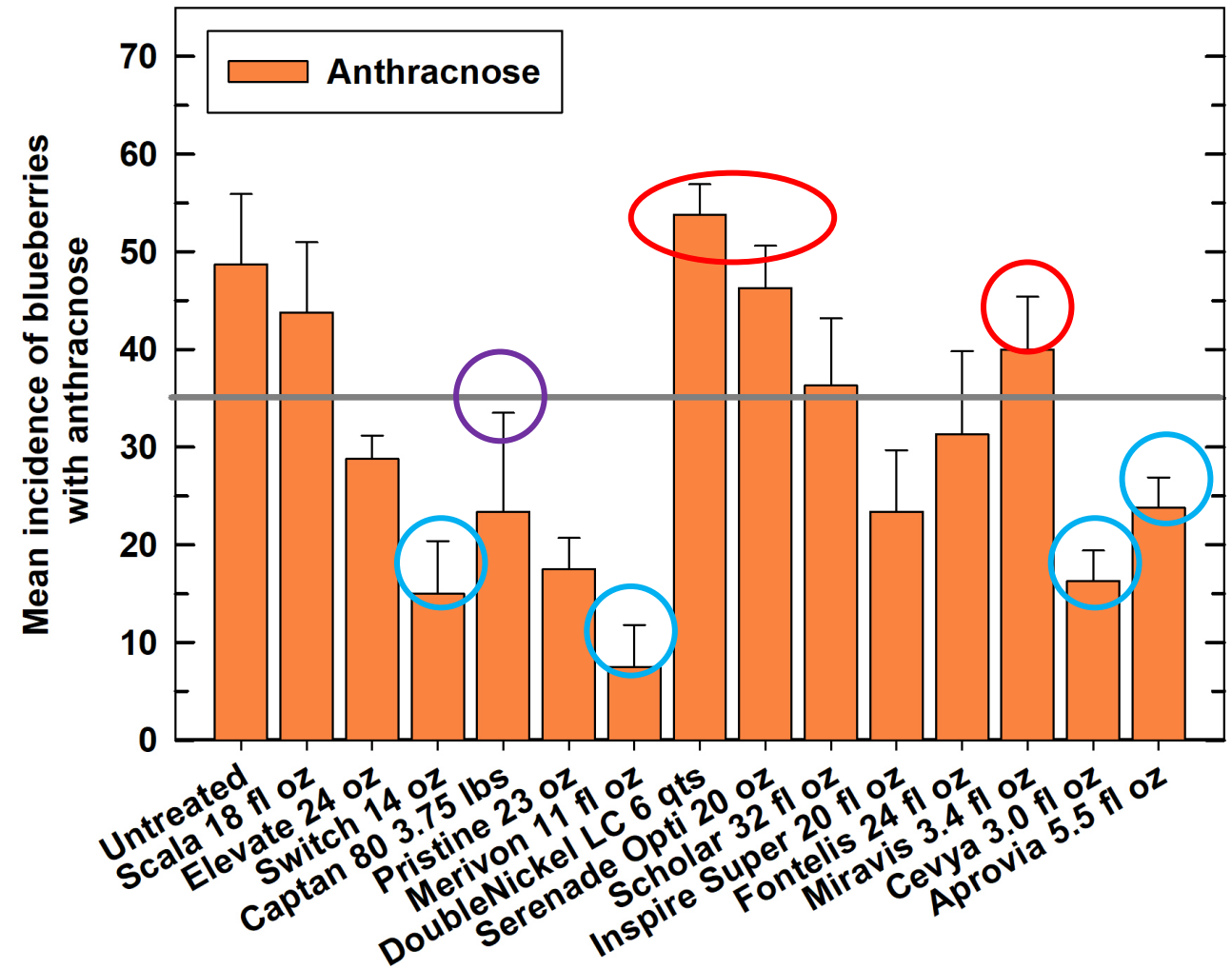
- ‘Blueray’ blueberries are treated with fungicides at harvest maturity in replicated plots
- Inoculated harvested fruit rot pathogens & incubated at room temperature until rot begins in untreated fruit





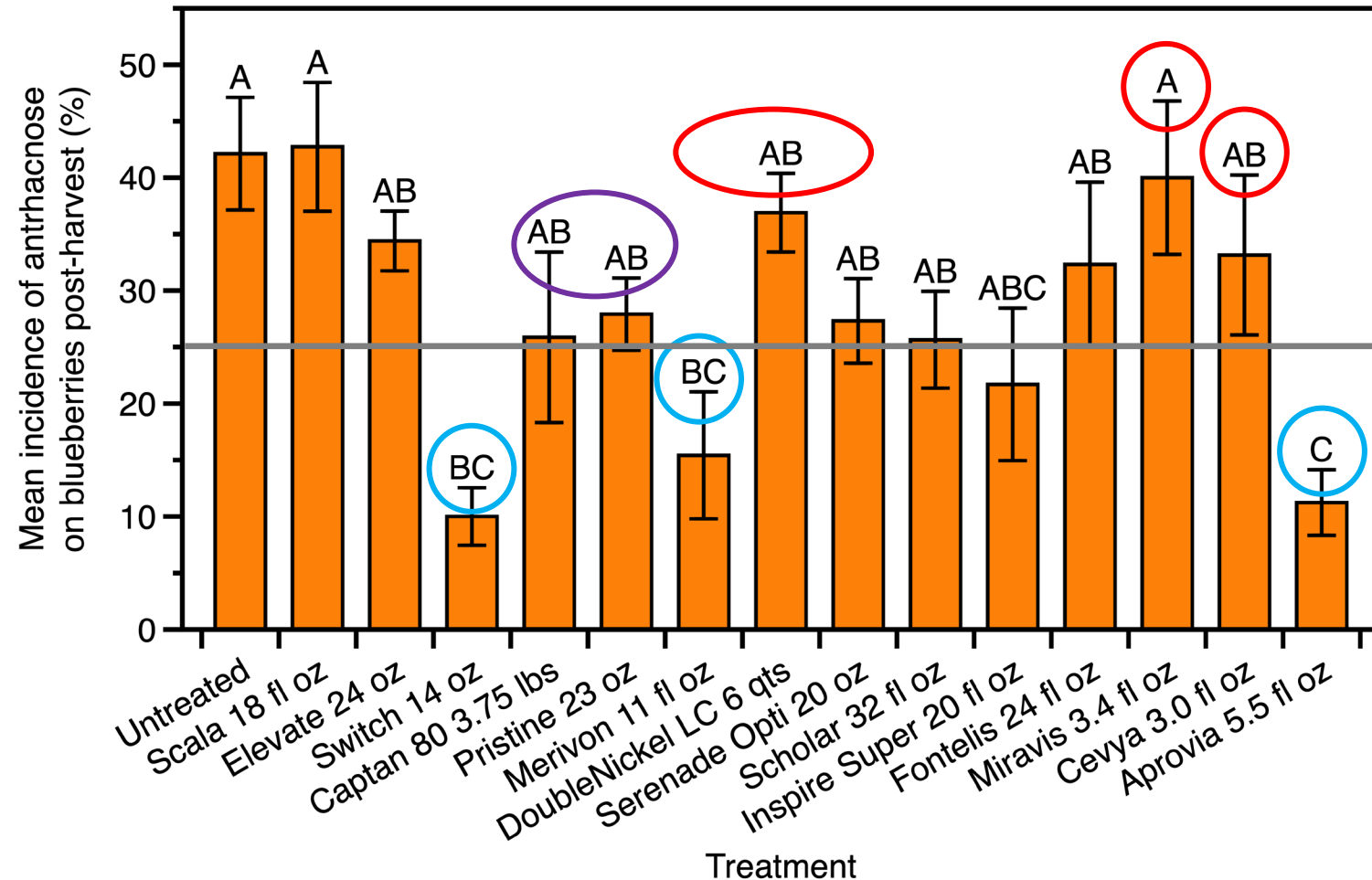
# Pre/post-harvest fruit rot trials: Anth 2021

- Effective: Merivon, Switch, Cevya, Aprovia
- Less effective: Captan, Miravis, Biopesticides
- Test using *C. fioriniae*



# Pre/post-harvest fruit rot trials: Anth 2022

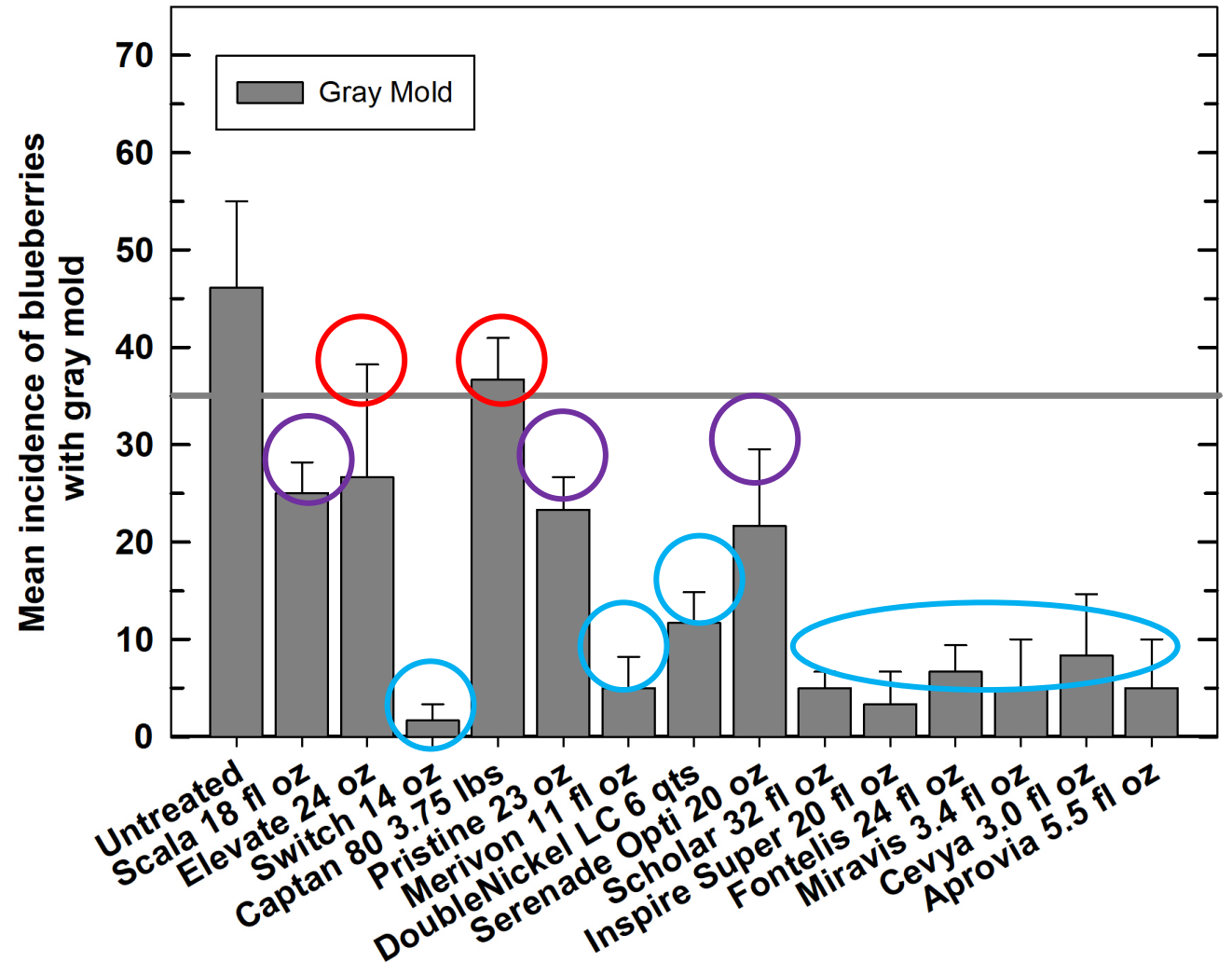
- Effective: Merivon, Switch, Cevya, Aprovia
- Less effective: Captan, Miravis, Biopesticides
- Test NY *C. nymphaeae*





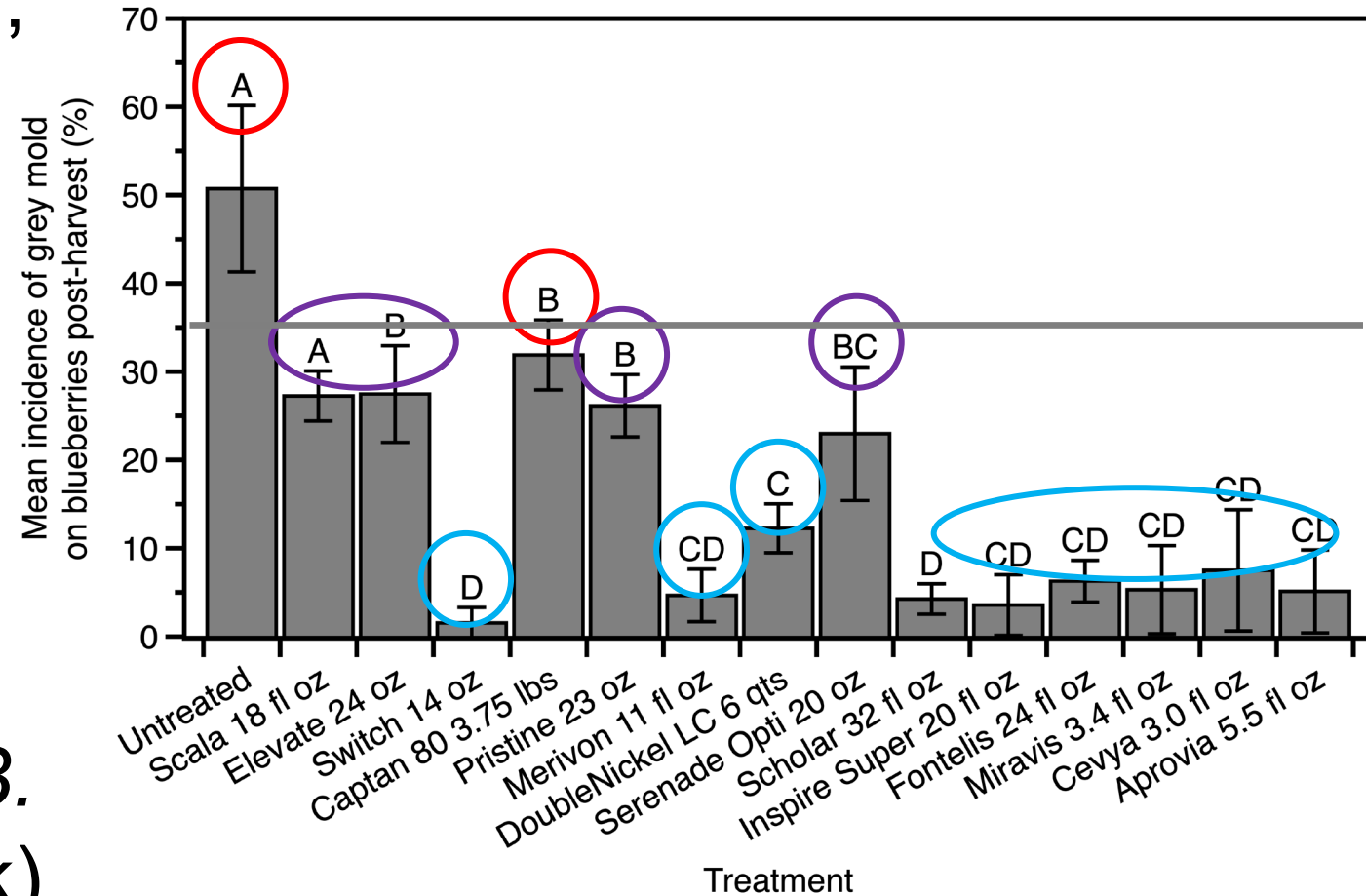
# Pre/post-harvest fruit rot trials Bot 2021

- Effective: Merivon, Switch, Biopesticides, Cevya, Aprovia, all group 7
- Less effective: Captan and Elevate
- Test using Qol-resistant *B. cinerea* (Group 7+11 work)



# Pre/post-harvest fruit rot trials Bot 2022

- Effective: Merivon, Switch, Biopesticides, Cevya, Aprovia, all group 7
- Less effective: Captan, Pristine, Scala, & Elevate
- Test using Qol-resistant *B. cinerea* (Group 7+11 work)





# Summary points for fruit rot trials

---

- Fungicides differ infectiveness to different species of *Colletotrichum*:
- Protectants like captan (sustainability issues) not appreciably effective
- Many single-sites effective against gray mold: Pristine not able to overcome QoI resistance in test isolate, but ~~Merivon~~ can
- Switch, ~~Merivon, Aprovia~~ Ceyva – all around effective single-site
- Biopesticides need a boost: forecasting & protected agriculture

# Acknowledgments

**Program research  
funded by**



Cox Lab Members

Alexandra

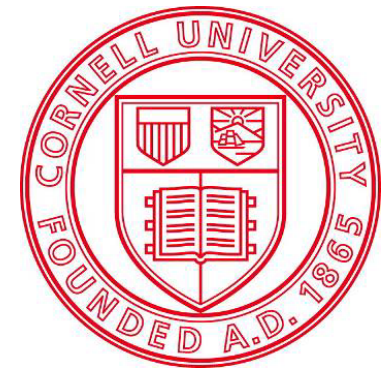
Davidson

Isabella Yannuzzi

Andrew Painton

Mary Cowser

McKenzie Schessi



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