PROCEEDINGS

92nd Annual
Cumberland-Shenandoah Fruit Workers Conference

December 1st and 2nd, 2016
Hilton Garden Inn
Winchester, Virginia

(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the

Cumberland-Shenandoah Fruit Workers Conference

92nd Annual Meeting

December 1st and 2nd, 2016

Hilton Garden Inn

Winchester, Virginia

Jim Walgenbach

Mountain Horticultural Crops Research and Extension Center

North Carolina State University

Mills River, North Carolina

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Plant Pathology

CSFWC current and past executive officers

2017

President: Greg Krawczyk (PSU)

Secretary/Treasure: Chris Bergh (VT)

President-elect: Mike Dimock (Certis USA)

Immediate-past president: James Walgenbach (NCSU)

2016

President: James Walgenbach (NCSU)

Secretary/Treasure: Chris Bergh (VT)

President-elect: Greg Krawczyk (PSU)

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92^{nd} Cumberland-Shenandoah Fruit Workers Conference
December 1-2, 2016

Hilton Garden Inn, Winchester, VA

CONFERENCE AGENDA

Thursday, December 1

8:00 – 9:00	**Registration** – Pre-registration room
9:00 – 9:10	**Call to Order** – 92^{nd} Cumberland-Shenandoah Fruit Workers Conference
9:10 – 10:10	**Call of the States**
10:10 – 11:00	**Call of the Industry**
11:00 – 11:15	**Break**
11:15 – 12:15	**General Session** **Apple production in Jumla, Nepal.** Chris Bergh. Virginia Tech, AHS Jr. AREC, Winchester, VA. **Virginia's wine grape industry beyond 2020: Plant, planting and pest considerations.** Tony Wolf. Virginia Tech, AHS Jr. AREC, Winchester, VA.
12:15 – 1:15	**Lunch**
1:15 – 5:00	**Concurrent Sessions** Entomology Horticulture Plant Pathology
5:30	**Mixer**

Friday, December 2

8:00 – 9:00	**Business Meeting**
9:00	**Concurrent Sessions continued**

Concurrent Sessions Agenda
Entomology

Thursday, December 1

1:15 – 1:30	**Ambrosia beetle trials in NY apples – Round 2.** Art Agnello, Dave Combs, Forest English-Loeb, and Josh Neal. Cornell University, NYSAES, Geneva, NY.
1:30 – 1:45	**How the loss of Lorsban could affect apple IPM.** David Biddinger and Katie Ellis. Penn State University, FREC, Biglerville, PA.
1:45 – 2:00	**Control of periodical cicada oviposition damage on non-bearing apple trees using methods approved for organic production.** Daniel Frank. WV University, Morgantown, WV.
2:00 – 2:15	**Field validation of the Z-Trap technology for monitoring codling moth and oriental fruit moth.** Greg Krawczyk, Brian Lehman, Larry Hull, and Johnny Park. Penn State University, FREC, Biglerville, PA.
2:15 – 2:30	**Performance of pheromone lures and sprayable pheromone for mating disruption of oriental fruit moth and codling moth**. Steve Schoof and Jim Walgenbach. NC State University, MHCREC, Mills River, NC.
2:30 – 2:45	**Emergence of overwintering *Halyomorpha halys* from experimental shelters along a transect from New Jersey to Georgia**. Chris Bergh, Tracy Leskey, Jim Walgenbach, George Hamilton, Mike Toews and Angel Acebes-Doria. Virginia Tech. AHS Jr. AREC, Winchester, VA.
2:45 – 3:00	***Halyomorpha halys* feeding and mortality comparison of Closer and Bifenthrin treated fruit.** Peter Jentsch and Dana Acimovic. Cornell University, Hudson Valley Lab, Highland, NY.
3:00 – 3:15	**Break**
3:15 – 3:30	**Refinement of perimeter-based management tactics for *H. halys* in apple orchards**. Brent Short and Tracy Leskey. USDA-ARS AFRS, Kearneysville, WV.
3:45 – 4:00	**Association of pheromone trap captures and BMSB damage in NC apples**. Emily Ogburn, Steve Schoof, and Jim Walgenbach. NC State University, MHCREC, Mills River, NC.
4:00 – 4:15	**Differences in population response of *Halyomorpha halys* to pheromone traps in apple and peach.** Anne Nielsen, Joe Kaser and Clement Akosten-Mensah. Rutgers University, RAREC, Bridgeton, NJ.
4:15 – 4:30	**Improving trap-based monitoring tools for brown marmorated stink bug.** Tracy Leskey, Brent Short, William Morrison, Kevin Rice and Tom Kuhar. USDA-ARS AFRS, Kearneysville, WV.
4:30 – 4:45	**Monitoring brown marmorated stink bug and its egg parasitoids in**

the tree canopy: Initial approaches. Nicole Quinn, Tracy Leskey and Chris Bergh. Virginia Tech, AHS Jr. AREC, Winchester, VA.

4:45 – 5:00 **Host stimuli affects the foraging of the brown marmorated stink bug**. Rob Morrison and Tracy Leskey. USDA-ARS AFRS, Kearneysville, WV.

Friday, December 2

9:00 – 9:15 **Effect of trap position and bait type on capture of spotted wing drosophila.** Dean Polk and Kyle Clement. Rutgers University, RFREC, Cream Ridge, NJ.

9:15 – 9:30 **Does canopy manipulation impact yield and SWD infestation levels in the outer versus inner canopies of raspberries?** Chris Taylor, Bryan Butler and Kelly Hamby. Univ. Maryland, College Park, MD.

9:30 – 9:45 **Developing attract-and-kill strategies to manage spotted wing drosophila, *Drosophila suzukii* Katsumara, in raspberry.** Peter Jentsch and Tim Lampasona. Cornell University, Hudson Valley Lab.

9:45 – 10:00 **Development of attract-and-kill strategy for spotted wing drosophila.** Kevin Rice and Tracy Leskey. USDA-ARS AFRS, Kearneysville, WV.

Concurrent Sessions Agenda
Horticulture

Thursday, December 1

1:15 – 1:30 **Development of the Northeast Center to Advance Food Safety (NECAFS).** Christopher Walsh. University of Maryland, College Park, MD.

1:30 – 1:45 **A fruit maturity program for the Mid-Atlantic region; New cultivars and new technologies.** Christopher Walsh, Kathleen Hunt, Brianne Redman, Tara Baugher, and Norma Young. University of Maryland, College Park, MD.

1:45 – 2:00 **Bitter pit in Honeycrisp on G-41 vs M9-337: Field observations from a grower extension visit**. Daniel Donahue. Cornell University, Highland, NY.

2:00 – 2:15 **Mystery blotches on peach fruit: Occurrence and things that do NOT cause bronzing.** Guido Schnabel, Juan Carlos Melgar, and Jaine Allran. Clemson University, Clemson, SC.

2:15 – 2:30 **Sunburn management of Honeycrisp in New York**. Gemma Reig Cordoba. Cornell University, Highland, NY.

2:30 – 2:45 **Using paper bags for the production of high-quality peaches in the southeastern U.S.** Juan Carlos Melgar, Jaine Allran, and Guido Schnabel.

Clemson University, Clemson, SC.

2:45 – 3:00 **Planting hole amendment and mulch effects on blueberry establishment and yield in southern Delaware.** Emmalea Ernest. University of Delaware, Georgetown, DE.

3:00 – 3:15 **Can a weak graft union be predicted by a tree's cellular anatomy?** Michael Basedow and Robert Crassweller. Penn State University, University Park, PA.

3:15 – 3:30 **Break**

3:45 – 4:00 **Evaluation of early thinning with 1-Naphthaleneacetamide or artificial spur extinction (ASE), with and without post-bloom 1-Napthaleneacetic acid plus carbaryl.** Jim Schupp, Edwin Winzeler, and Melanie Schupp. Penn State University, Biglerville, PA.

4:00 – 4:15 **An autonomous measurement system for dormant trees.** Amy Tabb. USDA-ARS, Kearneysville, WV.

4:15 – 4:30 **Thermal shock temperature and timing effects on apple stigmatic receptivity, pollen tube growth, and leaf injury.** Tom Kon and Jim Schupp. NC State University, Mills River, NC.

4:30 – 5:00 **Catch-up/Discussion**

Concurrent Sessions Agenda
Plant Pathology

Thursday, December 1

1:15 – 1:30 **Quiescent *Erwinia amylovora* in apple budwood.** Kerik Cox and Kiersten Tancos, Cornell University, Geneva, NY

1:30 – 1:45 **Changes in epiphytic bacteria in the apple phyllosphere following post-bloom applications of streptomycin and kasugamycin**. Kerik Cox and Kiersten Tancos, Cornell University, Geneva, NY

1:45 – 2:00 **Managing fire blight in Pennsylvania: What worked and what didn't in 2016.** Kari Peter and Brian Lehman, Penn State University, Biglerville, PA.

2:00 – 2:15 **Evaluation of low rates of kudos and two new prohexadione formulations for suppressing shoot growth and fire blight management.** Brian Lehman, Edwin Winzeler, Jim Schupp, and Kari Peter, Penn State University, Biglerville, PA

2:15 – 2:30 **Population dynamics of *Erwinia amylovora* on apple flower stigmas and effect of antibiotic treatment.** Suzanne Slack and George Sundin, Michigan State University, East Lansing, MI

2:30 – 2:45 **Fire blight management in apple: Observations from Mid-Atlantic tree fruit iPiPE project.** Mahfuz Rahman, West Virginia University.

2:45 – 3:00 **Armed and dangerous: Postharvest fungicide-resistant blue mold.** Wayne Jurick II, USDA-ARS, Beltsville, MD.

3:00 – 3:15 **Breaking the mold with *Penicillium* comparative genomics.** Wayne Jurick II, USDA-ARS, Beltsville, MD.

3:15 – 3:30 **Break**

3:45 – 4:00 **Brown rot management in Pennsylvania: Fungicides and fruit bagging.** Kari Peter and Brian Lehman, Penn State University, Biglerville, PA.

4:00 – 4:15 **Peach bacterial spot control: Comparison of oxytetratcycline, fasugamycin, and copper bactericides.** Norman Lalancette and Lorna Blaus, Rutgers University, Bridgetown, NJ

4:15 – 4:30 **Management of peach diseases with biorational and conventional fungicides**. Norman Lalancette, Lorna Blaus and Peninah Feldman, Rutgers University, Bridgetown, NJ.

4:30 – 4:45 **Methods for identifying *Colletotrichum* species causing ripe rot of grape in Virginia.** Charlotte Oliver and Mizuho Nita, Virginia Tech, Winchester, VA.

4:45 – 5:00 **2016 Glomerella observations in apple: Not your average bitter rot.** Sara Villani, NC State University, Mills River, NC.

Friday, December 2

9:00 – 9:15 **DMI fungicides for control of *Colletotrich*um species**. Guido Schnabel and Shuning Chen, Clemson University, Clemson SC.

9:15 – 9:30 **Understanding bitter rot in apples: A review of recent literature.** David Rosenberger, Cornell University, Highland, NY.

9:30 – 9:45 **Highlights of 2016 fungicide testing on apples.** Keith Yoder, VA Tech, Winchester, VA.

9:45 – 10:00 **2016 Fungicide efficacy trials for apple disease management in Pennsylvania**. Kari Peter and Brian Lehman, Penn State University, Biglerville, PA.

10:00 – 10:15 **Fungicide performance trials for management of grape powdery mildew, downy mildew, and late season rots at Winchester, VA**. 2016. Mizuho Nita, Sabrina Hartley, and Amanda Bly, VA Tech, Winchester, VA.

Business and Financial Reports

2016 Cumberland-Shenandoah Fruit Workers Conference, Inc.

Minutes from the Business meeting on Dec 2, 2016

Compiled by Chris Bergh, Secretary/Treasurer

- Meeting called to order at 8:00 a.m. by current CSFWC President, Jim Walgenbach
- 39 CSFWC members in attendance (37.1% of 105 members currently in good standing)
- No old business to discuss
- New business:

1. Discussed the language amendment to Articles of Incorporation that reflects the three scientific disciplines represented by the members. Arthur Agnello moved to adopt the amendment, seconded by Bob Rauss. Unanimous vote (39:0) in favor.
2. Treasurer delivered Financial Report. Tracy Leskey moved to accept the report, seconded by Dean Polk. Unanimous vote (39:0) in favor.
3. Financing of the mixer was discussed in view of a Virginia law related to 301(c) organizations soliciting funds from out-of-state organizations. The discussion focused on whether and how to fund the meeting mixer. Options included no mixer, raise registration fees to cover the mixer, continue to receive support from corporate members. One question was if a CSFWC member is an employee of an ag company, is sponsorship by that company allowed. Can sponsorship be rolled into registration? Can corporate members hold a mixer as a separate event (i.e. coordinated and paid for separately?). Suggestion of contacting an Association of Non-Profit Organizations in Virginia for their feedback. It was decided that that Don Ganske and Chris Bergh would meet with an attorney about this issue.
4. Nomination of President-Elect. Tracy Leskey nominated Mike Dimock, seconded by Brett Highland. Unanimous vote (39:0) in favor.
5. Discussion of new venue in 2016 (i.e. Hilton Garden Inn) and dates for 2017 meeting. All satisfied with venue, except additional seating during breakout sessions will be needed in 2017. Dates for 2017 meeting: Nov 30-Dec 1
6. Discussion about raising the registration fee by $5.00 to absorb the fee by PayPal. Tracy Leskey moved to raise the fee, seconded by Mike Dimock. Unanimous vote (39:0) in favor.
7. Meeting adjourned at 9:00 a.m.

CSFWC, Inc. 2015-2016 Treasurer's Report

Income 2015

Receipts from Registrations (105)	6,480.00
Sponsorship for Mixer	3,275.00
Interest	NA (non-interest bearing account)
Total Income	**9,755.00**

Meeting Expenses 2015

Room rental, luncheon, breaks, mixer	7,172.99
Deposit for 2016 meeting (Hilton Garden Inn)	150.00

Other Expenses 2015

Attorney fees for incorporation	1,350.00
State fees for incorporation	204.11
Chartered accountant fee	1,035.00
Total expenses (meeting + other fees)	**9,762.10**

Account balance as of December 2, 2016: $21,226.29 (+ $475 checks for deposit)

Call of the States

Maryland State Report

Bob Rouse, Emeritus Faculty
University of Maryland

Fall 2015 and early winter were very mild. March and April 2016 were very cold.

Good sites and aggressive frost protection were critical to making a fruit crop.

Late May and early June were wet, then it was dry until mid-September. Summer was one of the hottest on record. September was our wettest month. From mid-September until November 30 we were without rain and exceptionally mild.

2016 proved to be a very challenging year for fruit and vegetable production.

Michigan Call of the States Update 2016

Paul Umlor
Wilbur Ellis Company

The year stared out fast and furious with warm temps and no nighttime temps below 32 all after bud break. A good healthy extended bloom with warm weather caused good to over setting of most varieties. Most growers thinned close to adequate with some aggressive growers over thinning during the heat on some hard to thin varieties (gala, fuji)

With only 9 infections with 4 inches of rainfall during scab season we battled scab and black rot and mildew pretty well with almost none showing up in progressive growers' orchards at harvest.

We did have more that favorable fire blight weather at times during bloom (highest EIP we have seen in 10+ years), as well as some high winds at times cause fire blight to become a big concern on Pink lady, Gala, Fuji, Jonathon. A lot of step and Fireline sprayed as well as Kasumin on bearing blocks. Most nonbearing blocks received weekly copper sprays through the whole season.

With 12 out of our 21 inches of season rainfall coming in Aug/Sept/Oct, we found ourselves battling sooty blotch and fly spec more than we ever have. With at least 3 full covers of Strobulurins as well as a Captan or Ziram in this time, we still found ourselves with more than acceptable amounts of fly spec in certain areas. Looking into possible resistance or product rotations for 2017.

BMSB finally showed up in commercial apple orchards in August. Few orchards did border sprays for this insect but they are present now and we will most likely be doing border sprays and/or covers for BMSB in 2017

San Jose Scale was and has been becoming more and more of a problem in certain areas of the Ridge. The thoughts of Lorsban becoming more and more weak every year has us pointing our finger there. We will be paying special attention to this pest in the upcoming few year. Any advice would be more than helpful from whomever reads this update……

Wolly apple aphid is another pest that continues to show up more and more ever year. We have been blaming out softer chemistries and the less effective Lorsban for the comeback of this pest. Might even start some site specific chemistries like Movento for this pest in areas.

With our UV index high and high temps over 85 degrees 20 times this summer we battled sunburn and internal breakdown of many varieties of fruit this season. Where we sprayed a calcium carbonate (Diffusion©) based product that seemed to reduce the incidence and severity of the negative effects.

With hot harvest weather and hot growing conditions, a lot of Retain and Harvista were used to ensure longer storability of valuable fruit. Plenty were in bad shape at harvest but the valuable varieties were taken care of.

We will see how well we actually did when it comes out of storage and gets run over the packing lines for the chain stores.

If you have any questions or need clarification, Please feel free to contact me: pumlor@wilburellis.com or (616) 520-3055

Call of the States: Cumberland Shenandoah Fruit Workers Conference 2016
New Jersey Fruit Observations 2016
Rutgers Fruit IPM Program

David Schmitt – Program Associate, Atanas Atanassov - Program Associate, Carrie Mansue – Program Associate, and Dean Polk - Statewide Agent

Tree Fruit

Tree phenology in 2016 was relatively normal based on historical observations. Cropping was very light or absent in many orchards due to a 2 night freeze event on April 4th and 5th when temperatures got as low as 16° F. According to the NJ State Climatologist, monthly temperatures were above average for much of the growing season. August recorded the highest temperature on record for that month. Rainfall was below average except for May and July which had above average precipitation.

Disease pressure was subdued due to lower than average rainfall, however in apples scab and fruit rots (both white rot and anthracnose in particular) still were troublesome. In peach rots were not a major problem except where high degrees of split and shattered pits were present as a result of the April freeze event

Brown Marmorated Stink Bug populations, while still relatively low, appeared to rebound slightly in late summer. Low to moderate levels of damage was noted in most apple varieties. Internal worm damage in apple continues to be a challenge as more farms in southern counties experience significant damage. Trap captures continue to increase in numbers and duration across the region regardless of management practices. Statewide Tufted Apple Budmoth and STLM trap captures continue to increase relative to recent years, however little damage was noted.

Observations of Ambrosia Beetle damage increased again this year as new infestation sites were identified. In 2015 it was found infesting peach, however damage was limited as peach does not appear to be a good host because of the tendency to exude thick sap in wounds. In 2016 damage to plums and both sweet and sour cherries was noted. Unlike peach these Prunus sp. appear to be suitable hosts and significant tree loss was observed in infested blocks. Prior to 2014 Ambrosia Beetle was a long known pest of nursery stock but had not been identified as a significant pest of tree fruit in NJ.

In pears, pear psylla populations remain high, however early season applications of surround and season long applications summer oils resulted in very good suppression. In 2015 Comstock Mealybug was observed in a few pear and apple blocks. In 2016 overwintered populations produced crawlers, however control was excellent using effective materials timed to crawler emergence.

Blueberry

The New Jersey Blueberry harvest started slightly later than was originally anticipated due to prolonged cool, wet weather and 7.98 inches of rain during April through May. Weather factors and poor pollination contributed to a reduced crop size by about 30%. First harvest of Duke was on June 15. Overall fruit quality was good.

Most insect activity was normal, with primary pests such as the blueberry maggot (BBM), spotted wing drosophila (SWD) and sharpnosed leafhopper (SNLH) first detected during the week of June 24th. Early detections of insect pests, along with intensive SWD spraying prevented fruit injury throughout the growing season for most growers. Poor market conditions led some growers to reduce sprays, resulting in infested fruit. Populations of sharpnosed leafhopper are normally higher in areas with an abundance of alternate and wild hosts. However this was not the case this year where trap captures reflected very low populations, except in large commercially managed areas where trap captures were higher. Insecticide use continues to trend toward repeated pyrethroid applications, due to both SWD management and export MRL requirements.

Early season Botrytis infections were common this year, as well as early infections of Anthracnose, even on Duke. Botrytis was seen just after bees were removed, and fruit infections of Anthracnose were visible the week of June 24th. Temperatures for the month of June were an average of 71°F and some days reaching a high of 90°F. From our observations and examining grower spray records, it appears that the growers were applying their fungicides at the appropriate times, but coverage was difficult to maintain amidst heavy rainfalls in April and May.

Lastly, weed management in blueberries was a concern among growers in 2016 as was in 2015. In many cases weed control breaks down by early August. Improved late season weed management, along with grower identification of weed problems is an emerging issue.

Tree Fruit Phenology – Southern Counties 2016

Pest Event or Growth Stage	**Approximate Date**	**2016 Observed Date**
1/4" Green Tip Red Delicious	March 31 +/- 13 Days	March 22
Tight Cluster Red Delicious	April 9 +/- 13 Days	April 3
Pink Peach (Redhaven)	April 4 +/- 15 Days	March 28
Pink Apple (Red Delicious)	April 14 +/- 12 Days	April 8
Full Bloom Peach (Redhaven)	April 9 +/- 14 Days	April 5
Full Bloom Apple (Red Delicious)	April 22 +/- 11 Days	April 20
Petal Fall (Redhaven)	April 24+/- 12 Days	April 22
Petal Fall (Red Delicious)	April 27 +/- 14 Days	May 8
Shuck Split (Redhaven)	April 30 +/- 11 Days	May 2
Pit Hardening - Peach	June 15 +/- 9 Days	June 12

Call of the States – New York 2016

Art Agnello[1], Peter Jentsch[1], Srdjan Acimovic[2] and Kerik Cox[2]
[1]Dept. of Entomology, Cornell University
[2]Dept of Plant Pathology & Plant Microbe Biology
NYS Agricultural Experiment Sta., Geneva, NY & Hudson Valley Research Lab, Highland, NY

Entomology

We started out this year with some wary observations about the oddly warm winter weather and its anticipated impact on orchard insects, and it seems that this was destined to be one of those seasons where the weather superceded most other things capable of influencing fruit and tree health, including insects. A cold and rainy late March and early April (with some obligatory single-digit plunges that took out most of our peaches and abused several apple varieties) transitioned into irregular May weather patterns, but by the end of the month we were already running a rainfall deficit and the temperatures were starting to mimic the southeastern states; things didn't revert to "NY normal" until fall.

Western NY

As often happens during variable petal fall periods, **plum curculio** posed something of a challenge around the state, with some growers unable to beat the beetles to the fruitlets on the front end, and not always protecting them long enough at the end of the egg-laying period. **Codling moth** and **oriental fruit moth**, the internal leps that have established themselves as primary drivers of many insect management programs, were initially somewhat delayed in their normal mid-May appearance, but soon reached their normal flight patterns in June and required the typical level of attention we've come to expect. **Obliquebanded leafroller** was present as usual, but didn't appear to pose too many real problems in most areas. Predictably, mites responded to the continued high temperatures with outbreaks of both **European red mites** and **twospotted spider mites** reported in various sites. **Apple maggot** was somewhat delayed in its normal first occurrence, probably owing to the dry soil conditions, but continued to fly and generate some concern well into September. **Brown marmorated stink bug** was essentially a no-show for most of the season, but in mid-August began showing up in traps near some western NY packinghouses, and in September weekly trap catches were exceeding 200, comprising both adults and early instar nymphs, posing the question of whether this represented a second generation, or just protracted development of the first brood. A low level of stink bug damage was documented in a Cameo planting west of Rochester, but the species responsible could not be determined.

Some of our major-minor pests, like **San Jose scale** and **woolly apple aphid**, did show up here and there, but their level of severity appeared not to be very high this season. Some normally marginal species, like **apple leafcurling midge** and **Japanese beetle**, caught the attention of observers in various plantings, which doesn't happen regularly, but this season was anything but regular. Finally, there was continued concern this year over the troublesome **black stem borer**, an ambrosia beetle that has been found as the cause of tree decline and death in numerous plantings around the state. Regrettably, we don't appear to be any closer to finding a good solution to this problem, and the stress caused by drought conditions this year has only heightened our awareness of how easily stressed trees can become targets for attack.

Hudson Valley

Rainfall accumulations: The start of the 2016 season began very dry in March increasing above the average through April with rainfall accumulations of 2.20" in March (3.6" Avg), 4.40" in April (3.8" Avg), and 2.55" in May (4.4" Avg). The month of June saw a significant increase in rain events totaling 7.31" (4.4" Avg), with enough rain to produce moderate levels of apple scab infection, especially in newly planted blocks. Each week in July had less than 0.5" of rain requiring weekly irrigation as only 1.23" of rain fell (4.7" Avg). August experienced below average rainfall with accumulations of only 3.34" (4.2" Avg). Total rainfall for the March 1st through September 1st growing season totaled 21.03" of rain, below the seasonal average of 25.1".

Tree phenology: Bud development was hampered in 2016 by a freeze event which occurred on the 4th and 5th of April (23.9°F and 18.9°F, respectively). This event killed most stone fruit buds in the Hudson Valley, reducing pome fruit bloom depending on variety and site across the region. The season began as one of the earliest seasons on record. However, by petal-fall, the season was only one day earlier than the 37-year mean. McIntosh green tip (17 March) occurred 18 days earlier than the 37-year historical mean (see McIntosh phenology), one day shy of the earliest recorded day. King bloom on McIntosh began on the 25th of April. Predominately cool temperatures prevailed ranging between 50°F and 80.7°F for an extended bloom period lasting 17 days, 7 days longer then the mean of 9.4 days. This was followed by 10 days of mean high temps of 59°F to 83°F post petal fall. The 80% PF in McIntosh occurred on 12th May. There was ample sunlight, yielding strong pollination and conditions for fruit set, yet under conditions of severe cold injury from freeze temperatures on two nights of April 5th and 6th. Early water stress was a concern for tree fruit growers, which lingered throughout most the season. Degree-day accumulations were the highest on record dating back to 1997 for base 43, the accumulating 597.8DD compared with the mean of 484.7DD43 by petal fall on 12th. By the 23rd of May, McIntosh king fruit had sized to 17mm with lateral fruitlets at 14.5mm.

Tarnished Plant Bug (TPB) presence and fruit injury was slightly above average this season, requiring timely applications for management in orchards with historical fruit damage. Pre-bloom applications of a pyrethroid did not significantly reduce fruit injury compared with the UTC in Gingergold this season. Relatively dry conditions during the pre-bloom period favor TPB activity, often requiring applications at both TC and Pink that in many years show numeric reduction in fruit injury, yet this season were not significant during analysis. We observed TPB injury at 5.5% in Ginger Gold on 6 June in untreated plots with increasing damage noted in these plots at harvest.

Plum Curculio (PC) damage levels were low in early varieties and moderate in late varieties this season, yet required three applications in most orchards beginning at 80% PF, followed by 1st and 2nd cover for most mid to late varieties. Rains 9 days after the 1st cover application prompted a 2nd cover re-application. PC damage began shortly after fruit set given the very warm post-bloom temperature we experienced. PC migration into orchards, oviposition and migration completion prediction model was calculated to end on 2nd of June at the HVRL using 308 DD50 from petal fall of McIntosh. Rains during the PF-1C period exceeded 0.61" and an additional 1.92" fell after the 1C application up to the morning of June 2nd. Moderate pressure was observed this season with PC injury observations prior to *June Drop* exceeding 10% in Red Delicious. In harvest assessments, damage was 16.3% in Ginger Gold.

European apple sawfly (EAS) activity occurred in very low numbers this season with early varieties showing 1.8% injury in Ginger Gold and McIntosh cluster fruit evaluations. This was the third year in which EAS populations were at very low levels.

San Jose scale (SJS) crawler emergence was predicted to occur during the first week of June using 1st adult capture on the 16th of May using 400 DD51 model. Nymphs were observed on fruit on the 10th of June, 8 days after the predicted emergence date. In general SJS scale levels were high in infested trees. The infestation means ranged from 27.3% to 86% injury observed in HVRL research plots on 26th August. In conventionally treated orchards, the SJS has become a major insect pest to manage in apple, requiring targeted applications for multiple generations. In 2015 we observed a 3rd generation in late September.

Lepidopteran complex: Overwintering larvae of the spotted green fruitworm (SGFW), redbanded leafroller (RBLR) and OBLR during the pre-bloom period through fruit set remain a concern for most Hudson Valley and Lake Champlain pome fruit growers. A relatively low level of infestation was observed in the pre-bloom and early season leafroller complex.

Codling moth (CM) 1st generation sustained adult flight occurred on 19th May with larval emergence predicted for 31st May using 220 DD50 from CM biofix. The internal lepidopteran complex, lesser apple worm (LAW), oriental fruit moth (OFM) and CM showed moderate levels of damage to apple, with 9.3% damage from 1st generation evaluated on 16th June on Red Delicious and with 7.0% & 23.1% for 1st and 2nd generation on Gingergold, respectively. The 2nd generation adult sustained catch for the CM biofix occurred on 20th July with management for larval emergence prediction using 250 DD50 to occur on 28th July.

Obliquebanded leafroller (OBLR) monitoring and management by tree fruit growers continues to be a high priority. Targeting up to three seasonal application windows while employing a single mode of action for each period, growers can achieve successful management of the OBLR larvae. These include the pre-bloom through Petal Fall period for the overwintering generation, often using IGRs such as Proclaim and Intrepid, the summer generation using either Altacor / Belt or Delegate, and later in August applying either Altacor / Belt or Delegate. Recommendations for applications were made using insect phenology predictions for early emergence, using 340 DD50 from biofix to manage emergence of larvae, predicted to occur in mid-June. In general, low levels of leafroller feeding were observed on developing foliage and fruitlets this spring. Trap captures were moderate for 1st generation OBLR, averaging 9.0 / day during the peak periods (5th June). The 2nd generation flight of OBLR biofix was low during August, averaging 2.0 / day during the peak periods (8th August). We are seeing a trend of increasingly high levels of RBLR with mixed populations of **tufted apple bud moth** (TABM) and *Sparganothis fruitworm* (SFW) during the season, contributing to the overall leafroller damage each year.

Apple maggot (AM) emergence was late this season, with first emergence on 11th July. Threshold of 5 flies per trap per block was observed on the 18th of August. AM density was low to moderate throughout the region, with reduced emergence due to the lack of late season rainfall in July and early August. Low populations of adults were noted in the mid-Hudson Valley with seasonal accumulation totals near 40 flies per trap (mean n=4) by 31st August. Highest populations occurred late in the season as rainfall in August providing more ideal emergence conditions for the adult fly.

The **brown marmorated stink bug** (BMSB), *Halyomorpha halys,* has been observed throughout the southern Hudson Valley for the past 7 years, with the first BMSB confirmation in December 2008. Since that time, increasing populations have been documented in urban environments and present on many farms throughout the season in the lower to mid-Hudson Valley region. We have observed a second generation over the past two years, developing in mid-late August in HVRL voltinism studies.

Although there appeared to be stink bug feeding in apple this season, both BMSB and the **green stink bug**, *Acrosternum hilare* was found from mid-season through harvest on pome fruit in lower to mid-Hudson Valley, with increasing northern observations and fruit injury occurring in Columbia County. In 2016, we monitored the population throughout NYS in 44 tree fruit orchard sites, employing a trap threshold of 10 total BMSB adults per trap to recommend management timing for tree fruit production. We are presently recommending that growers access https://www.eddmaps.org/bmsbny/ for weekly updates on BMSB monitoring of adults and fruit injury requiring management, with only 7 sites above threshold this season.

Spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilae) were first observed in NY by late August 2011. We monitored SWD in four counties throughout the lower to mid-Hudson Valley this season using baited traps across small fruit, grape and tree fruit. The first SWD trap captures were found at the HVRL on the week of the 5th of July. Growers who harvested frequently and kept to a 3-7 day spray program were able to maintain low infestations levels (<15%) this season. We are presently recommending that growers access http://www.eddmaps.org/project/project.cfm?proj=9 for weekly updates on BMSB monitoring of adults and fruit injury for early season management.

Plant Pathology

Western NY

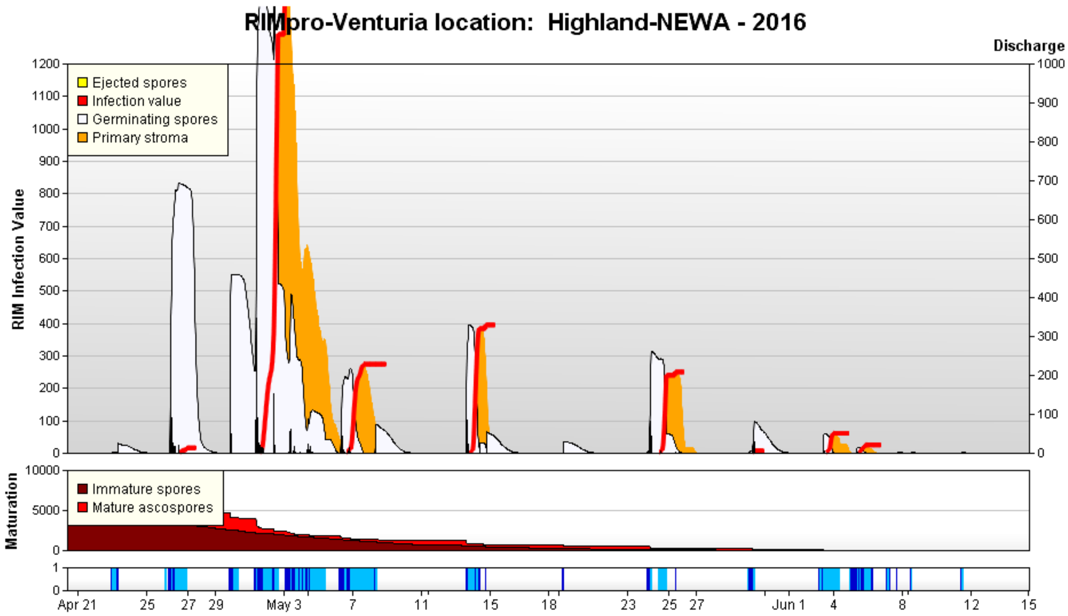
Apple Scab: There were few apple scan infection periods following green tip to early June, but these were light and led to questions as to whether and all of the ascospores were releases. From mid-June to mid-august, the region received less than an inch of rain and arrested the development and prevent secondary cycles of apple scab.

Fire blight: There were high risk weather for blossom blight infections at full bloom from the 11th to the 12th of May. The weather in western N cooled considerably and bloom remained on the trees when the temperatures increased into Jun leading to considerable shoot blight epidemic later in the summer. Although blossom blight control appeared to be satisfactory, there could have some low levels of blossom blight that served as primary inoculum for shoot blight

RAD: There were numerous sites with 2-7 year old trees that rapidly declines with necrosis restricted to the graft union. Fire blight was never recovered from these trees and nearly all affected plantings where planted to fire blight resistant root stocks. Older trees at the same site were unaffected. The necrosis stopped at the graft union and soil line where drip irrigation was present. It was common to recover wood decay ascomycetes and basidiomycetes from the necrotic areas and there were no barrages indicating encounters between multiple fungi and other pathogenic stramenopiles. As scientists in PA have suggested, the die off may have occurred from the freezes in February and April followed by heavy drought all summer long combined with heavy cropping.

Hudson Valley

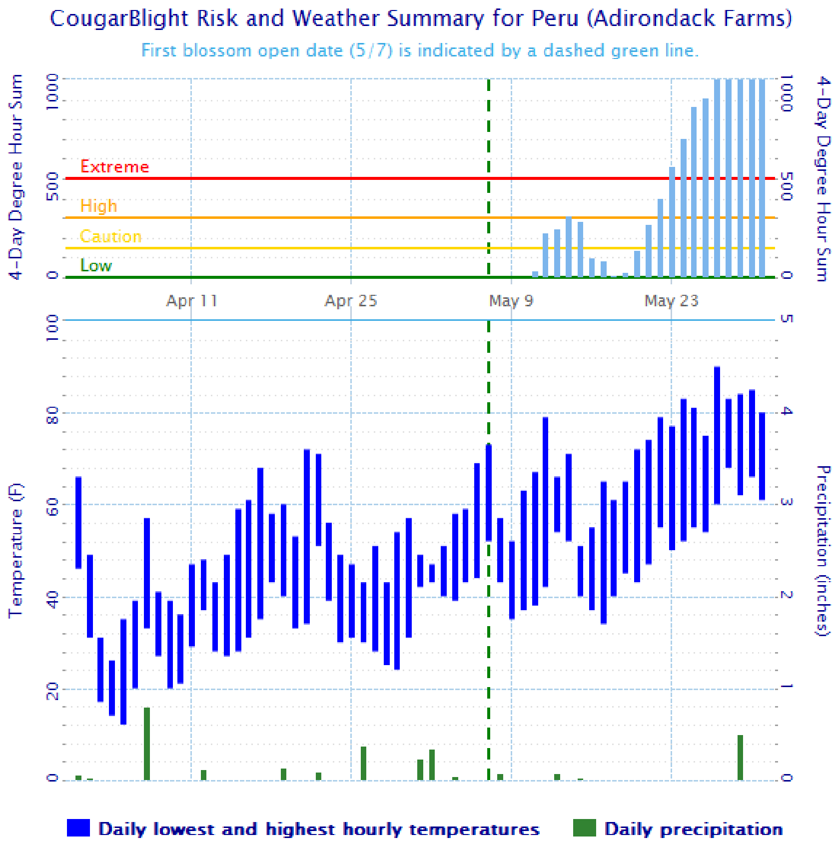
Apple scab infection periods (8) based on the RIMpro prediction model that were predicted from 17 April onward turned out not to lead to infections since conditions after the rainfall events were cold and fast drying. Weather forecasts at this period were often unreliable farther than 2-3 days ahead and predictions for 7 days ahead changed substantially from day to day. In addition, it was complex to determine and recommend when and what to spray for scab early in April due to cold injury to the leaves on 4th and 5th of April. Even though infections were predicted to occur in April, it seems that none of the discharged ascospores that germinated in water droplets led to infections. The first major ascospore discharges that led to infections were on May 1st to May 4th. It was predicted that around 90% of ascospores were discharged from pseudothecia at this period. Much weaker infection periods continued on May 6th, 13th, 14th and 24th, and June 3rd and 5th (Figure available below).



In the Hudson Valley, first scab symptoms were observed on 15 May on Jersey Mac fruit. However, Dr. David Rosenberger, who found these infections, warned that these infections indicate two things: 1) infections were probably initiated from conidia overwintering from last year in buds, and 2) if all sprays that were recommended before May 1st were omitted, green tissues were under risk from pre-bloom infections. Many fungicides are available for scab control, but due to cold injury to leaves, Manzate or Polyram were recommended 1-2 days after cold event. In case of major infection periods tank mix applications of Manzate with Inspire Super before or 72 h after this infection period were preferred.

Cedar apple rust and quince rust symptoms in Hudson Valley started showing on apple fruit and leaves from May 15-18th onward. Infection periods continued through mid-June whenever rain was available and cedars were close by with sources of infection. Manzate in combination with Luna Sensation or Inspire Super provide good control.

Fire blight was not a big problem in Hudson Valley, with few strikes occasionally visible in a few orchards with fire blight history. Cooler conditions during bloom, especially during the night, did not favor growth of fire blight populations on flowers. However, in Northeastern and North-western NY, severe fire blight infections that were predicted by models through NEWA, occurred on May 21st, 29th and 30th. Transition from Caution to High and then to Extreme risk from infection occurred in three days from May 21st - May 23rd. Several key apple cultivars were at the end of bloom at that time, allowing more than enough open flowers for fire blight bacteria to grow their populations rapidly and allow intensive spreading to growing shoots.



The key weather conditions that promoted bacterial population growth in on flowers leading to an epidemic were a sudden rise of temperatures from 50s and 60s to 70s and high 80s, rain events on May 21st, 29th and 30th, high relative air humidity, prolonged leaf wetness, all followed by a few hail storms in June. First blighted clusters and shoot strikes started showing around June 6, indicating extremely favorable conditions for pathogen development on flowers and massive infections on intensively growing shoots that were a long ways from terminal bud set, when they become more resistant to infection. Sprays of streptomycin during bloom were not applied in mature orchards. Most of young orchards were sprayed and relatively successfully protected. Overall response to established infections was slow, and flower and shoot infections led to formation of many fire blight cankers and rootstock infections via trunk or suckers.

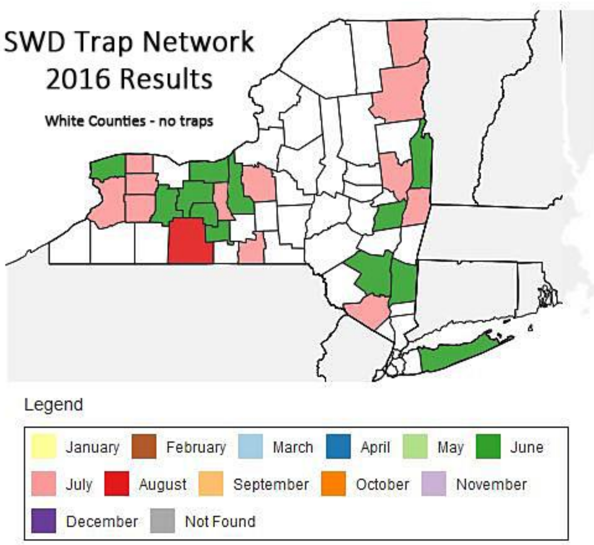
SBFS - Sooty Blotch & Flyspeck in the Hudson Valley were first detected on 'Honeycrisp' during the week of August 12, 2016. In the untreated control plot these symptoms were visible mostly on the compact fruit clusters where thinning did not occur and on the clusters at the bottom of the tree crown. In this plot, the last fungicide spray for plot maintenance, after which the plot was untreated, was on 6 June (Captan @ 3lb/A + Flint @ 2.5 oz/A). Hence, from that spray onward, it seems that the incubation period requirement of accumulated 190 hr of wetting was most likely fulfilled or exceeded.

Bitter Rot occurring in the orchards has been quite a problem across NY State in 2016. Dr. David Rosenberger reported that the several following factors contributed to the overall higher incidence of this disease in the past and in 2016: more frequent summer days with warm wetting (climate change) and new susceptible and late-maturing apple cultivars. Due to late maturing, these cultivars require continued fungicide sprays through the end of September to the beginning of October for good control. In 2016, bitter rot outbreaks seem to have occurred in the orchards where 21-day interval or higher between fungicide sprays was used from mid-July and fungicide deposits on fruit were depleted by 2" rainfall, much of it before or close to the harvest. An additional factor could be that mid-label rates of Captan were used instead of the high rates, and that in that case Captan was not used in mix with Flint, Sovran, Pristine or Merivon.

Spotted Wing Drosophila (SWD) 2016 Report for New York State

Juliet Carroll, Fruit IPM Coordinator

All SWD trapping locations had caught SWD by August 13th. First trap catch occurred over a nine- to ten-week-long period, from June 8 to August 13. SWD was caught earlier this year than in prior years, but the hot and extremely dry weather across New York State appears to have benefited early- and mid-season berry crops, which suffered lower infestation rates in July than might have been expected from the early arrival of SWD. However, later in the summer, fall raspberries and late-maturing fruit were hard hit and growers had a difficult time maintaining insecticide coverage and control.



SWD arrival in New York, as of August 13, 2016. Data from the SWD network operated by 25 Cornell scientists in 25 Counties, monitoring 117 traps.

Twenty-five scientists monitored traps in 25 Counties this year. A total of 117 Scentry traps were deployed in the network, primarily in raspberry (summer and fall) and blueberry. The first trap network site to report SWD trap catch was in Suffolk County, Long Island. At about the same time, SWD was caught at a research location in the Finger Lakes region. Fifty-three blogs were posted on the SWD blog, blogs.cornell.edu/swd1/, this year to alert subscribers about SWD trap catch. SWD resources are found on Cornell Fruit Resources, www.fruit.cornell.edu/spottedwing/

Although SWD might show up around the same time each year in a particular location, this doesn't often hold true. For instance, the location in 2015 at which my program caught SWD first was among the last of our monitoring locations to catch SWD this year.

The long length of time, 66 days, over which first trap catch reports came in from across NY in 2016 and in prior years (56 days in 2015, 56 days in 2014, 76 days in 2013) provides evidence that SWD arrival across NY isn't synchronous. For this reason, in addition to trap catch reports, growers must consider crop maturity and crop susceptibility to infestation when formulating management decisions.

Call of the States – North Carolina

The 2016 growing season presented a challenge for tree fruit growers in North Carolina. A number of freeze events throughout the state during the first two weeks of April resulted in a very small peach crop in both the piedmont and mountains. While there was considerable damage to apples following a freeze on April 10, many late-emerging blossoms resulted in a larger crop than anticipated – about 75% of a crop. Weather conditions were normal through late June, after which there was an abundance of rainfall during July and August in the mountain production regions, while hot and dry conditions persisted in foothill and piedmont regions. In Henderson County, the largest apple producing county in NC, a total of 16.1 inches of rain fell between June 27 and August 20. Rain fell on 40 of the 55 days, including two stretches where rain occurred on 12 and 15 consecutive days. Hail storms were also numerous during this period. Conversely, in the piedmont production area of Lincoln County, a total of only 6.6 inches of rain fell from June through August. The difference in temperatures between the Henderson and Lincoln counties were reflected in the cumulative heat units (base 50°F) from May 1 to 30 September, which were 3,230 and 5,756, respectively.

Arthropods:
The insect pests of greatest importance in 2016 were brown marmorated stink bug (BMSB), codling moth and oriental fruit moth (OFM). Following significant levels of damage by BMSB for the first time in 2015, most apple growers initiated a series of pyrethroid applications at 2-wk intervals beginning in mid-July in the piedmont and mid-August in mountain orchards. Overall BMSB damage averaged about 5% of fruit in 2016, compared to levels ranging from 20-60% in 2015. This was the first year that a pyrethroid of any type was applied to most NC apple orchards. Codling moth was an issue in several orchards that relied strictly on pyrethroids insecticides beginning in mid-season sprays. OFM has been a recurring problem in several orchards that regularly use mating disruption for both OFM and codling moth. The cause of this problem is not fully understood, although application of pheromone dispensers well after first generation flight has begun is suspected as contributing to the problem.

Diseases:
Fire blight and Glomerella leaf spot/fruit rot were the most economically devastating apple diseases in North Carolina in 2016. Several mid- to late-blooming cultivars that had entered king bloom just prior to the freeze on April 10 remained in bloom for greater than a 30-day period. The cold snap during April, in combination with low chilling units due to the uncharacteristically warm winter, led to a rattail bloom situation in which open blossoms were still being observed in mature trees into the summer months. As a result, fire blight was reported in several orchards throughout the state. High levels of rainfall in Western NC throughout July and the beginning of August made it difficult to maintain fungicide residues on apple trees. Symptoms of Glomerella leaf spot started to appear on foliage and fruit during the 2nd to 3rd week of July. Gala and Golden Delicious appeared to have the greatest

incidence and severity of the disease, however lesions and fruit rot due to Glomerella were also observed on Pink Lady. In young (3 to 6 year old) trees planted on dwarfing rootstocks in high density systems, a rapid decline and subsequent death of the trees was observed for the first time in NC in 2016. Like other apple-growing regions, the causes leading to this decline seem to be many, however, a combination of stressors such as flooding conditions, drought conditions, and winter injury are believed to be involved.

Pennsylvania State Report for CSFWC, 2016

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Horticulture: mild weather in March 2016 advanced flower bud development ahead of seasonal average. This was followed by four severe freezes in early April (Table A), which reduced apple flower survival at FREC by 18 – 49% (Table B).

Table A. Minimum temperatures at three locations in Adams County, PA

	Minimum temperature (°F)		
Date	Biglerville elev. 732 ft.	Piney Mountain elev. 1217 ft.	York Springs elev. 740 ft.
4/3	29.6	26.6	28.0
4/5	24.1	21.9	22.9
4/6	25.3	19.6	24.6
4/10	24.7	21.4	22.2

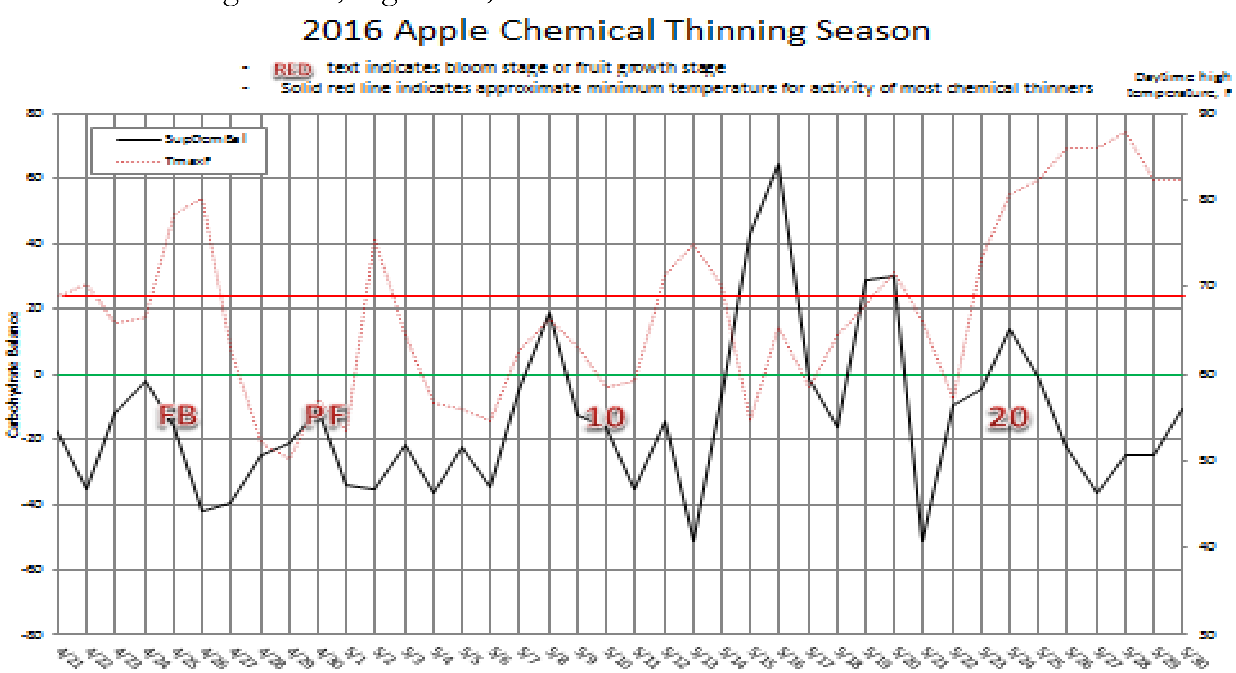
Despite these freezes, the numbers of surviving blossoms were more than adequate to set a full crop of apples. Reduction in viable flower number may have actually reduced competition for carbon assimilates, strengthening the potential of remaining flowers to set. Bloom was early and prolonged. Peach flower mortality from the freezes ranged from 28-74%. The peach crop was reduced by about a third; however the eating quality of that remaining was outstanding.

The window of time for apple chemical thinning occurred during cool cloudy weather. Although this resulted in extended periods of carbon deficit, as measured by the Cornell Carbon Balance Model, temperatures were sub-optimal for chemical thinning activity throughout most of this period (Figure 1). Tree responses to chemical thinners were in many cases, sub-optimal. Rescue thinning with ethephon and hand thinning were common practices as a result.

Table B. Apple flower viability following multiple cold events in March and April 2016, in Adams County, PA

Site	Variety	% viable	% full crop	Number of blossoms examined
Piney Mountain	Crimson Gala	72	936%	391
	Honeycrisp	74	675%	374
	Golden Delicious	48	581%	380
	Fuji BC2	64	730%	445
Biglerville, FREC	Buckeye Gala	51	767%	460
	Honeycrisp	81	1140%	562
	Red Delicious	51	472%	586
	Golden Delicious	82	1172%	592
	Brak Fuji	62	745%	404
	Maslin Pink Lady	77	1080%	515
York Springs	Buckeye Gala	62	753%	341
	Honeycrisp	61	739%	501
	Golden Delicious	54	667%	448
	Fuji BC2	26	275%	409

Figure 1. Daily carbon balance and daytime high temperatures during the 2016 apple chemical thinning season, Biglerville, PA.



The growing season from mid-June to early September was hot, with below normal and sporadic rainfall. For the period July – September, 51% of the days had daytime highs exceeding 86°F. Only one meaningful rain event occurred between mid-June and mid-August. A localized hailstorm on June 21 caused severe damage in the York Springs area, resulting in a lot of apples being diverted from fresh fruit to processing. Fruit size was less than optimal, and although the apple fruits were exceptionally sweet, fruit color was poor. Symptoms of scarf skin, sunburn and bitter pit on apple were much worse than recent years. The dry spell was broken by heavy rains in September that caused widespread fruit cracking of apples, even in cultivars not usually susceptible to fruit cracking. Differences in cracking between cultivars were observed: GoldRush were almost a complete loss; cracking in Fuji and Pink Lady was bad, York Imperial were a little cracked, while only a few Golden Delicious showed much cracking. Few harvest days were lost to rain, as dry weather resumed through October. Many PA fruit growers will be glad to see end of the 2016 season.

Plant pathology: the season kicked off early this year with green tip occurring for the southcentral PA region during the week of March 7. Overall, it was a dry season for Pennsylvania: From March to August, we saw 16.3 inches of rain. This is in contrast to 2015 where we saw over 31 inches of rain during the same time period. However, in September, we received almost 8 inches of rain.

Apple and pear diseases: For fire blight, reasonable conditions prevailed this year and the disease was more than manageable for controlling blossom blight. We only had one significant infection period in late April; fire blight conditions didn't manifest until the latter half of May – and everyone in PA was out of bloom by then. Another benefit for us was an unusually cold period during the first half of May. This also kept any bacteria from reaching high numbers. Unfortunately, any leftover cankers wreaked havoc in the orchard and a lot of shoot blight occurred as a result warm conditions in mid-June until mid-July. For apple scab, we detected the first scab spores on March 9. March and April were relatively dry with only 3 scab infection periods. In May, we had 7 infection periods. During May, we had an approximately 2.5 week infection period during the time when the overwintering spores were peaking in their dispersal. There were enough breaks in the rain for growers to be able to apply and re-apply fungicides. The only issues noted among growers with scab were those using alternate row middle and the intervals were stretched too much. The hot and dry summer slowed the spread of the disease; however, our untreated checks still had high incidence. For powdery mildew, our dry April afforded the ability for powdery mildew to establish very early. In some cases, blossoms were blighted on very susceptible varieties. For cedar apple rust, this was a fantastic rust year. Cedar trees in Adams County looked like Christmas trees with the number of galls on them this year, thanks to the persistent wet conditions from late April until mid-May. Anyone not adequately protecting for rust was hit very hard (organic growers, homeowners). For sooty blotch and flyspeck, although we reached our wetting hours in early June, our first recorded incidence of flyspeck was in early August in our untreated check. The dry weather in July most likely played a role in the prevalence or lack thereof. For apple rots, we observed fruit rots early (late July – early August) and reports coming from the field were primarily due to bitter rot.

Other unusual issues: In the last several years, we been noticing rapid apple decline in young apple blocks on dwarfing rootstocks. This seems to be an ongoing issue and not related to particularly year. Trees 3 – 5 years old seem to be most affected. The predominant symptom is at the graft union – necrosis begins and travels up the tree, with the tree eventually girdled and dying. We believe it may be complex of issues and not just one thing.

Stone fruit diseases: For bacterial spot, conditions were was very hot and humid this season favoring disease development. For cherry leaf spot, this was a slightly lighter disease pressure compared to last year. There were 4 infection periods in April; 6 infections periods in May; and 3 infection periods in June. For peach and cherry powdery mildew, conditions were favorable and the disease was established in our Loring (rusty spot on fruit) and our tart cherry block very well. We saw rusty spot early on and subsequent "scabbing" of the fruit later in the season. Finally, for fruit rots**,** brown rot wasn't as prevalent as in years past due to the very dry summer we experienced. We did notice a high incidence of the postharvest disease, Rhizopus rot.

Entomology: despite warmer than usual weather in March, the biofixes for most common insect pests occurred at dates similar to previous years. The biofix for oriental fruit moth was established on April 12, codling moth on May 07, obliquebanded leafroller on June 01 and tufted apple budmoth on May 10.

Throughout the season, the internal fruit feeders, codling moth and Oriental fruit moth were not very common and consequently only about 100 fruit loads with the CM/OFM split of 60:40 were rejected by PA fruit processors. Majority of the rejected fruit loads originated from the orchards damaged by hail.

The brown marmorated stink bug populations survived winter in good shape however the number of adults in the spring were lower than in the past, mainly due to lower BMSB population going to diapause during the fall of 2015. Suitable weather conditions during the season contributed to significant rebound in the numbers of BMSB during August and September. During the fall, many PA fruit growers reported significant injuries on late apple cultivars due to the intensive feeding by BMSB adults.

Spotted lanternfly *Lycorma delicatula* (Hemiptera: Fulgoridae) an invasive plant hopper, native to China, India and Vietnam is reported from 6 counties with multiple municipalities in southeast Pennsylvania. PDA imposed quarantine, however the insect appears to continuously spreading from the original area where it was first identified late during the 2014 season. The list of potential host plants includes grapes, apples and stone fruit trees.

Another invasive insect pest, although present in the eastern US for a long time, leopard moth, *Zeuzera pyrina* (Lepidoptera: Cossidae) was reported from at least five different commercial fruit orchards across Pennsylvania. Large yellowish larvae feed inside multiple young branches and can reach up to 40 mm in size. The larvae attack mostly young trees and need 2-3 seasons to complete their development.

Virginia report for Call-of-States, 2016

Entomology

Despite an unusually early spring, biofix dates for oriental fruit moth (April 11), codling moth (April 25) and tufted apple budmoth (May 2) at the Winchester AREC were within historical norms since 2000. The cool and wet period preceding, during, and following bloom were conducive to a prolonged period of movement of plum curculio into orchards that translated to high levels of injury in some orchards. There were no unusual insect or mite issues reported in Virginia, including few reports of severe infestations from codling moth, oriental fruit moth or leafrollers. Also, there were fewer reports of woolly apple aphid outbreaks than in some recent years, likely due to increasing grower awareness of the pitfalls of heavy use of some pesticides for brown marmorated stink bug (BMSB) management during the post-bloom period, although one orchard consultant reported some issues with San Jose scale in the region. The mild winter in 2015-2016 was thought to promote greater survivorship of overwintering adult BMSB populations, although BMSB captures in pheromone traps in the northern part of Virginia were relatively low until the second half of August, when captures increased markedly through most of September and to levels that exceeded those in 2015. The numbers of adult BMSB reported moving to overwintering sites in private residences and other buildings in late September and October was lower than anticipated, considering the high captures during September, and the peak period of this movement was somewhat delayed compared with previous seasons. BMSB injury to apples at harvest was significant in some orchards, with most damage seemingly occurring late in the season. The Asian parasitoid of BMSB eggs, *Trissolcus japonicus*, was detected on numerous occasions at Winchester via sentinel eggs, yellow sticky traps, and destructive sampling of felled Tree of Heaven, and this beneficial appears to be well established locally.

Tree fruit pathology

Early season: We just missed a heavy apple scab infection period at silver tip Mar 13-15 at Virginia Tech AREC, Winchester; some other areas may have had green tissue exposed, resulting in earlier secondary infection.

Then after the slow start this year, we ended up with 23 scab infection periods Apr 22 - May 31, including 13 infection periods in 15 days, Apr 28-May 12. Thirteen of the above scab infection periods were also favorable for cedar-apple rust, until inoculum from the galls was depleted about May 12. In spite of heavy cedar-apple rust pressure on leaves, fruit mostly escaped quince rust infection, which can occur with warm wetting periods during blossom susceptibility at the pink to petal fall stages. Apple powdery mildew conidia were first available Mar 16, there were 21 dry weather "mildew infection days" by May 5, and 35 mildew infection days through June 13. There was a lot of secondary mildew infection present on susceptible, poorly protected trees. Fire blight infection days, as confirmed by Maryblyt, occurred on Apr 21, Apr 22, Apr 24-26 and 2-3 May. Natural blossom blight symptoms were first observed on York apple May 9. Blossom and shoot symptoms observed in commercial orchards may have been due to some infection of late bloom that was stimulated by frost/freeze conditions Apr 9.

Summer diseases: Commercially, there was more moldy core in 2016 because of the extended wetting that occurred during the post-bloom period, while the calyx tube remained open on Red Delicious. Frogeye leaf spot and rots were observed in situations where fruit mummies or dead twigs were present. After May 26 we have had 18 possible "bitter rot favorable periods" with some of the wetting occurring at 70ºF or higher. Bitter rot was observed on Honey Crisp at the AREC as early as 22 Jun. For predicting the development of the sooty blotch and flyspeck (SBFS) fungal complex, we started recording wetting hours from rainfall or dew, starting May 14, 10 days after petal fall. As of Aug 30, accumulated wetting hours (ACW) toward the 250-wetting hour threshold for specific treatment against the SBFS fungal complex were: at 909 ft elevation, 901 hr (with the 250-hr threshold reached Jun 5 and SBFS was observed Jul 6); at 952 ft elevation, 675 hr (threshold reached Jun 23); and at the 983 ft elevation, 511 hr ACW (threshold reached Jun 28). Early apple harvest was relatively dry, but a 6-in. rain Sep 28-30 caused some fruit cracking, and may impact potential storage rots.

Grape Pathology

Some growers are still seeing the damage from the 2013-14 winter, which resulted in crown gall outbreaks. Frost in mid-April caused some of early cultivars to drop their primary shoots, but secondary shoots made up for the loss in many cases. However, some growers in SE VA had very extensive damage due to frost. We had an extensive rain period between April to May, which resulted in outbreaks of Phomopsis leaf and cane spots. However, these rain events were at relatively cold temperatures, thus, downy mildew did not develop regardless of rain. Then the month of August to mid-September for Northern VA was very dry. Due to this, many growers picked early and did not have issues with late season rots, such as Botrytis and sour rot. However, some also had issues with maturing of berries, and decided to keep clusters hanging longer, resulting in some level of Botrytis in the end.

Entomology

AMBROSIA BEETLE MANAGEMENT TRIALS IN NY APPLES – ROUND 2

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In two Wayne Co. sites with known orchard infestations of black stem borer (BSB), Furber and Fowler, trials were set up using potted Rome Beauty nursery apple trees inside wooded areas directly adjacent to the orchard planting. The potted trees were flooded to stress them into producing ethanol, so as to attract beetles and promote new attacks. Additionally, individual ethanol lures were attached to each tree to increase their attractiveness to the beetles. On May 10, just as the adult flight was starting, trunks of the potted trees were sprayed with one of four candidate insecticides using a Solo backpack sprayer: Lorsban Advanced (chlorpyrifos, Dow AgroSciences), 1.5 qt/100 gal; Cobalt (chlorpyrifos+lambda-cyhalothrin, Dow AgroSciences), 1.3 qt/100 gal; Perm-Up (permethrin, UPI), 10 fl oz/100 gal; or Danitol (fenpropathrin, Valent), 16 fl oz/100 gal; plus a Check (unsprayed). Trees were arranged in circular 5-tree groupings in the wooded areas, which were replicated 10 times at each site. Another identical set of 10 replicate tree groupings was also deployed at each site, with a dispenser of a commercial repellent, BeetleBlock (verbenone, ChemTica) hung ~1 m high on a pole placed in the center of each of the 5-tree groupings.

Verbenone, a natural terpene compound found in many plants such as pine trees, is used in the control of bark beetles such as mountain pine beetle and Southern pine bark beetle. It is produced, probably as a defensive mechanism, when the number of insects in an infested tree approaches the maximum that the tree can support, and acts as repellent to other beetles. Because it has demonstrated efficacy in related groups of bark boring beetles, as well as this species, we proposed that it might offer a higher degree of prevention than using insecticide sprays alone. Half of the treated replicates were evaluated for infestations on July 6, after the end of the first adult flight of the season, and the remaining replicates were evaluated near the end of the season, on August 19. Infestations were quantified and assessed by destructive sampling and dissection in the lab, to determine the following classes of infestation in the test trees: # of attack sites/tree, # of trees containing empty galleries, # of trees containing live adults, dead adults, and brood.

Results of the preliminary evaluation (Table 1) showed no statistical differences among the insecticide-alone or insecticide-plus-verbenone treatments in the following categories of infestation: number of attack sites per tree (both sites); number of trees with empty galleries only (Fowler); number of trees with live adults or dead adults (Furber); and number of trees with brood (Fowler). Among the variables with some statistical differences: at the Furber site, significantly fewer Danitol-treated trees (with or without verbenone) had empty gallery-only infestation sites than did the Check trees and Perm-Up trees without verbenone. At

Fowler, fewer live adults were taken from Danitol-plus-verbenone trees than from those treated with Perm-Up-plus-verbenone. Also, the Lorsban-plus-verbenone trees at the Fowler site had a statistically higher level of dead adults than the Checks. At Furber, the following trees had statistically fewer trees with brood than did the Lorsban-plus-verbenone trees: Danitol-plus-verbenone, and both Cobalt and Danitol without verbenone. In no case did the combination of verbenone repellent plus insecticide sprays appear to improve the control of BSB over the insecticides alone; levels of infestations were just as likely to be higher with the addition of verbenone as lower. Although statistical separation among treatments was not uniformly seen in these results, there was a trend (in 8 out of 10 comparisons) for the Danitol treatments to have among the lowest numerical values in the different infestation categories overall.

The final evaluation of these treatments (Table 1) revealed similar trends. The number of attack sites per tree generally increased over levels seen in the July evaluation, with a small number of statistical differences being found. At the Furber site, Lorsban-plus-verbenone was the only treatment significantly lower than any of the others (in this case, Perm-Up-plus-verbenone and Danitol-plus-verbenone). At the Fowler site, the Perm-Up treatment had significantly fewer attack sites than the Perm-Up-plus-verbenone; all other treatments were statisically comparable. Once again, there were no cases where the addition of verbenone improved control.

In the other categories of infestation, the final evaluation showed statistical differences in the following treatments: empty galleries - Danitol had the lowest incidence at Furber, and Perm-Up was significantly different than the other treatments at Fowler. For dead adults - at Furber, Cobalt-plus-verbenone had the lowest levels and Perm-Up-plus-verbenone the highest levels (perhaps a more indicative measure of efficacy?); at Fowler, Lorsban-plus-verbenone was lowest, Lorsban alone and Perm-Up-plus-verbenone were highest. For sites containing brood, Fowler had the highest numbers in the untreated Check, and the lowest in the verbenone-only plots; there were no treatment differences at Furber. There were also no treatment differences in sites with live adults at either Furber or Fowler.

Many of the infestation category readings had a high level of variability, so results showing statistical differences were not always the lowest mean values.

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Table 1. Mean number of trees with different categories of infestation by black stem borer after May 10 insecticide trunk applications and a verbenone repellent; preliminary evaluation, July 6; final evaluation, August 19, 2016.

Furber Brood	Mean # Attack Sites		Mean # of Sites Containing Empty Galleries		Live Adults		Dead Adults			
Treatment	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final
Check-no verb	13.0 a	17.0 ab	1.6 a	4.4 ab	0.0 a	2.6 a	4.0 a	1.8 ab	2.4 ab	1.4 a
Check-verb	11.6 a	11.0 ab	0.6 ab	3.8 abc	0.4 a	1.8 a	4.4 a	1.2 ab	2.0 ab	1.2 a
Cobalt-no verb	7.0 a	13.4 ab	1.0 ab	4.8 ab	0.2 a	1.8 a	1.6 a	1.6 ab	1.2 b	1.0 a
Cobalt-verb	7.6 a	8.6 ab	1.4 ab	2.4 abc	0.0 a	1.0 a	2.8 a	0.6 b	2.4 ab	0.6 a
Danitol-no verb	9.0 a	5.8 ab	0.0 b	1.0 c	0.0 a	1.0 a	3.6 a	2.2 ab	1.2 b	0.2 a
Danitol-verb	5.4 a	17.4 a	0.0 b	6.0 a	0.4 a	2.8 a	1.0 a	1.4 ab	0.6 b	1.4 a
Lorsban-no verb	8.6 a	13.6 ab	0.6 ab	2.4 bc	0.6 a	2.8 a	3.4 a	4.6 ab	1.2 b	1.6 a
Lorsban-verb	11.4 a	10.6 b	0.4 ab	3.8 abc	0.0 a	1.6 a	4.2 a	0.8 ab	4.6 a	0.2 a
Perm-Up-no verb	14.4 a	17.2 ab	1.6 a	3.4 ab	0.2 a	1.6 a	3.4 a	3.0 ab	1.8 ab	2.4 a
Perm-Up-verb	11.0 a	22.8 a	0.8 ab	7.2 a	0.4 a	3.0 a	2.4 a	3.8 a	2.2 ab	0.6 a

Fowler Brood	Mean # Attack Sites		Mean # of Sites Containing Empty Galleries		Live Adults		Dead Adults			
Treatment	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final
Check-no verb	6.2 a	18.0 ab	1.8 a	2.4 ab	1.0 ab	4.4 a	0.4 b	2.6 ab	0.4 a	1.2 a
Check-verb	4.6 a	11.4 ab	1.2 a	2.2 ab	0.8 ab	0.2 a	0.6 ab	2.6 ab	1.0 a	0.0 b
Cobalt-no verb	6.2 a	10.8 ab	0.2 a	4.2 a	1.0 ab	0.4 a	1.8 ab	2.0 ab	1.2 a	0.4 ab
Cobalt-verb	6.6 a	6.4 ab	1.6 a	2.0 ab	1.0 ab	1.0 a	0.8 ab	0.8 bc	1.4 a	0.4 ab
Danitol-no verb	9.6 a	14.8 ab	3.0 a	3.4 ab	1.0 ab	1.6 a	1.2 ab	1.4 abc	2.0 a	1.0 ab
Danitol-verb	5.4 a	11.8 ab	1.4 a	3.6 ab	0.2 b	1.4 a	1.2 ab	1.0 abc	0.6 a	0.2 ab
Lorsban-no verb	9.6 a	17.0 ab	0.4 a	6.0 a	0.8 ab	1.6 a	2.2 ab	3.4 a	1.6 a	0.4 ab
Lorsban-verb	11.6 a	7.2 ab	1.0 a	2.0 ab	1.2 ab	1.4 a	2.8 a	0.2 c	2.4 a	0.4 ab
Perm-Up-no verb	10.8 a	7.2 b	2.0 a	3.0 b	1.4 ab	0.8 a	1.8 ab	1.0 bc	2.4 a	0.2 ab
Perm-Up-verb	11.8 a	17.0 a	0.0 a	4.8 ab	2.6 a	1.2 a	1.2 ab	3.2 a	1.4 a	0.6 ab

Means within a column followed by the same letter are not significantly different (Student's t Test, $P<0.05$).
Data was transformed log ($x + 0.1$) prior to analysis.

Assessing Attract and Kill Disks in Conventional and Organic Small Fruit Production

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The newly invasive spotted wing drosophila (SWD), *Drosophila suzukii*, (Figure 1) entered the continental United States in California in 2008 with first observations in the northern Hudson Valley of NY in 2011 on late season organic raspberry (Figure 2). The rapid spread of the insect, its exponential reproductive capacity, lack of native biological control constraints and the inherent lack of competition for fruit resources from other insects during early fruit development provide ample opportunity for the insect to be a highly successful pest of small fruit. The estimated losses in 2012 exceeded 1.3 million in NY State blueberry with significant losses in raspberry and blackberry that went undocumented. Since then, yearly infestation levels of 40-100% injury to berry had been observed in commercial small fruit by mid-late August in commercial raspberry and blackberry plantings.

The root of the problem lies in the insect physiology, beginning with its ability to lay its eggs into un-ripened fruit using a highly serrated and sclerotization or thickened ovipositor (Figure 3). Its ability to penetrate very firm fruit with the capacity to lay over 300 eggs during its brief life of 3-6 weeks makes it a formidable pest. No other native drosophila can achieve this, and as such, it occupies a non-competitive niche increasing its reproductive success. Escalating SWD populations often begin in late June, as the insect develops on non-crop hosts. These fruiting plants reside in agricultural perimeter hedgerows, woody or riparian 'weedy' margins, and landscapes with ornamentals, unmanaged shrubs and vines. In the Hudson Valley of NY the Tartarian honeysuckle, also an invasive and native to Asia produces berries highly favored by the SWD. Couple this with rapid larval development and short generational intervals of 12 days for the completion of a generation, and the pest has the potential to give rise to unprecedented severity of damage in mid-late summer and fall berry. In years with low relatively humidity egg production can be negatively influenced as was seen in 2016 [1].

Management to reduce the severity of injury to raspberry, blackberry and in some vineyards, thin-skinned grape, requires intensive insecticide programs. From research efficacy studies, raspberry and blackberry require 3-4 day insecticide application intervals for fruit to retain commercial market acceptability. In very strict cultural markets a zero tolerance of eggs or larva within the fruit is required. Yet blueberry and grape management require a 7-day schedule to maintain sound fruit, weather and material efficacy permitting. In conservative management programs this is initiated upon first trap capture of the adult using frequently monitored, commercially available traps. In more advanced management systems, the detection of the adult fly and the first egg found in fruit are used to initiate insecticide programs. This level of committed management has forced many farmers, especially those using organic production systems, to reduce or eliminate late season berry production altogether. Infestations by SWD also become a threat to Hudson Valley cherry growers in

2015, while this year, thinned skin grape varieties such as Pinot Noir, Marquette and Vignoles along with late season raspberry and blackberry suffered highest levels of injury.

Sustainable Ag. Research Using Attract and Kill (AtK) Strategies. Behaviorally based pest management techniques have been developed and utilized to reduce or eliminate a specific pest from the environment. These strategies employ an attractant, typically a nutritional bait or reproductive lure which the insect seeks out, feeds on or simply is arrested upon, causing it to linger on the media that contains a toxicant. AtK stations are designed for a specific insect pest group based on its biology, behavior and physiology. This can be narrowed further to an insect species when insect pheromones are used.

The AtK system is designed to augment and or provide an alternative to directed residual applications in homes, landscape and agricultural commodities. Benefits of effective AtK systems provide long term solutions in population reductions leading to lower levels of insect infestations and injury to the home, ornamental plants or crops. As these systems often employ toxicants ingested by the insect they can be very effective, while containing reduced risk and or lower levels of environmental toxicants to reduce consequences to non-target organisms. The shortcomings of these systems, especially in agriculture, lie in their degree of attractiveness, the intent being to outcompete the host for the attention of field pest populations as a feeding or egg-laying site.

Attract and Kill for SWD Management on Raspberry. Over the past three years the Jentsch Lab has worked on a species-specific attract and kill system to manage the SWD. Developing effective olfactory and visual fruit-mimicking cues in an attract and kill system has been found to increase the overall success in host finding [3]. With that in mind we evaluated natural lures tested by a host of research entomologists, to develop a highly attractive AtK station for use in small fruit against the SWD. The lure, size, shape, color, addition of sugars, yeast and placement of the AtK system within the bramble canopy to optimize SWD relative humidity requirements, are selected to act in synergy during host finding to increase attraction by the target insect to the lure [4,5,6,7].

The goal in the design of this system was to construct an effective yet economically viable and long lasting lure to effectively outcompete the fruit for the attention of the SWD adult female. Upon finding and alighting on the disk, the fly engages in feeding and cleaning behavior, ingesting the bait and toxicant. This results in reducing the overall *Drosophila suzukii* population, leading to significant reduction of egg laying by the pest on the crop. For conventional producers, AtK may reduce application frequency while lengthening spray intervals, possibly reducing the need for insecticide applications directly to the crop altogether, especially late in the season. Secondarily, the AtK system may provide a means by which organic small fruit growers can utilize a system that reduces the potential of SWD to develop resistance to the few effective insecticides, such as Entrust (spinosad), by providing a long lasting residual control.

The attractants we use in these stations include red raspberry concentrate, high in fructose, apple cider vinegar and brewers yeast, highly attractive to vinegar flies (*Drosophila sp.*), all of which are used to formulate the 'AtK solution'. The station also employs a Super Absorbent Polymer (SAP) and gelatin embedded and layered over each side of a 3" polypropylene netted disk, acting as a substrate to bind the components together. When the AtK solution is applied to the netted substrate it develops into a firm yet dynamic gel with properties that absorbs and retains moisture from rain and dew under high humidity while releasing volatiles during low relative humidity to maintain its attractiveness throughout the season (Figure 3).

In laboratory efficacy studies we tested insecticides registered in NY for small fruit applied to AtK disks. Active ingredients in 1% A.I. concentrations were mixed into the AtK solution to 'mask' the odor of the formulation thereby reducing repellency when applied to disks. We then placed 13 female and 12 male SWD adults into insectary 'tents'. A single disk was added having received AtK solution plus insecticide 1 hour prior to adult fly exposure. Red raspberries were added into which flies would deposit their eggs.

To address resistance management concerns we used hydrogen borate, a formulation of boric acid in AtK stations this season. This active ingredient is accepted for use in organic productions practices (OMRI) and allowed with specific restrictions. From efficacy studies, boric acid has been shown to have comparable results to spinosad when formulated using a 1% concentration tested in combination with 2 mL of AtK solution applied to disks in both laboratory and field studies. Boric acid is approved with restrictions for use in OMRI / NOFA organic production systems. EPA has determined that, because they are of low toxicity and occur naturally, boric acid and its sodium salts should be exempted from the requirement of a tolerance (maximum residue limit) for all raw agricultural commodities[7],[8].

2016 Field Trials: This season we deployed attract and kill stations (AtK) in conventional and commercial production systems on three farm sites in two Hudson Valley counties of NY State. Two of the three farms are NOFA certified organic farms, one in the city of Poughkeepsie, NY (Dutchess County) and the other in Accord, NY (Ulster County) with a conventional farm in Milton, NY (Ulster County). We placed AtK stations along both sides of single rows of raspberry with individual treatment plots 30' in length, established in a complete replicated block design in a V-Pattern (Figure 6). Three treatments were replicated six times across the blocks on each farm including untreated plots (UTC). Four individual plots include untreated AtK disks with stations spaced at 36" intervals (Green), treated disks with 1% Boric Acid spaced at 18" (Red) and treated disks with 1% Boric Acid (BA) spaced at 36" intervals (Yellow) (Figure 7). The block was split into two groups or Replicates (Reps) to which weekly retreatment intervals of AtK solution was applied to disks in Reps I-III compared to retreatment intervals of 3-4 days / week in Reps IV-VI.

The raspberry sites on each of the three farms had differences in SWD adult populations resulting in different levels of egg laying, represented in fruit as seen in the x-axis of each graph shown as eggs per gram of berry weight.

The conventionally treated block on a 7-day program had the lowest level of infestation of the three farms (Figure 8). Weekly applications of insecticides reduced the overall population and fruit infestations throughout the season. *The AtK treated rows receiving twice weekly retreatment intervals of the AtK solution plus BA using the 18" spacing (Red Trmt.) provided 86.1% lower infestation levels of fruit,* yet not *statistically lower then the conventionally treated fruit without AtK stations*. Spacing differences between the AtK stations sprayed on a 3-4 day spray schedule demonstrated a 10-20% lower incidence of fruit infestation compared to the disks that were sprayed on the 7-day schedule.

The organically managed raspberry sprayed rotationally with Entrust (spinosad), had higher infestations overall then the conventionally sprayed block, demonstrating a 63.4% lower incidence of fruit infestation compared to the Entrust only sprayed fruit. In the unsprayed raspberry planting, SWD infestations were highest. AtK Stations provided 60.0% to 70.0% reduction in fruit infestation compared to unsprayed fruit with all plots statistically lower then the untreated plots. When we combined the data and analyzed all of the sites we found statistical separation between the disks sprayed 2x/week, disks that were unsprayed and the untreated plots (Table 1).

Discussion. We observed a significant reduction of fruit injury to raspberry employing attract and kill stations with 1% boric acid in three unique production systems this season. The question now is whether modifications in this approach can be made to increase attractiveness, further reducing fruit injury for the system to act as a stand-alone pest management approach. As it stands, AtK stations for SWD can be employed as one component in a diversified pest management system. Additional strategies would include crop sanitation with the removal of infested fruit in the bramble canopy and floor, frequent harvest intervals to reduce available fruit resources to the pest and cultural controls of weed and plant canopy to reduce relative humidity, all of have been shown to limit the reproductive success of the fly, reducing fruit infestations in European practices. We plan to further develop the station by reducing the size and increase the number of disks. Attending to retaining canopy where the AtK stations reside while opening the canopy to reduce relative humidity and increase air flow and volatility of the attractant may also increase effectiveness. Further testing comparative placement of the AtK stations, focusing on the lower canopy, may reduce the number of AtK stations needed within the row to further reduce costs of the system.

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Figures

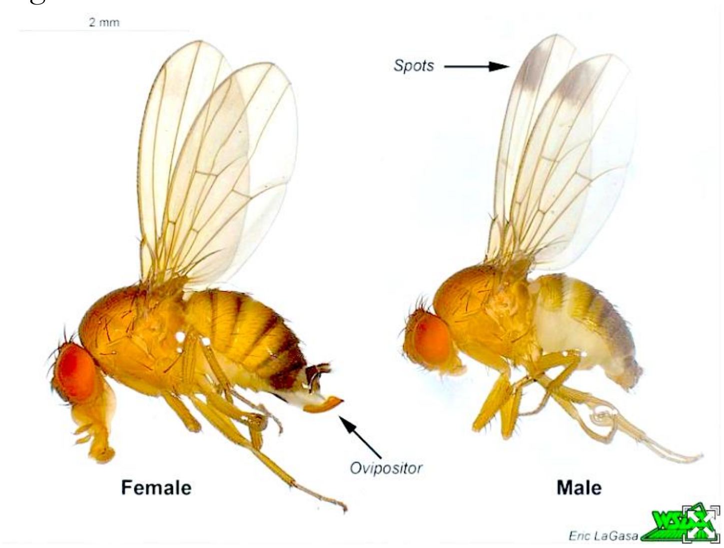

Figure 1. Spotted wing drosophila, *Drosophila suzukii*.

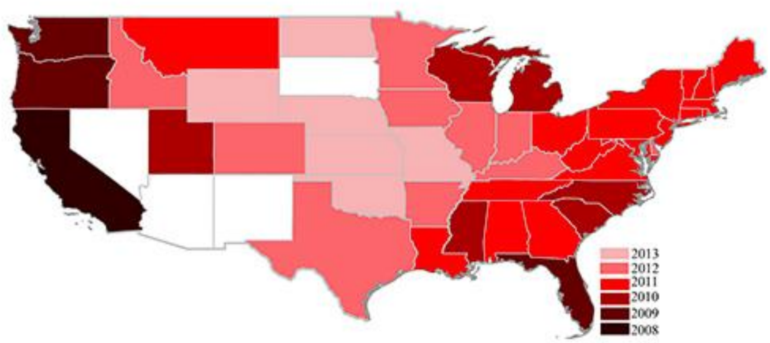

Figure 2. Map of SWD detections and spread in the US: 2008-2013.
Source: Hannah Burrack, NC State Univ.

Figure 3. The female SWD (L) with scleratinized & serrated ovipositor (magnified).

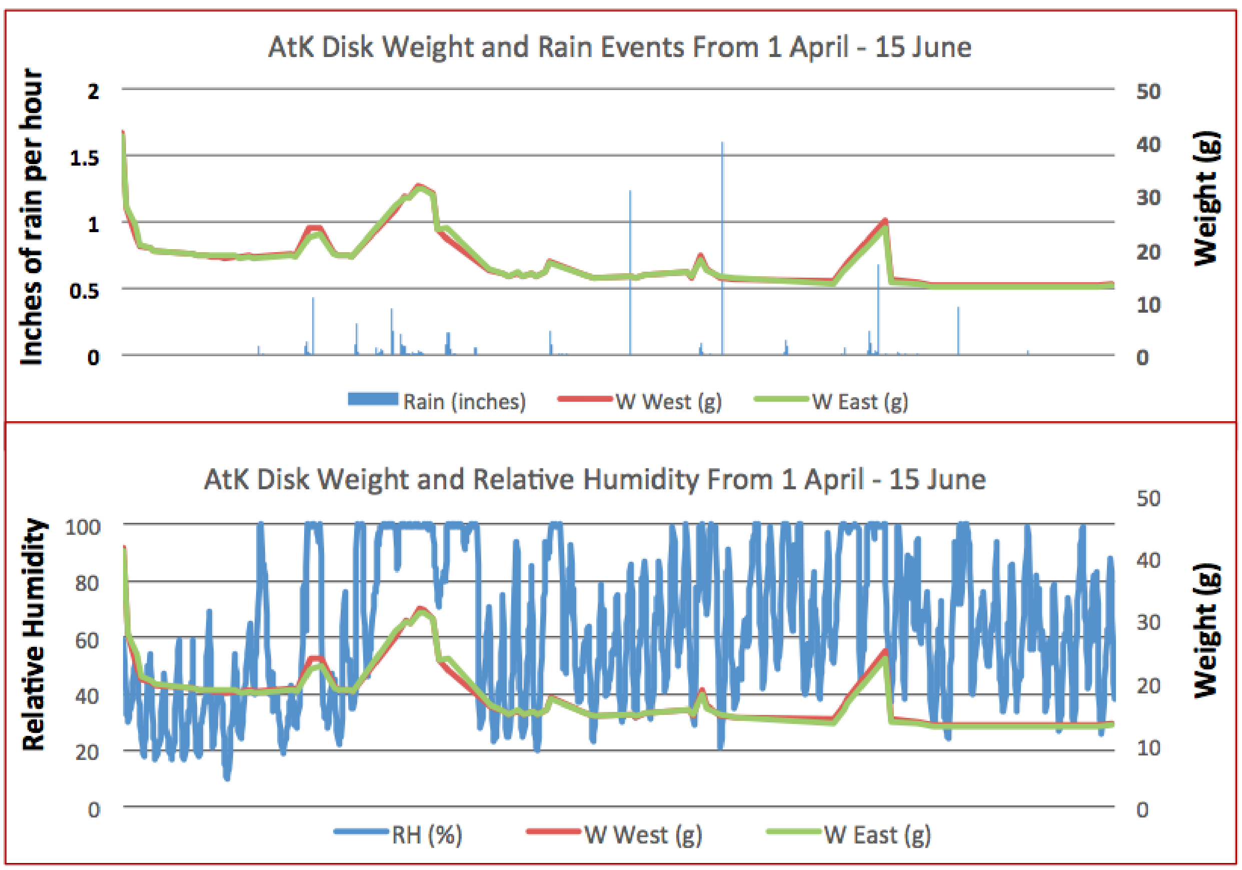

Figure 4. Changes of AtK disk weight relative to rain events and relative humidity in spring.

Figure 5. Attract and Kill Station disk (L) and AtK in the field after 4 months (R).

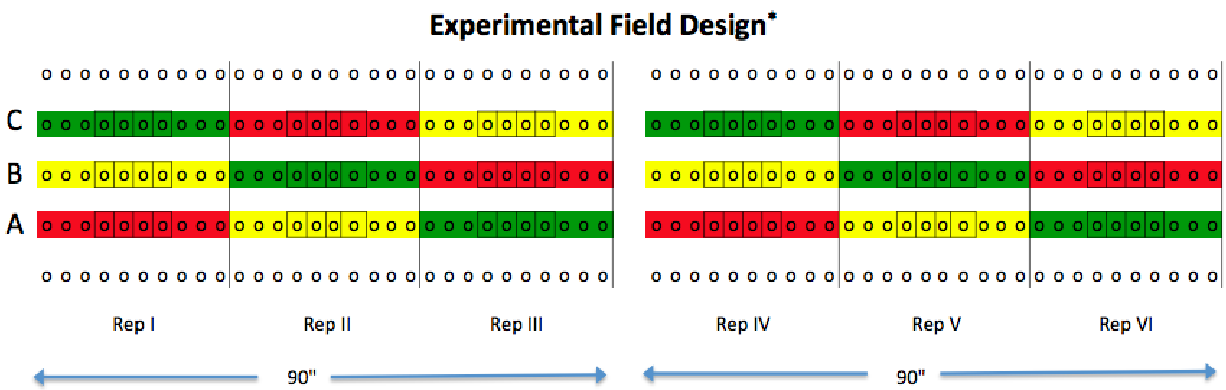

Figure 6. Experimental plots established in bramble using a split plot, complete replicated block design.

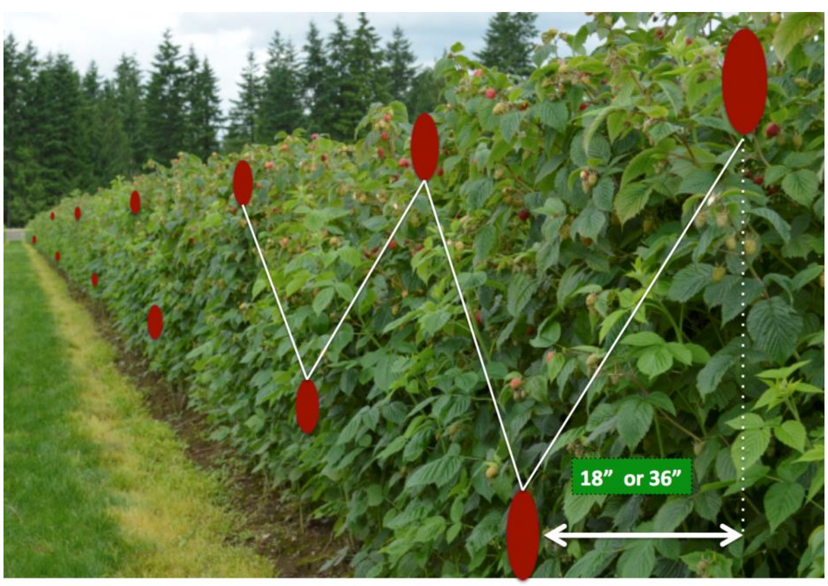

Figure 7. AtK spacing and position diagram in raspberry plots.

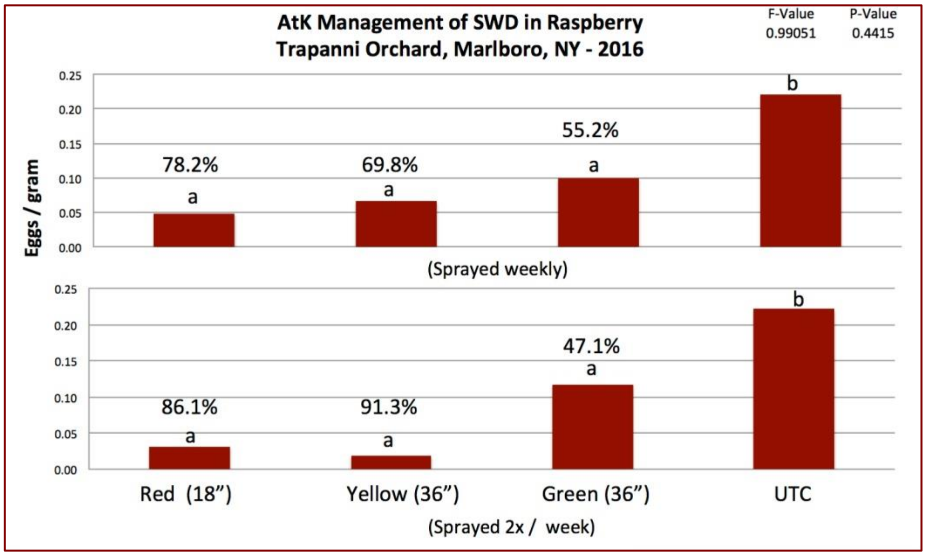

Figure 8. Efficacy of AtK in Conventional Raspberry

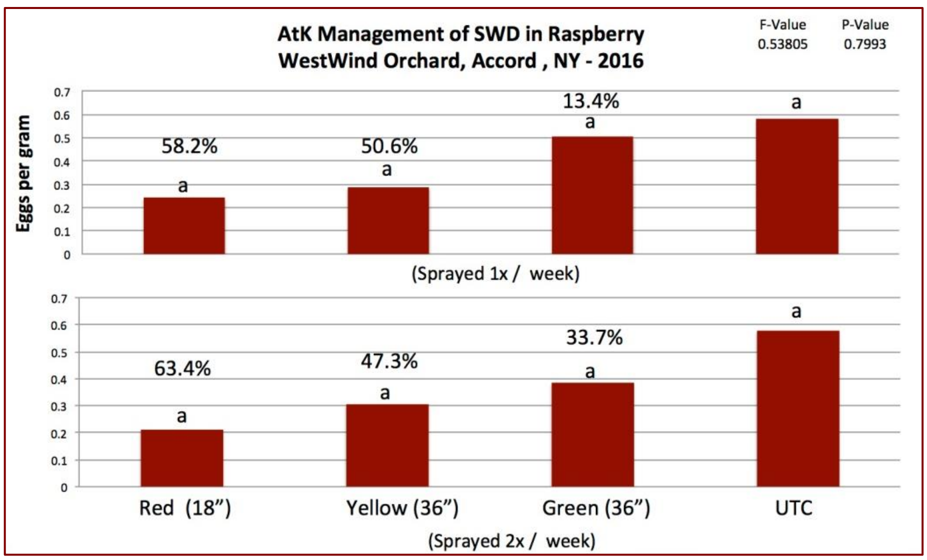

Figure 9. Efficacy of AtK in Commercial Organic Raspberry

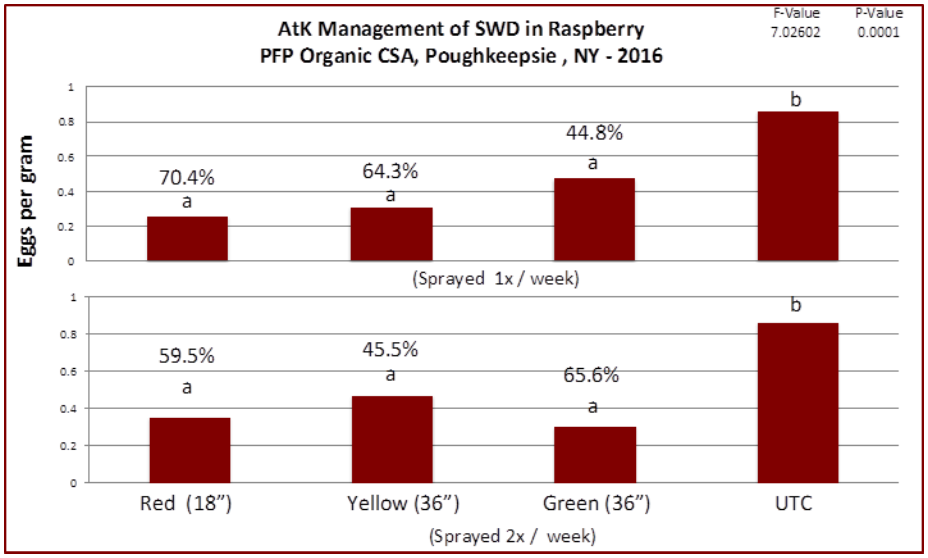

Figure 10. Efficacy of AtK in Untreated Raspberry

Comparison of Late Season Application of Sulfoxaflor and Bifenthrin for Controlling the Brown Marmorated Stinkbug, *Halyomorpha halys,* on Apple – Hudson Valley Research Laboratory 2016

The brown marmorated stink bug (BMSB), *Halyomorpha halys,* has been observed throughout the southern Hudson Valley for the past 7 years with the first BMSB confirmation in December 2008. Since that time increasing BMSB populations have been documented in urban environments and are now present on many lower to mid-Hudson Valley regional fruit and vegetable farms throughout the season. In two of the past three years we've observed a second generation develop in mid-late August during voltinism studies. The rise of a second generation of BMSB from mid-August through mid-November has caused significant injury to late season fruit. The industry is in need of insecticide tools with a short pre-harvest interval to address injury from this insect pest.

In 2016 we conducted a field examination of Closer SC, recently registered for use on tree fruit in the US, to determine the impact of this insecticide on adult and nymphs feeding on late season apple. Treatments were applied to 8-tree plots replicated six times in a RCB design. Each plot employed six trees of 8 year old 'Red Delicious' cultivars bordered by guard trees to inhibit drift, spaced at 3' x 12' ft., 10 ft. in height, comprising 1210 trees per acre. All dilutions are based on 300 gallons/acre with plot requirements ranging from 12 to 15 gallons increasing seasonally with developing canopy. Treatments were applied dilute to runoff using a tractor mounted high-pressure handgun sprayer operated at 300 psi delivering approximately 378.1 GPA.

Red Delicious on dwarfing rootstock strains were sprayed with Closer SC (sulfoxaflor – Dow AgroSciences; EPA Reg. No. 62719-623), and Bifenture EC (25% bifenthrin, UPI, EPA Reg. No. 70506-227) at 12.8 fl. ozs. (0.20 lbs. ai.) per acre using highest labeled rates on the 2nd of August, 24 hours prior to BMSB placement. Three intervals of BMSB placement were made at 24 hr., 48 hr. and 72 hr. Both 3rd instar nymphs and adults were placed onto the north side of fruit in the shaded canopy of the apple for each exposure date. Over top of each insect life stage was placed a 1 oz. screened cup secured by a single #30 rubber band (ULINE 2" x 1/8"), (Image 1). After 7d and prior to insect removal a circled was scored with black 'Sharpie' defining the arena perimeter. The circled areas of the fruit were evaluated at harvest for stink bug injury assessing 'Feeding Sites' using 14x microscope of fruit surface, discoloration coined as 'Green Dimples', and upon skin removal, subsurface 'Corking' was appraised including undamaged 'Clean' fruit on September 14th (Tables 1-3).

Results: Overall there were no statistical differences between Bifenture EC and Closer SC residual efficacy to adult stink bug feeding on apple. Both Closer SC and Bifenthure EC providing statistical reductions in fruit feeding injury by adults compared to the UTC when placed on fruit at 24 and 48 hour timing placement dates. Statistical differences between treatments in feeding sites and corking were observed at 48-hour placement timing of nymphs. These results suggest that Closer SC applied at 7 days prior to harvest can reduce feeding injury to fruit, yet provide little in the way of mortality to nymph or adult BMSB in the field.

Table 1 Comparison of Late Season Application of Closer and Bifenthrin for controlling Brown Marmorated Stinkbug *Halyomorpha halys* in Apple [a].HVRL. Highland N.Y. - 2016

			Incidence (%) of insect damaged cluster fruit			
Treatment	Hr. Post Appl	Life Stage	# Feeding Sites	Green Dimples	Corking	% Clean
Closer	24h	Adult	0.0a	0.3 a	0.0 a	0.1 a
Bifenthrin	24h	Adult	0.3 a	0.6 a	0.4 a	0.5 ab
UTC	24h	Adult	1.6 b	0.9 a	1.6 b	0.9 b
P value			0.0079	0.6411	0.0109	0.024
Closer	48h	Adult	0.3 a	0.0 a	0.7 a	0.1 a
Bifenthrin	48h	Adult	0.7 a	0.3 a	0.7 a	0.7 ab
UTC	48h	Adult	0.9 a	1.4 b	1.1 a	0.7 b
P value			0.6113	0.0018	0.7383	0.0641
Closer	72h	Adult	0.0 a	0.4 a	0.3 a	0.3 a
Bifenthrin	72h	Adult	0.9 a	0.4 a	1.1 a	0.4 a
UTC	72h	Adult	1.1 a	0.8 a	1.8 a	0.6 a
P value			0.3548	0.499	0.3131	0.4854
Closer	24h	Nymph	0.1 a	0.3 a	0.1 a	0.4 a
Bifenthrin	24h	Nymph	0.4 a	0.3 a	0.6 a	0.6 a
UTC	24h	Nymph	1.1 a	1.4 a	1.1 a	0.7 a
P value			0.149	0.3699	0.1649	0.4526
Closer	48h	Nymph	0.0 a	0.3 a	0.1 a	0.3 a
Bifenthrin	48h	Nymph	0.3 a	1.4 a	0.3 a	0.6 a
UTC	48h	Nymph	1.8 b	2.0 a	2.8 b	0.7 a
P value			0.0267	0.3394	0.007	0.2
Closer	72h	Nymph	0.0 a	0.4 a	0.3 a	0.3 a
Bifenthrin	72h	Nymph	0.9 a	0.4 a	1.1 a	0.4 a
UTC	72h	Nymph	1.1 a	0.4 a	1.8 a	0.6 a
	P value		0.3548	0.499	0.3131	0.4854

[a] Evaluation made on August 14 on Red Delicious cultivar. Data were transformed using arcsine(Sqrt(x)) using Fishers Protected LSD ($P \leq 0.05$). Treatment means followed by the same letter are not significantly different. Arithmetic means reported.

Table 2 Comparison of Late Season Application of Closer and Bifenthrin for Controlling Brown Marmorated Stinkbug Nymphs, *Halyomorpha halys* in Apple [a].HVRL Highland N.Y. - 2016

Nymphs in Cups Day after Exposure	Treatment	Alive (%)	Mortality(%)
2	Closer	86.3 b	13.7
	Bifenthrin	44.3 a	55.7
	UTC	90.5 b	9.5
	P-Value	0.0086	
10	Closer	28.0 a	72.0
	Bifenthrin	8.9 a	91.1
	UTC	39.9 a	60.1
	P-Value	0.3023	
15	Closer	18.5 a	81.5
	Bifenthrin	4.7 a	95.2
	UTC	35.7 a	64.3
	P-Value	0.2239	
21	Closer	18.5 a	81.5
	Bifenthrin	4.8 a	95.2
	UTC	26.8 a	73.2
	P-Value	0.2756	
26	Closer	13.7 a	86.3
	Bifenthrin	4.8 a	95.2
	UTC	22.6 a	77.4
	P-Value	0.3289	
33	Closer	9.5 a	90.5
	Bifenthrin	4.8 a	95.2
	UTC	13.7 a	86.3
	P-Value	0.6159	

[a] Evaluation made on August 14 on Red Delicious cultivar. Data were transformed using arcsine(Sqrt(x)) using Fishers Protected LSD ($P \leq 0.05$). Treatment means followed by the same letter are not significantly different. Arithmetic means reported.

Table 3	Comparison of Late Season Application of Closer and Bifenthrin for Controlling Brown Marmorated Stinkbug Adults, *Halyomorpha halys* in Apple [a]. HVRL. Highland N.Y. - 2016

Adults in Cups

Days after Exposure	Treatment	Alive (%)	Mortality (%)
2	Closer	91.7 b	8.3
	Bifenthrin	29.2 a	70.8
	UTC	76.2 b	23.8
	P-Value	0.031	
7	Closer	16.7 a	83.3
	Bifenthrin	9.7 a	90.3
	UTC	14.3 a	85.7
	P-Value	0.901	
15	Closer	0.0	100.0
	Bifenthrin	0.0	100.0
	UTC	0.0	100.0
	P-Value	-	

[a] Evaluation made on September 14 on Red Delicious cultivar. Data were transformed using arcsine(Sqrt(x)) using Fishers Protected LSD ($P \leq 0.05$). Treatment means followed by the same letter are not significantly different. Arithmetic means reported.

Image 1. BMSB in arena on apple.

Performance of OFM Lures in Mating Disruption and Non-Disrupted Orchards

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The use of sprayable pheromone for managing oriental fruit moth in apples has become a common practice among growers not using hand-applied or puffer dispensers for season-long disruption of CM and OFM. This trial was conducted in three commercial orchards in North Carolina (Henderson, Polk, and Lincoln Counties) to evaluate Trécé's MEC (microencapsulated) CM and OFM sprayable products along with a sprayable formulation of DA pear ester to enhance the efficacy of the pheromone. A second objective was to compare the capture of OFM and codling moths in pheromone traps baited with lures containing various components to enhance moth attraction.

Materials and Methods

The experiment was conducted in three different orchards managed by different growers in Fruitland (Henderson County), Mill Spring (Polk County), and Vale (Lincoln County), NC (see maps). Each orchard was divided into three blocks of at least 5 acres each. One block (MD1) received applications of OFM MEC + CM PUM, one (MD2) received OFM MEC + CM PUM + CideTrak DA MEC, and one (Non-MD) did not use mating disruption. Rates and timing of applications are listed in Table 1. For each orchard, the two treatment blocks had four pheromone traps for OFM (two baited with TRE-1123 lures and two with OFM L2) and two for CM (one baited with a CMDA Combo lure plus acetic acid (AA) and one with CM L2). The control block had eight OFM traps (four TRE-1123 and four L2) and four CM traps (two CMDA Combo + acetic acid and two CM L2). Traps were checked weekly from the beginning of the experiment (mid-May) through September, and lures were replaced once in mid-July, approximately 8 weeks after traps were deployed. At the Laughter and Lynch orchards, fruit damage was assessed at harvest (25 Aug and 22 Sep) by removing 50 apples from each of five sites in each treatment of each orchard and recording the number with larval entries and surface stings. At the Crotts orchard, 20 fruit were examined in each of 12 sites in each treatment (4 Aug). OFM trap captures were analyzed by using a 3-factor ANOVA to compare treatment, orchard, and lure effects after transforming data by square root. For CM, a t-test (paired two-sample for means) was used to compare lure types and treatments.

Sprayable pheromones were applied by growers using airblast sprayers at 100 GPA at all sites. Except for the test materials, no other mating disruption was used in these orchards. However, all treatments were sprayed with insecticides post bloom and are listed below.

- Laughter orchard: Delegate (31 May and 13 Jun), Admire (26 July), Altacor (17 Aug), and Brigade (30 Aug and 12 Sep) for BMSB.

- Lynch orchard: Delegate (18 May), Assail (22 Jun), and pyrethroids for BMSB control (Warrior or Bifenture) at 2-week intervals (6 Jul through late mid August).

- Crotts orchard: Delegate (2 and 30 May), Altacor (early Aug) and pyrethroids for BMSB control (Warrior, Proaxis, or Brigade) at 7 to 10 day intervals (late Jun to early Sep).

Results

When pheromone trap capture data were analyzed, orchard ($F=57.01$ $P<0.001$), mating disruption ($F=6.28$, $P<0.001$), and lure effects ($F=25.15$, $P<0.001$) were all significant factors. OFM populations were significantly higher at the Laughter orchard (48.5 season total moths per trap) than at either the Lynch or Crotts orchards (1.7 and 6.7 moths per trap, respectively) (Table 2). Trap captures were also higher in non-mating disruption vs. mating disruption orchards, and in traps baited with TRE 1123 versus OFM L2 lures. The orchard x MD treatment x lure interaction was also significantly different ($F=5.05$, $P=0.001$), which was the result of higher trap captures in the Laughter versus other orchards. This resulted in trap captures not being significantly different between MD treatment effects in the latter two orchards. Seasonal trap captures with OFM L2 and TRE 1123 lures in the Laughter orchard are shown in Fig. 1 in both the mating disruption blocks and the non-disrupted block. The greater attraction of moths to TRE 1123 versus OFM L2 lures made it very easy to differentiate between the second and third flights of OFM, which occurred from early June to early July and from early August to early September, respectively. At peak flight of moths, TRE 1123 lures captured approximately 3 to 6 times more moths than OFM L2 lures.

Codling moth trap captures were high at the Crotts orchard, very low at Lynch, and virtually nonexistent at Laughter (Table 3). Consequently, there were no significant factors in the ANOVA. Focusing on trap captures at only the Crotts orchard, the highest trap captures surprisingly occurred in the MD1 treatment, which averaged nearly 16 moths per trap per week over the course of the season. This is compared to only 5.6 and 7.3 in the MD2 and control, respectively (Table 3), which were still fairly high trap captures. When captures were separated out by generation (Table 4), first generation moth capture was highest in the MD 1 plot. It is likely that overwintering populations were higher in this location and accounted for the higher trap captures during the first generation. The increase in trap captures in succeeding generations suggests that neither the sprayable pheromone (CM PUM) nor the Delegate applications in May were effective in suppressing codling moth populations. Also of interest is that pyrethroid applications were made at approximately 10-day intervals from late June through early September, and they did not suppress codling moth populations.

It is also worth noting that, similar to previous years' studies, pheromone traps baited with CMDA Combo lures + Acetic Acid did not outperform CM L2 lures. In fact, season total captures of moths were higher in CM L2 compared to CMDA + AA in all three treatments, although differences were not significant. The weekly trap captures in the two lures in mating disruption and non-disrupted plots is shown in Fig. 2.

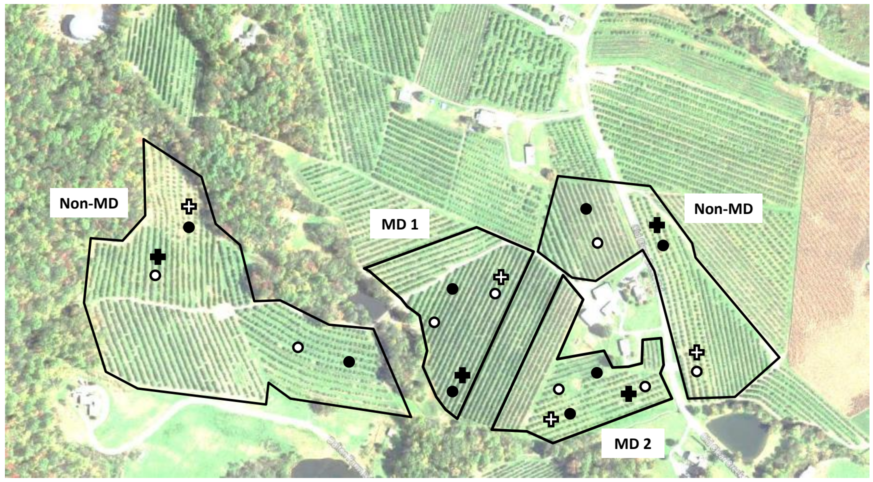
Virtually no damage occurred in any treatments in the Laughter and Lynch orchards. In the Crotts orchard, 12.2% of fruit in the MD 1 block contained larval entries, which is where trap captures were highest (Table 5). Despite the relatively high captures in MD2 and the non-disrupted blocks, damage was fairly low in these blocks. These results were clearly the opposite of what was expected, and suggests that the sprayable pheromone was either applied at too low of a rate or spray intervals of four weeks were not adequate.

ORCHARD MAPS

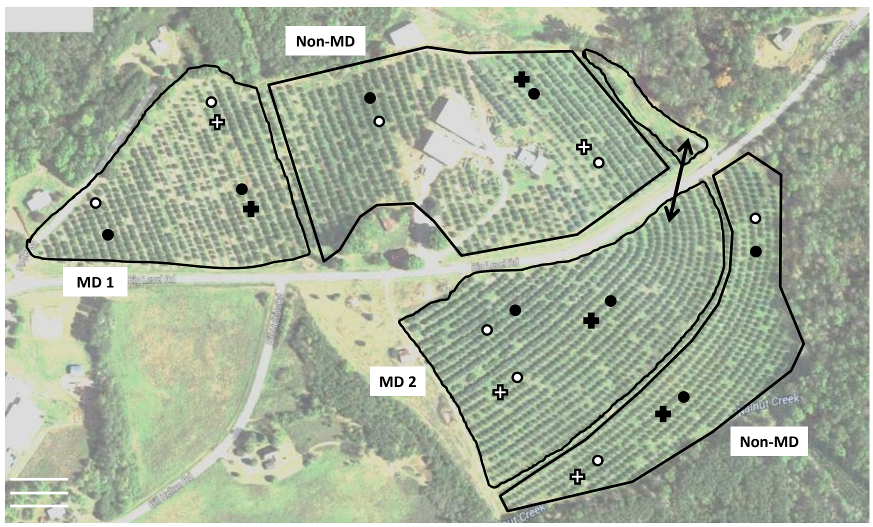
Trap placement:

- ○ OFM TRE-1123
- ● OFM L2
- ✚ CMDA Combo + AA
- ✙ CM L2

Laughter Orchard, Fruitland (Henderson County), NC



Lynch Orchard, Mill Spring (Polk County), NC



Crotts Orchard, Vale (Lincoln County), NC

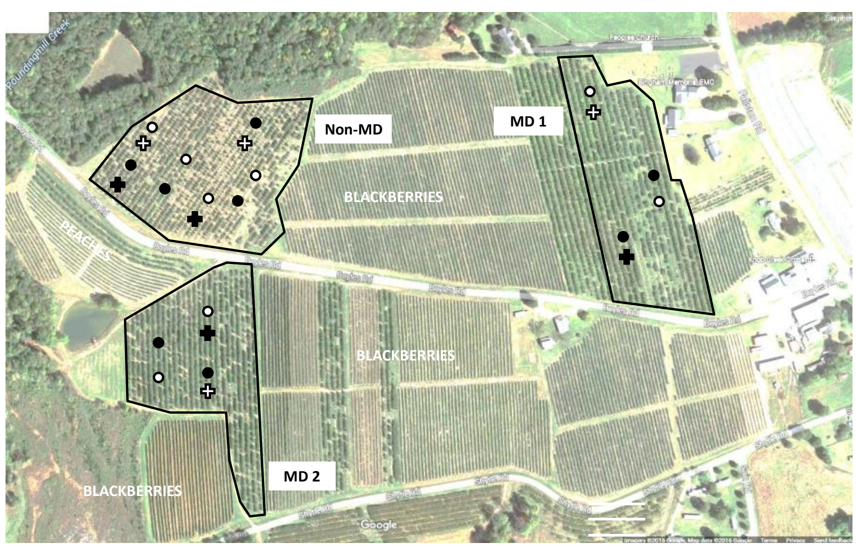


Table 1. Materials, rates, and application dates for mating disruption studies in three different orchards. Henderson, Polk, and Lincoln Counties, NC. 2016.

Orchard	Treatment	Material	Amount/Acre	Application dates
Laughter (Hend.)	MD 1	OFM MEC + CM PUM	3.4 oz 3.4 oz	5/16, 6/23, 7/25
	MD 2	OFM MEC + CM PUM + CideTrak DA MEC	3.4 oz 3.4 oz 0.43 oz	5/16, 6/23, 7/25
	Non-MD	–	–	–
Lynch (Polk)	MD 1	OFM MEC + CM PUM	3.4 oz 3.4 oz	5/18, 6/22
	MD 2	OFM MEC + CM PUM + CideTrak DA MEC	3.4 oz 3.4 oz 0.43 oz	5/18, 6/22
	Non-MD	–	–	–
Crotts (Lincoln)	MD 1	OFM MEC + CM PUM	3.4 oz 3.4 oz	5/16, 6/20, 7/18
	MD 2	OFM MEC + CM PUM + CideTrak DA MEC	3.4 oz 3.4 oz 0.43 oz	5/16, 6/20, 7/18
	Non-MD	–	–	–

Table 2. Season total OFM trap captures compared by treatment, lure, and orchard effects. Henderson, Polk, and Lincoln Counties, NC. 2016.

Effect		Season total mean OFM captures	S.E.
Treatment	MD (avg)	12.9b	3.7392
	Non-MD	31.0a	14.9693
Lure	OFM L2	8.1a	3.0509
	TRE 1123	29.8b	10.3594
Orchard	Laughter	48.5a	13.2556
	Lynch	1.7b	0.4144
	Crotts	6.7b	2.5587

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

Table 3. Weekly average CM trap captures in orchards with different mating disruption treatments. Henderson, Polk, and Lincoln Counties, NC. 2016.

Orchard	Treatment	Average weekly CM/trap
Laughter (Hend.)	MD (avg)	0.0a
	Non-MD	0.0a
Lynch (Polk)	MD (avg)	0.2a
	Non-MD	0.2a
Crotts (Lincoln)	MD 1	15.9a
	MD 2	5.6b
	Non-MD	7.3b

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

Table 4. CM captures using different trap lures in orchards with different mating disruption treatments. Henderson, Polk, and Lincoln Counties, NC. 2016.

		Average weekly CM/trap				
Location/treatment	Lure type	1st gen	2nd gen	3rd gen	Season-long	Season-long cumulative
Laughter (Hend.)						
MD (avg):	CM L2 CMDA	0.0a	0.1a	0.0a	0.0a	0.5
	Combo+AA	0.0a	0.0a	0.0a	0.0a	0.0
Non-MD:	CM L2 CMDA	0.1a	0.0a	0.0a	0.0a	0.0
	Combo+AA	0.0a	0.0a	0.1a	0.0a	0.5
Lynch (Polk)						
MD (avg):	CM L2 CMDA	0.2a	0.3a	0.5a	0.3b	5.0
	Combo+AA	0.1a	0.1a	0.0a	0.1a	1.0
Non-MD:	CM L2 CMDA	0.3a	0.0a	0.0a	0.2a	4.0
	Combo+AA	0.2a	0.2a	0.4a	0.2a	3.0
Crotts (Lincoln)						
MD 1:	CM L2 CMDA	10.1a	21.2a	34.0a	19.0a	323.0
	Combo+AA	5.6a	10.4a	30.0a	12.8b	217.0
MD 2:	CM L2 CMDA	2.5a	11.4a	5.3a	5.8a	98.0
	Combo+AA	2.5a	1.4a	16.5a	5.5a	93.0
Non-MD:	CM L2 CMDA	1.4a	5.1a	23.3a	8.2a	140.0
	Combo+AA	2.5a	10.4a	17.5a	6.3a	107.0

Means in the same column followed by the same letter are not significantly different by LSD ($p=0.05$).

Table 5. Mean percent CM damage to apples treated with different sprayable pheromone products. Henderson, Polk, and Lincoln Counties, NC. 2016.

		% Fruit Damage	
Orchard	Treatment	Stings	Entries
Laughter (Hend.)	MD 1	0.0a	0.0a
	MD 2	0.8b	0.0a
	Non-MD	0.0a	0.0a
Lynch (Polk)	MD 1	0.0a	0.0a
	MD 2	0.0a	0.2a
	Non-MD	0.0a	0.0a
Crotts (Lincoln)	MD 1	0.0a	12.2c
	MD 2	0.0a	1.3b
	Non-MD	0.0a	0.0a

Means in the same column followed by the same letter are not significantly different by LSD (p=0.05).

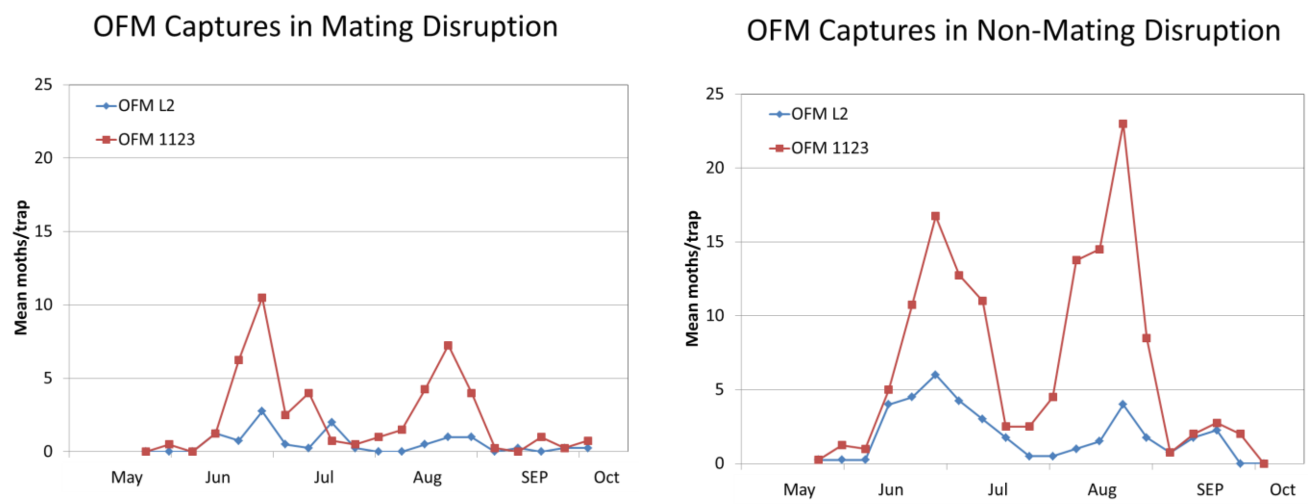


Fig. 1. Weekly captures of OFM in traps baited with OFM L2 or TRE 1123 lures in blocks treated with sprayable pheromone for mating disruption (left) and in non-mating disrupted orchards (right).

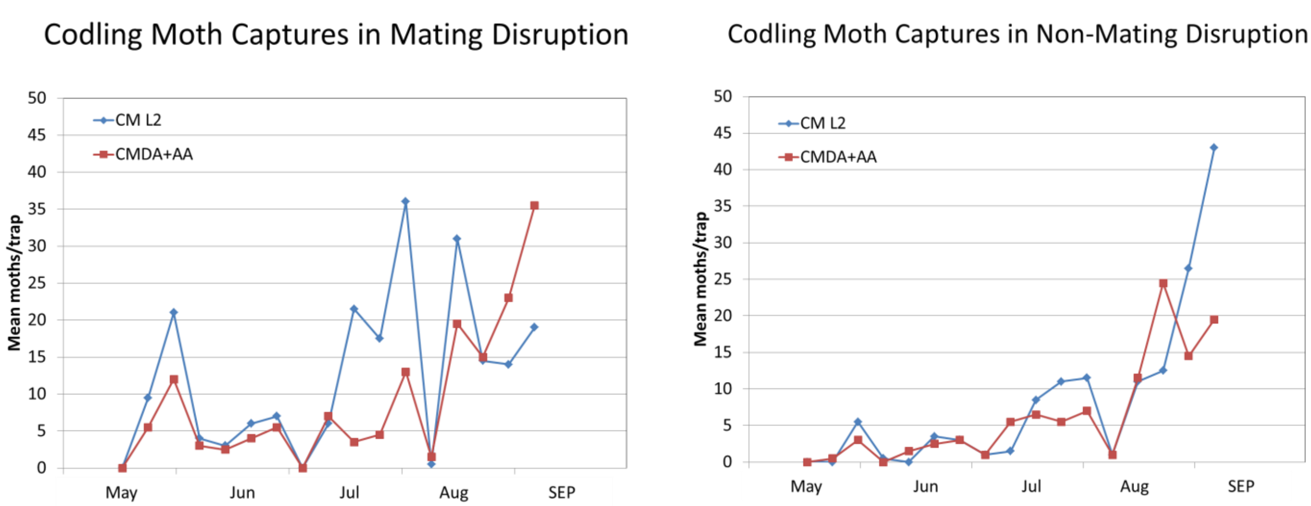


Fig 2. Weekly captures of codling in traps baited with CM L2 or CMDA+AA lures in blocks treated with sprayable pheromone for mating disruption (left) and in non-mating disrupted orchards (right).

DOES CANOPY MANIPULATION IMPACT YIELD AND SWD INFESTATION LEVELS IN THE OUTER VERSUS INNER CANOPIES OF RASPBERRIES?

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Spotted Wing Drosophila (SWD), *Drosophila suzukii*, is a major invasive pest of small fruits. Like other fruit flies it reproduces quickly and prolifically, and its populations steadily build through the growing season. Unlike other fruit flies, SWD has a serrated ovipositor, with which it attacks and damages ripening fruit. Developing IPM strategies has been difficult and has left growers with few options other than pesticide sprays, which are the current primary means of control. In order to develop more sustainable management options, we are investigating whether manipulating the crop environment can reduce SWD damage.

For this study, we applied three different pruning treatments (**Fig 1**) to fall bearing primocane red raspberries to determine whether canopy density had an impact on SWD infestation rates. The study was replicated at two sites, WMREC in Keedysville, MD and WyeREC in Queenstown, MD. At each site, three rows of raspberries were each partitioned into three sections, with each section receiving one of the three pruning treatments (**Fig 2**). Both sites are unsprayed and remained that way for the duration of the growing season. It is important to note that these are still young plantings, and the plants themselves were small. A LI-COR LAI2000 Leaf Canopy Analyzer was used to quantify the pruning treatments by measuring the foliage density of all the replicates. At both sites we saw the highest foliage density in the no pruning treatment and the lowest foliage density in the high pruning treatment. However, these differences were much starker at Keedysville than they were at Queenstown, with no statistical difference detected at Queenstown.

Fig 1. Raspberry pruning treatments, left to right: no pruning, medium pruning, high pruning

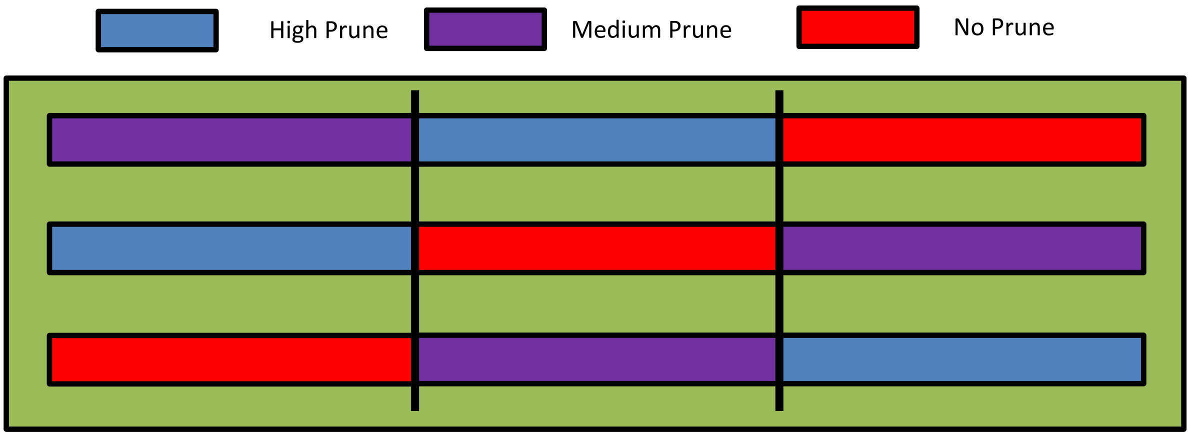

Fig 2. Each of the 3 rows at each site were divided into one of the three treatments

For each of the three replicate sections of each row, the middle cluster of canes was designated the 'data plant,' where we deployed a temperature logger in the inner and outer canopy (**Fig 3**). The loggers recorded the temperature every 20 minutes for the duration of the growing season. Studies have shown that SWD ceases development at temperatures above 87.6 degrees Fahrenheit[1] so we compared the number of 20 minute 'hot events' that crossed this developmental threshold across treatments and between canopy locations. At Keedysville there were significantly fewer of these hot events in the no pruning treatment versus the medium and high pruning treatments, but at Queenstown there was no significant difference. At both sites, the frequency of these hot events decreased the longer the season went on at both sites.

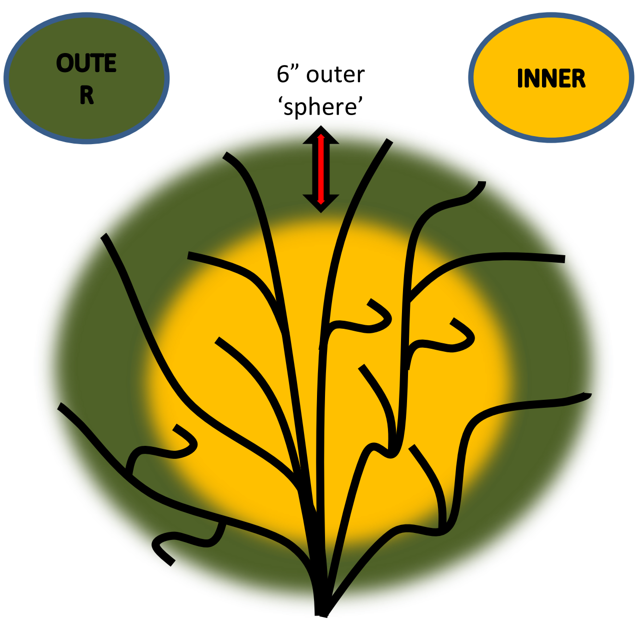

Fig 3: Each raspberry plant was divided into an inner and outer (6" outer 'sphere') canopy

We harvested ripe fruit weekly during August (early harvest), September (mid harvest) and October (late harvest) from each data plant. Significantly more fruit was collected per week in the no pruning treatment versus the medium and high pruning treatments at Keedysville, but no significant differences were detected at Queenstown. There was also no significant difference in berry weight across treatments at either site. While harvesting, we measured the internal berry temperature of five inner canopy and five outer canopy berries for each plant, and at both sites berry temperature was significantly cooler in the inner canopy versus the outer canopy.

All fruit collected each week was categorized as either marketable (fully intact fruit exhibiting no signs of damage, infection or infestation), chewed (mostly Japanese beetle and green June beetle damaged fruit), moldy (fruit with the presence of fungal pathogens such as *Botrytis spp.*, *Cladosporium spp.*, and/or yellow rust, *Phragmidium rubi-idaei*), or SWD infested (fruit that was soft, pulpy, oozing, and/or contained larvae). At Keedysville, a significantly higher percentage of fruit with SWD damage was collected from the no pruning treatment, but no difference across treatments was detected at Queenstown. By late harvest, almost no fruit collected at either site was of marketable quality. To assess the quality of the marketable fruit of each plant, the firmness of five inner canopy and five outer canopy fruit was measured with a penetrometer, and three inner canopy and three outer canopy fruit were frozen for BRIX measurements of berry sweetness. There was no significant difference in berry sweetness across treatments and canopy locations at either site, but for both sites the inner canopy fruit was significantly softer than the outer canopy fruit across treatments.

A sample of the fruit from each plant each week was assessed for larval SWD presence to measure infestation rates. Each week, ten inner canopy and ten outer canopy fruit were broken apart and submerged in a sucrose solution for 12 minutes, and the total number of larvae that emerged were counted and divided by ten to generate a number of larvae per fruit value. At both sites, the average number of larvae per fruit increased the later in the harvest season, but this difference was only significant at Queenstown. At both sites, there were numerically more larvae per fruit on average in the no pruning treatment, but this was only statistically significant at Keedysville.

The preliminary results of these studies seem to indicate that denser plants are more favorable to SWD. At Keedysville (where the differences in treatment foliage densities were significant) there were significantly fewer hot events and more SWD damaged fruit in the no pruning treatment, as well as significantly more larvae per fruit. Across all treatments, the inner canopy also seemed to display more favorable conditions for SWD (since the fruit was significantly softer and cooler than the outer canopy fruit) although significant differences in infestation rates and damaged fruit were not detected. We plan to replicate these studies in the coming years as the plants mature to determine whether these observed differences become more pronounced as the plants grow.

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Plant Pathology

PEACH DISEASE MANAGEMENT WITH EARLY SEASON BIORATIONAL AND LATE SEASON CONVENTIONAL FUNGICIDE PROGRAMS

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This field study examined the efficacy of the biorational, OMRI-listed fungicides Fracture, Double Nickel, Serenade Optimum, Kumulus, Armicarb, and Triology for early season management of brown rot blossom blight and rusty spot. For comparison, the standard conventional fungicide treatment used Rovral and Rally for control of blossom blight and rusty spot, respectively.

In each of the above early season programs, captan was applied for the remaining cover sprays. A variety of recently-registered conventional and new biorational fungicides were then applied during the preharvest period for management of brown rot and other fruit rots. These materials included Luna Sensation / Indar alternations, Rhyme, Oso, Fracture, and Iron Soap. The conventional preharvest standard for comparison was Indar.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2016 growing season. The test block consisted of a 21-year-old 'Autumnglo' peach orchard planted at 25 ft x 25 ft spacing.

Treatments. Fungicide treatments were replicated four times in a randomized complete block design with single tree plots. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.5 mph was used for applications. A bud-swell application, typically Ziram, was <u>not</u> applied for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing are shown in Table 1.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 12 July by examining 20 shoots per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 7 June by examining 40 fruit per tree. Scab (*Fusicladium carpophilum*) was evaluated on 26 Aug by examining 25 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 2 Sep by examining all fruit on arbitrarily selected branches (~ 75 fruit / tree). For postharvest evaluations, 25 asymptomatic uninjured fruit were harvested from each replicate tree and placed on benches in a shaded greenhouse (average temp. = 71°F). Brown rot and other rots were evaluated at 3 and 6 days postharvest (DPH).

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 23X data logger located at the research station. This weather station is part of the Mesonet Network operated by the Office of the NJ State Climatologist. Observations were taken every two minutes and summarized every hour. Hourly temperature and rainfall data were averaged and summed, respectively, for each day of the growing season (Table 1).

Statistical Analysis. Analyses of variance (ANOVA) and treatment mean comparisons were performed using the General Linear Models (GLM) procedure of SAS v9.4. The Bayesian Waller-Duncan means test was used to compare treatment means. Arcsin and log transformations were performed as needed for proportions and lesion count data, respectively, to correct for departures from the ANOVA assumptions.

RESULTS AND DISCUSSION

Environment. Bloom began in late March 2016, about a week ahead of normal. Air temperatures were somewhat cooler, but more than adequate moisture and inoculum from mummies were available for considerable blossom blight infection. Eleven days with rainfall ≥ 0.10 inches occurred during the bloom period from 28 Mar (two days before pink spray) to shuck-split on 4 May (Table 1).

Conditions were also favorable for scab. A total of 25 days with rainfall ≥ 0.10 inches occurred between shuck-split and 5C (mid-July), the infectious period for scab (Table 1). However, only three days with rain occurred during the preharvest fruit ripening period. Nevertheless, given the high inoculum levels in the orchard from blossom blight cankers, this amount of moisture was sufficient for creating moderate brown rot pressure at harvest.

Blossom Blight. Blossom blight disease pressure in 2016 was lower than observed in 2015, but still very high. On non-treated control trees, 63.8% of shoots were infected with an average of 1.2 cankers per shoot (Table 2). In comparison, 81% of non-treated shoots were infected in 2015 with about 3 cankers per shoot.

Regardless of the high disease pressure, all treatments significantly reduced canker incidence and severity (Table 2). The most effective biorational treatment was Serenade Optimum (59% control), which provided control statistically equivalent to the Rovral standard (69% control). Serenade and Rovral reduced the number of cankers per shoot by 73% and 78%, respectively.

All remaining biorational treatments yielded 43 to 47% control and were not significantly different from each other (Table 2). These materials provided an intermediate level of control: treated trees had significantly less blossom blight canker incidence and severity than on non-treated trees, but disease levels were significantly greater than on trees receiving the Rovral standard. Canker numbers per shoot were reduced 49 to 58% for this group.

All materials would probably have performed better under lower disease pressure typically encountered in commercial conditions.

Rusty Spot. Although the wet early season conditions were less favorable for rusty spot, the high susceptibility of 'Autumnglo' peach nevertheless resulted in considerable disease pressure in 2016. Almost 80% of non-treated fruit were infected (Table 3). Lesion density, as a measure of disease severity, was approximately 1.5 lesions per fruit on control trees. These levels of incidence and severity agree with past data characterizing the incidence-severity relationship.

Under the severe disease-favorable conditions of the study, the Rally standard provided 70% control of rusty spot and was significantly better than all other [biorational] materials (Table 3). Fracture, Double Nickel, and Kumulus provided an intermediate level of control. Although they significantly reduced disease incidence and severity relative to the control, these materials only provided 18 to 23% control.

Trilogy, Serenade Optimum, and Armicarb failed to significantly reduce disease incidence, although the Trilogy and Serenade did significantly reduce lesion density (Table 3). This lack of control was most likely due to the high susceptibility of 'Autumnglo' cultivar. In past multi-year studies on moderately susceptible cultivars, these three materials have been shown to significantly reduce rusty spot disease levels.

Scab. Conditions were quite favorable for scab development in 2016. Non-treated trees had 74% infected fruit with 55% of these fruit having 10 or more lesions (Table 4).

The early season programs in this study were primarily designed to examine biorational control of blossom blight and rusty spot (Table 4). However, the high levels of scab observed in the block provided an opportunity to evaluate management of scab with these same biorational compounds. The timings of interest were early shuck-split (SS) through fifth cover (5C), the period during which scab spores were being produced on twig lesions. Since all treatments received captan at 4C and 5C, the biorational materials applied from SS through 3C can be compared.

Only one biorational material, Kumulus, was observed to significantly reduce scab disease incidence (Table 4). This material, which provided 45% control, also reduced the percent of fruit with > 10 lesions. This outcome was expected since sulfur fungicides are commonly used for peach scab control.

All other biorational materials failed to provide significant control of scab. The conventional fungicide Rally, which is the rusty spot standard but not a standard for peach scab, also did not provide significant scab control. This outcome is in stark contrast to control of apple scab. Rally and other DMI fungicides generally provide good control of apple scab (assuming no resistance).

Brown Rot. Brown rot disease pressure was moderate during the preharvest fruit ripening period, the time when fruit are most susceptible. Almost 47% of non-treated fruit had brown rot lesions at harvest (Table 5).

All treatment programs except Iron Soap significantly reduced brown rot incidence at harvest relative to the non-treated control (Table 5). Iron Soap provide an intermediate level of control, being not significantly different from both the control and most other treatments. Only the Indar standard had significantly less rot than Iron Soap.

The single material preharvest programs (all three sprays), Rhyme and Oso, provided very good to excellent rot management at harvest, yielding 80% and 89% control, respectively. The Indar / Fracture / Indar, Luna Sensation / Indar / Luna Sensation, and Indar / Luna Sensation / Indar integrated programs provided excellent rot management at 87, 88, and 91% control, respectively. Finally, the Indar standard yielded 96% control of rot, the highest level observed.

After **3-days postharvest incubation**, almost 38% of non-treated fruit were observed with brown rot (Table 5). The Iron Soap treatment continued to provide an intermediate level of control (50%); it was not significantly different from the NTC and two other treatments. The remaining treatments provided good to excellent brown rot management. Percent control (%) for these treatments was Oso (73%); Indar / Fracture / Indar (87%); Rhyme (89%); Indar / Luna Sensation / Indar (92%); Luna Sensation / Indar / Luna Sensation (95%), and the Indar standard (95%).

After **6-days postharvest incubation**, brown rot increased to 65% incidence on non-treated fruit, an increase of 27% in only three days (Table 5). By this point in the incubation period, the Iron Soap treatment no longer provided significant control of brown rot development. The remaining treatments provided fair to excellent brown rot management (% control): Oso (68%); Indar / Fracture / Indar (72%); Rhyme (72%); Indar / Luna Sensation / Indar (92%); Luna Sensation / Indar / Luna Sensation (92%); and the Indar standard (92%). Note Oso, Indar / Fracture / Indar, and Rhyme showed the greatest decrease in control from the 3- to 6-day incubation assessments.

Other Rots. *Rhizopus* rot, anthracnose, and *Phomopsis* or *Botryosphaeria* spp. fruit rots were observed during the harvest and postharvest assessments. However, disease levels were too low for analyses.

Acknowledgement

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Table 1. Weather and spray timings for 2016 growing season at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stage. Units for daily average air temperature and rainfall accumulation are ºF and inches.

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Mar	50	0		1-Apr	68	0.20		1-May	49	0.45	
2-Mar	43	0.17		2-Apr	55	0.25		2-May	56	0.16	
3-Mar	32	0		3-Apr	39	0.03		3-May	55	0.47	
4-Mar	32	0.20		4-Apr	50	0.12		4-May	50	0.01	**Shuck Split**
5-Mar	33	0		5-Apr	35	0		5-May	51	0	
6-Mar	34	0		6-Apr	39	0		6-May	50	1.11	
7-Mar	44	0		7-Apr	54	0.54	**Bloom**	7-May	53	0.17	
8-Mar	57	0		8-Apr	44	0		8-May	58	0	
9-Mar	59	0		9-Apr	35	0.75		9-May	57	0	
10-Mar	65	0		10-Apr	38	0		10-May	55	0	
11-Mar	60	0		11-Apr	54	0		11-May	56	0.31	
12-Mar	48	0		12-Apr	55	0.29		12-May	64	0	
13-Mar	49	0.26		13-Apr	46	0		13-May	62	0.17	
14-Mar	47	0.78		14-Apr	46	0		14-May	62	0.15	
15-Mar	46	0		15-Apr	47	0	**Petal Fall**	15-May	52	0	
16-Mar	53	0		16-Apr	49	0		16-May	53	0	**1st Cover**
17-Mar	52	0		17-Apr	52	0		17-May	54	0.30	
18-Mar	52	0		18-Apr	61	0		18-May	57	0	
19-Mar	39	0.06		19-Apr	62	0		19-May	61	0	
20-Mar	36	0.20		20-Apr	55	0		20-May	62	0	
21-Mar	39	0.01		21-Apr	57	0		21-May	56	0.72	
22-Mar	44	0		22-Apr	67	0		22-May	57	0.21	
23-Mar	57	0		23-Apr	60	0.39		23-May	61	0.23	
24-Mar	59	0		24-Apr	54	0		24-May	67	0.13	
25-Mar	62	0.01		25-Apr	59	0		25-May	72	0	
26-Mar	47	0		26-Apr	68	0.05		26-May	75	0	**2nd Cover**
27-Mar	49	0		27-Apr	50	0		27-May	78	0	
28-Mar	54	0.48		28-Apr	47	0.07		28-May	76	0	
29-Mar	50	0		29-Apr	47	0.01		29-May	73	1.06	
30-Mar	44	0	**Pink**	30-Apr	51	0		30-May	72	0.64	
31-Mar	62	0						31-May	75	0	

Table 1 – continued –

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Jun	74	0		3-Jul	68	0		4-Aug	72	0	
2-Jun	70	0		4-Jul	71	0.57		5-Aug	73	0	
3-Jun	68	0.44		5-Jul	78	0.32		6-Aug	80	0	
4-Jun	71	0		6-Jul	81	0		7-Aug	77	0	
5-Jun	72	0.47		7-Jul	82	0		8-Aug	75	0	
6-Jun	75	0		8-Jul	81	0	**5th Cover**	9-Aug	77	0	
7-Jun	74	0.09		9-Jul	74	0.34		10-Aug	83	0	
8-Jun	62	0.10		10-Jul	75	0		11-Aug	85	0	
9-Jun	64	0		11-Jul	73	0		12-Aug	86	0	
10-Jun	65	0	**3rd Cover**	12-Jul	75	0		13-Aug	87	0	
11-Jun	75	0		13-Jul	75	0.16		14-Aug	87	0	
12-Jun	81	0		14-Jul	83	0		15-Aug	83	0.01	**18-dph**
13-Jun	68	0		15-Jul	82	0		16-Aug	82	0.02	
14-Jun	69	0		16-Jul	80	0.10		17-Aug	83	0.05	
15-Jun	68	0		17-Jul	79	0		18-Aug	78	0.39	
16-Jun	65	0.86		18-Jul	80	0.25		19-Aug	78	0.02	
17-Jun	69	0		19-Jul	79	0		20-Aug	77	0	
18-Jun	69	0		20-Jul	74	0.21		21-Aug	76	0.91	
19-Jun	76	0		21-Jul	76	0	**6th Cover**	22-Aug	73	0	
20-Jun	77	0		22-Jul	81	0		23-Aug	68	0	
21-Jun	74	0.19		23-Jul	83	0		24-Aug	72	0	**9-dph**
22-Jun	75	0		24-Jul	80	0		25-Aug	76	0	
23-Jun	73	0.5		25-Jul	83	0.09		26-Aug	82	0	
24-Jun	70	1.67	**4th Cover**	26-Jul	81	0.01		27-Aug	79	0	
25-Jun	72	0		27-Jul	82	0		28-Aug	76	0	
26-Jun	71	0		28-Jul	78	0.78		29-Aug	78	0	
27-Jun	71	0		29-Jul	77	0.79		30-Aug	77	0	
28-Jun	74	0.66		30-Jul	77	0.12		31-Aug	77	0	**2-dph**
29-Jun	75	0		31-Jul	80	0.16		1-Sep	74	0.57	
30-Jun	73	0		1-Aug	76	0.05		2-Sep	70	0	**Harvest**
1-Jul	74	0.12		2-Aug	74	0.01	**7th Cover**	3-Sep	69	0	
2-Jul	72	0		3-Aug	71	0		**dph** = days pre-harvest			

Table 2. Blossom Blight Canker Incidence and Severity [1]					
Treatment [2]		Rate / A	Timing	% Shoots w. Canker [3]	# Cankers per Shoot [3]
1	Non-treated control	--------	--------	63.8 a	1.19 a
2	**Rovral 4F** **Rovral 4F + Rally 40WSP** Rally 40 WSP Captan 80WDG Indar 2F + Latron B-1956	1.5 pt 1.5 pt + 6 oz 6 oz 3.125 lb 9 fl oz + 8 fl oz	**P, B** **PF** SS, 1C-3C 4C-7C 18, 9, 2 dph	20.0 c	0.26 c
3	**Fracture 2.1SC + Latron B-1956** Captan 80WDG Indar 2F + Latron B-1956 Fracture 2.1SC + Latron B-1956	30.5 fl oz + 8 fl oz 3.125 lb 9 fl oz + 8 fl oz 30.5 fl oz + 8 fl oz	**P, B, PF,** SS,1C-3C 4C-7C 18, 2 dph 9 dph	35.0 b	0.51 b
4	**Double Nickel 25WDG** Captan 80WDG Oso 0.44SC + Latron B-1956	3 lb 3.125 lb 6.5 fl oz + 8 fl oz	**P, B, PF,** SS, 1C-3C 4C-7C 18, 9, 2 dph	36.3 b	0.50 b
5	**Serenade Optimum 26.2WP** Captan 80WDG Luna Sensation 4.2 F Indar 2F + Latron B-1956	20.0 oz 3.125 lb 5.0 fl oz 9 fl oz + 8 fl oz	**P, B, PF,** SS, 1C-3C 4C-7C 18, 2 dph 9 dph	26.3 c	0.33 c
6	**Kumulus 80DF** Captan 80WDG Indar 2F + Latron B-1956 Luna Sensation 4.2F	15 lb 3.125 lb 9 fl oz + 8 fl oz 5.0 fl oz	**P, B, PF,** SS, 1C-3C 4C-7C 18, 2 dph 9 dph	36.3 b	0.60 b
7	**EcoMate Armicarb "O" 85SP** Captan 80WDG Rhyme 2.08SC	5 lb 3.125 lb 6.5 fl oz	**P, B, PF,** SS 1C-3C 4C-7C 18, 9, 2 dph	33.8 b	0.55 b
8	**Trilogy 5.46EC** Captan 80WDG CX-10370 Iron Soap	1 gal 3.125 lb 1% vol/vol	**P, B, PF,** SS, 1C-3C 4C-7C 18, 9, 2 dph	36.3 b	0.50 b

[1] Blossom blight treatments, rates, and application timings in **boldface**.
[2] Potassium bicarbonate added to spray water to correct pH for Double Nickel, Serenade, and Armicarb treatments.
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 3. Rusty Spot Incidence and Severity[1]					
Treatment [2]		**Rate / A**	**Timing**	**% Infected Fruit** [3]	**# Lesions per Fruit** [3]
1	Non-treated control	--------	--------	79.9 a	1.47 a
2	Rovral 4F **Rovral 4F + Rally 40WSP** **Rally 40WSP** Captan 80WDG Indar 2F + Latron B-1956	1.5 pt 1.5 pt + 6 oz 6 oz 3.125 lb 9 fl oz + 8 fl oz	P, B **PF** **SS, 1C-3C** 4C-7C 18, 9, 2 dph	24.4 c	0.27 c
3	**Fracture 2.1SC + Latron B-1956** Captan 80WDG Indar 2F + Latron B-1956 Fracture 2.1SC + Latron B-1956	30.5 fl oz + 8 fl oz 3.125 lb 9 fl oz + 8 fl oz 30.5 fl oz + 8 fl oz	P, B**, PF, SS, 1C-3C** 4C-7C 18, 2 dph 9 dph	66.6 b	0.91 b
4	**Double Nickel 25WDG** Captan 80WDG Oso 0.44SC + Latron B-1956	3 lb 3.125 lb 6.5 fl oz + 8 fl oz	P, B, **PF, SS, 1C-3C** 4C-7C 18, 9, 2 dph	65.6 b	0.96 b
5	**Serenade Optimum 26.2WP** Captan 80WDG Luna Sensation 4.2F Indar 2F + Latron B-1956	20.0 oz 3.125 lb 5.0 fl oz 9 fl oz + 8 fl oz	P, B, **PF, SS, 1C-3C** 4C-7C 18, 2 dph 9 dph	70.0 ab	1.12 b
6	**Kumulus 80DF** Captan 80WDG Indar 2F + Latron B-1956 Luna Sensation 4.2F	15 lb 3.125 lb 9 fl oz + 8 fl oz 5.0 fl oz	P, B, **PF, SS, 1C-3C** 4C-7C 18, 2 dph 9 dph	61.3 b	0.91 b
7	**EcoMate Armicarb "O" 85SP** Captan 80WDG Rhyme 2.08SC	5 lb 3.125 lb 6.5 fl oz	P, B, **PF, SS 1C-3C** 4C-7C 18, 9, 2 dph	69.4 ab	1.17 ab
8	**Trilogy 5.46EC** Captan 80WDG CX-10370 Iron Soap	1 gal 3.125 lb 1% vol/vol	P, B, **PF, SS, 1C-3C** 4C-7C 18, 9, 2 dph	72.5 ab	1.16 b

[1] Rusty spot treatments, rates, and application timings in **boldface**.
[2] Potassium bicarbonate added to spray water to correct pH for Double Nickel, Serenade, and Armicarb treatments.
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 4. Scab Incidence and Severity[1]						
Treatment[2]		**Rate / A**	**Timing**	**% Inf Fruit[3]**	**% Fruit 1-10 Les[3]**	**% Fruit >10 Les[3]**
1	Non-treated control	--------	--------	74.0 a	19.0 b	55.0 a
2	Rovral 4F Rovral 4F + Rally 40WSP **Rally 40WSP** **Captan 80WDG** Indar 2F + Latron B-1956	1.5 pt 1.5 pt + 6 oz 6 oz 3.125 lb 9 fl oz + 8 fl oz	P, B PF **SS, 1C-3C** **4C, 5C**, 6C,7C 18, 9, 2 dph	63.0 ab	38.0 ab	25.0 b
3	**Fracture 2.1SC + Latron B-1956** **Captan 80WDG** Indar 2F + Latron B-1956 Fracture 2.1SC + Latron B-1956	30.5 fl oz + 8 fl oz 3.125 lb 9 fl oz + 8 fl oz 30.5 fl oz + 8 fl oz	P, B, PF**, SS, 1C-3C** **4C, 5C**, 6C, 7C 18, 2 dph 9 dph	76.0 a	42.0 a	34.0 ab
4	**Double Nickel 25WDG** **Captan 80WDG** Oso 0.44SC + Latron B-1956	3 lb 3.125 lb 6.5 fl oz + 8 fl oz	P, B, PF**, SS, 1C-3C** **4C, 5C,** 6C, 7C 18, 9, 2 dph	78.0 a	47.0 a	31.0 ab
5	**Serenade Optimum 26.2WP** **Captan 80WDG** Luna Sensation 4.2F Indar 2F + Latron B-1956	20.0 oz 3.125 lb 5.0 fl oz 9 fl oz + 8 fl oz	P, B, PF**, SS, 1C-3C** **4C, 5C**, 6C, 7C 18, 2 dph 9 dph	67.0 ab	38.0 ab	29.0 ab
6	**Kumulus 80DF** **Captan 80WDG** Indar 2F + Latron B-1956 Luna Sensation 4.2F	15 lb 3.125 lb 9 fl oz + 8 fl oz 5.0 fl oz	P, B, PF, **SS, 1C-3C** **4C, 5C,** 6C, 7C 18, 2 dph 9 dph	43.0 b	30.0 ab	13.0 b
7	**EcoMate Armicarb "O" 85SP** **Captan 80WDG** Rhyme 2.08SC	5 lb 3.125 lb 6.5 fl oz	P, B, PF**, SS, 1C-3C** **4C, 5C**, 6C, 7C 18, 9, 2 dph	68.0 ab	35.0 ab	33.0 ab
8	**Trilogy 5.46EC** **Captan 80WDG** CX-10370 Iron Soap	1 gal 3.125 lb 1% vol/vol	P, B, PF, **SS, 1C-3C** **4C, 5C**, 6C, 7C 18, 9, 2 dph	63.0 ab	33.0 ab	30.0 ab

[1] Scab treatments, rates, and application timings in **boldface**.
[2] Potassium bicarbonate added to spray water to correct pH for Double Nickel, Serenade, and Armicarb treatments.
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test ($\alpha=0.05$, $K=100$).

Table 5. Brown Rot Harvest and Post-Harvest Incidence [1]						
				% Infected Fruit		
Treatment [2]		**Rate / A**	**Timing**	**Harvest** [3]	**3-DPH** [3]	**6-DPH** [3]
1	Non-treated control	--------	--------	46.7 a	37.6 a	64.8 a
2	Rovral 4F Rovral 4F + Rally 40WSP Rally 40WSP Captan 80WDG **Indar 2F + Latron B-1956**	1.5 pt 1.5 pt + 6 oz 6 oz 3.125 lb 9 fl oz + 8 fl oz	P, B PF SS, 1C-3C 4C-7C **18, 9, 2 dph**	1.9 c	2.0 c	5.0 b
3	Fracture 2.1SC + Latron B-1956 Captan 80WDG **Indar 2F + Latron B-1956** **Fracture 2.1SC + Latron B-1956**	30.5 fl oz + 8 fl oz 3.125 lb 9 fl oz + 8 fl oz 30.5 fl oz + 8 fl oz	P, B, PF, SS, 1C-3C 4C-7C **18, 2 dph** **9 dph**	6.1 bc	5.0 bc	18.0 b
4	Double Nickel 25WDG Captan 80WDG **Oso 0.44SC + Latron B-1956**	3 lb 3.125 lb 6.5 fl oz + 8 fl oz	P, B, PF, SS, 1C-6C 4C-7C **18, 9, 2 dph**	5.2 bc	10.0 bc	21.0 b
5	Serenade Optimum 26.2WP Captan 80WDG **Luna Sensation 4.2F** **Indar 2F + Latron B-1956**	20.0 oz 3.125 lb 5.0 fl oz 9 fl oz + 8 fl oz	P, B, PF, SS, 1C-3C 4C-7C **18, 2 dph** **9 dph**	5.4 bc	2.0 c	5.0 b
6	Kumulus 80DF Captan 80WDG **Indar 2F + Latron B-1956** **Luna Sensation 4.2F**	15 lb 3.125 lb 9 fl oz + 8 fl oz 5.0 fl oz	P, B, PF, SS, 1C-3C 4C-7C **18, 2 dph** **9 dph**	4.2 bc	3.0 c	5.0 b
7	EcoMate Armicarb "O" 85SP Captan 80WDG **Rhyme 2.08SC**	5 lb 3.125 lb 6.5 fl oz	P, B, PF, SS 1C-3C 4C-7C **18, 9, 2 dph**	9.3 bc	4.0 c	18.0 b
8	Trilogy 5.46EC Captan 80WDG **CX-10370 Iron Soap**	1 gal 3.125 lb 1% vol/vol	P, B, PF, SS, 1C-3C 4C-7C **18, 9, 2 dph**	21.2 ab	19.0 ab	53.0 a

[1] Brown rot treatments, rates, and application timings in **boldface**; **dph** = days pre-harvest; **DPH** = days post-harvest.
[2] Potassium bicarbonate added to spray water to correct pH for Double Nickel, Serenade, and Armicarb treatments.
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

MANAGEMENT OF PEACH BLOSSOM BLIGHT AND RUSTY SPOT

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This field study examined several fungicides of different chemistry for their ability to manage both peach blossom blight and rusty spot. The fungicides Rhyme, Oso, and Iron Soap were applied alone to determine their efficacy against both diseases. Rhyme and Luna Sensation were also applied in alternation with Rovral during bloom to examine the efficacy of these integrated programs for management of blossom blight.

In addition to the above treatments, a blossom blight program with Vangard at pink, Rovral at full bloom, and Rally at a high rate at petal fall was included in the study. Rally is not normally used for blossom blight, but the petal fall timing is also the first application for rusty spot. Thus, if a high rate of Rally can provide acceptable control of blossom blight, then this one fungicide can be used at that timing for both diseases.

The study had two types of standard programs for blossom blight control: (i) a single chemistry using Rovral for all bloom applications; and (ii) a multi-chemistry program using Vangard, Rovral, and Vangard + Rally for the three bloom sprays at pink, full bloom, and petal fall, respectively. Rally applied at petal fall through third cover served as the standard for rusty spot control.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2016 growing season. The test block consisted of a 20-year-old 'Encore' peach orchard planted at 25 ft x 25 ft spacing.

Sub-freezing temperatures (22°F) during full bloom on 6 April caused considerable flower kill. Initially, a sufficient number of unopened flowers were thought to have survived the freeze to allow a full-season fungicide efficacy study. However, many apparently healthy fruit dropped in June, leaving enough fruit for a rusty spot assessment but insufficient fruit for brown rot evaluation. Consequently, most of the preharvest treatments originally planned for this study were moved to an 'Autumnglo' peach block that had adequate fruit for rot evaluation; see that report for results.

Treatments. Fungicide treatments were replicated four times in a randomized complete block design with single tree plots. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.5 mph was used for applications. A bud-swell application, typically Ziram, was <u>not</u> applied for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing are shown in Table 1.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 5 July by examining 20 shoots per tree for the presence of cankers. Rusty spot (*Podosphaera leucotricha*) was evaluated on 22 June by examining 40 fruit per tree. The total number of lesions per fruit were counted for estimation of incidence and severity.

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 23X data logger located at the research station. This weather station is part of the Mesonet Network operated by the Office of the NJ State Climatologist. Observations were taken every two minutes and summarized every hour. Hourly temperature and rainfall data were averaged and summed, respectively, for each day of the growing season (Table 1).

Statistical Analysis. Analyses of variance (ANOVA) and treatment mean comparisons were performed using the General Linear Models (GLM) procedure of SAS v9.4. The Bayesian Waller-Duncan means test was used to compare treatment means. Arcsin and log transformations were performed as needed for proportions and lesion count data, respectively, to correct for departures from the ANOVA assumptions.

RESULTS AND DISCUSSION

Environment. Bloom began in late March 2016, about a week ahead of normal. A total of eight days with rainfall ≥ 0.10 inches occurred during the susceptible period between pink and shuck split (Table 1). Although air temperatures were well below optimum for blossom blight infection (77°F), adequate moisture was available from these rainfalls to allow some infection at lower temperatures (as low as 41°F).

Frequent rains between petal fall (PF) and third cover (3C) generally discourage development of rusty spot. However, warmer temperatures (70's) during the second half of May through June, plus the moderate susceptibility of 'Encore' provided conditions favorable for epidemic development.

Blossom Blight. Blossom blight disease pressure in the Encore block was low relative to pressure observed in other blocks. Only 12.5% of flowering shoots on control trees were observed to have blossom blight cankers (Table 2). In contrast, 64% and 70% of non-treated shoots had canker in the 'Autumnglo' and 'Suncrest' blocks, respectively.

Two factors may have contributed to the difference in blossom blight canker development between orchard blocks. Flowers on the later blooming Autumnglo and Suncrest trees experienced additional rainfalls at warmer temperatures, thereby resulting in higher cankers incidences. Also, earlier infections of the Encore flowers may have predisposed them to injury from the 6 April freeze, thereby reducing the number of successful infections that lead to canker development.

Under the unusual weather and infection conditions of the study, the Vangard / Rovral / Rally and the Luna Sensation / Rovral / Luna Sensation programs had disease levels that were not significantly different from the non-treated control (Table 2). These three treatments provided only 30%, and 40% control of blossom blight, respectively.

Increasing the Rally application rate to 6.0 oz/A, the highest allowed by the label, was insufficient to provide adequate blight control for that program. Note the Vangard / Rovral / Vangard + Rally program had significant less disease than the control, providing 70% control.

The low 40% disease control exerted by the Luna Sensation / Rovral / Luna Sensation program was unexpected. This same exact program in 2015 provided 94% control under much heavier disease pressure (68% of non-treated shoots with canker).

All remaining treatments yielded significantly lower canker incidence levels than the non-treated control and were not significantly different from each other (Table 2). The levels of disease control were: Rovral / Rhyme / Rovral (60%); Rovral / Luna Sensation / Rovral (70%); Rhyme (70%); Oso (80%); and the Rovral standard (90%).

The Iron Soap was not applied during bloom (late arrival), so evaluation was not possible.

Rusty Spot. Disease pressure for rusty spot development was good to very good. Approximately 39% of non-treated control fruit were infected with an average of 0.44 lesions per fruit (Table 3). This disease level is near the upper maximum expected for a moderately susceptible cultivar such as Encore. In comparison, the highly susceptible Autumnglo cultivar had 80% fruit infection this season.

The most effective rusty spot treatments, applied from petal fall (PF) through third cover (3C), were the two Rally standards (trts 3 & 9) and Rhyme. These treatments were not significantly different from each other. The highest level of control, 95%, was observed when Rally was applied at 6 oz/A at PF with all subsequent applications at 5 oz/A. Rally applied at 5 oz/A for all five sprays yielded a lower but very acceptable 90% control.

Rhyme fungicide (flutriafol; DMI) provided excellent management of rusty spot, yielding 93% control. The current Rhyme label does not list peach rusty spot; if future findings confirm its efficacy, then addition to the label would be warranted. Oso significantly reduced disease levels, but was not as effective as Rally or Rhyme. Oso provided 55% control. Finally, Iron Soap provided only 15% control. However, this treatment lacked the critical PF spray, so further testing is needed.

All treatments that had *only* captan applied from shuck split (SS) through third cover (3C) were not designed for evaluation of rusty spot control. These treatments yielded only 31 to

40% control. Captan is not effective for control of rusty spot. In these treatments, the captan was applied as a maintenance material for control of scab. The level of rusty spot control achieved by these treatments was most likely due to the test material applied at petal fall.

Table 1. Weather and spray timings for 2016 growing season at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stage. Units for daily average air temperature and rainfall accumulation are ºF and inches.

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
25-Mar	62	0.01	**Pink**	26-Apr	68	0.05		28-May	76	0	
26-Mar	47	0		27-Apr	50	0		29-May	73	1.06	
27-Mar	49	0		28-Apr	47	0.07		30-May	72	0.64	
28-Mar	54	0.48		29-Apr	47	0.01	**ShuckSplit**	31-May	75	0	
29-Mar	50	0		30-Apr	51	0		1-Jun	74	0	
30-Mar	44	0		1-May	49	0.45		2-Jun	70	0	
31-Mar	62	0		2-May	56	0.16		3-Jun	68	0.44	
1-Apr	68	0.20		3-May	55	0.47		4-Jun	71	0	
2-Apr	55	0.25		4-May	50	0.01		5-Jun	72	0.47	
3-Apr	39	0.03		5-May	51	0		6-Jun	75	0	**3rd Cover**
4-Apr	50	0.12		6-May	50	1.11		7-Jun	74	0.09	
5-Apr	35	0		7-May	53	0.17		8-Jun	62	0.10	
6-Apr	39	0	**Bloom**	8-May	58	0		9-Jun	64	0	
7-Apr	54	0.54		9-May	57	0		10-Jun	65	0	
8-Apr	44	0		10-May	55	0		11-Jun	75	0	
9-Apr	35	0.75		11-May	56	0.31	**1st Cover**	12-Jun	81	0	
10-Apr	38	0		12-May	64	0		13-Jun	68	0	
11-Apr	54	0		13-May	62	0.17		14-Jun	69	0	
12-Apr	55	0.29		14-May	62	0.15		15-Jun	68	0	
13-Apr	46	0		15-May	52	0		16-Jun	65	0.86	
14-Apr	46	0	**Petal Fall**	16-May	53	0		17-Jun	69	0	
15-Apr	47	0		17-May	54	0.30		18-Jun	69	0	
16-Apr	49	0		18-May	57	0		19-Jun	76	0	
17-Apr	52	0		19-May	61	0		20-Jun	77	0	
18-Apr	61	0		20-May	62	0		21-Jun	74	0.19	
19-Apr	62	0		21-May	56	0.72		22-Jun	75	0	
20-Apr	55	0		22-May	57	0.21		23-Jun	73	0.50	
21-Apr	57	0		23-May	61	0.23		24-Jun	70	1.67	
22-Apr	67	0		24-May	67	0.13	**2nd Cover**	25-Jun	72	0	
23-Apr	60	0.39		25-May	72	0		26-Jun	71	0	
24-Apr	54	0		26-May	75	0		27-Jun	71	0	
25-Apr	59	0		27-May	78	0		28-Jun	74	0.66	

Table 2. Blossom Blight Canker Incidence and Severity [1]

Treatment		Rate / A	Timing	% Shoots w. Canker [2]	# Cankers per Shoot [2]
1	Non-treated control	--------	--------	12.5 ab	0.14 ab
2	**Rovral 4F** Captan 80WDG	**1.5 pt** 3.125 lb	**P, B, PF** SS, 1C-3C	1.3 d	0.01 c
3	**Vangard 75WG** **Rovral 4F** **Vangard 75WG + Rally 40WSP** Bravo Ultrex 82.5WDG + Rally 40WSP Captan 80WDG + Rally 40WSP	**5 oz** **1.5 pt** **5 oz + 5 oz** 3.3 lb + 5 oz 3.125 lb + 5 oz	**P** **B** **PF** SS 1C-3C	3.8 cd	0.06 bc
4	**Rhyme 2.08SC** Rhyme 2.08SC	**6.5 fl oz** 6.5 fl oz	**P, B, PF** SS, 1C-3C	3.8 cd	0.04 c
5	**Rovral 4F** **Rhyme 2.08SC** Captan 80WDG	**1.5 pt** **6.5 fl oz** 3.125 lb	**P, PF** **B** SS, 1C-3C	5.0 cd	0.06 bc
6	**Luna Sensation 4.2F** **Rovral 4F** Captan 80WDG	**5 fl oz** **1.5 pt** 3.125 lb	**P, PF** **B** SS, 1C-3C	7.5 bcd	0.09 bc
7	**Rovral 4F** **Luna Sensation 4.2F** Captan 80WDG	**1.5 pt** **5 fl oz** 3.125 lb	**P, PF** **B** SS, 1C-3C	3.8 cd	0.04 c
8	**Oso 0.44SC + Latron B-1956** Oso 0.44SC + Latron B-1956	**6.5 fl oz + 8 fl oz** 6.5 fl oz + 8 fl oz	**P, B, PF** SS,1C-3C	2.5 cd	0.03 c
9	**Vangard 75WG** **Rovral 4F** **Rally 40WSP** Bravo Ultrex 82.5WD + Rally 40WSP Captan 80WDG + Rally 40WSP	**5.0 oz** **1.5 pt** **6.0 oz** 3.3 lb + 5.0 oz 3.125 lb + 5.0 oz	**P** **B** **PF** SS 1C-3C	8.8 bc	0.10 bc
10	CX-10370 Iron Soap	1% vol/vol	SS, 1C-3C	16.3 a	0.20 a

[1] Blossom blight treatments, rates, and application timings in **boldface**.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 3. Rusty Spot Incidence and Severity[1]					
Treatment		**Rate / A**	**Timing**	**% Infected Fruit**[2]	**# Lesions per Fruit**[2]
1	Non-treated control	--------	--------	38.8 a	0.44 a
2	Rovral 4F **Captan 80WDG**	1.5 pt **3.125 lb**	P, B, **PF** **SS, 1C-3C**	26.3 bc	0.36 ab
3	Vangard 75WG Rovral 4F **Vangard 75WG + Rally 40WSP** **Bravo Ultrex 82.5WDG + Rally40WSP** **Captan 80WDG + Rally 40WSP**	5 oz 1.5 pt **5 oz + 5 oz** **3.3 lb + 5 oz** **3.125 lb + 5 oz**	P B **PF** **SS** **1C-3C**	3.8 d	0.04 c
4	**Rhyme 2.08SC** **Rhyme 2.08SC**	**6.5 fl oz** **6.5 fl oz**	P,B, **PF** **SS, 1C-3C**	2.7 d	0.03 c
5	**Rovral 4F** Rhyme 2.08SC **Captan 80WDG**	**1.5 pt** 6.5 fl oz **3.125 lb**	P, **PF** B **SS, 1C-3C**	25.8 bc	0.28 ab
6	**Luna Sensation 4.2F** Rovral 4F **Captan 80WDG**	**5 fl oz** 1.5 pt **3.125 lb**	P, **PF** B **SS, 1C-3C**	26.9 abc	0.30 ab
7	**Rovral 4F** Luna Sensation 4.2F **Captan 80WDG**	**1.5 pt** 5 fl oz **3.125 lb**	P, **PF** B **SS, 1C-3C**	23.1 bc	0.33 ab
8	Oso 0.44SC + Latron B-1956 **Oso 0.44SC + Latron B-1956**	6.5 fl oz + 8 oz **6.5 fl oz + 8 oz**	P, B **PF, SS, 1C-3C**	17.4 c	0.21 b
9	Vangard 75WG Rovral 4F **Rally 40WSP** **Bravo Ultrex 82.5WD+Rally40WSP** **Captan 80WDG + Rally 40WSP**	5.0 oz 1.5 pt **6.0 oz** **3.3 lb + 5.0 oz** **3.125 lb+5.0 oz**	P B **PF** **SS** **1C-3C**	2.1 d	0.03 c
10	**CX-10370 Iron Soap**	**1% vol/vol**	**SS, 1C-3C**	32.9 ab	0.39 a

[1] Rusty spot treatments, rates, and application timings in **boldface**. Note Iron Soap treatment lacks PF spray.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

PEACH BACTERIAL SPOT CONTROL: COMPARISON OF OXYTETRACYCLINE, KASUGAMYCIN, AND COPPER BACTERICIDES

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Infection of peach fruit by the bacterial spot pathogen *Xanthomonas arboricola* pv. *pruni* results in the formation of blackened, pitted lesions on the fruit epidermis. Infections that occur early in growing season result in larger, deeper pitted lesions, while those that occur in mid-to-late summer tend to be more numerous, but shallow. Infection of foliage, results in the formation of angular, black lesions that eventually shot-hole. If a sufficient number of lesions occur, the leaves become chlorotic and abscise. In disease favorable years, significant crop loss and defoliation can occur on susceptible cultivars.

The purpose of this study was to examine the ability of the antibiotic kasugamycin, sold as Kasumin 2L, to manage bacterial spot on peach. Kasumin is currently registered for use on apple, but not peach. Results from the kasugamycin treatment will be compared to the current copper and antibiotic standards, Kocide 3000 and oxytetracycline (FireLine, Mycoshield). Comparisons will be made using disease incidence, disease severity, and marketable fruit assessments.

In an earlier 2007 study, Kasumin significantly reduced disease incidence by 35% and lesion density 92% when applied at weekly intervals. In a more recent 2015 study, Kasumin failed to provide any significant reduction in fruit disease incidence or lesion density. However, in this latter study, spray intervals were relatively long for an antibiotic (10-11 days) and frequent, heavy rainfalls occurred. Thus, in the current study, a set of rules were followed to determine spray timing based on rainfall probability (from weather forecasts) and time of last bactericide application.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2016 growing season at the Rutgers Agricultural Research and Extension Center. The test block trees consisted of highly susceptible O'Henry cultivar grafted on Halford or Lovell rootstock. Trees were 10-12 years old and planted at 25 ft x 25 ft spacing.

Treatments. Bactericide treatments were replicated four times in a randomized complete block design. Experimental plots consisted of single trees. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.5 mph was used for applications. Insecticides and miticides were applied as needed using a commercial airblast sprayer. A leaf curl application at budswell was not applied. No fungicides were applied during the course of the study. Bactericide treatment application dates and phenological timing are shown in Table 1. The rules followed for timing applications are presented in the Table 1 footnote.

Available water for spraying was acidic (pH=4.8). Thus, an alkaline buffer, potassium carbonate, was used to adjust water pH to 7.0 prior to addition of the copper material, Kocide 3000. This pH correction was not necessary for the two antibiotics.

Assessment. The first fruit disease assessment, which consisted of incidence (% infected fruit) and severity (# lesions per fruit) evaluations, was performed on 27 June. A second assessment, which consisted of fruit disease incidence and marketable fruit evaluations, was conducted on 1 August. A total of 25 fruit were examined per plot during each assessment. For the marketable fruit assessment, fruit were graded based on lesion size and area of fruit surface covered by lesions. Definitions for the grades, which are used commercially by NJ growers, are given in the data table footnotes.

Infection of leaves by the bacterial spot pathogen *X. arboricola* pv. *pruni* results in the formation of leaf spots, shot-holing, and defoliation. A foliar assessment for all three of these symptoms was performed on 25 July. During each assessment, the number of missing leaves and infected leaves (with at least one lesion and/or one shot-hole) were counted on each of ten vegetative shoots per plot. Results were presented as % infected leaves, % abscised leaves, and % infected and abscised leaves. The final variable provides a measure of total foliar damage or loss.

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 23X data logger located at the research station. This weather station is part of the Mesonet Network operated by the Office of the NJ State Climatologist. Observations were taken every two minutes and summarized every hour. Hourly temperature and rainfall data were averaged and summed, respectively, for each day of the growing season (Table 1).

Statistical Analysis. Analyses of variance (ANOVA) and treatment mean comparisons were performed using the General Linear Models (GLM) procedure of SAS v9.4. The Bayesian Waller-Duncan means test was used to compare treatment means. Arcsin and log transformations were performed as needed for proportions and lesion count data, respectively, to correct for departures from the ANOVA assumptions.

RESULTS

Environment. Average daily air temperatures from the first spray at shuck-split (27 Apr) through the 4th cover spray (23 May) were quite cool. Temperatures during this period ranged from 47°F to 64°F with an overall daily mean temperature of 55°F (Tables 1 and 2). These temperatures were well below the optimum range of 75°F to 84°F for growth of the pathogen; hence, little infection probably occurred during this period. However, much warmer conditions with temperatures in the 70's began in late May and continued throughout the remainder of the growing season, thereby providing much opportunity for infection during rainy periods.

The rules used for timing bactericide applications (Table 1 footnote) resulted in a total of 12 sprays at 5- to 11-day intervals, with an average interval of 7.8 days (Table 2). These intervals were considerably shorter than the 10-11 day intervals used in the prior 2015 study. Rainfall totals in the prior study were also much higher, with four intervals having totals ranging from 3.23 to 5.18 inches, whereas the highest total in the current study was 2.33 inches.

Fruit Infection. By 27 June, 38% of non-treated fruit were infected with an average severity of 1.8 lesions per fruit (Table 3). At this mid-point stage in the bacterial spot epidemic, only the oxytetracycline standard (FireLine) was observed to significantly reduce fruit disease incidence and severity. FireLine provided 68% control and reduced lesion density by 78%. In contrast, Kasumin and Kocide provided only 4.5% and 11.8% control, respectively, with 50 to 56% reduction in lesion density.

At approximately one month after the first assessment, the level of fruit disease incidence on non-treated trees had increased to 86% fruit infection (Table 4). All bactericides significantly reduced disease incidence, but the level of control varied. The Kocide 3000 and FireLine standards were the most effective, providing 46% and 51% control, respectively, and were not significantly different from each other. The Kasumin, however, provided an intermediate response, having significantly less disease than the non-treated control, but significantly more than the two standards. At this late stage in the epidemic, Kasumin yielded 27% control.

Results from the marketable fruit assessment mimicked results for disease incidence (Table 4). On non-treated trees, 54% of fruit were saleable (grades 1+2) with 35% grade 1 and 19% grade 2. Trees receiving the Kocide and FireLine standards had significantly greater amounts of grade 1 and saleable (grades 1+2) fruit than the control. Approximately 70 to 72% of fruit for these two standards were grade 1 and 85 to 88% were saleable.

As with the disease incidence results, Kasumin provided an intermediate level of control relative to the standard and control treatments (Table 4). Only 55% of fruit were grade 1 for the Kasumin treatment, which was significantly more than the control, but less than observed for the two standards. However, total saleable fruit (grades 1+2) for the Kasumin treatment was not significantly different from the levels observed for Kocide and FireLine. This outcome was due to the significantly higher amount of fruit recorded in market grade 2 for the Kasumin. Essentially, the increase in grade 23 fruit compensated for the lower amount of grade 1 fruit.

Foliar Infection. On non-treated control trees, more than half the leaves on shoots were infected and nearly one-third had abscised by late July (Table 5). The Kocide and FireLine standards significantly reduced the number of infected leaves and number of infected + abscised leaves. However, only FireLine significantly reduced defoliation. Although Kocide reduced infection, it also causes leaf drop from foliar phytotoxicity; hence the high level of defoliation.

Unlike results observed for fruit disease control, Kasumin did not appear to provide any control of foliar infection (Table 5). No significant differences were observed between the Kasumin foliar disease levels and those of the non-treated control treatment.

CONCLUSION

Kasumin was not as effective as FireLine and Kocide 3000, but did significantly reduce bacterial spot on fruit. Although Kasumin did provide an equivalent amount of total saleable fruit as the standards, the proportion of grade 1 and grade 2 fruit were significantly lower and higher, respectively, than observed for the standards. Thus, crop values may be diminished, even though total saleable fruit may be the same.

Kasumin is not currently registered on peach. Given the intermediate level of fruit disease control and apparent lack of foliar disease control, Kasumin would probably be best deployed in combination with copper bactericides if it were to become available. This combination may provide enhanced control (to be determined). Also, alternation of this mixture with FireLine or Mycoshield would produce a robust program for pathogen resistance management.

Table 1. Weather and spray timings for 2016 growing season at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stage. Units for daily average air temperature and rainfall accumulation are ºF and inches.

Date	Temp	Rain	Spray *	Date	Temp	Rain	Spray *	Date	Temp	Rain	Spray *
1-Apr	68	0.20		1-May	49	0.45		1-Jun	74	0	
2-Apr	55	0.25		2-May	56	0.16	**1st Cover**	2-Jun	70	0	
3-Apr	39	0.03		3-May	55	0.47		3-Jun	68	0.44	
4-Apr	50	0.12		4-May	50	0.01		4-Jun	71	0	
5-Apr	35	0		5-May	51	0		5-Jun	72	0.47	
6-Apr	39	0		6-May	50	1.11		6-Jun	75	0	**6th Cover**
7-Apr	54	0.54		7-May	53	0.17		7-Jun	74	0.09	
8-Apr	44	0		8-May	58	0		8-Jun	62	0.10	
9-Apr	35	0.75		9-May	57	0		9-Jun	64	0	
10-Apr	38	0		10-May	55	0	**2nd Cover**	10-Jun	65	0	
11-Apr	54	0		11-May	56	0.31		11-Jun	75	0	
12-Apr	55	0.29		12-May	64	0		12-Jun	81	0	
13-Apr	46	0		13-May	62	0.17		13-Jun	68	0	
14-Apr	46	0		14-May	62	0.15		14-Jun	69	0	
15-Apr	47	0		15-May	52	0		15-Jun	68	0	**7th Cover**
16-Apr	49	0		16-May	53	0		16-Jun	65	0.86	
17-Apr	52	0		17-May	54	0.30	**3rd Cover**	17-Jun	69	0	
18-Apr	61	0		18-May	57	0		18-Jun	69	0	
19-Apr	62	0		19-May	61	0		19-Jun	76	0	
20-Apr	55	0		20-May	62	0		20-Jun	77	0	
21-Apr	57	0		21-May	56	0.72		21-Jun	74	0.19	
22-Apr	67	0		22-May	57	0.21		22-Jun	75	0	
23-Apr	60	0.39		23-May	61	0.23	**4th Cover**	23-Jun	73	0.50	
24-Apr	54	0		24-May	67	0.13		24-Jun	70	1.67	**8th Cover**
25-Apr	59	0		25-May	72	0		25-Jun	72	0	
26-Apr	68	0.05		26-May	75	0		26-Jun	71	0	
27-Apr	50	0	**Shuck split**	27-May	78	0		27-Jun	71	0	
28-Apr	47	0.07		28-May	76	0		28-Jun	74	0.66	
29-Apr	47	0.01		29-May	73	1.06		29-Jun	75	0	
30-Apr	51	0		30-May	72	0.64		30-Jun	73	0	
				31-May	75	0	**5th Cover**				

Table 1 – continued –

Date	Temp	Rain	Spray *	Date	Temp	Rain	Spray *	Date	Temp	Rain	Spray *
1-Jul	74	0.12	**9th Cover**	12-Jul	75	0	**10th Cover**	22-Jul	81	0	**11th Cover**
2-Jul	72	0		13-Jul	75	0.16		23-Jul	83	0	
3-Jul	68	0		14-Jul	83	0		24-Jul	80	0	
4-Jul	71	0.57		15-Jul	82	0		25-Jul	83	0.09	
5-Jul	78	0.32		16-Jul	80	0.10		26-Jul	81	0.01	
6-Jul	81	0		17-Jul	79	0		27-Jul	82	0	
7-Jul	82	0		18-Jul	80	0.25		28-Jul	78	0.78	
8-Jul	81	0		19-Jul	79	0		29-Jul	77	0.79	
9-Jul	74	0.34		20-Jul	74	0.21		30-Jul	77	0.12	
10-Jul	75	0		21-Jul	76	0		31-Jul	80	0.16	
11-Jul	73	0									

* **Application Timing Rules**

- First Application at ~ 5% shuck split
- Subsequent sprays at 10-day intervals while daily rainfall chance < 50 %
- If daily chance of rainfall is forecasted ≥ 50% then:
  1. If last spray ≥ 5 days ago & daily rainfall chance ≥ 70%, then apply next spray
  2. If last spray ≥ 7 days ago & daily rainfall chance is 50% to 69%, then apply next spray

TABLE 2. Average air temperature, rainfall frequency, and total rainfall during bactericide spray intervals resulting from application timing rules					
Bactericide Application Interval			Ave. Temp.	# Rains	Rainfall
Spray Dates	**Phenology**	**Length (d)**	**°F**	**≥ 0.10 in**	**Total (in)**
27 Apr – 1 May	SS – 1C	5	48.8	1	0.52
2 May – 9 May	1C – 2C	8	53.8	4	1.92
10 May – 16 May	2C – 3C	7	57.7	4	0.93
17 May – 22 May	3C – 4C	6	57.8	4	1.56
23 May – 30 May	4C – 5C	8	71.8	4	2.06
31 May – 5 Jun	5C – 6C	6	71.7	2	0.91
6 Jun – 14 Jun	6C – 7C	9	70.3	1	0.19
15 Jun – 23 Jun	7C – 8C	9	71.8	2	1.55
24 Jun – 30 Jun*	8C – 9C	7	72.3	2	2.33
1 Jul – 11 Jul	9C – 10C	11	75.4	4	1.35
12 Jul – 21 Jul	10C – 11C	10	78.3	4	0.72
22 Jul – 31 Jul**	11C + 10 days	10	80.2	4	1.95

* First fruit assessment on 27 June
** Second fruit assessment on 1 August

TABLE 3. Bacterial Spot on Fruit: Assessment #1 (27 June)				
Treatment	**Rate / A**	**Timing**	**% Infected Fruit [1]**	**# Lesions / Fruit [1]**
Non-treated control	--------	------	38.0 a	1.8 a
Copper and Antibiotic Standards				
Kocide 3000 30DF [2]	1.7 oz	SS, 1C-11C	33.5 a	0.8 ab
FireLine 17WP	1.5 lb	SS, 1C-11C	12.0 b	0.4 b
Experimental Treatment				
Kasumin 2L + Regulaid	64 fl oz + 1 pt	SS, 1C-11C	36.3 a	0.9 ab

[1] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100.

[2] Spray water adjusted to pH=7.0 with potassium carbonate prior to addition of bactericide.

TABLE 4. Bacterial Spot on Fruit: Assessment #2 (1 August)							
				% Fruit in Category [1, 2]			
Treatment	**Rate/A**	**Timing**	**% Infected Fruit[2]**	**Market Grade 1**	**Market Grade 2**	**Grades 1 + 2**	**Cull**
Non-treated control	--------	------	86.0 a	35.0 c	19.0 ab	54.0 b	46.0 a
Copper and Antibiotic Standards							
Kocide 3000 30DF*	1.7 oz	SS, 1C-11C	46.5 c	70.1 a	14.6 b	84.7 a	15.3 b
FireLine 17WP	1.5 lb	SS, 1C-11C	42.0 c	72.0 a	16.0 b	88.0 a	12.0 b
Experimental Treatment							
Kasumin 2L + Regulaid	64 fl oz + 1 pt	SS, 1C-11C	63.0 b	55.0 b	22.0 a	77.0 a	23.0 b

[1] Market grade 1 = total lesion area no larger than 1/8" diameter; market grade 2 = total lesion area no larger than 3/16" diameter and no single lesion larger than 1/8"; cull = total lesion area larger than 3/16" and/or single lesion larger than 1/8".

[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

[4] Spray water adjusted to pH=7.0 with potassium carbonate prior to addition of bactericide.

TABLE 5. Bacterial Spot on Foliage: 25 July					
Treatment	**Rate / A**	**Timing**	**% Infected Leaves [1, 2]**	**% Abscised Leaves [1, 2]**	**% Infected & Abscised Leaves [1, 2]**
Non-treated control	--------	------	57.6 a	28.0 a	67.5 a
Copper and Antibiotic Standards					
Kocide 3000 30 DF [3]	1.7 oz	SS, 1C-11C	27.0 b	31.0 a	49.1 b
Fireline 17WP	1.5 lb	SS, 1C-11C	30.3 b	12.2 b	36.9 b
Experimental Treatment					
Kasumin 2L + Regulaid	64 fl oz + 1 pt	SS, 1C-11C	67.1 a	37.0 a	77.4 a

[1] Infected leaves = leaves with at least one lesion and/or one shot-hole; abscised leaves are missing leaves

[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

[3] Spray water adjusted to pH=7.0 with potassium carbonate prior to addition of bactericides.

FULL SEASON MANAGEMENT OF PEACH DISEASES: COMPARISON OF DIFFERENT FUNGICIDE CHEMISTRIES

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This field study examined the efficacy of five conventional fungicides for full season management of peach diseases. Fungicides tested were Torino at three different rates (cyflufenamid; phenyl-acetamide); Scala (pyrimethanil; AP); Luna Privilege (fluopyram; SDHI); Inspire (difenoconazole; DMI); and Indar (fenbuconazole; DMI).

The standard used for blossom blight control was a Vangard, Rovral, and Vangard + Rally program at pink, bloom, and petal fall timings, respectively. The standard for rusty spot control was Rally at petal fall through second cover. The standard for scab control was Bravo Ultrex at shuck-split followed by captan cover sprays. And, finally, the standard for brown rot control was a multi-chemistry program of Gem, Indar, and Fontelis at 17-, 8-, and 1-day before harvest, respectively.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2016 growing season. The test block consisted of a 21-year-old 'Suncrest' peach orchard planted at 25 ft x 25 ft spacing.

Treatments. Fungicide treatments were replicated four times in a randomized complete block design with single tree plots. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.5 mph was used for applications. A bud-swell application, typically Ziram, was not applied for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing are shown in Table 1.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 19 July by examining 20 shoots per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 20 June by examining 40 fruit per tree. Scab (*Fusicladium carpophilum*) was evaluated on 29 July by examining 25 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 11 Aug by examining all fruit on arbitrarily selected branches (~ 75 fruit / tree). For postharvest evaluations, 25 asymptomatic uninjured fruit were harvested from each replicate tree and placed on benches in a shaded greenhouse. Brown rot and other rots were evaluated at 3 and 6 days postharvest (DPH).

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 23X data logger located at the research station. This weather station is part of the

Mesonet Network operated by the Office of the NJ State Climatologist. Observations were taken every two minutes and summarized every hour. Hourly temperature and rainfall data were averaged and summed, respectively, for each day of the growing season (Table 1).

Statistical Analysis. Analyses of variance (ANOVA) were performed using the General Linear Models (GLM) procedure of SAS v9.4. The Bayesian Waller-Duncan test was used to compare treatment means. Arcsin and log transformations were performed as needed for proportions and lesion count data, respectively, to correct for departures from the ANOVA assumptions.

RESULTS AND DISCUSSION

Environment. Bloom began in late March 2016, about a week ahead of normal. Air temperatures were somewhat cooler, but more than adequate moisture was available for considerable blossom blight infection. Eight days with rainfall ≥ 0.10 inches occurred during the bloom period from 24 Mar (pink) through shuck-split on 27 Apr (Table 1). Rain also occurred a few days before the pink spray, at which time 6% of flowers were open.

Conditions were also favorable for scab. A total of 27 days with rainfall ≥ 0.10 inches occurred between shuck-split and 6C (mid-July), the infectious period for scab (Table 1). However, only four days with significant rain (28-31 Jul) occurred during the preharvest fruit ripening period. Nevertheless, given the high inoculum levels in the orchard from blossom blight cankers, this amount of moisture was sufficient for creating medium to high brown rot pressure at harvest.

Blossom Blight. Blossom blight disease pressure in 2016 was very high in the test block. On non-treated control trees, 70% of shoots were infected with an average of 2 cankers per shoot (Table 2). . In comparison, canker incidence in this block in 2009, 2010, 2011, and 2013 was 10, 24, 15, and 26%, respectively. Only disease levels in 2012, a record 87.5% shoot incidence with an average 2.8 cankers per shoot, were higher than the current growing season

Regardless of the high disease pressure, all treatments significantly reduced canker incidence and severity (Table 2). The two most effective treatments, based on both disease incidence and severity, were the standard (Vangard / Rovral / Vangard + Rally) and Indar, which both provided 48% control. Four other treatments had disease incidence and severity levels that were not significantly different from the standard and Indar: Torino – high rate (39% control); Luna Privilige (38% control); Torino – low rate (34% control); and Inspire (34% control). The two least effective treatments, which had disease incidence levels significantly greater than the standard, were Torino – medium rate and Scala, which only provided 25% and 23% control, respectively.

Although all treatments reduced disease development, the degree of control – including that of the standard - was below accepted commercial levels. The cause for this outcome is unknown. One possibility may be that 34% of flowers opened between the Pink spray (6% open) and the full bloom spray (40% open). A large number of these unprotected flowers may have gotten infected during the rains on 1 and 2 April, immediately before the bloom spray was applied. There was much overwintering inoculum in the orchard from many mummies in the tree canopies.

Another possible explanation for the low level of control may be that the efficacy of the standard program was inadequate for the disease pressure encountered. In past studies, Vangard / Rovral / Vangard programs, while effective for commercial disease levels (5-20% shoots w. canker), have not performed as well as all Rovral programs under heavy disease pressure. However, like Rovral, Indar and Inspire [Super] are also rated excellent for blossom blight control and they- did not perform well in the study.

Rusty Spot. Disease pressure for rusty spot development was high in 2016. Approximately 49% of non-treated control fruit were infected with an average of 0.67 lesions per fruit (Table 3). This disease level is near the maximum expected for a moderately susceptible cultivar such as Suncrest. In comparison, the highly susceptible Autumnglo cultivar had 80% fruit infection this season.

All treatments significantly reduced both disease incidence and lesion density, but considerable differences were observed among treatments (Table 3). The most effective treatments were Inspire and Rally (standard), which were not significantly different from each other and provided 73% and 81% control, respectively. All other treatments, which had significantly higher levels of disease incidence than the Rally standard, provided control ranging from 60% for Indar to only 24% for Scala.

No significant differences were observed among the three Torino rates for either disease measure. However, numerically, increasing the rate from low to medium to high resulted in successive reductions in lesion density; the high rate had 35% fewer lesions per fruit than the low rate. Also, the lesion density for the Torino high rate treatment was statistically equivalent to that observed for the Rally standard. These results suggest that even higher rates may further improve rusty spot control.

Scab. Disease pressure for peach scab was very high. On non-treated control trees, 100% of fruit were infected with 99% of those fruit having > 10 lesions (Table 4).

The most effective treatment was Inspire, which provided 97% control and only 3% of infected fruit with 1-10 lesions / fruit (Table 4). Indar and the Bravo / Captan standard were the next most effective treatments, yielding 74% and 66% control, respectively.

The three Torino treatments, Scala, and Luna Privilege were the least effective, providing 0 to 8% control. These materials had disease incidence levels not significantly different from the non-treated control.

Brown Rot. Brown rot disease pressure was moderately high at harvest. Approximately 56% of fruit on control trees had brown rot (Table 5). Although disease pressure was high, all fungicide programs significantly reduced rot development, although the level of control was low for some treatments.

Indar, the Gem / Indar / Fontelis standard, and Inspire treatments were the most effective, yielding 89%, 89%, and 85% control, respectively. The tree Torino treatments, Scala, and Luna Privilege had significantly more brown rot than the top three treatments. Control levels for these four treatments ranged from 56 to 63%.

After **3- and 6-days incubation** in the post-harvest test, brown rot incidence on control fruit increased to 51% and 95%, respectively (Table 5). Fewer statistical differences were observed among most treatments. Those treatments that did not perform well at harvest were also the least effective in the post-harvest study. However, the Gem / Indar / Fontelis standard continued to provide significantly better control than all other treatments. The standard provided 96% and 82% control of brown rot at the 3-DPH and 6-DPH assessments, respectively.

Past studies have shown that high levels of scab predisposes fruit to brown rot infection, making it difficult for effective fungicides to control the rot. Heavily scabbed fruit, as observed for the Torino, Scala, and Luna Privilege treatments, resulted in fruit cracking during the preharvest period as fruit increased in size. These fissures, which expose unprotected fruit mesocarp, are readily colonized by *M. fructicola*. Such infection also occurs when insects are not controlled during the preharvest period. Thus, it is recommended that the three fungicides be tested for brown rot control either (*i*) in a block with low scab inoculum, or (*ii*) in a program with effective scab fungicides.

Anthracnose. Anthracnose disease pressure is typically low, and often too low for statistical comparison of treatments. However, this season some treatment differences were observed at harvest (Table 6).

On non-treated control trees, 1.6% of fruit were observed with anthracnose (Table 6). Most treatments did not significantly reduce anthracnose levels. However, the standard (Captan) and Scala treatments did reduce anthracnose, providing 100% and 81% control, respectively.

Other Rots. Very low levels of fruit rots from *Rhizopus*, *Phomopsis*, or *Botryosphaeria* spp. were observed at harvest and during the post-harvest study. Disease levels were inadequate for comparison.

Table 1. Weather and spray timings for 2016 growing season at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stage. Units for daily average air temperature and rainfall accumulation are ºF and inches.

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Mar	50	0		1-Apr	68	0.20		1-May	49	0.45	
2-Mar	43	0.17		2-Apr	55	0.25		2-May	56	0.16	
3-Mar	32	0		3-Apr	39	0.03	**Bloom**	3-May	55	0.47	
4-Mar	32	0.20		4-Apr	50	0.12		4-May	50	0.01	
5-Mar	33	0		5-Apr	35	0		5-May	51	0	
6-Mar	34	0		6-Apr	39	0		6-May	50	1.11	
7-Mar	44	0		7-Apr	54	0.54		7-May	53	0.17	
8-Mar	57	0		8-Apr	44	0		8-May	58	0	
9-Mar	59	0		9-Apr	35	0.75		9-May	57	0	**1st Cover**
10-Mar	65	0		10-Apr	38	0		10-May	55	0	
11-Mar	60	0		11-Apr	54	0		11-May	56	0.31	
12-Mar	48	0		12-Apr	55	0.29		12-May	64	0	
13-Mar	49	0.26		13-Apr	46	0	**Petal Fall**	13-May	62	0.17	
14-Mar	47	0.78		14-Apr	46	0		14-May	62	0.15	
15-Mar	46	0		15-Apr	47	0		15-May	52	0	
16-Mar	53	0		16-Apr	49	0		16-May	53	0	
17-Mar	52	0		17-Apr	52	0		17-May	54	0.30	
18-Mar	52	0		18-Apr	61	0		18-May	57	0	
19-Mar	39	0.06		19-Apr	62	0		19-May	61	0	
20-Mar	36	0.20		20-Apr	55	0		20-May	62	0	**2nd Cover**
21-Mar	39	0.01		21-Apr	57	0		21-May	56	0.72	
22-Mar	44	0		22-Apr	67	0		22-May	57	0.21	
23-Mar	57	0		23-Apr	60	0.39		23-May	61	0.23	
24-Mar	59	0	**Pink**	24-Apr	54	0		24-May	67	0.13	
25-Mar	62	0.01		25-Apr	59	0		25-May	72	0	
26-Mar	47	0		26-Apr	68	0.05		26-May	75	0	
27-Mar	49	0		27-Apr	50	0	**Shuck split**	27-May	78	0	
28-Mar	54	0.48		28-Apr	47	0.07		28-May	76	0	
29-Mar	50	0		29-Apr	47	0.01		29-May	73	1.06	
30-Mar	44	0		30-Apr	51	0		30-May	72	0.64	
31-Mar	62	0						31-May	75	0	

Table 1 - *continued* -

Date	Temp	Rain	Spray
1-Jun	74	0	
2-Jun	70	0	**3rd Cover**
3-Jun	68	0.44	
4-Jun	71	0	
5-Jun	72	0.47	
6-Jun	75	0	
7-Jun	74	0.09	
8-Jun	62	0.10	
9-Jun	64	0	
10-Jun	65	0	
11-Jun	75	0	
12-Jun	81	0	
13-Jun	68	0	
14-Jun	69	0	
15-Jun	68	0	**4th Cover**
16-Jun	65	0.86	
17-Jun	69	0	
18-Jun	69	0	
19-Jun	76	0	
20-Jun	77	0	
21-Jun	74	0.19	
22-Jun	75	0	
23-Jun	73	0.50	
24-Jun	70	1.67	
25-Jun	72	0	
26-Jun	71	0	
27-Jun	71	0	
28-Jun	74	0.66	
29-Jun	75	0	**5th Cover**
30-Jun	73	0	

Date	Temp	Rain	Spray
1-Jul	74	0.12	
2-Jul	72	0	
3-Jul	68	0	
4-Jul	71	0.57	
5-Jul	78	0.32	
6-Jul	81	0	
7-Jul	82	0	
8-Jul	81	0	
9-Jul	74	0.34	
10-Jul	75	0	
11-Jul	73	0	
12-Jul	75	0	
13-Jul	75	0.16	**6th Cover**
14-Jul	83	0	
15-Jul	82	0	
16-Jul	80	0.10	
17-Jul	79	0	
18-Jul	80	0.25	
19-Jul	79	0	
20-Jul	74	0.21	
21-Jul	76	0	
22-Jul	81	0	
23-Jul	83	0	
24-Jul	80	0	
25-Jul	83	0.09	**17-dph**
26-Jul	81	0.01	
27-Jul	82	0	
28-Jul	78	0.78	
29-Jul	77	0.79	
30-Jul	77	0.12	
31-Jul	80	0.16	

Date	Temp	Rain	Spray
1-Aug	76	0.05	
2-Aug	74	0.01	
3-Aug	71	0	**8-dph**
4-Aug	72	0	
5-Aug	73	0	
6-Aug	80	0	
7-Aug	77	0	
8-Aug	75	0	
9-Aug	77	0	
10-Aug	83	0	**1-dph**
11-Aug	85	0	**Harvest**
12-Aug	86	0	
13-Aug	87	0	
14-Aug	87	0	
15-Aug	83	0.01	
16-Aug	82	0.02	
17-Aug	83	0.05	
18-Aug	78	0.39	
19-Aug	78	0.02	
20-Aug	77	0	
21-Aug	76	0.91	
22-Aug	73	0	
23-Aug	68	0	
24-Aug	72	0	
25-Aug	76	0	
26-Aug	82	0	
27-Aug	79	0	
28-Aug	76	0	
29-Aug	78	0	
30-Aug	77	0	
31-Aug	77	0	
dph = days pre-harvest			

Table 2. Blossom Blight Canker Incidence and Severity [1]					
Treatment		Rate / A	Timing	% Shoots w. Canker [2]	# Cankers per Shoot [2]
1	Non-treated control	--------	--------	70.0 a	1.96 a
2	**Vangard 75WG** **Rovral 4F** **Vangard 75WG + Rally 40WSP** Bravo Ultrex 82.5WDG + Rally 40WSP Captan 80WDG + Rally 40WSP Captan 80WDG Gem 500SC Indar 2F + Latron B-1956 Fontelis 1.67SC	**5 oz** **1.5 pt** **5 oz + 5 oz** 3.3 lb + 5 oz 3.125 lb + 5 oz 3.125 lb 3.8 fl oz 9 fl oz + 8 fl oz 20 fl oz	**P** **B** **PF** SS 1C, 2C 3C-6C 17 dph 8 dph 1 dph	36.3 c	0.65 c
3	**Torino 0.85SC + Latron B-1956**	**6.0 fl oz + 8 fl oz**	**P, B, PF**, SS 1C-6C 17, 8, 1 dph	46.3 bc	0.76 bc
4	**Torino 0.85SC + Latron B-1956**	**9.0 fl oz + 8 fl oz**	**P, B, PF,** SS, 1C-6C, 17, 8, 1 dph	52.5 b	1.19 b
5	**Torino 0.85SC + Latron B-1956**	**12 fl oz + 8 fl oz**	**P, B, PF,** SS 1C-6C 17, 8, 1 dph	42.5 bc	0.76 bc
6	**Scala 5SC** Scala 5SC Scala 5SC	**14.0 fl oz** 14.0 fl oz 18.0 fl oz	**P, B, PF,** SS 1C-6C 17, 8, 1 dph	53.8 b	0.93 bc
7	**Luna Privilege 4.16F**	**2.82 fl oz**	**P, B, PF,** SS 1C-6C, 17, 8, 1 dph	43.8 bc	0.94 bc
8	**Inspire 2.08EC**	**7.0 fl oz**	**P, B, PF,** SS 1C-6C 17, 8, 1 dph	46.3 bc	0.91 bc
9	**Indar 2F**	**9.0 fl oz**	**P, B, PF,** SS 1C-6C 17, 8, 1 dph	36.3 c	0.66 c

[1] Blossom blight treatments, rates, and application timings in **boldface**.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 3. Rusty Spot Incidence and Severity[1]					
Treatment		**Rate / A**	**Timing**	**% Infected Fruit**[2]	**# Lesions per Fruit**[2]
1	Non-treated control	--------	--------	48.8 a	0.67 a
2	Vangard 75WG Rovral 4F **Vangard 75WG +Rally 40WSP** **Bravo Ultrex 82.5WDG + Rally 40WSP** **Captan 80WDG + Rally 40WSP** Captan 80WDG Gem 500SC Indar 2F + Latron B-1956 Fontelis 1.67SC	5 oz 1.5 pt **5 oz + 5 oz** **3.3 lb + 5 oz** **3.125 lb + 5 oz** 3.125 lb 3.8 fl oz 9 fl oz + 8 fl oz 20 fl oz	P B **PF** **SS** **1C, 2C** 3C-6C 17 dph 8 dph 1 dph	9.4 e	0.10 e
3	**Torino 0.85SC + Latron B-1956**	**6.0 fl oz + 8 fl oz**	P, B, **PF, SS** **1C, 2C**, 3C-6C 17, 8, 1 dph	22.5 c	0.33 c
4	**Torino 0.85SC + Latron B-1956**	**9.0 fl oz + 8 fl oz**	P, B, **PF, SS** **1C, 2C** 3C-6C 17, 8, 1 dph	22.5 c	0.26 cd
5	**Torino 0.85SC + Latron B-1956**	**12 fl oz + 8 fl oz**	P, B, **PF, SS** **1C, 2C** ,3C-6C 17, 8, 1 dph	20.0 cd	0.21 cde
6	**Scala 5SC** **Scala 5SC** Scala 5SC	**14.0 fl oz** **14.0 fl oz** 18.0 fl oz	P, B, **PF, SS** **1C, 2C,** 3C-6C 17, 8, 1 dph	36.9 b	0.46 b
7	**Luna Privilege 4.16F**	**2.82 fl oz**	P, B, **PF, SS** **1C, 2C,** 3C-6C 17, 8, 1 dph	23.1 c	0.28 cd
8	**Inspire 2.08EC**	**7.0 fl oz**	P, B, **PF, SS** **1C, 2C**, 3C-6C 17, 8, 1 dph	13.1 de	0.18 de
9	**Indar 2F**	**9.0 fl oz**	P, B, **PF, SS** **1C, 2C**, 3C-6C 17, 8, 1 dph	19.4 cd	0.23 cd

[1] Rusty spot treatments, rates, and application timings in **boldface**.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 4. Scab Incidence and Severity[1]						
					% Fruit with	
Treatment		**Rate / A**	**Timing**	**% Inf Fruit**[2]	**1-10 Les**[2]	**>10 Les**[2]
1	Non-treated control	--------	--------	100 a	1 d	99 a
2	Vangard 75WG Rovral 4F Vangard 75WG +Rally 40WSP **Bravo Ultrex 82.5WDG + Rally40WSP** **Captan 80WDG + Rally 40WSP** **Captan 80WDG** Gem 500SC Indar 2F + Latron B-1956 Fontelis 1.67SC	5 oz 1.5 pt 5 oz + 5 oz **3.3 lb + 5 oz** **3.125 lb + 5 oz** **3.125 lb** 3.8 fl oz 9 fl oz + 8 fl oz 20 fl oz	P B PF **SS** **1C, 2C** **3C-6C** 17 dph 8 dph 1 dph	34 b	22 a	12 c
3	**Torino 0.85SC + Latron B-1956**	**6 fl oz + 8 fl oz**	P, B, PF **SS, 1C-6C** 17, 8, 1 dph	98 a	9 bcd	89 ab
4	**Torino 0.85SC + Latron B-1956**	**9 fl oz + 8 fl oz**	P, B, PF **SS, 1C-6C** 17, 8, 1 dph	100 a	2 cd	98 a
5	**Torino 0.85SC + Latron B-1956**	**12 fl oz + 8 floz**	P, B, PF **SS, 1C-6C** 17, 8, 1 dph	100 a	2 cd	98 a
6	Scala 5SC **Scala 5SC** Scala 5SC	14.0 fl oz **14.0 fl oz** 18.0 fl oz	P, B, PF **SS, 1C-6C** 17, 8, 1 dph	92 a	12 b	80 b
7	**Luna Privilege 4.16F**	**2.82 fl oz**	P, B, PF **SS, 1C-6C** 17, 8, 1 dph	98 a	12 b	86 b
8	**Inspire 2.08EC**	**7.0 fl oz**	P, B, PF **SS, 1C-6C** 17, 8, 1 dph	3 c	3 bcd	0 d
9	**Indar 2F**	**9.0 fl oz**	P, B, PF **SS, 1C-6C** 17, 8, 1 dph	26 b	11 bc	15 c

[1] Scab treatments, rates, and application timings in **boldface**.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 5. Brown Rot Harvest and Post-Harvest Incidence [1]						
				% Infected Fruit [2]		
Treatment		**Rate / A**	**Timing**	**Harvest**	**3-DPH**	**6-DPH**
1	Non-treated control	--------	--------	55.7 a	51.0 a	95.0 a
2	Vangard 75WG Rovral 4F Vangard 75WG +Rally 40WSP Bravo Ultrex 82.5WD + Rally 40WSP Captan 80WDG + Rally 40WSP Captan 80WDG **Gem 500SC** **Indar 2F + Latron B-1956** **Fontelis 1.67SC**	5 oz 1.5 pt 5 oz + 5 oz 3.3 lb + 5 oz 3.125 lb + 5 oz 3.125 lb **3.8 fl oz** **9 fl oz + 8 fl oz** **20 fl oz**	P B PF SS 1C, 2C 3C-6C **17 dph** **8 dph** **1 dph**	6.2 c	2.0 e	17.0 d
3	**Torino 0.85SC + Latron B-1956**	**6 fl oz + 8 fl oz**	P, B, PF, SS 1C-6C **17, 8, 1 dph**	22.5 b	15.0 cd	44.0 bc
4	**Torino 0.85SC + Latron B-1956**	**9 fl oz + 8 fl oz**	P, B, PF, SS, 1C-6C **17, 8, 1 dph**	22.7 b	25.2 bc	59.7 b
5	**Torino 0.85SC + Latron B-1956**	**12 fl oz + 8 floz**	P, B, PF, SS 1C-6C **17, 8, 1 dph**	24.3 b	19.0 bc	55.0 bc
6	Scala 5SC Scala 5SC **Scala 5SC**	14.0 fl oz 14.0 fl oz **18.0 fl oz**	P, B, PF, SS, 1C-6C **17, 8, 1 dph**	24.2 b	16.0 bcd	55.0 bc
7	**Luna Privilege 4.16F**	**2.82 fl oz**	P, B, PF, SS 1C-6C **17, 8, 1 dph**	20.7 b	25.0 b	60.0 b
8	**Inspire 2.08EC**	**7.0 fl oz**	P, B, PF, SS 1C-6C **17, 8, 1 dph**	8.5 c	9.0 d	37.0 c
9	**Indar 2F**	**9.0 fl oz**	P, B, PF, SS 1C-6C **17, 8, 1 dph**	5.9 c	8.0 d	38.0 c

[1] Brown rot treatments, rates, and application timings in **boldface**; **dph** = days pre-harvest; **DPH** = days post-harvest.
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 6. Anthracnose at Harvest [1]				
Treatment		**Rate / A**	**Timing**	**% Infected Fruit**[2]
1	Non-treated control	--------	--------	1.6 a
2	Vangard 75WG Rovral 4F Vangard 75WG +Rally 40WSP Bravo Ultrex 82.5WDG + Rally 40WSP **Captan 80WDG + Rally 40WSP** **Captan 80WDG** Gem 500SC Indar 2F + Latron B-1956 Fontelis 1.67SC	5 oz 1.5 pt 5 oz + 5 oz 3.3 lb + 5 oz **3.125 lb + 5 oz** **3.125 lb** 3.8 fl oz 9 fl oz + 8 fl oz 20 fl oz	P B PF SS **1C, 2C** **3C-6C** 17 dph 8 dph 1 dph	0.0 c
3	**Torino 0.85SC + Latron B-1956**	**6.0 fl oz + 8 fl oz**	P, B, PF, SS **1C, 2C, 3C-6C** 17, 8, 1 dph	2.5 ab
4	**Torino 0.85SC + Latron B-1956**	**9.0 fl oz + 8 fl oz**	P, B, PF, SS, **1C, 2C, 3C-6C** 17, 8, 1 dph	2.6 a
5	**Torino 0.85SC + Latron B-1956**	**12 fl oz + 8 fl oz**	P, B, PF, SS **1C, 2C, 3C-6C** 17, 8, 1 dph	1.6 abc
6	Scala 5SC **Scala 5SC** Scala 5SC	14.0 fl oz **14.0 fl oz** 18.0 fl oz	P, B, PF, SS, **1C, 2C, 3C-6C** 17, 8, 1 dph	0.3 bc
7	**Luna Privilege 4.16F**	**2.82 fl oz**	P, B, PF, SS **1C, 2C, 3C-6C** 17, 8, 1 dph	2.8 ab
8	**Inspire 2.08EC**	**7.0 fl oz**	P, B, PF, SS **1C, 2C, 3C-6C** 17, 8, 1 dph	1.8 abc
9	**Indar 2F**	**9.0 fl oz**	P, B, PF, SS **1C, 2C, 3C-6C** 17, 8, 1 dph	2.6 ab

[1] Anthracnose treatments, rates, and application timings in **boldface**; **dph** = days pre-harvest;
[2] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

EVALUATION OF LOW RATES OF KUDOS AND TWO NEW PROHEXADIONE FORMULATIONS FOR SUPPRESSING SHOOT GROWTH AND FIRE BLIGHT MANAGEMENT

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In 2005, a fire blight epiphytotic destroyed thousands of acres of high density apple orchards in MI, resulting in millions of dollars loss by fruit growers. Similar climatic conditions and orchard planting practices create the same potential magnitude of loss for apple growers in the Mid-Atlantic region today.

Prohexadione calcium (PCa), the active ingredient in Kudos, is labelled for reducing vegetative growth in apple. PCa has long been known to serve a useful purpose in suppressing fire blight infection in apple trees, and is recommended for this purpose. Previously, this beneficial effect was observed in trees where the rate and scheduling of PCa applications were sufficient to suppress shoot growth.

Recent research at Michigan State University has reported that low, non-growth-suppressive rates of PCa can also suppress fire blight infection, when used in a prophylactic manner. The nature of this disease suppression is reportedly related to a thickening of plant cell walls by PCa. Cell wall thickening inhibits the ability of the fire blight bacteria to digest cell walls, the mechanism by which they obtain the nutrients necessary to grow and continue to infect plant tissues.

Fire blight disease suppression would be of great potential benefit in modern high density apple orchards, where close spacing of blight-susceptible cultivars and renewal pruning procedures heighten the risk of tree mortality to fire blight. Many of these orchards are young and the trees are still filling their space. Achieving blight suppression without slowing the development of the bearing surface would be valuable in such orchards. The objective of this study was to evaluate prophylactic sprays of a low rate and a growth-suppressive rate of Kudos on infections caused by simulated shoot blight, and on growth of terminal shoots and renewal shoots of young high density apple trees. A second objective was to evaluate the same effects of two new experimental prohexadione formulations from Fine Chemical.

Materials and Methods:

This study was used moderately vigorous five-year-old Crimson Crisp apple trees grafted on M.9 rootstocks at the Penn State Fruit Research and Extension Center in Biglerville, PA. The trees were pruned to the tall spindle training system, which included renewal-style cuts to generate new primary branches. Treatments included a control, Kudos at 2 oz. per acre, Kudos at 4 oz. per acre, FAL-2040 at 3.6 fl. Oz. per acre, and FAL-2015 at 2 oz. per acre.

All Kudos sprays were applied with LI-700 at 16 fluid ounces per acre, and Choice Weather Master water conditioner at 16 fl. oz. / acre, using an air-blast sprayer calibrated to apply 100 gallons of water per acre. Spray applications were made on 18 Apr at pink, 11 May at petal fall flower stage, 25 May for first cover, and 10 Jun for third cover spray timings. The experiment was designed as a completely random design with four multi-tree replications.

On 26 May, Between petal fall and first cover, shoot blight infection was induced by inoculating five shoot tips/tree by dipping scissors into a bacterial suspension of 10^7 cfu/ml of the *Erwinia amylovora* strain Ea273 and cutting the last two leaves of the shoot tip. Infection rate and severity of natural and induced fire bight shoot infection was evaluated on the current year's growth and the previous year's growth. The number of cankers forming on the central leader (spindle) was counted.

Shoot extension growth of terminal shoots and bourse shoots was measured at the time of inoculation with fire blight, at three additional times during the vegetative growth phase, and a final measure was taken after terminal buds were set. The final length of renewal shoots was measured in October, after extension growth originating from stub cuts was complete. Vegetative growth and disease data was statistically analyzed and tabulated.

Results and Discussion:

The efficacy of regular and reduced rates of Kudos and an experimental compound on vegetative growth and fire blight infection were compared. All formulations and rates of Prohexadione reduced shoot growth by ~40 to ~50% **(Table 1, Figures 1 – 3)**. All Prohexadione treatments were equally effective. The efficacy of the lowest rate of Kudos in reducing shoot growth is unexpected, as the 2 ounce per acre rate is well below that recommended for growth control. The moderate level of vegetative vigor in this orchard may have been more easily managed by Prohexadione than in trees in a high state of vigor. The early initiation of sprays at pink, and the three applications of Prohexadione during the major growth period also may have contributed to this high level of efficacy. Toward the end of the major vegetative flush, the weather turned hot and dry, which likely kept vegetative growth in a quiescent state and thus prevented late shoot growth.

The ability of reduced rates of Kudos and an experimental compound to mitigate shoot blight symptoms were compared. Conditions were conducive for infection at the time of fire blight inoculations and symptoms were moderately severe. Incidence of shoot blight on the control was nearly 100 percent and incidence on all treatments was more than 60 percent. All of the chemical treatments reduced fire blight severity on the current year's growth **(Figure 4)**. The 4 ounce rate of Kudos and the two experimental chemicals reduced fire blight severity significantly more than the 2 ounce rate of Kudos. Similar results were obtained on the previous year's growth on inoculated shoots (**Figure 5**). The 4 ounce Kudos treatment reduced fire blight more than the other treatments, but it was not statistically different from the two experimental chemicals. The only instances where a canker formed on the central leader was when the shoot coming from the leader was the current year's growth. This type of shoot only accounted for four shoots in the entire experiment. Although a small number of these shoots were inoculated, 4/4 shoots were infected and the infection traveled to the central leader. The could suggest that PCa may not impact this type of shoot; however, we do not know if there are differences of effect the PCa on this growth versus new growth emerging from shoots that had one-year-old or older wood. All other shoots in the experiment had one-year-old or older wood coming from the central leader and this was enough to prevent the infection from reaching the leader. This study suggests that while there can still be a high incidence of fire blight using growth regulators, consecutive applications at low rates may reduce the severity of fire blight, thereby reducing the potential to spread in an orchard while conditions are ideal for shoot blight.

Reducing the rate of PCa to 2 oz. per acre for fire blight management on young trees may still result in a noticeable level of growth inhibition, especially if tree vigor and weather conditions do not favor vegetative growth. The 2 oz. rate conferred some benefit in reducing the severity of subsequent fire blight infection, but was not as effective as the 4 oz. rate. We conclude that while the application shows promise for management of shoot blight, more research should be done to optimize this use. Four applications may be more than is needed, and the timing and intervals between sprays should be further refined to optimize fire blight suppression with minimal growth restriction.

Acknowledgments:

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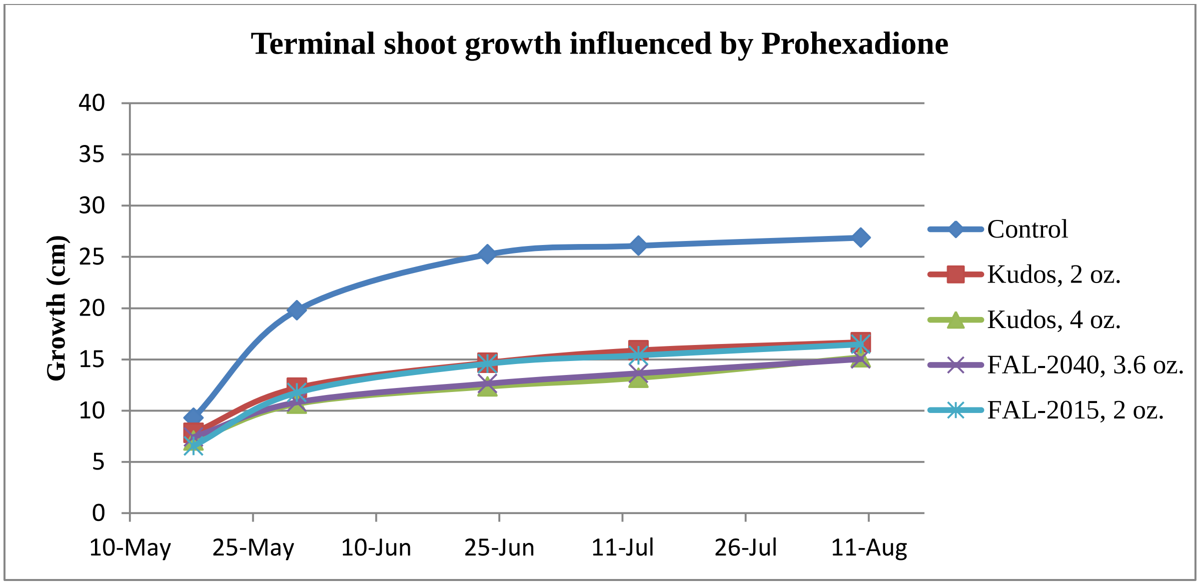

Figure. 1. The effect of Kudos and an experimental compound on **terminal shoot growth** of Crimson Crisp apples.

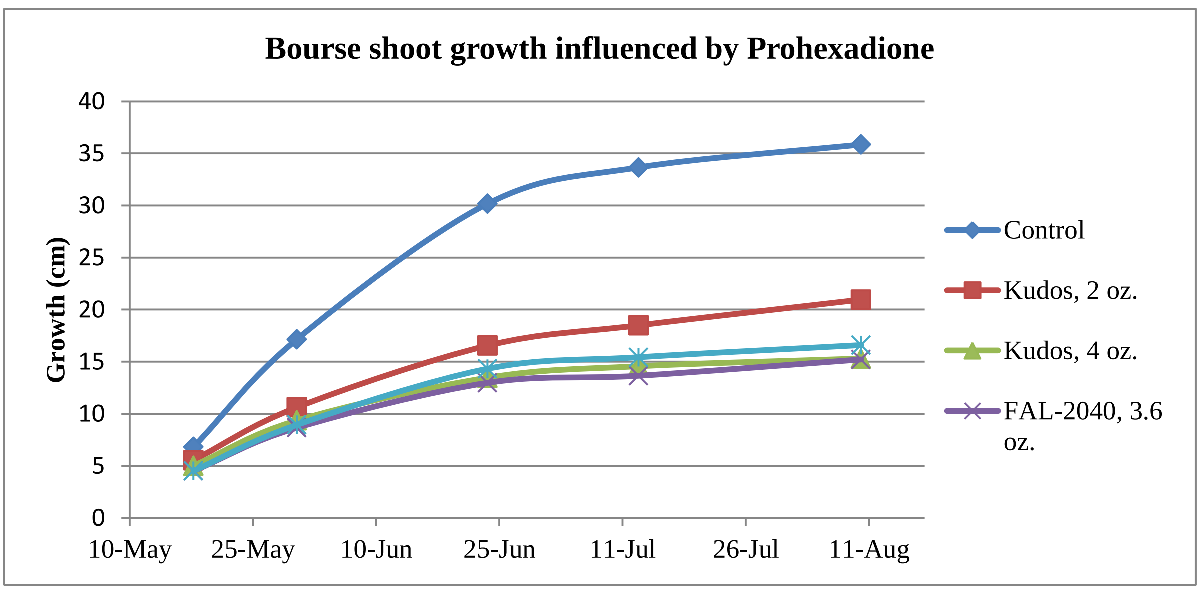

Figure. 2. The effect of Kudos and an experimental compound on **bourse shoot growth** of Crimson Crisp apples.

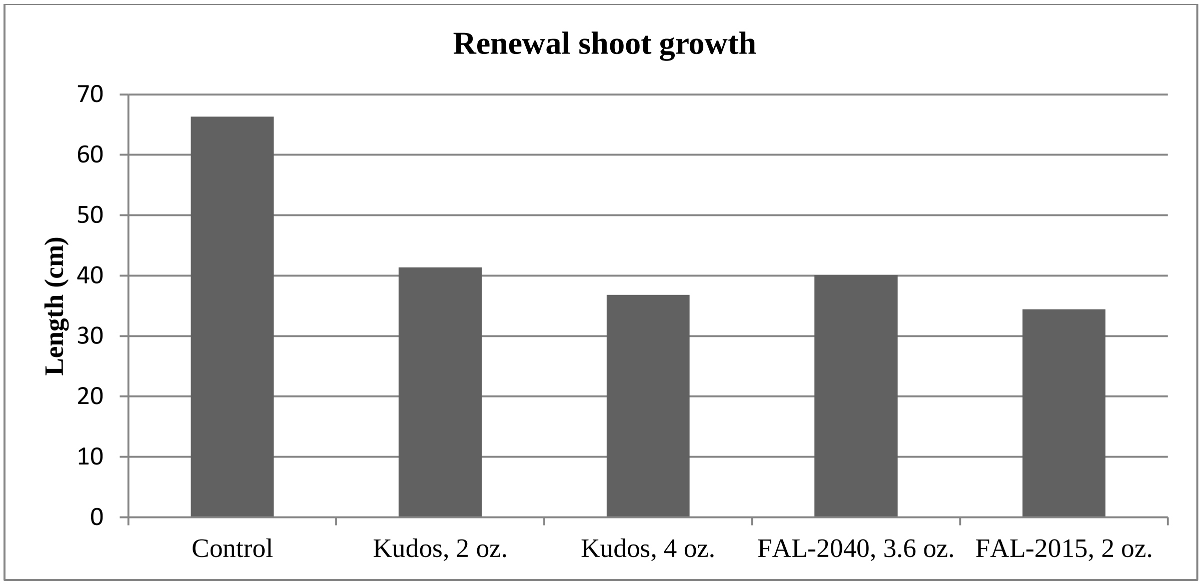

Figure. 3. The effect of Kudos and an experimental compound on **renewal shoot growth** of Crimson Crisp apples.

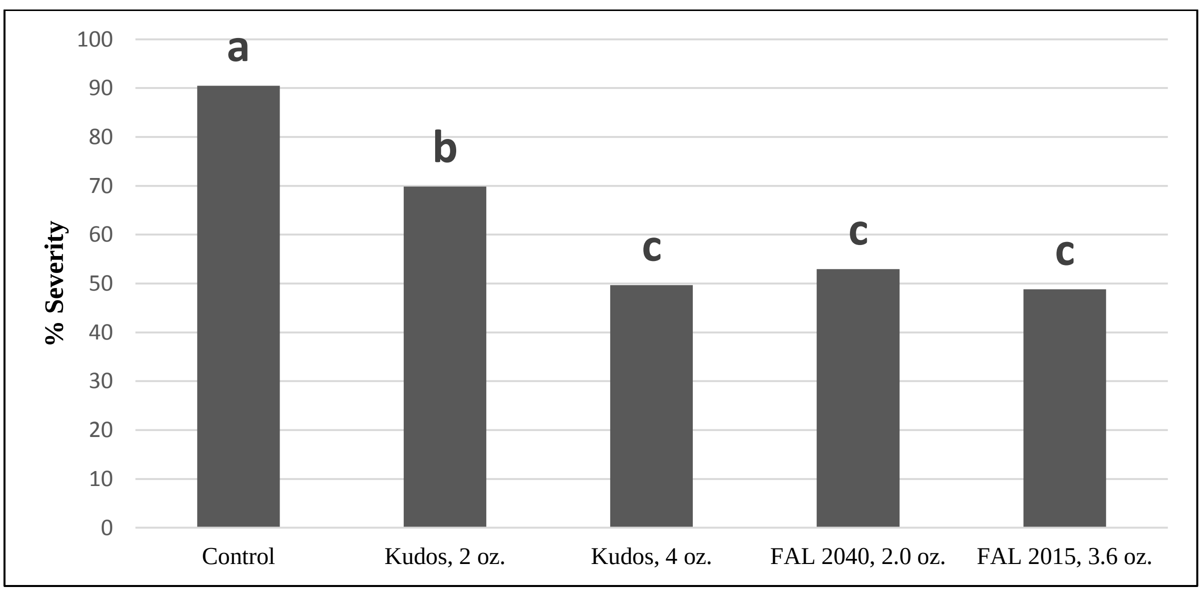

Figure. 4. The effect of Kudos and an experimental compound to reduce the severity of shoot blight on the **current year's growth** of Crimson Crisp apples.

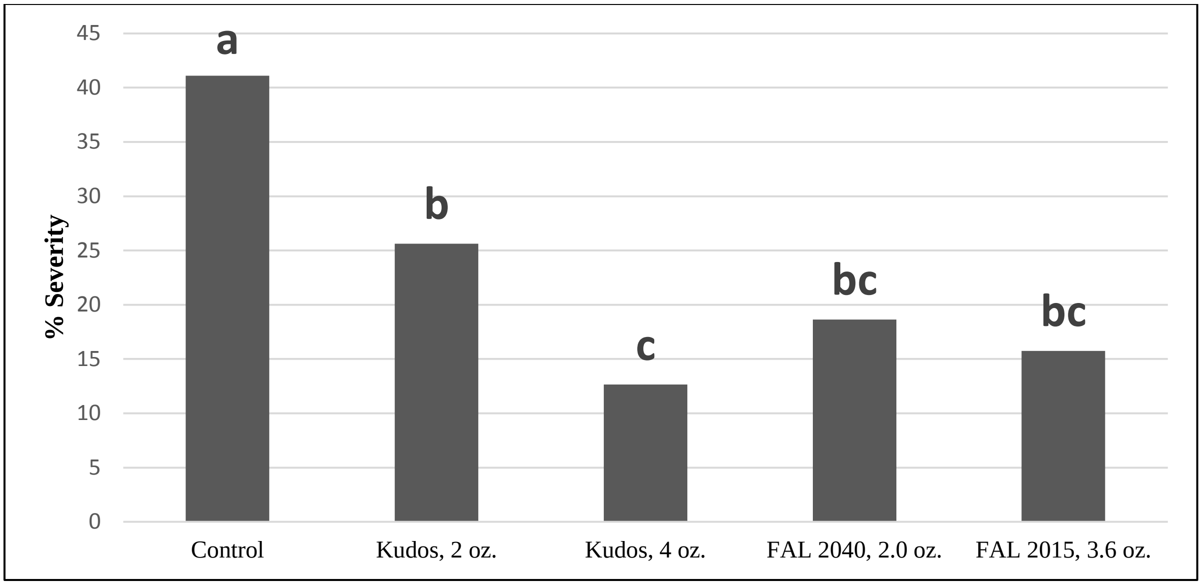

Figure 5. The effect of Kudos and an experimental compound to reduce the severity of shoot blight on the **previous year's growth** of Crimson Crisp apples.

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MANAGING FIRE BLIGHT IN PENNSYLVANIA: WHAT WORKED AND WHAT DIDN'T IN 2016

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A trial evaluating the effectiveness of conventional and alternative bactericide programs to control the blossom blight phase of fire blight was conducted at the Penn State Fruit Research and Extension Center in Biglerville, PA. Fourteen year-old 'Gala' trees on M.7 rootstocks were used and single tree treatments were arranged in a randomized complete block with four replications. Before the first treatment was applied, three branches were selected per tree, marking 25 - 30 blossom clusters on the branch. Treatments were applied in the morning using a backpack mist blower until mist run-off: 19 April (50% Bloom); 21 April (100% Bloom); 25 April (Late Bloom). Mid-afternoon on the same day as the treatment application, blossoms on tagged branches were inoculated with a bacterial suspension of 10^7 *Erwinia amylovora* cells/ml using a spray bottle. Blossoms were inoculated on 19 April and 21 April. Blossom clusters were evaluated for infection on 25 May, which was a few weeks later than we would have typically evaluated for disease incidence. A cold period following bloom limited symptom progress and, as a result, we delayed our blossom evaluation by two weeks. A cluster was rated infected if at least one blossom had fire blight symptoms. Total fire blight shoot strikes on the tree were also counted on 13 June. Fruit finish was evaluated early in the season on the fruitlets, as well as at the end of the season at harvest. Weather data was corded with a Decagon weather monitoring system, and fire blight (MaryBlyt 7.1) infection periods were reported; one day during the bloom period (26 April) had favorable conditions for infection. Standard fungicide and insecticide maintenance programs were applied to the entire orchard with an airblast sparyer. Mean percent incidence was calculated and data was analyzed using analysis of variance and the Fisher's Protected LSD Test determined the mean separation.

In contrast to last year, conditions were less severe for fire blight infection and we observed a better separation of how the treatments performed this year. Bloom started in our Gala block on 15 April and continued through approximately 28 April. Temperatures were on the cooler side and averages ranged from 47 – 68 °F. Rain accumulated on 21 – 23, 26 – 28 April. Of those wetting periods, only 26 April was considered an infection event; the other days risk was either low (26 April), medium (20, 23, 24, 27, 28 April) or high (19, 21, 22 April). Cool weather persisted until about 24 May with average temperatures ranging from 48 – 64 °F. This is important to note since symptoms were delayed compared to what we have observed in the past when average temperatures have been higher. We observed the first symptoms in the middle of May (dead blossoms), with oozing apparent from infected blossoms during late May when average temperatures were higher. As a result of the cool spring and earlier bloom, natural infections in the region were minimal since bacterial infections did not have the heat units for replication. This is in contrast to our neighbors in New England and Canada where bloom was later in May and coincided with warm temperatures. As a result, fire blight infections were a major problem in these regions this year.

Overall, the treatments including streptomycin (FireWall; Treatments 13, 14, 18) performed much better for blossom blight control than the biopesticides, copper, Lime Sulfur, and Kasumin treatments. Streptomcyin by itself (Treatment 18) yielded 70% control, which was the best for management and is the control we typically observe during years where conditions are not extreme. When rotating an alternative, such as Serenade Opti, the best control is when it is used following two sprays of streptomycin (Treatment 14) as opposed to rotating (Treatment 13); however, treatments 13 and 14 are not statistically different. In addition, subsequent shoot blight was mitigated in all streptomycin treatments. The antibiotic kasugamycin (Kasumin 2L; Treatment 20) was also evaluated this year since this became available last year for use. Unfortunately, Kasumin 2L was less effective (31% control) compared to streptomycin (70% control) in blossom blight control. This is in contrast to results observed in Michigan, where Kasumin has been used in orchards where streptomycin resistant *E. amylovora* is present. For copper treatments, Cueva (Treatment 7), Serenade Opti followed by two Cueva sprays (Treatment 10), Regalia and MagnaBon (Treatment 16), and MagnaBon by itself (Treatment 17) performed similarly and are not statistically different. Regalia (extract of *Reynoutria sachalinensis*), which is a product that is labeled to boost the plants' defense system to defend against certain fungal and bacterial diseases, and improve plant health, performed similarly with or without MagnaBon (Treatments 15 and 16, respectively). Worth to note, Regalia is phytotoxic to blossoms at high rates. We noticed browning and subsequent premature petal fall on Regalia-only treatments (2 qt/A rate). Similar symptoms were observed on the trees treated with the lower rate (Treatment 16); however, the incidence was less than the higher rate (Treatment 15). This did not appear to affect the susceptibility of the blossom to *E. amylovora* infection as both treatments were significantly better in blossom blight control than the control or other biopesticide treatments (such as Fire Quencher and Seranade Opti only). Similar to the results in 2015, the bacteriophage, Fire Quencher, did not offer blossom blight control and was not different compared to the inoculated check (Treatments 3 – 6). Treatment 4 (Fire Quencher + Serenade Opti) had the best control of the four phage treatments; however, the control most likely came from the Serenade Opti and not the phage since it was not statistically different from the Serenade Opti only treatment (Treatment 8). Treatment 5 included a UV protectant with the Fire Quencher. Phage is susceptible to UV degradation, which is why a UV protectant was included in this treatment. Unfortunately, the UV protectant did not enhance the efficacy of the phage. Either UV issues, the lack of susceptibility of our *E. amylovora* to the Fire Quencher phage cocktail, and/or timing of application could be contributing to ineffective blossom blight control. Utilizing living viruses as a means for controlling plant diseases in an open system, such as the environment, faces significant efficacy challenges. Lime sulfur, which is an often used in organic management to control for fire blight, did not offer much control and was not significantly different from the untreated, inoculated control (Treatment 19). As far as shoot blight incidence for the treatments, the more blossom blight was controlled, the less incidence of subsequent shoot blight.

Of the biopesticide treatments, Blossom Protect (*Aureobasidium pullulans*) shows the most promise; however, **this year we did note crop safety issues on the fruit of trees treated with Blossom Protect**. Blossom Protect was evaluated at Penn State in 2014 and 40% control was observed; 15% control in 2015; and 33% control in 2016. This product doesn't seem to perform as well as how it has been observed on the West Coast, which has results comparable to using an antibiotic. A prevailing thought is the microbial community in the blossoms may be more diverse and the *A. pullulans* cannot establish as well. Using Oxidate to "sterilize" the blossoms is a good idea; however, it possibly should be used as a treatment prior to the Blossom Protect being applied than after (Treatment 9). Applying Oxidate after a Blossom Protect treatment is counterintuitive since the Oxidate will most likely kill the *A. pullulans*. Consequently, this could explain the poorer control results of Blossom Protect with (17% control) and without Oxidate (33% control) in the program. Unfortunately, Oxidate by itself provided little control to prevent blossom blight and was not significantly different than the untreated, inoculated control (Treatment 11). This year at harvest, we did observe russetting on the fruit from trees treated with Blossom Protect, whereas trees not treated with Blossom Protect (even when Oxidate was used) did not exhibit fruit russetting. *A. pullalans* can establish easily in the orchard. It is known to cause fruit russetting when ideal conditions follow treatment, such as those necessary for apple scab infection (warm, wet weather). This season, we had persistently wet weather three weeks following our last blossom treatment, which could very well explain the high incidence of fruit russetting this year. As far as viability for limiting fire blight infections during East Coast conditions, using Blossom Protect is better than using nothing if growers are not concerned about fruit finish; however, its performance during severe years may be challenged. In addition, the number of fungicides is limited for managing apple scab when Blossom Protect is used during bloom, which is the peak dispersal period for apple scab spores from overwintering leaves. We have yet to find our strep-comparable alternative and exploring alternative options for East Coast growers needs to continue. Outside of Blossom Protect, no phytotoxicity was observed on the fruit for the other treatments.

Table 1. 2016 Evaluation of fire blight blossom blight suppression on 'Gala' at the Penn State Fruit Research and Extension Center, Biglerville, PA

	Treatment & Rate/A	Timing[1]	% Control	% Incidence	# Strikes in June
1	Untreated - Uninoculated	--		27.9 hi	27.3 cd
2	Untreated - Inoculated	--	0 ab[2]	72.6 ab	65.8a
3	Fire Quencher A	1 – 3	2 ab	71.3 ab	41.8 bc
4	Fire Quencher A + Serenade Opti 20 oz	1 – 3	14 a-d	62.3 a-d	28.8 c
5	Fire Quencher B	1 – 3	- 4 a	75.3 a	74.3 a
6	Fire Quencher C	1 – 3	4 a-d	69.9 a-d	24.5 c
7	Cueva 2 qt	1 - 3	17 b-f	60.4 b-f	25.8 cd
8	Serenade Opti 20 oz	1 - 3	8 a-d	66.5 a-d	34.8 c
9	Blossom Protect 1.25 lb + Buffer Protect 8.75 lb Oxidate 1 gal + Nufilm 0.125% v/v	1 2, 3	17 b-f	61.7 b-f	68.5 a
10	Serenade Opti 20 oz Cueva 2 qt	1 2, 3	10 a-d	65.1 a-d	35.8 c
11	Oxidate 1 gal + Nufilm 0.125% v/v	2, 3	3 a-c	70.4 a-c	69.5 a
12	Blossom Protect 1.25 lb + Buffer Protect 8.75 lb	1 – 3	33 fg	48.4 fg	32.3 c
13	FireWall 1. 5 lb + Regulaid 1 pt Serenade Opti 20 oz	1, 3 2	45 gh	39.7 gh	5.5 ef
14	FireWall 1. 5 lb + Regulaid 1 pt Serenade Opti 20 oz	1, 2 3	52 hi	34.7 hi	9 d-f
15	Regalia 2 qt	1 – 3	21 c-f	57.7 c-f	28.5 c
16	Reglia 1 qt + MagnaBon CS2005 1 pt	1 – 3	22 d-f	56.9 d-f	32.8 c
17	MagnaBon CS2005 1 pt	1 – 3	18 b-f	59.6 b-f	37.8 c
18	FireWall 1.5 lb + Regulaid 1 pt	1 – 3	70 i	22.1 i	1.8 f
19	Lime Sulfur 1.5%	1 – 3	9 a-d	66.4 a-d	59.5 ab
20	Kasumin 2L 64 fl oz + Regulaid 1 pt	1 – 3	31 e-g	49.9 e-g	23 c-e

[1]Applied treatments using a backpack mist blower until mist run-off: 1 (50% Bloom; 19 April); 2 (100% Bloom; 21 April); 3 (Late Bloom; 25 April).
[2]Values within columns follow by the same letter(s) are not significantly different ($P \leq 0.05$) according to Fisher's Protected LSD test.

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BROWN ROT MANAGEMENT IN PENNSYLVANIA: FUNGICIDES AND FRUIT BAGGING

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2016 Fungicide evaluation to manage brown rot on peach

Fungicide programs were evaluated to manage late season brown rot infection on peach. Twenty-year old 'Loring' peach trees were used for the trial. Treatments were arranged in a randomized complete block with 4 replications as single tree treatments. Treatments were applied using a boom sprayer at 400 psi, delivering 100 gal/A at a 10 - 14 day interval, with the exception of the last three treatments; the application timing was as follows: Pink (29 March); Bloom (13 April); Petal Fall (21 April); first cover (12 May); second cover (27 May); third cover (10 June); fourth cover (27 June); fifth cover (8 July); 18 days preharvest (27 July); 9 days preharvest (8 August); 1 day preharvest (15 August). Standard insecticide management program was applied to the treatments with an airblast or boom sprayer delivering 100 gal/A at 400 psi. The weather was warm and relatively dry during the growing season. Rainfall totals for April, May, June, and July were 1.99, 5.01, 2.06, and 1.2 inches, respectively. During the 18 day preharvest period, 2.4 inches of rain fell between 18 and 9 days preharvest (27 July and 8 August), 0.09 inches fell between the 9 and 1 day preharvest (8 August and 15 August). For the evaluation, fruit were harvested on 16 August with 25 fruit collected per treatment per rep (total evaluated: 100 fruit per treatment). Random fruit were chosen from the tree and rated for brown rot. At the end of the rating, 25 clean fruit/tree/treatment (total evaluated: 100 fruit per treatment)were collected for postharvest evaluation of brown rot and Rhizopus rot and kept on fruit trays at room temperature (~70°F) for 8 days. Fruit were evaluated for brown rot and Rhizopus rot 3 days, 6 days, and 8 days postharvest. Data were analyzed using analysis of variance and the Fisher's Protected LSD Test used to determine the mean separation.

The treatments this year varied in their bloom treatment and the treatment applied during 9 days preharvest. Since the bloom was dry and cool, no blossom blight was detected in any treatment, even in the untreated. The dry conditions carried throughout the season. As a result of the dry conditions, little brown rot was detected at harvest among the treated and untreated (4% incidence) samples. All programs performed similarly and were not statistically different than the untreated check (**Table 1**). At 6 and 8 days postharvest, the treated fruit showed less incidence of brown rot and were statistically different when compared to the untreated check. All programs performed similarly. In contrast to brown rot, Rhizopus rot was the predominant rot occurring during postharvest. During 3 days postharvest, the treatment with the least incidence of Rhizopus rot was Treatment 6, which had Rhyme (flutriafol; FRAC group 3) applied at 9 days preharvest. However, during 6 and 8 days postharvest, Treatment 6 had numerically less incidence of rot, but it was not statistically significant compared to the other treatments and the untreated check. Indar (although it is not labelled for Rhizopus rot) was the primary fungicide used during preharvest (18 and 1 day preharvest) and it does not provide adequate protection from Rhizipus rot. During years where dry conditions are occurring at harvest, using strobilurin fungicides (FRAC group 11), which are labeled to control Rhizopus rot, at least 1 day preharvest may be warranted to keep postharvest rots, such as Rhizopus rot, in check.

Table 1. Fungicide evaluation to manage brown rot pre- and postharvest.

			% Incidence of brown rot				% Incidence Rhizopus Rot			
	Treatment & Rate/A	**Timing[z]**	**0 d**	**3 d**	**6 d**	**8 d**	**0 d**	**3 d**	**6 d**	**8 d**
1	Untreated	--	4 a[y]	2 a	17 a	21 a	0	25 ab	44 a	58 a
2	Rovral 4F 1.5 pt Indar 12 fl oz + LI-700 1 pt Captan 3 lb Indar 9 fl oz + LI 700 1 pt	P, PF B 1C – 5C PH: 18 d, 9 d, 1 d	5 a	1 a	4 b	4 b	0	21 ab	38 a	55 a
3	Rovral 4F 1.5 pt Indar 12 fl oz + LI-700 1 pt Captan 3 lb Indar 12 fl oz + LI 700 1 pt	P, PF B SS – 5C PH: 18 d, 1 d	3 a	1 a	2 b	2 b	0	37 a	51 a	63 a
4	Rovral 4F 1.5 pt Indar 9 fl oz + LI-700 1 pt Captan 3 lb Indar 9 fl oz + LI 700 1 pt	P, PF B SS – 5C PH: 18 d, 1 d	4 a	1 a	3 b	3 b	0	27 ab	45 a	55 a
5	Rovral 4F 1.5 pt Rhyme 2.08 SC 7 fl oz + LI-700 1 pt Captan 3 lb Indar 12 fl oz + LI 700 1 pt Fracture 2.1 SC 30.5 fl oz + LI-700 1 pt	P, PF B SS – 5C PH: 18 d, 1 d PH: 9 d	4 a	0 a	0 b	0 b	0	25 ab	43 a	68 a
6	Rovral 4F 1.5 pt Fracture 2.1 SC 30.5 fl oz + LI-700 1 pt Captan 3 lb Indar 12 fl oz + LI 700 1 pt Rhyme 2.08 SC 7 fl oz+ LI-700 1 pt	P, PF B SS – 5C PH: 18 d, 1 d PH: 9 d	2 a	0 a	0 b	0 b	0	16 b	31 a	51 a
7	Rovral 4F 1.5 pt Oso 6.5 fl oz + LI-700 1 pt Captan 3 lb Indar 12 fl oz + LI 700 1 pt Oso 6.5 fl oz+ LI-700 1 pt	P, PF B SS – 5C PH: 18 d, 1 d PH: 9 d	4 a	0 a	2 b	3 b	0	35 a	50 a	60 a

[z]Application timings: Pink (P; 29 March); Bloom (B; 13 April); 1st Cover (1C; 12 May); 2nd Cover (2C; 27 May); 3rd Cover (3C; 10 June); 4th Cover (4C; 27 June); 5th Cover (5C; 8 July); 18 days preharvest (PH: 18 d; 27 July); 9 days preharvest (PH: 9 d; 8 August); 1 day preharvest (PH: 1 d; 15 August)

[y] Values within columns follow by the same letter(s) are not significantly different ($P \leq 0.05$) according to Fisher's Protected LSD test.

Bagging peaches to mitigate brown rot

Pre-harvest fruit bagging is commonly used throughout the world to manage pests and diseases. Most recently, fruit bagging was evaluated in South Carolina at Clemson University to manage peach brown rot and it was shown to be successful. During the 2016 season, we evaluated peach fruit bagging under Pennsylvania conditions to understand the usefulness in preventing brown rot infections.

Bags were purchased early spring from Clemson University at the commercial grower rate. The paper bags were opaque-white, notched at the top with a twist tie to secure to the branch; two slits at the bottom were vents. We chose five orchard sites to bag peaches: four peach blocks (Autumn Glo, Beekman, and Loring, and Sweet N Up) at the Penn State Fruit Research and Extension Center in Biglerville, PA; and one commercial grower peach block (Loring) located in Media, PA. At each site, we chose five trees at random in the peach block and bagged all peaches on the tree. Peaches were approximately the size of a golf ball prior to bagging. With the exception of one site at Penn State, which was not treated with any fungicides during the season, fruit were treated with a fungicide spray two days prior to bagging. At harvest, the bags were removed from the fruit and evaluated for brown rot and bacterial spot incidence, as well as insect damage. On nearby trees, we collected the same number of unbagged fruit compared to our bagged fruit number and rated those fruit for disease incidence and insect damage. Asymptomatic bagged and unbagged fruit were taken to the Penn State Fruit Research and Extension Center where the fruit were kept at room temperature (~72°F) and evaluated 5 and 10 days postharvest.

The 2016 season was challenging for this project: The peach season started off difficult with damaging temperatures during a critical period in April and the summer was dry, which decreased brown rot incidence overall. Due to bags falling off of the tree throughout the season, our fruit numbers were not consistent at each site. We chose to treat each site as a replicate and combined the data. We did not see a difference between unbagged versus bagged fruit for brown rot incidence at harvest (17% and 16%, respectively). In contrast, we did observe a difference for postharvest disease incidence where there was less disease on the bagged fruit (16%) compared to unbagged (26%) at 5 days postharvest; 26% vs 39% at 10 days postharvest (bagged vs unbagged, respectively). Insect damage was also recorded and there was no significant difference between unbagged and bagged fruit (14% and 11%, respectively). We realized our method of closing the bag (cinching the sides) allowed insects to enter. As a result of our experiences during 2016, as well as conversations with Clemson researchers, we have recognized pitfalls that most likely influenced the results and we hope to avoid them in 2017. On a small scale, such as for U-Pick, organic growers, and homeowners, fruit bagging shows promise as an alternative to managing pests and diseases.

Table 2. Cumulative summary of all peach sites for disease incidence and insect damage on bagged and unbagged peaches.

	Brown Rot % Incidence				
	Harvest	5 d postharvest	10 d postharvest	% Bacterial spot	% Insect damage
Unbagged	17 a	25 a	39 a	50 a	14 a
Bagged	16 a	16 b	26 b	33 b	11 b

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Bitter Rot of Apples: Recent Changes in What We Know and Implications for Disease Management

(A review of recent literature and perspectives on what we still need to learn)

Compiled November 2016 by

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Apple growers, private consultants, and extension specialists have all noted that bitter rot is increasingly common and is causing sporadic but economically significant losses throughout the northeastern and north central apple growing regions of North America. Forty years ago, bitter rot was considered a "southern disease" and apples with bitter rot were rarely observed in northern production regions.

Four factors have probably contributed to the increasing incidence of bitter rot in these regions. First, as a result of global warming, we have more days during summer with warm wetting events that are essential for initiating bitter rot infections and perhaps for increasing inoculum within orchards before the bitter rot pathogens move to apple fruit. Second, some new cultivars (e.g., Honeycrisp) are very susceptible to infection. Third, we are also growing more late-maturing cultivars such as Cripps Pink that may be picked in early November, and these cultivars may need additional fungicide sprays during September and/or early October if they are to be fully protected from bitter rot. Finally, mancozeb fungicides are very effective against *Colletotrichum* species, and the season-long use of mancozeb may have suppressed *Colletotrichum* populations in apple orchards prior to 1990 when the mancozeb labels were changed to prohibit applications during summer (i.e., within 77 days of harvest).

During the same time that bitter rot was expanding into more northern production regions, scientific breakthroughs enabled us to better identify the species that cause both bitter rot of pome fruit and the associated apple leaf spot disease in various regions around the world. This new information helps to explain some of the regional differences that were observed many years earlier, but the new information also leads to new questions on how best to manage this disease.

Changes in our understanding of *Colletotrichum* species affecting pome fruit:

Ten years ago, the general consensus was that bitter rot in apples in North and South America was attributable to three pathogens: *Colletotrichum acutatum, C. gloeosporioides,* and *Glomerella cingulata* (Gonzales et al., 2006). Thanks to improved capabilities for accurately identify fungi using DNA analyses, there are now at least 18 recognized species of *Colletotrichum* that can infect apples or pears (Table 1). Those species belong to three different species complexes within the genus *Colletotrichum*. Some of the species listed in Table 1 are probably rare in pome fruits and may occur only where a preferred non-rosaceous host is planted close to pome fruits. For example, *C. salicis* may have moved to apples from the willows that are used as wind breaks in New Zealand (Damm et al., 2012a).

The worldwide distribution of the various species affecting pome fruits remains unclear. The preponderance of literature suggests that *C. fioriniae* is the predominant species in apples in northeastern United States and *C. godetiae* is one of the most frequently reported species from apples in Europe, although *C. acerbum* and *C. rhombiforme* have also been reported there. *C. gloeosporioides* may be the most common species in southeastern United States. It is not yet clear which species predominate in southeastern Asia. Bragança et al. (2016) noted that while *C. acutatum* species in clades 1 and 2 (Table 1) have been found in apples in Brazil, *C. acutatum* species from other clades that are important in other regions (*C. fioriniae* in North America, *C. godetia* and *C. acerbum* in Europe, and *C. salicis* in New Zealand) have not been found on apples in Brazil and might therefore be considered for quarantine status.

Our abilities to interpret older literature are now compromised due to uncertainties about which species of *Colletotrichum* were being investigated in any given report. In some of the older literature, especially European literature on postharvest diseases, it is also easy to confuse bitter rot with other fruit rot pathogens (especially *Gloeosporium* species) that are identical or related to the pathogens causing bull's eye rot in the United States (Table 2). Storage decays caused by *Nectria galligena*, the cause of European apple tree canker can also be confused with biter rot. The species listed in Table 2 generally cause postharvest decays rather than decays that are evident at harvest. However, the initial symptoms of diseases listed in Table 2 are very similar to the initial symptoms of bitter rot when the latter develops as a postharvest decay (Børve and Stensvand, 2007). When any of these decays appear in stored fruit, the causal agent can be identified with certainty only by making isolations and then using DNA analyses to identify the pathogen.

The fruit decay symptoms caused by the various *Colletotrichum* species are virtually identical, but the pathogen biology and the recommended management strategies can differ significantly among the species. For example, the *Colletotrichum* species present in Brazil and southeastern United States can cause a leaf spot disease that rapidly defoliates Gala trees (González et al., 2006; Velho et al., 2015) whereas *C. fioriniae* in NY has only occasionally been found in leaf spots (Rosenberger, D., 2012; Beaudoin et al., 2015). The *Colletotrichum* species found in Norway, later identified as *C. godetiae* and *C. rhombiforme* (Børve and Stensvand, 2016), cause significant postharvest losses (Børve and Stensvand, 2015), and *C. fioriniae* has been reported as a postharvest pathogen in the U.S. (Kou et al., 2014; Rosenberger and Cox, 2016). However, Brooks and Cooley (1917) reported that one of the species in eastern United Sates (probably *C. gloeosporioides*) does not grow at temperatures below 41 °F.

In general, species in the *C. gloeosporioides* complex have higher temperature optima for growth and sporulation than species in the *C. acutatum* complex. Thus, it is not surprising that, as pome fruit pathogens, the latter are reported more frequently in cooler growing regions whereas the former are generally more predominant in warmer growing regions.

The biology of the various *Colletotrichum* species is still poorly understood, especially as it relates to inoculum cycling in apple orchards. Several species have been shown to colonize a wide range of host plants, some of which may carry endophytic populations of *Colletotrichum* without displaying any evidence of disease (Table 3). At least three species, including the one causing most of the bitter rot in apples in Northeastern United States, have been shown to cause mortality in insects: *C. fioriniae* attacks Hemlock scale (Marcelino et al., 2008); *C. gloeosporioides f. sp. orthezìidae* infects citrus scale (Cesnik et al., 1996, although this *Colletotrichum* species may be *C. nymphaeae* instead according to Damm et al., 2012a); and an unidentified species from the *C. acutatum* complex was recently shown to cause mortality in the Asian chestnut gall wasp (Graziosi and Rieske, 2015). Another species has been shown to protect cocoa plants from *Phytophthora* infections (Arnold et al., 2003, Mejía et al., 2008, Rojas et al., 2010). Several investigators have suggested that *Colletotrichum* may have developed a commensal or mutualistic relationship with some plant hosts because of its ability to suppress insect pests and/or other pathogens.

The traditional understanding of the life cycle of *Colletotrichum* species in apples in North America involved a pathogen that overwintered primarily in dead tissues that remained in trees (especially in wood killed by fire blight), although it was also known to overwinter in buds and fruit mummies (Sutton, 2014). The role of bud infections has received little emphasis in North America whereas it has been investigated in Norway, Brazil, and New Zealand (Bernardi et al., 1983; Crusius et al., 2002; Børve and Stensvand, 2007). Crusius et al. (2002) reported that isolates recovered from buds in Brazil (*C. gloeosporoiodes* group) were able to cause leaf spot but isolates recovered from fallen leaves and fruit mummies were only able to cause fruit rot. Fruit with bitter rot that overwinter on the orchard floor in Northeastern United States have also been suggested as potential overwintering sites (Rosenberger and Cox, 2016), although the importance of fruit mummies on the ground has not been documented in that region. However, research in other cropping systems suggest that *Colletotrichum* species can overwinter in plant debris on the soil surface even though they generally do not survive very well as spores in soil under field conditions.

Observations during several bitter rot outbreaks in NY have also implicated shade or forest trees on orchard perimeters as inoculum sources for some epidemics. Infections in tall trees would presumably allow for dissemination of the rain-splashed spores over greater distances during gusty thunderstorms than would be likely to occur with spores found only in apple tree canopies or in litter on the orchard floor.

The role of species associated with the leaf spot disease known as Glomerella leaf spot also requires more study. Various species within the *C. gloeosporioides* complex have been shown to cause leaf spot epidemics that result in early defoliation of trees in Brazil and southeastern United States (González and Sutton, 1999; Velho et al., 2015). A leaf spot disease is also caused by *C. karstii*, the only known apple pathogen in the *C. bionense* group (Velho et al., 2015). Although González et al. (2006) recovered *C. acutatum sensu lato* from apple leaves, they were not able to recreate apple leaf spot disease by inoculating plants with those same isolates. Børve and Stensvand (2015) reported that their isolates of *C. acutatum sensu lato* caused leaf spot disease on inoculated plants, and although the identity of the pathogen they used apparently was not verified via DNA analysis, they later reported that most of the species from apples in Norway were *C. godetiae* or *C. rhombiforme* (Børve and Stensvand, 2016).

Results from leaf isolations can be confusing because, although *C. acutatum sensu lato* can be recovered from leaves, those species may not be sufficiently pathogenic to cause disease in the absence of predisposing factors. What remains unclear is whether isolates from the *C. acutatum* group can cause leaf spot disease when inoculated onto healthy leaves in the absence of other predisposing factors (e.g., necrotic leaf blotch and/or high populations of the leaf epiphyte, *Aureobasidium pullulans*). In work completed in the Hudson Valley of New York in late summer of 2012, we recovered *Colletotricum* from most isolation attempts from leaf lesions showing colored bands sometimes associated with Glomerella leaf spot (Rosenberger, 2012). Representative isolates from among those that were recovered from leaves in 2012 were identified by Wallhead et al. (2014) as *C. fioriniae*. However, when we attempted similar isolations in the Hudson Valley in 2013, we failed to recover *Colletotrichum* isolates from leaves in more than 50 attempts even though the leaf lesions were identical to those observed the previous year. This experience raises the possibility that weather conditions in 2012 had allowed *C. fioriniae* to colonize tissue being killed by necrotic leaf blotch disease whereas environmental conditions in summer of 2013 may have been unfavorable for development of *C. fioriniae* even though trees were again affected by necrotic leaf blotch. Thus, the ability of *C. fioriniae* to infect healthy leaves remains questionable.

At this point in time, the accumulated literature suggests that Glomerella leaf spot in North and South America can be caused by *C. karstii* and by various species in the *C. gloeosporioides* complex, but probably not by species in the *C. acutatum* complex except when the pathogen acts as a secondary invader of damaged leaves.

Practical implications:

The role of *Colletotrichum* in symptomless, endophytic infections in weeds in the orchard ground cover remains unknown. To date, there is no evidence that endophytically infected plants produce spores or act as inoculum sources so long as they are alive. However, in at least some of these hosts, the fungus may sporulate on the infected host tissue after the tissue dies. Thus, plant species in orchard ground covers that are capable of hosting *Colletotrichum* species may ultimately contribute to orchard inoculum if the fungus can sporulate on portions of the plant that are remove by mowing, are killed by herbicides, or die of other causes. The list of endophytically infected host species encompasses many weeds commonly found in orchards, including dandelion, broad-leaf plantain, narrow-leaf plantain, white clover, and chickweed (Table 3). Peres et al (2005) stated that *C. acutatum (sensu lato)* had never been recovered from grasses, but Marcelino et al. (2009) reported that C. fioriniae could grow endophytically in barley. If broad-leaved weeds are a significant reservoir for *Colletotrichum* species in apple orchards, growers might benefit from applying herbicides such as 2-4D and/or Stinger to eliminate these plants from the ground cover while maintaining only grasses in the row middles. Elimination of broad-leaved weeds could be further justified because some of them are preferred hosts for rosy apple aphid and plant bug, and because flowering plants can attract wild pollinators into orchards during summer when insecticides applied to apples are likely to kill pollinators attracted to the flowering ground cover plants growing within orchards.

Colletotrichum species may vary in their susceptibility to fungicides (Lee et al., 2007; Velho et al., 2015, Munir et al., 2016, Chen et al., 2016). In general, species in the *C. gloeosporioides* complex are more susceptible to benzimidazole fungicides that species in the *C. acutatum* complex. Chen et al. (2016) found that five *Colletotrichum* species that were collected from peach orchards in South Carolina and Georgia varied significantly in their susceptibility to DMI fungicides, with some DMIs being more effective than other DMIs against some of the species. Munir et al. (2016) reported that species varied considerably both in their aggressiveness on inoculated apple fruit and in their sensitivity to thiophanate-methyl, myclobutanil, trifloxystrobin, and captan. Isolates from the *C. gloeosporioides* complex were generally more sensitive to all four of the fungicides than were isolates from the *C. acutatum* complex. The presence of fungicide-resistant populations and/or the potential for development of fungicide resistance to single-site inhibitor fungicides for the various *Colletotrichum* species remains to be determined.

In fungicide trials with sooty blotch and flyspeck, none of the fungicides, not even Pristine, remained effective following 2.2 inches of rainfall (Rosenberger & Meyer, 2007). It seems likely that fungicide residue concentrations required to control bitter rot will be higher than those required to control sooty blotch and flyspeck, so even lesser amounts of rainfall may remove protection against bitter rot. Thus, fruit may become infected by some species of *Colletotrichum* in late September or October if weather favors infection after residues from the last fungicide application (often in late August) have been depleted. With cultivars such as Cripps Pink, which appears susceptible to bitter rot and sometimes is not harvested until early November, growers may need to consider applying fungicide sprays as late as October in some years. Postharvest treatment with fungicides such as fludioxonil (Scholar) may eliminate infections that occurred just several days before harvest, but postharvest fungicides cannot eradicate incubating infections of *C. fioriniae* that were established in the fruit more than a few days prior to infection (Rosenberger & Rugh, 2013).

Recently, New York growers experienced problems with bitter rot decays in fruit coming out of storage. Isolations made from stored fruit in the Cox lab verified that the decays were still being caused by *C. fioriniae* rather than some other introduced species of *Colletotrichum* associated with storage decays elsewhere in the world (Rosenberger and Cox, 2016). *C. fioriniae* was also reported as a postharvest pathogen in Pennsylvania (Kou et al., 2014). The most likely explanation for development of bitter rot in storage is failure of growers to maintain fungicide coverage on apples during the immediate preharvest period, although gaps in coverage earlier in the season might have allowed *Colletotrichum* species to establish quiescent infections. However, development of bitter rot during storage may also occur if storage operators fail to cool fruit quickly. In too many cases, fruit temperatures in the center of bin stacks may remain above 40 °F for more than a week after harvest because limited refrigeration capacity and/or air movement with storage rooms result in delayed cooling (Waelti 1992, Thompson 2006). More research is needed on the abilities of *C. fioriniae* and other apple-infecting species to grow at low temperatures, both after harvest and during long and cool wetting periods that can occur in late fall when water and spores collect in the calyx and/or the stem cups of fruit following fall rains.

Throughout New York and New England, a low incidence of bitter rot is not uncommon in Honeycrisp orchards. However, occasionally bitter rot outbreaks occur in other cultivars. The trigger for these epidemics has not been determined, but in at least several cases I suspect that the epidemic developed after *C. fioriniae* invaded heat-damage fruit (Rosenberger, 2015). It is also possible, however, that extended periods of hot wet weather favored development of massive amounts of inoculum either within trees, in litter on the orchard floor, or in endophytically infected plants in the ground cover. The relative importance of these inoculum sources must be determined before we can development appropriately directed management strategies.

Management strategies will need to include more than just fungicides. In one trial at the Hudson Valley Lab, even the best fungicide programs were ineffective for controlling bitter rot on Honeycrisp during a major infection event that may have been attributable to drought and heat stress (Rosenberger et al., 2012; Rosenberger, 2015). Thus, new management strategies may need to include irrigation to avoid heat/drought stress, sprayable reflective coatings to reduce heat absorption by fruit in late summer, management of orchard perimeters to limit inoculum influx from tall border trees, sanitation via removal of leaves, fruit mummies, and dead twigs from beneath trees where bitter rot was a problem, and perhaps use of broadleaf herbicides to eliminate the potential for inoculum production from endophytically infected plants in the orchard ground cover. The benefits (if any) for all of the above-mentioned strategies remain to be proven.

Critical research questions:

1. What species of *Colletotrichum* are **economically** important in orchards in our various production regions? Published research tells us which ones may be present but very little about whether some of the less common species are economically important.
2. What is the relative importance of the various inoculum sources that have been identified or suggested: infections in buds, litter on the orchard floor, endophytically infected plants in the ground cover, dead tissue within the tree canopy?
3. What are appropriate pathogenicity tests for assessing the likelihood that different species of *Colletotrichum* can infect apple fruit or leaves under natural conditions as opposed to results from inoculation trials with massive amounts of inoculum on wounded leaves or fruit? How can we be certain that natural epiphytes such as *Aureobasidium pullulans* are not important for predisposing apple leaves to infection in pathogenicity trials with *Colletotrichum* species?
4. What triggers massive infection events in the northeast? Heat/drought stress? Exceptionally high inoculum development? A specific series of environmental events? Some published reports (e.g., Biggs, 1995) suggest that *Colletotrichum* species may be endemic in most orchards but, although present on apple skins at harvest, they often fail to trigger disease unless fruit is stored until it is senescent.
5. Will any of the non-chemical management strategies suggested in the last paragraph of the previous section provide cost-effective reductions in losses to bitter rot?
6. Are *Colletotrichum* species in apple orchards developing tolerance to QoI fungicides, or is that likely to occur in the future with continued use of QoI fungicides?
7. Which *Colletotrichum* species can grow in cold storage and/or infect fruit during long cool wetting periods in the fall?
8. Given that international trade is likely to transfer the various species of *Colletotrichum* from their sources of origin to regions where they did not exist in the past, should we expect increasing problems with bitter rot over the next decade?

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Table 1. *Colletotrichum* species reported to cause bitter rot in apple or pear fruit.

	Species/organs affected [z]	Regions where found on apple or pear	Citations for pome fruits [y]	Other common disease hosts
***C. gloeosporioides* complex,** *Musae* clade			19	
C. gloeosporioides (Penz.) Penz. & Sacc.	AP fruit/lvs	**Southeastern US**, Uruguay	16	Blueberry
Synonym: *Gloeosporium fructigenum* Berk.				
Teleomorph: *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk	AP fruit, lvs	Brazil, US	8	
	PR fruit, lvs	China, Japan	10	
C. fructicola Prihastuti, L. Cai & K.D. Hyde	AP fruit, lvs	**Brazil, Uruguay**, US (NC, KY), China	8, 11, 15 16, 19, 21	coffee, peanut
	PR fruit, lvs	Japan, China	12, 19	
C. alienum B.S. Weir & P.R. Johnston	PR	Japan	19	
	AP fruit	New Zealand	16	
C. siamense Prihastuti, L. Cai & K.D. Hyde	AP fruit	US (NC, KY)	15, 19	Many subtropical
C. aenigma B.S. Weir & P.R. Johnston	AP fruit, lvs	China	18	
	PR	Japan	19	
C. piri Noack	AP	Brazil,	6	
C. theobromicola Delacr.	AP fruit	Uruguay, US (KY)	12, 15, 16	
***C. acutatum* complex** (by clades [6], and with "A-x" groupings as per Sreenivasaprasad & Talhinhas 2005)				
Clade 1:				
C. paranaense *C.A.D. Bragança & Damm*	AP fruit	Brazil	5	Sour nut, peach
C. melonis Damm (fruits)	AP fruit	Brazil, Uruguay	5	Muskmelon, citrus
Clade 2 (A2): ***C. nymphaeae*** (Pass.) Aa	AP fruit	Brazil, US (KY) Korea, Japan	3, 5, 14, 15, 16	Strawberry, olives
Clade 3 (A3): ***C. fioriniae*** Marcelino & Gouli	AP fruit, (lvs?)	Northeastern US Korea, Brazil	3, 13 14, 17	Blueberry, grape, celery
Teleomorph: *Glomerella acutata* var. *fioriniae*		Slovenia, Latvia, Croatia		Avocado, strawberry, olives
Clade 4: ***C. acutatum*** J.H. Simmonds (A5)	PR fruit	New Zealand, Japan	6	Papaya, strawberry, olives
Clade 5: ***C. acerbum*** Damm	AP fruit	New Zealand, Norway	3	
C. godetiae Neerg. (A4)	AP fruit	Europe: Croatia, Slovenia, Bulgaria, UK, Norway, Netherlands, UK, US	2, 3, 20	Strawberry, olives very broad host range
C. pyricola Damm, P.F. Cannon & Crous	PR fruit	New Zealand	6	
C. rhombiforme Damm, P.F. Cannon & Crous	AP	Norway	4	
C. salicis (Fuckel) Damm, P.F. Cannon & Crous (A7)	AP fruit	Croatia, New Zealand	3, 6	Willows (opportunistic via wind breaks in NZ)
C. boninense *complex* (Damm et al., 2012b)				
C. karstii Y.L. Yang	AP leaves	US (VA?), Brazil	7, 16	Tropical/sub-tropical

[z] AP = apples, PR = pears, lvs = leaves (i.e., causing a leaf spot)

[y] References cited (see full citations listed as 'Literature cited'):

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5. Bragança et al., 2016
6. Damm et al., 2012a
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9. Gonzalez et al., 2006
10. Heng et al., 2011
11. Hoge et al., 2016
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13. Kou et al., 2014
14. Lee et al., 2007
15. Munir et al., 2016
16. Velho et al., 2015
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18. Wang et al., 2015a
19. Weir et al., 2012
20. Wenneker et al., 2016
21. Zhang et al., 2015

Table 2. Other (mostly postharvest) diseases sometimes confused with bitter rot and pathogens that cause them:

Common name	Pathogen names	Reference*
Gloeosporium rot (European literature)	*Neofabraea alba* (E.J. Guthrie) Verkley Synonyms: *Gloeosporium album* Osterw. *Pezicula alba* Guthrie Anamorph: *Phlyctema vagabunda* Desm.	Snowden, A. L. 1990
	Pezicula malicorticis (Jackson) Nannf. Anamorph: *Gloeosporium perennans* Zeller & Childs	Snowden 1990
Bull's eye rot	*Neofabraea malicorticis* H.S. Jacks. Anamorph: *Cryptosporiopsis curvispora* (Peck) Gremmen	Spotts, R. A. 2014
	Neofabraea perennans Keinholz Anamorph: *Cryptosporiopsis perennans* (Zeller and Childs) Wollenw.)	Spotts, R. A. 2014
	Neofabraea alba (E.J. Guthrie) Verkley Synonyms: *Gloeosporium album* Osterw. *Pezicula alba* Guthrie Anamorph: *Phlyctema vagabunda* Desm.	Spotts, R. A. 2014
	Cryptosporiopsis kienholzii (Seifert, Spotts & Lévesque)	Spotts, R. A. 2014
Nectria eye rot (Cylindrocarpon rot)	*Neonectria galligena* (Bres.) Rossman & Samuels Anamorph: *Cylindrocarpon heteronema* (Berk. & Broome) Wollenw. Teleomorph synonym: *Nectria galligena* Bresad.	Creemers, P. 2014
Side rot (mostly on pears)	*Cadophora malorum* (Kidd & Beaumont) W. Gams Synonyms: *Phialophora malorum* Kidd & Reaumont) McColloch *Sporotrichum malorum* Kidd & Beaumont *Sporotrichum carpogenum* Ruehle	Sugar, D. 2014

*See full citations listed under 'Literature cited'. Synonyms as determined from www.mycobank.org/ .

Table 3: A partial list of plants shown to harbor populations of *C. acutatum* species, often endophytically.

Plants that can harbor *C. fioriniae* (Marceline et al., 2009)	
Acer saccharum (Aceraceae)	sugar maple
Alliaria petiolata (Brassicaceae)	garlic mustard
Aralia nudicaulis (Araliaceae)	Wild sarsaparilla
Arisaema triphyllum (Araceae)	jack-in-the-pulpit
Aster sp. (Asteraceae)	asters
Barberis thunbergii (Berberidaceae)	Japanese barberry
Capsicum annuum var. New Ace (Solanaceae)	pepper
Catalpa speciosa (Bignoniaceae)	catalpa tree
Fragaria x *ananassa* var. Honeoye (Rosaceae)	strawberry
Hamamelis *virginiana* (Hamamelidaceae)	American witch-hazel
Hordeum vulgare (Gramineae)	barley
Liriodendrum tulipifera (Magnoliaceae)	tulip poplar
Magnolia sp. (Magnoliaceae)	magnolia
Pachysandra terminalis (Buxaceae)	Japanese pachysandra
Parthenocissus quinquefolia (Vitaceae)	Virginia creeper
Phaseolus vulgaris var. Blue Lake 274 (Fabaceae);	beans
Prunus avium (Rosaceae)	sweet cherry
Rosa sp. (Rosaceae)	rose
Rosa multiflora (Rosaceae)	multiflora rose
Rubus idaeus (Rosaceae)	red raspberry
Sassafras albidum (Lauraceae)	sassafras tree
Solanum lycopersicum var. Patio (Solanaceae)	tomato,
Sorbus americana (Rosaceae)	American mountain ash
Tilia americana (Tiliaceae)	American linden
Trientalis borealis (Primulaceae)	starflower
Tsuga canadensis (Pinaceae)	eastern hemlock
Tussilago farfara (Asteraceae)	coltsfoot
Ulmus sp. (Ulmaceae)	elm
Vaccinium sp. (Rosaceae)	blueberry
Verbascum sp. (Scrophulariaceae)	mullein
Plants that supported *C. acutatum sensu lato*	
From Parikka and Lemmetty (2012):	
Epilobium angustifolium	rosebay willow herb
Tripleurospermum inodorum	scentless mayweed
Plantago major	greater plantain
Taraxacum vulgare	dandelion
Capsella bursa-pastoris	shepherd's purse
Stellaria media	common chickweed
Phacelia tanacetifolia	fiddleneck
Carum carvi	caraway
Trifolium repens	white clover
Mentha sp.	mint
Ranunculus repens	creeping buttercup
Phacelia tanacetifolia	blue tansy
From Berrie and Burgess (2003)	
Rumex obtusifolius	broad-leaved dock
Plantago lanceolata	narrow-leaved plantain

SENSITIVITY OF COLLETOTRICHUM SPP. TO DMI FUNGICIDES

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Chemical management of anthracnose is a challenge because few chemical classes are effective. Apart from multisite fungicides such as captan, the most commonly used chemical classes for anthracnose control are the benzimidazoles (against *C. gloeosporioides*) and quinone outside inhibitor (QoI) fungicides. However, their widespread use over the last decades has led to resistance problems to both chemical classes of fungicides. Sterol demethylation-inhibitor fungicides (DMIs) are widely used against fungal plant pathogens due to their broad spectrum activity, more favorable toxicity profile compared to many protectants, and post-infection activity. In stone fruits they became the main stay for brown rot control after resistance to the benzimidazoles led to control failures and they are still used extensively for preharvest brown rot control. The triazoles difenoconazole, propiconazole, tebuconazole, metconazole, flutriafol, and fenbuconazole are currently registered to control peach diseases and recent research suggests that some DMI fungicides may be used to manage *Colletotrichum* species as well.

Isolates of the *Colletotrichum acutatum* species complex were collected from South Carolina and Georgia peach orchards and phylogenetic analysis of the combined Internal Transcribed Spacer region, glyceraldehyde-3-phosphate dehydrogenase, and beta-tubulin gene sequences separated the isolates into *Colletotrichum nymphaeae* and *Colletotrichum fioriniae*. The sensitivity of these and three other previously reported *Colletotrichum* species from peach, including *Colletotrichum fructicola, Colletotrichum siamense, and Colletotrichum truncatum* to demethylation inhibitor (DMI) fungicides difenoconazole, propiconazole, tebuconazole, metconazole, flutriafol, and fenbuconazole was determined based upon mycelial growth inhibition. Results show that difenoconazole, propiconazole, metconazole and tebuconazole were more effective in controlling *Colletotrichum* species than flutriafol and fenbuconazole (**Fig. 1**). *Colletotrichum truncatum* was resistant to many of these DMIs (data not shown), but this species does not appear to be widespread and thus may not pose a management issue. Specifically, *Colletotrichum truncatum* was resistant to tebuconazole, metconazole, flutriafol, and fenbuconazole and *C. nymphaeae* was resistant to flutriafol and fenbuconazole based on EC_{50} values >100 μg/ml. Resistance of *C. truncatum* to DMI fungicides may be based on point mutations in the target gene CYP51. We found mutations in the Substrate Recognition Site 6 (S511T) that were previously shown to confer resistance to DMI fungicides in *M. graminicola*. Other mutations in SRS5 were found that have not been reported to be DMI fungicide resistance determinants.

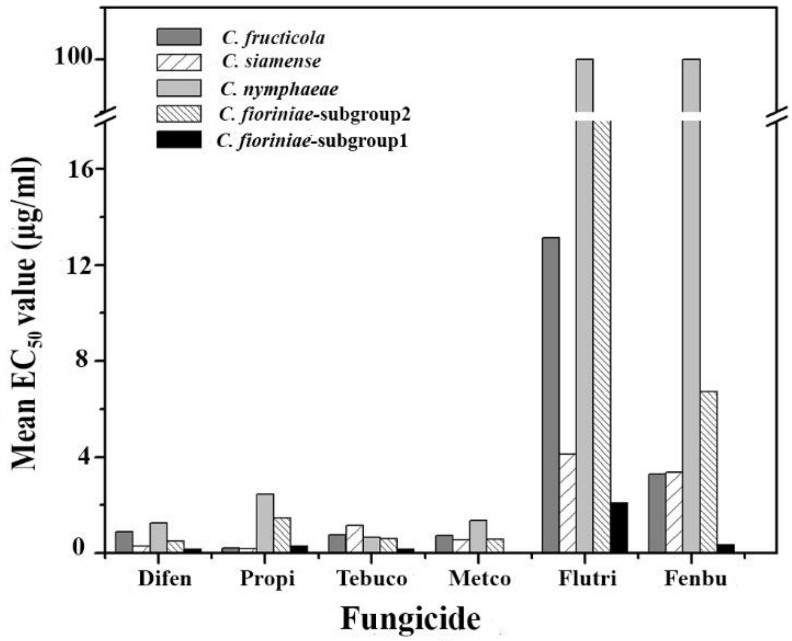

Fig. 1. EC_{50} values of *Colletotrichum* species for difenoconazole (Difen), propiconazole (Propi), tebuconazole (Tebuco), metconazole (Metco), flutriafol (Flutri), and fenbuconazole (Fenbu). Shown are average values of three isolates.

Colletotrichum fructicola and *C. siamense* were sensitive to all DMI fungicides (EC_{50} values ranging between 0.2 and 13.1 μg/ml). *Colletotrichum fioriniae* subgroup 2 isolates were less sensitive to DMI fungicides (EC_{50} values ranging from 0.5 to 16.2 μg/ml) compared with *C. fioriniae* subgroup1 (EC_{50} values ranging from 0.03 to 2.1 μg/ml). Difenoconazole and propiconazole provided the best control efficacy in vitro to all five species with EC_{50} values ranging from 0.2 to 2.7 μg/ml. Tebuconazole and metconazole were effective against all *Colletotrichum* species, except for *C. truncatum*. The strong in vitro activity of some DMI fungicides against *Colletotrichum* species may be exploited for improved anthracnose disease management of peach. Field tests are warranted to investigate the potential of DMI fungicides for anthracnose control. We hypothesize that high rates of DMI fungicides typically used to control *Monilinia fructicola* with resistance to DMI fungicides (i.e. 8 oz of Tebuzol 45DF) may be effective against anthracnose disease. However, control success may depend on the species present in the field. This work was recently published: Chen, S. N., C.X. Luo, M.J. Hu, and G. Schnabel 2016. Sensitivity of *Colletotrichum* species, including *C. fioriniae* and *C. numphaeae*, from peach to demethylation inhibitor fungicides. **Plant Dis.** 100:2434-2441.

APPLE (*Malus domestica* 'Idared')
Powdery mildew; *Podosphaera leucotricha*
Scab; *Venturia inaequalis*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Bitter rot; *Colletotrichum* spp.
White rot; *Botryosphaeria dothidea*
Fruit finish

K. S. Yoder, A. E. Cochran II,
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A.G.F. Engelman, A. Kowalski,
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Winchester, VA 22602

Control of powdery mildew and other diseases by experimental fungicides and mixed schedules on Idared apple, 2016.

Sixteen treatments involving experimental and registered combinations were directed at control of powdery mildew and other early season diseases in an area where SI and QoI fungicide effectiveness has been declining. The test was established as four randomized blocks on 35-yr-old trees using single-tree replications with border rows between treatment rows. Treatment rows had been used as non-treated border rows in 2015 to stabilize mildew inoculum pressure for 2016. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Fungicide treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 30 Mar (TC, tight cluster), 13 Apr (P-Bl, pink-bloom), 20 Apr (Bl, bloom), 4 May (PF, petal fall), 1C-8C (1st-8th covers): 16 May, 27 May, 10 Jun, 23 Jun, 7 Jul, 20 Jul, 2 Aug, 17 Aug. Maintenance materials applied to the entire test block with the same equipment included: Altacor, Asana XL, Assail, BioCover, Beleaf, Belt, Calypso, Danitol, Delegate, Imidan, Intrepid, and Lannate LV. Inoculum over each Idared test tree included cedar rust galls and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies placed 23 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 7 Jun. Apparent suppressive effect on appearance of primary mildew was rated on six primary mildew shoots per tree, 8 Jun using a scale of 1-10 (1= none; 10= excellent effect). Post-harvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 20 Sep, first rated 21 Sep and then rated for rots on 4 Oct after 14 days' ambient temperature incubation 65-87°F (mean 72.4°F). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew conidia were present 16 Mar, and there were 21 dry weather "mildew infection days" from 16 Mar until 5 May, resulting in moderate infection of non-treated trees (Table 1). Under these conditions, all treatments gave significant control of percent leaves and/or percent leaf area infected with mildew. Alternating Topguard with Merivon (Trt #1) had a strong suppressive effect on primary mildew development and good control of secondary infection of leaves and fruit, but two other treatments also gave excellent secondary control of mildew: #15 (Sercadis) and #16 (Merivon). Given that primary mildew control was not so good, the higher rate of Torino (#4) gave good control of mildew incidence and percent leaf area infected. GWN-10511 (#5) was significantly less effective than the equivalent rate of

Torino. Rhyme (#6) and Topguard (#7) gave comparable mildew control at equal active ingredient rates. Treatments involving Aprovia were among the weakest for mildew control in this test. Early season dry weather resulted in a delay of the first scab infection period until 22 Apr and, in spite of having frequent wetting events in May, scab pressure was low on leaves and fruit in this test, and all treatments gave adequate control of fruit scab (Table 3). Cedar-apple rust pressure was moderate to light and all treatments with Topguard in a rotational sequence gave excellent control (Table 2). Generally, mancozeb (Koverall) also gave some protection under these conditions, as did Aprovia (#8 and 9). An exception for rust suppression occurred in Treatment #15 where Sercadis + Koverall had significantly more rust than Sercadis + Captan (#14). The unidentified "leaf spots" shown in Table 2 were likely related to partially inhibited rust lesions, but did not have any orange coloration to clearly identify them as such. Summer disease pressures were moderate in this test. The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 14 May, was reached as early as 5 Jun (before the 3rd cover application), and this resulted in strong SBFS test conditions (Table 3), with most treatments giving adequate SBFS control. Control of post-storage rots (mostly, bitter rot, white rot, and some Alternaria). No treatments significantly increased russet compare to non-treated fruit, and several treatments significantly reduced opalescence (#6, 10, 11, and 12 (Table 4).

Table 1. Powdery mildew control on Idared apples, 2016. Virginia Tech AREC, Winchester.

			Primary mildew	Mildew infection			
				% leaves		% fruit inf.	
	Treatment and rate /A	Timing	effect*	% lvs	area	% fruit	area
0	Non-treated control	---	1.3 g	43 j	11 i	57 e	10 e
1	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7	6.7 a	6 bc	2 b-d	11 a-c	1 a-c
	Merivon 4.18SC 5 fl oz + Induce 8 fl oz /100 gal	#2,4,6,8					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
2	Torino 0.85SC 5 fl oz + Koverall 75DF 3 lb +		3.2 ef	16 ef	3 d-g	16 a-c	2 a-d
	Induce 8 fl oz/100 gal	TC-4C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
3	Torino 0.85SC 6.5 fl oz + Koverall 75DF 3 lb +		2.6 f	18 e-h	3 d-f	17 b-d	2 a-d
	Induce 8 fl oz/100 gal	TC-4C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
4	Torino 0.85SC 8 fl oz + Koverall 75DF 3 lb +		3.2 f	9 cd	2 b-d	17 a-c	2 a-d
	Induce 8 fl oz/100 gal	TC-4C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
5	GWN-10511 8 fl oz + Koverall 75DF 3 lb +		3.1 f	27 hi	4 e-g	24 cd	3 cd
	Induce 8 fl oz/100 gal	TC-4C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
6	Rhyme 6.5 fl oz+ Koverall 75DF 3 lb	#1,3,5,7	4.7 cd	25 gh	4 fg	17 bc	2 a-d
	Aprovia 0.83EC 5.5 fl oz+ Koverall 3 lb	#2,4,6,8					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
7	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7	5.0 b-d	24 f-h	3 e-g	8 ab	1 ab
	Aprovia 0.83EC 5.5 fl oz+ Koverall 75DF 3 lb	#2,4,6,8					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
8	Aprovia 0.83EC 5 fl oz	TC-4C	3.4 ef	35 ij	7 h	19 b-d	2 b-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C					
9	Aprovia 0.83EC 5 fl oz (applied at 100 gpa, 2 apps.)	TC-P	3.6 ef	35 ij	4 g	17 b-d	2 a-d
	Aprovia 0.83EC 5 fl oz (applied at 200 gpa, 2 apps.)	Bl-PF					
	Aprovia 0.83EC 5 fl oz (applied at 300 gpa, 4 apps.)	1C-4C					
	Captan 80WDG 30 oz + Ziram 3 lb oz (at 100 gpa)	5C-8C					
10	Luna Sensation 5 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	5.5 bc	13 de	2 cd	16 a-c	2 a-d
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5					
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)					
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C					
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C					
	Serenade Optimum 1 lb	7C-8C					
11	Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3	6.0 ab	17 ef	3 d-f	17 b-d	2 b-d
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5					
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)					
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C					
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C					
	Serenade Optimum 1 lb	7C-8C					
12	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	5.2 b-d	18 e-g	2 de	34 d	4 d
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5					
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)					
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C					
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C					
	Serenade Optimum 1 lb	7C-8C					
13	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	5.3 b-d	20 e-h	3 e-g	19 b-d	3 cd
	Serenade Optimum 1 lb + ProPhyt 2 qt	#2,4					
	Topguard 13 fl oz + Koverall 75DF 3 lb	#5					
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)					
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C					
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C					
	Serenade Optimum 1 lb	7C-8C					
14	Sercadis 3.5 fl oz + Captan 80WDG 2 lb	#1-4	5.0 b-d	6 bc	1 a-c	8 ab	1 ab
	Sercadis 3.5 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C					
15	Sercadis 3.5 fl oz + Koverall 75DF 3 lb	#1-4	4.3 de	4 ab	1 ab	15 a-c	2 a-d
	Sercadis 3.5 fl oz + Koverall 75DF 3 lb + Silwet 114 ml	#5-8C					
16	Merivon 4 fl oz + Captan 80WDG 2 lb	#1-5	5.8 a-c	1 a	<1 a	6 a	1 a
	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C					

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots per tree rated 7 Jun, or harvest counts of 25 fruit per tree rated 21 Sep.

* Suppressive effect rated on six primary mildew shoots/tree 8 Jun, scale: 1-10 (1= none; 10= excellent effect).

Treatment dates: 30 Mar (TC), 13 Apr (P-Bl), 20 Apr (Bl), 4 May (PF), 1C-8C (1st-8th cvrs): 16 May, 27 May, 10 Jun, 23 Jun, 7 Jul, 20 Jul, 2 Aug, 17 Aug.

Table 2. Control of cedar-apple rust and “leaf spots” on Idared apple, 2016.

			Cedar-apple rust		“Leaf spots”*	
	Treatment and rate/A	App. #	% lvs infected	lesions / leaf	% leaves	lesions / leaf
0	Non-treated control	---	13 cd	0.9 c-e	6 a-d	0.3 ab
1	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7	1 a	<0.1 a	5 a-d	0.1 a
	Merivon 4.18SC 5 fl oz + Induce 8 fl oz /100 gal	#2,4,6,8				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
2	Torino 0.85SC 5 fl oz + Koverall 75DF 3 lb + Induce 8 fl oz/100 gal	TC-4C	2 a	<0.1 a	11 cd	0.8 bc
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
3	Torino 0.85SC 6.5 fl oz + Koverall 75DF 3 lb + Induce 8 fl oz/100 gal	TC-4C	7 bc	0.8 b-e	12 d	1.0 c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
4	Torino 0.85SC 8 fl oz + Koverall 75DF 3 lb + Induce 8 fl oz/100 gal	TC-4C	8 bc	1.0 de	6 a-d	0.4 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
5	GWN-10511 8 fl oz + Koverall 75DF 3 lb + Induce 8 fl oz/100 gal	TC-4C	5 b	0.3 a-e	6 a-d	0.2 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
6	Rhyme 6.5 fl oz+ Koverall 75DF 3 lb	#1,3,5,7	<1 a	<0.1 a	5 a-d	0.1 a
	Aprovia 0.83EC 5.5 fl oz+ Koverall 75DF 3 lb	#2,4,6,8				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
7	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7	<1 a	<0.1 a	4 a-d	0.1 a
	Aprovia 0.83EC 5.5 fl oz+ Koverall 75DF 3 lb	#2,4,6,8				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
8	Aprovia 0.83EC 5 fl oz	TC-4C	2 a	0.1 a	10 b-d	0.2 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C				
9	Aprovia 0.83EC 5 fl oz (applied at 100 gpa, 2 apps.)	TC-P	1 a	0.1 a	5 a-d	0.1 a
	Aprovia 0.83EC 5 fl oz (applied at 200 gpa, 2 apps.)	BI-PF				
	Aprovia 0.83EC 5 fl oz (applied at 300 gpa, 4 apps.)	1C-4C				
	Captan 80WDG 30 oz + Ziram 3 lb oz (at 100 gpa)	5C-8C				
10	Luna Sensation 5 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	<1 a	<0.1 a	4 a-d	0.1 a
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5				
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)				
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C				
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C				
	Serenade Optimum 1 lb	7C-8C				
11	Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3	1 a	0.2 a-c	4 ab	0.1 a
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5				
	Indar 8 fl oz + Koverall 3 lb	#6 (2C)				
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C				
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C				
	Serenade Optimum 1 lb	7C-8C				
12	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	1 a	<0.1 a	4 a-d	0.1 a
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5				
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)				
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C				
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C				
	Serenade Optimum 1 lb	7C-8C				
13	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	1 a	<0.1 a	2 a	<0.1 a
	Serenade Optimum 1 lb + ProPhyt 2 qt	#2,4				
	Topguard 13 fl oz + Koverall 75DF 3 lb	#5				
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)				
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C				
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C				
	Serenade Optimum 1 lb	7C-8C				
14	Sercadis 3.5 fl oz + Captan 80WDG 2 lb	#1-4	2 a	0.1 ab	3 a-d	0.1 a
	Sercadis 3.5 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C				
15	Sercadis 3.5 fl oz + Koverall 75DF 3 lb	#1-4	14 d	1.3 e	6 a-d	0.4 ab
	Sercadis 3.5 fl oz + Koverall 75DF 3 lb + Silwet 114 ml	#5-8C				
16	Merivon 4 fl oz + Captan 80WDG 2 lb	#1-5	<1 a	<0.1 a	3 a-c	0.1 a
	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C				

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots per tree rated 7 Jun.

*“Leaf spots” refers to an unidentified symptom; could be inhibited c-a rust, frogeye leaf spot or leaf injury.

Applied airblast at 100 gpa to both sides of the row on each application date as follows: 30 Mar (TC), 13 Apr (P-Bl), 20 Apr (Bl), 4 May (PF), 1C-8C (1st-8th covers): 16 May, 27 May, 10 Jun, 23 Jun, 7 Jul, 20 Jul, 2 Aug, 17 Aug.

Table 3. Scab and summer disease control on Idared apples, 2016.

			Scab,	% fruit infected at harvest				
	Treatment and rate /A	Timing	% lvs inf.	Scab	Bitter rot	Brooks spot	Sooty blotch	Fly speck
0	Non-treated control	---	4 c	17 b	14 e	3 bc	65 d	43 c
1	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7	4 c	1 a				
	Merivon 4.18SC 5 fl oz + Induce 8 fl oz /100 gal	#2,4,6,8						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C			0 a	0 a	2 ab	1 ab
2	Torino 0.85SC 5 fl oz + Koverall 75DF 3 lb +		3 a-c	0 a				
	Induce 8 fl oz/100 gal	TC-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C			1 ab	0 a	2 ab	0 a
3	Torino 0.85SC 6.5 fl oz + Koverall 75DF 3 lb +		2 a-c	0 a				
	Induce 8 fl oz/100 gal	TC-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C			0 a	0 a	1 ab	3 b
4	Torino 0.85SC 8 fl oz + Koverall 75DF 3 lb +		3 c	1 a				
	Induce 8 fl oz/100 gal	TC-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C			0 a	0 a	2 a-c	3 b
5	GWN-10511 8 fl oz + Koverall 75DF 3 lb +		2 a-c	0 a				
	Induce 8 fl oz/100 gal	TC-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C			0 a	0 a	1 ab	0 a
6	Rhyme 6.5 fl oz+ Koverall 75DF 3 lb	#1,3,5,7	1 a	0 a				
	Aprovia 0.83EC 5.5 fl oz+ Koverall 75DF 3 lb	#2,4,6,8						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C			0 a	0 a	3 a-c	0 a
7	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7	1 ab	1 a				
	Aprovia 0.83EC 5.5 fl oz+ Koverall 75DF 3 lb	#2,4,6,8						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C			0 a	0 a	1 ab	0 a
8	Aprovia 0.83EC 5 fl oz	TC-4C	1 a	0 a				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →			0 a	1 ab	7 c	0 a
9	Aprovia 0.83EC 5 fl oz (applied at 100 gpa, 2 apps.)	TC-P	1 a	0 a				
	Aprovia 0.83EC 5 fl oz (applied at 200 gpa, 2 apps.)	Bl-PF						
	Aprovia 0.83EC 5 fl oz (applied at 300 gpa, 4 apps.)	1C-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb oz (at 100 gpa)	5C-8C			0 a	1 ab	1 ab	0 a
10	Luna Sensation 5 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	2 a-c	1 a				
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5						
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C			2 a-c	0 a	1 ab	0 a
11	Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3	3 c	0 a				
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5						
	Indar 8 fl oz + Koverall 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C			4 d	3 c	4 bc	0 a
12	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	3 bc	1 a				
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5						
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C			3 cd	0 a	7 c	1 ab
13	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3	2 a-c	0 a				
	Serenade Optimum 1 lb + ProPhyt 2 qt	#2,4						
	Topguard 13 fl oz + Koverall 75DF 3 lb	#5						
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C			2 b-d	0 a	5 bc	0 a
14	Sercadis 3.5 fl oz + Captan 80WDG 2 lb	#1-4	2 a-c	0 a				
	Sercadis 3.5 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C			0 a	0 a	0 a	2 ab
15	Sercadis 3.5 fl oz + Koverall 75DF 3 lb	#1-4	3 bc	0 a				
	Sercadis 3.5 fl oz + Koverall 75DF 3 lb + Silwet 114 ml	#5-8C			0 a	0 a	0 a	0 a
16	Merivon 4 fl oz + Captan 80WDG 2 lb	#1-5	3 c	0 a				
	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C			0 a	0 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots per tree rated 7 Jun, or harvest counts of 25 fruit per tree rated 21 Sep.
Treatment dates: 30 Mar (TC), 13 Apr (P-Bl), 20 Apr (Bl), 4 May (PF), 1C-8C (1st-8th cvrs): 16 May, 27 May, 10 Jun, 23 Jun, 7 Jul, 20 Jul, 2 Aug, 17 Aug.

Table 4. Postharvest storage rots and fruit finish of Idared apples, 2016.

			% post-storage rots*				Fruit finish**	
	Treatment and rate/A	Timing	Any rot	Bitter rot	White rot	Alternaria rot	russet	opal-escence
0	Non-treated control	---	44 f	37 e	7 c	2 a	1.7 a	1.3 d
1	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7						
	Merivon 4.18SC 5 fl oz + Induce 8 fl oz /100 gal	#2,4,6,8					1.5 a	1.0 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	1 ab	1 ab	0 a	0 a		
2	Torino 0.85SC 5 fl oz + Koverall 75DF 3 lb +							
	Induce 8 fl oz/100 gal	TC-4C					1.5 a	0.9 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	8 c-e	5 a-d	3 ab	0 a		
3	Torino 0.85SC 6.5 fl oz + Koverall 75DF 3 lb +							
	Induce 8 fl oz/100 gal	TC-4C					1.7 a	1.0 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	5 a-e	4 a-d	0 a	1 a		
4	Torino 0.85SC 8 fl oz + Koverall 75DF 3 lb +							
	Induce 8 fl oz/100 gal	TC-4C					1.6 a	1.1 b-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	6 b-e	5 b-d	0 a	1 a		
5	GWN-10511 8 fl oz + Koverall 75DF 3 lb +							
	Induce 8 fl oz/100 gal	TC-4C					1.6 a	0.8 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	9 c-e	6 b-d	2 ab	2 a		
6	Rhyme 6.5 fl oz+ Koverall 75DF 3 lb	#1,3,5,7						
	Aprovia 0.83EC 5.5 fl oz+ Koverall 75DF 3 lb	#2,4,6,8					1.4 a	1.0 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	5 b-e	4 a-d	1 a	0 a		
7	Topguard 13 fl oz + Koverall 75DF 3 lb	#1,3,5,7						
	Aprovia 0.83EC 5.5 fl oz+ Koverall 75DF 3 lb	#2,4,6,8					1.9 a	0.9 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	3 a-d	2 ab	1 a	0 a		
8	Aprovia 0.83EC 5 fl oz	TC-4C					1.6 a	1.2 b-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →	10 c-e	3 ab	6 bc	2 a		
9	Aprovia 0.83EC 5 fl oz (applied at 100 gpa, 2 apps.)	TC-P						
	Aprovia 0.83EC 5 fl oz (applied at 200 gpa, 2 apps.)	Bl-PF					1.6 a	1.0 a-d
	Aprovia 0.83EC 5 fl oz (applied at 300 gpa, 4 apps.)	1C-4C						
	Captan 80WDG 30 oz + Ziram 3 lb oz (at 100 gpa)	5C-8C	13 de	11 cd	0 a	2 a		
10	Luna Sensation 5 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3						
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5					1.3 a	0.7 a
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C	9 b-e	8 a-d	1 a	0 a		
11	Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3						
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5					1.5 a	0.9 a-c
	Indar 8 fl oz + Koverall 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C	5 a-e	5 a-d	0 a	0 a		
12	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3						
	Topguard 13 fl oz + Koverall 75DF 3 lb	#2,4,5					1.3 a	0.8 ab
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C	18 e	17 d	0 a	1 a		
13	Luna Tranquility 11.2 fl oz + Koverall 3 lb + Induce 8 fl oz	#1,3						
	Serenade Optimum 1 lb + ProPhyt 2 qt	#2,4					1.6 a	1.2 cd
	Topguard 13 fl oz + Koverall 75DF 3 lb	#5						
	Indar 8 fl oz + Koverall 75DF 3 lb	#6 (2C)						
	Indar 8 fl oz + Captan 80WDG 30 oz	3C-4C						
	Luna Sensation 5 fl oz + Captan 80WDG 30 oz	5C-6C						
	Serenade Optimum 1 lb	7C-8C	5 a-e	4 a-d	1 a	0 a		
14	Sercadis 3.5 fl oz + Captan 80WDG 2 lb	#1-4					1.5 a	0.9 a-d
	Sercadis 3.5 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C	3 a-c	2 ab	0 a	1 a		
15	Sercadis 3.5 fl oz + Koverall 75DF 3 lb	#1-4					1.7 a	1.2 cd
	Sercadis 3.5 fl oz + Koverall 75DF 3 lb + Silwet 114 ml	#5-8C	5 a-e	3 a-c	1 a	1 a		
16	Merivon 4 fl oz + Captan 80WDG 2 lb	#1-5					1.7 a	0.9 a-d
	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	#5-8C	0 a	0 a	0 a	0 a		

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; Means of 25 fruit per replication harvested 21 Sep; rated for fruit finish and then rated for rots 4 Oct after 14 days' ambient temperature at 65-87ºF (mean 72.4ºF).
Treatment dates: 30 Mar (TC), 13 Apr (P-Bl), 20 Apr (Bl), 4 May (PF), 1C-8C (1st-8th cvrs): 16 May, 27 May, 10 Jun, 23 Jun, 7 Jul, 20 Jul, 2 Aug, 17 Aug.
** Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe opalescence or russet, presumed not to be mildew).

APPLE (*Malus domestica* 'Stayman Winesap', 'Idared', Granny Smith')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Bitter rot; *Colletotrichum* spp.
White rot; *Botryosphaeria dothidea*
Alternaria rot; *Alternaria* spp.

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Evaluation of mixed fungicide schedules for broad spectrum disease control on Stayman, Idared, and Granny Smith apples, 2016.

Nine combination treatments were tested on 30-yr-old trees in an area where scab and mildew fungus resistance to SI fungicides has been present since 2004. The test was conducted in a randomized block design with four replicates of three- tree sets separated by non-treated border rows. Treatment rows had been used as non-treated border rows in 2015 to stabilize mildew inoculum pressure for 2016. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Fungicide treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 17 Apr (P-Bl, pink-bloom); 27 Apr (Bl-PF, petal fall); 7 May (PF); 1C-8C (1st-8th covers): 18 May, 31 May, 14 Jun, 25 Jun, 8 Jul, 22 Jul, 2 Aug, 17 Aug. Maintenance materials applied to the entire test block with the same equipment included: Altacor, Assail, Asana XL, BioCover, Beleaf, Belt, Danitol, Delegate, Imidan, and Lannate LV. Inoculum, placed over each Idared test tree 26 Apr, included cedar rust galls, wild blackberry canes with the sooty blotch and flyspeck fungi, and bitter rot mummies 16 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 17 Jun (Idared), 21 Jul (Stayman) or 27 Jul (Granny Smith). Post-harvest fruit counts are means of 25-fruit samples picked from each of four paired-tree reps. Idared was sampled 15 Sep and held in cold storage until the first rating 20 Sep, then rated again for rots 5 Oct, after 15 days at 65-87ºF (mean 72.2ºF). Stayman was sampled 5 Oct, first rated 12 Oct, then rated again for rots 24 Oct, after 19 days at 64-82ºF (mean 70.0ºF). Granny Smith was sampled 4 Oct, first rated 7 Oct, then rated again for rots 21 Oct, after 19 days at 64-82ºF (mean 70.0ºF) Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew conidia were present 16 Mar, and 21 dry weather "mildew infection days" from 16 Mar until 5 May, resulted in moderate infection of non-treated trees (Table 5). Under these conditions, all treatments gave significant control of percent leaves and/or percent leaf area and percent fruit infected with mildew. Treatments #1-5 had parallel schedules of five different SDHI products + Manzate alternated with Inspire Super + Manzate in the first seven applications. Luna Sensation/Inspire Super (Trt #2) had the fewest leaves infected on all the cultivars. Among treatments #1-5, Aprovia/Inspire Super (Trt #4) was least effective for control of mildew on leaves. Treatments #6-8, carried through 4th cover spray, gave adequate control of mildew on foliage, but had the most mildew on fruit. Control of mildew on Idared fruit by KFD-218-01 was significantly improved by tank-mixing with KFD-285-01. The first scab infection period did not occur until 22 Apr (bloom); however, after this delayed start, there were 13 infection periods that occurred in 15 days from 28 Apr-12 May, and 23 infection periods through 31 May. Under these conditions, scab incidence was moderate to heavy on Stayman and Granny Smith, but lighter on Idared (Table 6). SI fungicide resistance has been present in the area and this was confirmed by poor scab control by Procure (#8). Aprovia + Manzate/Inspire Super+ Manzate (#4) gave excellent scab control on leaves and fruit. A continuous schedule of Luna Tranquility through 4th cover (#9) was less effective for scab control on Stayman and Granny Smith leaves and fruit than an alternating schedule of Luna Tranquility + Manzate/Inspire Super + Manzate (#3). Cedar-apple rust pressure was moderate to light on Idared leaves and fruit, and all treatments gave adequate control under these conditions (Table 7). The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 14 May, was reached as early as 5 Jun (before the 3rd cover application), and this resulted in strong SBFS test conditions (Table 8). All treatments received Captan + Ziram in the late cover applications, but there were significant differences in control related to what was applied as early as the 4th cover. SDHI products + Manzate alternated with Inspire Super + Manzate in the early applications (#1-5) gave good to excellent SBFS control under heavy pressure on Stayman and Granny Smith, while Procure (#8), KFD-218-01 (#6 & 7), and Luna Tranquility were weaker. The postharvest rot spectrum included mostly bitter rot, white rot and some Alternaria (Table 9). Generally, the schedules involving SDHI products + Manzate alternated with Inspire Super + Manzate in the first seven applications (#1-5) all gave better rot control than treatments #6-9 which did not have Manzate in the earlier applications. There were some significant fruit finish differences among treatments; all treatment significantly reduced russetting of Granny Smith compared to non-treated fruit (Table 10).

Table 5. Powdery mildew control on Stayman, Idared, and Granny Smith apples, 2016.

	Treatment and formulated rate/acre	Timing	% leaves or leaf area or fruit infected									
			Stayman		Idared				Granny Smith			
			leaves	area	lvs	area	fruit	area	lvs	area	fruit	area
0	No fungicide	--	47 d	20 b	41 c	16 c	62 f	9.3 f	52 e	20 e	28 d	3.9 f
1	Merivon 4.18SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	5 ab	1 a	20 ab	3 a	9 b-d	1.1 a-d	10 bc	2 a-c	2 ab	0.2 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
2	Luna Sensation 500SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	4 a	1 a	12 a	2 a	6 ab	0.2 ab	4 a	1 a	3 ab	0.3 ab
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
3	Luna Tranquility 4.16SC 11.2 fl oz + Manzate 3 lb	#1,3,5,7	10 bc	2 a	26 b	4 a	2 a	0.3 a	14 c	3 bc	1 a	0.1 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
4	Aprovia 0.83EC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	17 c	3 a	41 c	11 b	9 a-c	1.3 a-c	32 d	6 d	8 bc	1.2 b-d
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
5	Fontelis 1pt + Manzate 75DF 3 lb	#1,3,5,7	9 b	2 a	28 b	4 a	11 b-d	1.2 b-e	26 d	3 c	6 bc	0.9 cd
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
6	KFD-218-01 4SC 12 fl oz	Pk-4C	8 ab	1 a	15 a	2 a	27 e	3.0 e	10 bc	2 bc	15 c	2.3 ef
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
7	KFD-218-01 12 fl oz + KFD-285-01 4 fl oz/100gal	Pk-4C	7 ab	1 a	15 a	3 a	12 b-d	1.6 c-e	10 bc	2 bc	14 c	2.3 ef
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
8	Procure 4SC 12 fl oz	Pk-4C	8 ab	1 a	18 ab	3 a	21 de	2.9 de	10 bc	2 bc	13 c	1.9 de
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										
9	Luna Tranquility 4.16SC 11.2 fl oz	Pk-4C	8 ab	1 a	12 a	2 a	19 c-e	2.3 c-e	6 ab	2 ab	3 ab	0.3 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C										

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 17 Jun (Idared) 21 Jul (Stayman) or 27 Jun (Granny Smith) or harvest counts of 25-fruit samples picked from each of four single-tree reps 15 Sep (Idared), 5 Oct (Stayman), or 4 Oct (Granny Smith).

Test rows were used as non-treated border rows in 2015 to stabilize mildew inoculum pressure for 2016.

Treatments applied airblast at 100 gpa to both sides of the row on each application date.
Treatment dates: 17 Apr (P-Bl, pink-bloom); 27 Apr (Bl-PF, petal fall); 7 May (PF); 1C-8C (1st-8th covers): 18 May, 31 May, 14 Jun, 25 Jun, 8 Jul, 22 Jul, 2 Aug, 17 Aug.

Table 6. Scab and Brooks spot control on Stayman, Idared and Granny Smith apples, 2016.

			Scab, % leaves infected			Scab, % fruit infected			Brooks spot, % fruit inf.		
	Treatment and formulated rate/acre	Timing	Stay-man	Idared	Granny Smith	Stay-man	Idared	Granny Smith	Stay-man	Idared	Granny Smith
0	No fungicide	--	73 e	17 b	31 d	55 de	24 c	88 e	3 a	26 d	2 a
1	Merivon 4.18SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	14 b	4 a	9 bc	3 ab	1 a	0 a	0 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6									
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
2	Luna Sensation 500SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	11 ab	2 a	2 a	0 a	0 a	0 a	0 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6									
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
3	Luna Tranquility 4.16SC 11.2 fl oz + Manzate 3 lb	#1,3,5,7	9 ab	2 a	2 a	0 a	1 a	2 a	0 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6									
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
4	Aprovia 0.83EC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	6 a	2 a	1 a	0 a	0 a	0 a	0 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6									
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
5	Fontelis 1pt + Manzate 75DF 3 lb	#1,3,5,7	14 b	3 a	4 ab	4 b	2 a	3 a	0 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6									
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
6	KFD-218-01 4SC 12 fl oz	Pk-4C	58 d	17 b	28 d	21 c	25 c	46 cd	1 a	3 b	1 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
7	KFD-218-01 12 fl oz + KFD-285-01 4 fl oz/100gal	Pk-4C	62 d	21 b	31 d	67 e	33 cd	56 d	1 a	11 c	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
8	Procure 4SC 12 fl oz	Pk-4C	63 d	25 b	21 d	44 d	36 d	36 c	3 a	7 bc	1 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									
9	Luna Tranquility 4.16SC 11.2 fl oz	Pk-4C	31 c	5 a	12 c	14 c	7 b	15 b	0 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C									

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 17 Jun (Idared) 21 Jul (Stayman) or 27 Jun (Granny Smith) or harvest counts of 25-fruit samples picked from each of four single-tree replications 15 Sep (Idared), 5 Oct (Stayman), or 4 Oct (Granny Smith).

Treatments applied airblast at 100 gpa to both sides of the row on each application date.
Treatment dates: 17 Apr (P-Bl, pink-bloom); 27 Apr (Bl-PF, petal fall); 7 May (PF); 1C-8C (1st-8th covers): 18 May, 31 May, 14 Jun, 25 Jun, 8 Jul, 22 Jul, 2 Aug, 17 Aug.

Table 7. Control of cedar-apple rust and quince rust on Stayman and Idared apples, 2016.

			Cedar-apple rust, foliage % leaves or lesions/leaf				Harvest counts Idared, % fruit	
			Stayman		Idared		Cedar	Quince
	Treatment and formulated rate/acre	Timing	% inf.	les/lf	% inf.	les/lf	rust	rust
0	No fungicide	--	1.2 a	0.1 a	43 c	4.9 b	2 b	6 c
1	Merivon 4.18SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	0 a	0 a	<1 ab	<0.1 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
2	Luna Sensation 500SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	0 a	0 a	<1 ab	<0.1 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
3	Luna Tranquility 4.16SC 11.2 fl oz + Manzate 3 lb	#1,3,5,7	0 a	0 a	<1 ab	<0.1 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
4	Aprovia 0.83EC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7	0 a	0 a	0 a	0 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
5	Fontelis 1pt + Manzate 75DF 3 lb	#1,3,5,7	0 a	0 a	1 ab	<0.1 a	0 a	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
6	KFD-218-01 4SC 12 fl oz	Pk-4C	0 a	0 a	<1 ab	<0.1 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
7	KFD-218-01 12 fl oz + KFD-285-01 4 fl oz/100gal	Pk-4C	0 a	0 a	0 a	0 a	0 a	1 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
8	Procure 4SC 12 fl oz	Pk-4C	0 a	0 a	0 a	0 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
9	Luna Tranquility 4.16SC 11.2 fl oz	Pk-4C	0 a	0 a	2 b	0.1 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 17 Jun (Idared) and 21 Jul (Stayman) or harvest counts of 25-fruit samples from each of four single-tree reps 15 Sep (Idared) and 5 Oct (Stayman).

Treatments applied airblast at 100 gpa to both sides of the row on each application date: 17 Apr (P-Bl, pink-bloom); 27 Apr (Bl-PF, petal fall); 7 May (PF); 1C-8C (1st-8th covers): 18 May, 31 May, 14 Jun, 25 Jun, 8 Jul, 22 Jul, 2 Aug, 17 Aug.

Table 8. Control of sooty blotch and flyspeck by fungicides on Stayman, Idared, and Granny Smith apples, 2016.

		% fruit or fruit area infected, harvest counts											
		Sooty blotch						Flyspeck					
		Stayman		Idared		G. Smith		Stayman		Idared		G. Smith	
Treatment and rate/A	Timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0 No fungicide	--	97 c	15 c	85 e	11 e	99 e	15 e	96 c	8 c	78 c	5 c	99 d	8 e
1 Merivon 4.18SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7												
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	8 a	<1 a	3 a	<1 ab	3 a	<1 a	1 a	<1 a	0 a	0 a	2 a	<1 a
2 Luna Sensation 500SC 5.5 fl oz + Manzate 3 lb	#1,3,5,7												
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	11 a	<1 a	2 a	<1 a	5 a	<1 a	1 a	<1 a	0 a	0 a	4 a	<1 a
3 Luna Tranquility 4.16SC 11.2 fl oz + Manzate 3 lb	#1,3,5,7												
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	5 a	<1 a	8 a-c	<1 a-c	6 a	<1 a	0 a	0 a	0 a	0 a	0 a	0 a
4 Aprovia 0.83EC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7												
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	4 a	<1 a	2 a	<1 a	5 a	<1 a	0 a	0 a	0 a	0 a	2 a	<1 a
5 Fontelis 1pt + Manzate 75DF 3 lb	#1,3,5,7												
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	12 a	<1 a	4 ab	<1 ab	6 a	<1 a	3 a	<1 a	0 a	0 a	0 a	0 a
6 KFD-218-01 4SC 12 fl oz	Pk-4C												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	61 b	4 b	23 cd	2 cd	33 bc	2 bc	31 b	2 b	8 b	<1 b	18 b	<1 b
7 KFD-218-01 12 fl oz + KFD-285-01 4 fl oz/100gal	Pk-4C												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	65 b	4 b	36 d	2 d	49 cd	4 cd	44 b	2 b	7 b	<1 b	43 c	3 c
8 Procure 4SC 12 fl oz	Pk-4C												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	63 b	4 b	34 d	3 d	62 d	5 d	32 b	2 b	12 b	<1 b	59 c	5 d
9 Luna Tranquility 4.16SC 11.2 fl oz	Pk-4C												
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	53 b	4 b	22 b-d	2 b-d	17 ab	1 ab	27 b	2 b	0 a	0 a	17 b	1 b

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 17 Jun (Idared) 21 Jul (Stayman) or 27 Jun (Granny Smith) or harvest counts of 25-fruit samples picked from each of four single-tree reps 15 Sep (Idared), 5 Oct (Stayman), or 4 Oct (Granny Smith).

Treatments applied airblast at 100 gpa to both sides of the row on each application date.

Treatment dates: 17 Apr (P-Bl, pink-bloom); 27 Apr (Bl-PF, petal fall); 7 May (PF); 1C-8C (1st-8th covers): 18 May, 31 May, 14 Jun, 25 Jun, 8 Jul, 22 Jul, 2 Aug, 17 Aug.

Table 9. Control of post-harvest fruit rots on Stayman, Idared and Granny Smith apples, 2016.

		% bitter rot at harvest		% fruit infected, post-storage counts										
				Any rot			Bitter rot			White rot			Alternaria	
Treatment and rate/A	Timing	Idared	Gran. Smith	Stay-man	Ida-red	Gran. Smith	Stay-man	Ida-red	Gran. Smith	Stay-man	Ida-red	Gran. Smith	Stay-man	Ida-red
0 No fungicide	--	51 c	11 b	37 e	76 d	60 g	15 c	67 d	52 f	12 b	11 a	17 d	15 d	3 b
1 Merivon 4.18SC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7													
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	0 a	1 a	3 a	4 a	3 a	0 a	3 a	3 a	0 a	1 a	0 a	3 a-c	0 a
2 Luna Sensation 500SC 5.5 fl oz + Manzate 3 lb	#1,3,5,7													
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	2 a	1 a	9 bc	7 a	8 a-c	4 b	5 ab	6 ab	5 ab	2 a	2 ab	1 ab	0 a
3 Luna Tranquility 4.16SC 11.2 fl oz + Manzate 3 lb	#1,3,5,7													
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	10 ab	0 a	17 cd	14 ab	10 ab	9 bc	13 ab	7 a	4 ab	1 a	3 a-c	4 c	0 a
4 Aprovia 0.83EC 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5,7													
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	5 ab	1 a	1 a	15 a-c	13 b-d	0 a	12 ab	6 ab	0 a	2 a	7 a-d	1 ab	1 ab
5 Fontelis 1pt + Manzate 75DF 3 lb	#1,3,5,7													
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	2 a	4 ab	4 ab	6 a	10 ab	0 a	6 ab	8 a-c	3 ab	0 a	2 ab	0 a	0 a
6 KFD-218-01 4SC 12 fl oz	Pk-4C													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	7 ab	7 ab	17 cd	29 bc	24 de	7 bc	22 bc	15 b-d	7 ab	10 a	16 cd	3 a-c	0 a
7 KFD-218-01 12 fl oz + KFD-285-01 4 fl oz/100gal	Pk-4C													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	24 b	7 ab	17 cd	39 c	44 fg	13 bc	37 cd	33 e	1 ab	5 a	14 d	3 bc	0 a
8 Procure 4SC 12 fl oz	Pk-4C													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	5 ab	2 ab	27 de	17 a-c	21 c-e	13 c	15 a-c	17 c-e	11 ab	3 a	4 a-c	5 c	0 a
9 Luna Tranquility 4.16SC 11.2 fl oz	Pk-4C													
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	10 ab	8 ab	11 c	25 a-c	32 ef	6 b	23 a-c	25 de	4 ab	2 a	8 b-d	1 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Post-harvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps. Idared sampled 15 Sep and placed in cold storage; moved 20 Sep to ambient temperatures 65-87°F (mean 72.2°F) and rated for rots after 15 days' incubation. Stayman sampled 5 Oct, first rated 12 Oct, then rated for rots after 19 days incubation at ambient temperatures 64-82°F (mean 70.0°F). Granny Smith sampled 4 Oct, first rated 7 Oct, then rated for rots after 17 days incubation at ambient temperatures 64-82°F (mean 70.0°F).

Treatments applied airblast at 100 gpa to both sides of the row on each application date: 17 Apr (P-Bl, pink-bloom); 27 Apr (Bl-PF, petal fall); 7 May (PF); 1C-8C (1st-8th covers): 18 May, 31 May, 14 Jun, 25 Jun, 8 Jul, 22 Jul, 2 Aug, 17 Aug.

Table 10. Fruit finish effects by fungicide treatments on Stayman, Idared, and Granny Smith apples, 2016.

			Fruit finish ratings (0-5)*					
			Russet			Opalescence		
	Treatment and rate/A	Timing	Stayman	Idared	Granny S.	Stayman	Idared	Granny S.
0	No fungicide	--	1.4 a	1.5 a	1.4 e	0.8 a	1.3 b	1.4 d
1	Merivon 4.18SC 5.5 fl oz + Manzate 75DF 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 5C-8C	1.7 a	1.8 a	0.5 a	1.1 a	0.9 ab	0.5 ab
2	Luna Sensation 500SC 5.5 fl oz + Manzate 75DF 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 5C-8C	1.8 a	1.7 a	0.6 a-c	1.0 a	1.0 ab	0.4 a
3	Luna Tranquility 4.16SC 11.2 fl oz + Manzate 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 5C-8C	1.7 a	1.6 a	0.6 ab	1.0 a	0.8 a	0.5 a-c
4	Aprovia 0.83EC 5.5 fl oz + Manzate 75DF 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 5C-8C	1.8 a	1.8 a	0.7 a-d	0.9 a	0.9 ab	0.6 a-c
5	Fontelis 1pt + Manzate 75DF 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 5C-8C	1.7 a	1.6 a	0.5 a	1.1 a	0.8 a	0.5 a-c
6	KFD-218-01 4SC 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	Pk-4C 5C-8C	1.7 a	1.6 a	0.8 a-d	0.7 a	1.0 ab	0.8 bc
7	KFD-218-01 12 fl oz + KFD-285-01 4 fl oz/100gal Captan 80WDG 30 oz + Ziram 76DF 3 lb	Pk-4C 5C-8C	1.9 a	1.7 a	1.0 d	1.0 a	1.1 ab	1.2 d
8	Procure 4SC 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	Pk-4C 5C-8C	1.8 a	1.7 a	0.9 cd	0.8 a	1.1 ab	0.8 c
9	Luna Tranquility 4.16SC 11.2 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	Pk-4C 5C-8C	1.7 a	1.8 a	0.9 b-d	0.9 a	1.1 ab	0.8 bc

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Harvest counts of 25-fruit samples picked from each of four single-tree replications 15 Sep (Idared), 5 Oct (Stayman), or 4 Oct (Granny Smith).

* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe opalescence or russet, presumed not to be mildew).

Treatments applied airblast at 100 gpa to both sides of the row on each application date.
Treatment dates: 17 Apr (P-Bl, pink-bloom); 27 Apr (Bl-PF, petal fall); 7 May (PF); 1C-8C (1st-8th covers): 18 May, 31 May, 14 Jun, 25 Jun, 8 Jul, 22 Jul, 2 Aug, 17 Aug.

APPLE (*Malus domestica* 'Golden Delicious', 'Idared')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Brooks spot; *Mycosphaerella pomi*
Rots (unspecified)
Bitter rot; *Colletotrichum* spp.
White rot; *Botryosphaeria dothidea*
Alternaria rot; *Alternaria* spp.

K. S. Yoder, A. E. Cochran II,
W. S. Royston, Jr., S. W. Kilmer,
A.G.F. Engelman, A. L. Kowalski,
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Disease control by experimental and registered fungicides and mixtures on Golden Delicious and Idared apples, 2016.

Fifteen experimental or registered combination treatment schedules were compared on two-tree sets of 16-yr-old trees. The test was conducted in a randomized block design with four replicates separated by non-treated border rows. Test rows had been non-treated border rows in 2015, which allowed mildew inoculum pressure to stabilize on 2016 test trees. Fungicide treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 10 Apr (App. # 1, Golden Delicious open cluster-king bloom; Idared 10% bloom; York, pink); 20 Apr (App. # 2, bloom); 2 May (App. # 3, PF, petal fall); Apps. #4-10: (1C-8C, 1st-8th covers): 14 May, 25 May, 10 Jun, 24 Jun, 7 Jul, 20 Jul, 2 Aug, 18 Aug. Inoculum placed over each Golden Delicious test tree included cedar rust galls, wild blackberry canes with the sooty blotch and flyspeck fungi, and bitter rot mummies 24 May. Other diseases developed from inoculum naturally present in the test area, including cedar-apple rust inoculum from red cedars in the vicinity. Maintenance sprays, applied to the entire test block included Admire Pro, Altacor, Assail, Asana XL, BioCover, Belt, Beleaf, Calypso, Danitol, Delegate, FireLine, Imidan, Intrepid, and Lannate LV. Foliar data are from counts of ten shoots per replicate tree: 8 Jun (Golden Delicious) and 21 Jun (Idared), and fruit data represent postharvest counts of 25 fruit per replicate tree. Idared fruit were sampled 20 Sep, placed in cold storage until 13 Oct, moved to ambient temperatures (65-82ºF, mean 69.9ºF) and rated 19 Oct and 31 Oct. Golden Delicious fruit were sampled 27 Sep, and held in ambient temperatures (64-82ºF, mean 69.8ºF) and rated 4 Oct and 17 Oct. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Early season dry weather resulted in a delay of the first scab infection period until 22 Apr, two days after the first application at bloom. However, after this delayed start, there were 13 infection periods in 15 days from 28 Apr-12 May, and 23 infection periods through 31 May. Under these conditions, scab pressure was moderate, but scab resistance to SI and QoI fungicides has been present in the test area for several years, and this probably impacted the effectiveness of Treatments #1 and 2 (Table 11). GWN-10411 gave excellent scab control on leaves and fruit at the highest rate (#5). KFD-222-01 (#11) did not effectively control scab on leaves, but gave some suppression on fruit. Zn-Phite (#12 & 13) gave good scab control and showed a significant rate response. ProPhyt (#14) gave excellent scab suppression under these conditions. Mildew conidia were present 16 Mar, and there were 21 dry weather "mildew infection days" from 16 Mar until 5 May, resulting in moderately heavy infection of non-treated trees (Table 11). Treatments #1 and 2 were probably also affected by mildew resistance to the SI fungicides. Although GWN-10411 did not show a strong suppressive effect on primary mildew, it gave excellent mildew control of secondary infection on leaves with a significant rate effect (#5). Viathon suppressed scab and mildew infection on Idared leaves and fruit, scab on Golden Delicious fruit, and mildew on Golden Delicious leaves. Rally (#1 & 2) and Viathon (#15) gave excellent control under heavy cedar-apple rust and light quince rust pressure (Table 12). Rust control with GWN-10411 was somewhat erratic. Zn-Phite did not control rusts. The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 14 May, was reached 21 Jun (after the 3rd cover application), and this resulted in strong SBFS test conditions (Table 13). Under these conditions, nearly all treatments gave significant SBFS suppression. Commercial standards, Manzate, Merivon and Captan + Ziram (#1, 2 & 15) performing as expected. SBFS control with GWN-10411 was erratic at the higher rate. All treatments gave significant control of Brooks spot under moderate disease pressure (Table 14). Merivon + Manzate/Captan + Ziram gave superior rot control. Several treatments significantly reduced russetting or opalescence of Golden Delicious and Idared (Table 15); Zn-Phite (#12) significantly increased russetting and opalescence of Golden Delicious and Idared.

Table 11. Scab and Mildew control on Idared and Golden Delicious apples, 2016. Block 30, Virginia Tech AREC.

		Scab infection, % lvs. or fruit inf.				Idared	Mildew, % lvs., lf. area or fruit inf.				
		Idared		Golden Delicious		Primary mildew	Idared			G. Delicious	
Treatment and rate/acre	App. number	lvs	fruit	lvs	fruit	rating*	leaves	leaf area	fruit	leaves	leaf area
0 Non-treated control	---	17 f	25 d	21 gh	63 e	2.1 e	57 i	23 i	26 f	45 i	8 i
1 Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	Pk-3C 4C-8C	16 f	10 bc	24 h	3 ab	4.9 b	36 e-g	8 e-h	3 a-d	21 e-g	3 e-h
2 Merivon 5.5 fl oz + Manzate Pro-Stick 75DF 3 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5 #2,4,6 #7-8C	14 ef	3 a	21 gh	1 a	6.1 a	13 c	3 a-d	0 a	4 ab	1 bc
3 GWN-10411 20SC 2 fl oz	Pk-8C	8 c-e	7 a-c	6 bc	9 bc	3.7 c	14 bc	2 a-c	4 a-d	8 bc	1 cd
4 GWN-10411 20SC 3 fl oz	Pk-8C	4 a-c	4 a-c	3 ab	0 a	3.4 cd	12 a-c	2 a-c	7 b-e	5 b	1 bc
5 GWN-10411 20SC 4 fl oz	Pk-8C	2 a	2 a	2 a	1 a	3.7 c	6 a	1 a	4 b-e	2 a	1 a
6 GWN-10411 20SC 4 fl oz + Manzate Pro-Stick 75DF 3 lb GWN-10411 4 fl oz + Captan 80WDG 30 oz + Ziram 3 lb	Pk-3C 4C-8C	2 ab	1 a	2 a	1 a	3.7 c	5 ab	2 ab	4 a-d	2 a	1 ab
7 Penncozeb 75DF 4.5 lb	Pk-8C	8 c-e	5 a-c	11 c-e	1 a	3.6 c	24 de	4 b-e	2 a-c	18 d-f	2 d-f
8 Manzate Pro-Stick 75DF 4.5 lb	Pk-8C	8 c-e	1 a	15 e-g	0 a	3.1 cd	39 e-g	9 f-h	6 c-e	26 f-h	3 f-h
9 Ziram 76DF 4.5 lb	Pk-8C	11 d-f	7 a-c	16 fg	2 a	2.8 de	34 ef	5 d-f	1 ab	28 gh	3 f-h
10 Captan 80WDG 4.2 lb	Pk-8C	6 b-d	1 a	12 d-f	1 a	3.5 cd	48 g-i	10 h	1 ab	32 h	4 h
11 KFD-222-01 75DF 4.5 lb	Pk-8C	13 ef	3 ab	19 f-h	31 d	3.0 cd	52 hi	10 gh	2 a-c	29 gh	4 gh
12 Zn-Phite 2 gal	Pk-8C	4 ab	1 a	4 ab	1 a	3.4 cd	30 d-f	4 c-f	7 de	15 de	2 d-f
13 Zn-Phite 76.8 fl oz	Pk-8C	4 a-c	10 c	8 cd	8 c	3.5 cd	38 f-h	6 e-h	12 e	20 d-g	2 d-g
14 ProPhyt 2 qt	Pk-8C	4 a-c	2 a	9 cd	2 a	3.7 c	31 d-f	6 e-g	4 a-e	19 d-f	2 c-e
15 Viathon 4.08SC 4 pt Captan 80WDG 3.5 lb + ProPhyt 4 pt Merivon 5.5 fl oz + Captan 80 WDG 30 oz	Pk-3C 4C 5C-8C	6 b-d	3 ab	18 f-h	13 c	5.4 ab	20 cd	3 a-d	4 a-e	12 cd	2 c-e

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps, 10 shoots/tree 8 Jun (G. Delicious) or 21 Jun (Idared), or harvest counts of 25 fruit per tree picked 20 Sep (Idared) or 27 Sep (Golden Delicious).

* Suppressive effect rated on six primary mildew shoots/tree 8 Jun, scale: 1-10 (1= none; 10= excellent effect).

Treatment dates: 10 Apr (App. # 1, Golden Delicious open cluster-king bloom; Idared 10% bloom; York, pink); 20 Apr (App. # 2, bloom); 2 May (App. # 3, PF, petal fall); Apps. #4-11 (1C-8C, 1st-8th covers): 14 May, 25 May, 10 Jun, 24 Jun, 7 Jul, 20 Jul, 2 Aug, 18 Aug.

Table 12. Control of cedar-apple and quince rust on Idared and Golden Delicious apples, 2016.

	Treatment and rate/acre	App. number	Cedar-apple rust, % infected: Idared leaves	Idared fruit	Golden Del. leaves	Quince rust % fruit infected: Idared	G. Del.
0	Non-treated control	---	36 f	1 ab	48 g	5 b-d	14 d
1	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	Pk-3C	<1 a	0 a	<1 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C-8C					
2	Merivon 5.5 fl oz + Manzate Pro-Stick 75DF 3 lb	#1,3,5	0 a	0 a	<1 a	0 a	0 a
	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	#2,4,6					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7-8C					
3	GWN-10411 20SC 2 fl oz	Pk-8C	2 b	0 a	6 b	5 b-d	0 a
4	GWN-10411 20SC 3 fl oz	Pk-8C	12 d	1 ab	18 cd	11 cd	3 bc
5	GWN-10411 20SC 4 fl oz	Pk-8C	5 bc	3 b	6 b	9 d	0 a
6	GWN-10411 20SC 4 fl oz + Manzate Pro-Stick 75DF 3 lb	Pk-3C	5 bc	0 a	13 bc	0 a	0 a
	GWN-10411 4 fl oz + Captan 80WDG 30 oz + Ziram 3 lb	4C-8C					
7	Penncozeb 75DF 4.5 lb	Pk-8C	18 e	2 ab	30 ef	1 ab	0 a
8	Manzate Pro-Stick 75DF 4.5 lb	Pk-8C	23 e	0 a	25 de	0 a	0 a
9	Ziram 76DF 4.5 lb	Pk-8C	9 cd	0 a	19 cd	0 a	0 a
10	Captan 80WDG 4.2 lb	Pk-8C	12 d	0 a	23 de	0 a	1 ab
11	KFD-222-01 75DF 4.5 lb	Pk-8C	18 e	1 ab	26 de	0 a	1 ab
12	Zn-Phite 2 gal	Pk-8C	34 f	2 ab	47 g	3 a-c	3 b
13	Zn-Phite 76.8 fl oz	Pk-8C	34 f	1 ab	42 g	3 a-c	8 cd
14	ProPhyt 2 qt	Pk-8C	24 e	0 a	38 fg	5 b-d	0 a
15	Viathon 4.08SC 4 pt	Pk-3C	0 a	0 a	1 a	0 a	0 a
	Captan 80WDG 3.5 lb + ProPhyt 4 pt	4C					
	Merivon 5.5 fl oz + Captan 80 WDG 30 oz	5C-8C					

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps, 10 shoots/tree 8 Jun (G. Delicious) or 21 Jun (Idared), or harvest counts of 25 fruit per tree picked 20 Sep (Idared) or 27 Sep (Golden Delicious).
Treatment dates: 10 Apr (App. # 1, Golden Delicious open cluster- king bloom; Idared 10% bloom; York, pink); 20 Apr (App. # 2, bloom); 2 May (App. # 3, PF, petal fall); Apps. #4-11 (1C-8C, 1st-8th covers): 14 May, 25 May, 10 Jun, 24 Jun, 7 Jul, 20 Jul, 2 Aug, 18 Aug.

Table 13. Control of sooty blotch and flyspeck on Golden Delicious and Idared apples, 2016.

	Treatment and rate/acre	App. number	% fruit infected: Sooty blotch Golden Del.	Sooty blotch Idared	Flyspeck Golden Del.	Flyspeck Idared
0	Non-treated control	---	94 e	100 g	99 f	100 g
1	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	Pk-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C-8C	8 a-c	28 e	43 d	29 cd
2	Merivon 5.5 fl oz + Manzate Pro-Stick 75DF 3 lb	#1,3,5				
	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	#2,4,6				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7-8C	0 a	0 a	6 ab	8 a
3	GWN-10411 20SC 2 fl oz	Pk-8C	15 bc	18 c-e	51 d	51 e
4	GWN-10411 20SC 3 fl oz	Pk-8C	62 d	69 f	79 e	86 f
5	GWN-10411 20SC 4 fl oz	Pk-8C	82 e	82 f	92 ef	92 f
6	GWN-10411 20SC 4 fl oz + Manzate Pro-Stick 75DF 3 lb	Pk-3C				
	GWN-10411 4 fl oz + Captan 80WDG 30 oz + Ziram 3 lb	4C-8C	4 ab	2 ab	10 ab	8 ab
7	Penncozeb 75DF 4.5 lb	Pk-8C	0 a	3 ab	4 ab	3 a
8	Manzate Pro-Stick 75DF 4.5 lb	Pk-8C	7 a-c	7 a-d	12 bc	2 a
9	Ziram 76DF 4.5 lb	Pk-8C	7 a-c	18 de	31 cd	39 c-e
10	Captan 80WDG 4.2 lb	Pk-8C	1 a	8 b-d	39 d	23 bc
11	KFD-222-01 75DF 4.5 lb	Pk-8C	18 c	27 e	47 d	44 de
12	Zn-Phite 2 gal	Pk-8C	5 a-c	4 a-c	1 a	5 a
13	Zn-Phite 76.8 fl oz	Pk-8C	13 bc	6 a-d	8 ab	1 a
14	ProPhyt 2 qt	Pk-8C	11 bc	14 c-e	8 ab	7 a
15	Viathon 4.08SC 4 pt	Pk-3C				
	Captan 80WDG 3.5 lb + ProPhyt 4 pt	4C				
	Merivon 5.5 fl oz + Captan 80 WDG 30 oz	5C-8C	1 a	0 a	3 ab	1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications, Harvest counts of 25 fruit per tree picked 20 Sep (Idared) or 27 Sep (Golden Delicious).
Treatments dates: 10 Apr (App. # 1, Golden Delicious open cluster-king bloom; Idared 10% bloom; York, pink); 20 Apr (App. # 2, bloom); 2 May (App. # 3, PF, petal fall); Apps. #4-11 (1C-8C, 1st-8th covers): 14 May, 25 May, 10 Jun, 24 Jun, 7 Jul, 20 Jul, 2 Aug, 18 Aug.

Table 14. Control of Brooks spot and post-storage rots on Idared and Golden Delicious apples, 2016.

		Harvest counts,% fruit infected				Rot incidence after incubation, % fruit infected						
		Idared		G. Delicious		Idared (18 days)			G. Delicious (20 days)			
Treatment and rate/acre	App. number	Brooks spot	Bitter rot	Brooks spot	Any rot	Any rot	Bitter Rot	White rot	Any rot	Bitter Rot	White Rot	Alter-naria
0 Non-treated control	---	26 f	32 f	14 c	40 h	60 h	55 f	7 b	54 g	32 f	28 d	0 a
1 Rally 40WSP 5 oz + Manzate 75DF 3 lb	Pk-3C											
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C-8C	2 a-c	11 a-e	0 a	15 d-g	22 d-g	20 c-e	2 ab	25 c-f	14 c-f	13 bc	2 a
2 Merivon 5.5 fl oz + Manzate 75DF 3 lb	#1,3,5											
Rally 40WSP 5 oz + Manzate 75DF 3 lb	#2,4,6											
Captan 30 oz + Ziram 76DF 3 lb	#7-8C	0 a	2 a	0 a	3 ab	3 a	3 a	0 a	9 ab	3 ab	5 a	1 a
3 GWN-10411 20SC 2 fl oz	Pk-8C	0 a	11 b-e	0 a	16 d-g	14 b-d	14 bc	0 a	33 d-f	13 b-e	22 cd	0 a
4 GWN-10411 20SC 3 fl oz	Pk-8C	5 c-e	7 a-e	0 a	23 e-h	35 g	35 e	1 a	42 fg	18 c-f	29 d	0 a
5 GWN-10411 20SC 4 fl oz	Pk-8C	10 e	8 a-e	1 ab	30 g	27 e-g	25 c-e	2 ab	34 ef	24 ef	12 bc	0 a
6 GWN-10411 20SC 4 fl oz + Manzate 75DF 3 lb	Pk-3C											
GWN-10411 4 fl oz + Captan 30 oz + Ziram 3 lb	4C-8C	1 ab	2 a-d	0 a	9 b-e	18 c-e	16 b-d	3 ab	21 c-e	7 a-c	13 bc	1 a
7 Penncozeb 75DF 4.5 lb	Pk-8C	0 a	1 a	0 a	9 a-d	4 ab	3 a	1 a	12 a-c	5 a-c	7 ab	0 a
8 Manzate Pro-Stick 75DF 4.5 lb	Pk-8C	0 a	3 a-c	0 a	11 b-f	17 c-f	14 b-d	3 ab	22 c-e	9 a-e	14 bc	1 a
9 Ziram 76DF 4.5 lb	Pk-8C	0 a	13 de	0 a	26 f-h	28 e-g	26 c-e	2 a	31 d-f	8 a-e	23 cd	0 a
10 Captan 80WDG 4.2 lb	Pk-8C	0 a	12 c-e	0 a	5 a-c	25 d-g	25 c-e	0 a	11 ab	9 a-d	2 a	0 a
11 KFD-222-01 75DF 4.5 lb	Pk-8C	1 ab	14 d-f	1 ab	30 gh	26 d-g	26 c-e	0 a	32 d-f	6 a-d	27 d	0 a
12 Zn-Phite 2 gal	Pk-8C	4 b-d	8 a-e	1 ab	11 b-f	24 d-g	24 c-e	0 a	18 b-d	14 c-f	6 a	0 a
13 Zn-Phite 76.8 fl oz	Pk-8C	8 de	8 a-e	0 a	5 a-d	29 e-g	27 de	2 ab	23 c-e	18 d-f	5 ab	0 a
14 ProPhyt 2 qt	Pk-8C	3 a-d	14 ef	2 b	16 c-g	32 fg	31 e	2 ab	26 c-f	20 ef	6 ab	0 a
15 Viathon 4.08SC 4 pt	Pk-3C											
Captan 80WDG 3.5 lb + ProPhyt 4 pt	4C											
Merivon 5.5 fl oz + Captan 80 WDG 30 oz	5C-8C	0 a	2 ab	0 a	2 a	7 a-c	5 ab	2 ab	6 a	3 a	3 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications, 25 fruit / tree picked 20 Sep (Idared) or 27 Sep (Golden Delicious). Idared placed in cold storage; moved 13 Oct to ambient temperatures (65-82ºF, mean 69.9ºF) and rated 31 Oct. Golden Delicious moved to ambient temperatures (64-82ºF, mean 69.8ºF) and rated 17 Oct.

Treatment dates: 10 Apr (App. # 1, Golden Delicious open cluster-king bloom; Idared 10% bloom; York, pink); 20 Apr (App. # 2, bloom); 2 May (App. # 3, PF, petal fall); Apps. #4-11 (1C-8C, 1st-8th cover): 14 May, 25 May, 10 Jun, 24 Jun, 7 Jul, 20 Jul, 2 Aug, 18 Aug.

Table 15. Fruit finish of Golden Delicious and Idared apples, 2016.

	Appli-	Fruit finish rating (0-5) or USDA grade for russet*			
	cation	Russet rating (0-5)		Golden Del.	Opalescence
Treatment and rate/acre	number	Idared	Golden Del.	Fancy/X-Fcy	Idared
0 Non-treated control	---	2.2 bc	3.7 ef	28 d-f	1.6 de
1 Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	Pk-3C	1.5 a	2.2 a-c	69 ab	0.9 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C-8C				
2 Merivon 5.5 fl oz + Manzate Pro-Stick 75DF 3 lb	#1,3,5	1.5 a	1.8 ab	79 a	0.9 a
Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	#2,4,6				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7-8C				
3 GWN-10411 20SC 2 fl oz	Pk-8C	1.7 ab	1.9 a-c	76 a	1.2 a-d
4 GWN-10411 20SC 3 fl oz	Pk-8C	1.8 ab	3.7 ef	18 e-g	1.2 a-d
5 GWN-10411 20SC 4 fl oz	Pk-8C	1.8 ab	3.1 de	36 c-e	1.2 a-d
6 GWN-10411 20SC 4 fl oz + Manzate Pro-Stick 75DF 3 lb	Pk-3C	1.4 a	1.7 a	86 a	0.9 a
GWN-10411 4 fl oz + Captan 80WDG 30 oz + Ziram 3 lb	4C-8C				
7 Penncozeb 75DF 4.5 lb	Pk-8C	1.7 ab	2.5 b-d	64 a-c	1.0 a
8 Manzate Pro-Stick 75DF 4.5 lb	Pk-8C	1.7 ab	3.2 de	33 de	0.9 a
9 Ziram 76DF 4.5 lb	Pk-8C	1.9 ab	2.8 b-d	62 a-c	1.6 de
10 Captan 80WDG 4.2 lb	Pk-8C	1.9 ab	2.1 a-c	77 a	1.5 c-e
11 KFD-222-01 75DF 4.5 lb	Pk-8C	1.4 a	2.7 cd	43 b-d	1.2 a-d
12 Zn-Phite 2 gal	Pk-8C	3.8 d	4.6 g	3 g	1.8 e
13 Zn-Phite 76.8 fl oz	Pk-8C	2.7 c	4.4 fg	8 fg	1.5 b-e
14 ProPhyt 2 qt	Pk-8C	1.7 ab	3.5 e	28 de	1.2 a-c
15 Viathon 4.08SC 4 pt	Pk-3C	1.7 ab	2.7 cd	64 a-c	1.0 ab
Captan 80WDG 3.5 lb + ProPhyt 4 pt	4C				
Merivon 5.5 fl oz + Captan 80 WDG 30 oz	5C-8C				

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications, Harvest counts of 25 fruit per tree picked 20 Sep (Idared) or 27 Sep (Golden Delicious).

* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet or opalescence). USDA Extra-fancy and fancy grades after downgrading by russet presumed not to be caused by mildew.

Treatment dates: 10 Apr (App. # 1, Golden Delicious open cluster-king bloom; Idared 10% bloom; York, pink); 20 Apr (App. # 2, bloom); 2 May (App. # 3, PF, petal fall); Apps. #4-11 (1C-8C, 1st-8th covers): 14 May, 25 May, 10 Jun, 24 Jun, 7 Jul, 20 Jul, 2 Aug, 18 Aug.

APPLE (*Malus domestica* 'Golden Delicious',
'Red Delicious', and 'Rome Beauty')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Bitter rot; *Colletotrichum* spp.
White (Bot) rot; *Botryosphaeria dothidea*
Alternaria rot; *Alternaria* spp.

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Evaluation of conventional and OMRI-approved materials and mixtures for full season disease management on three apple cultivars, 2016.

Eight treatments, aimed primarily at early season and early summer diseases, were compared for season-long fungal disease control and fruit finish effects on three apple cultivars. Treatments were evaluated on 27-yr-old, three-cultivar tree sets in a four-replicate randomized block design. The Rome trees used in the test had not been treated in 2015 to allow powdery mildew inoculum to stabilize in the 2016 test trees. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 250 psi as follows: 20 Apr (Bl, bloom Red Delicious; Bl-PF, petal fall, Golden Delicious; pink, Rome); 29 Apr (petal fall); 1st-7th covers: 18 May, 31 May, 14 Jun, 29 Jun, 14 Jul, 28 Jul, 22 Aug. Inoculum over each Golden Delicious test tree included cedar rust galls and wild blackberry canes with the sooty blotch and flyspeck fungi placed 26 Apr and bitter rot mummies placed 16 May. Other diseases developed from inoculum naturally present in the test area, including cedar-apple rust inoculum from red cedars in the vicinity. Maintenance sprays, applied separately to the entire test block with a commercial airblast sprayer, included: Altacor, Asana XL, Assail, Beleaf, Belt, BioCover, Danitol, Imidan, and Lannate LV. Foliar data represent averages of counts of ten terminal shoots 15 Jun (Golden Delicious), or 18 Jul (Rome). Post-harvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps. Red Delicious was sampled 21 Sep and first rated 23 Sep then rated again for rots 11 Oct, after 20 days at 64-87ºF (mean 71.6ºF). Golden Delicious was sampled 27 Sep, first rated 28 Sep, then rated again for rots 17 Oct, after 20 days at 64-82ºF (mean 69.8ºF). Rome Beauty was sampled 4 Oct, first rated 5 Oct, then rated again for rots 20 Oct, after 16 days at 64-82ºF (mean 70.0ºF). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Early season dry weather resulted in a delay of the first scab infection period until 22 Apr, two days after the first application at bloom. However, after this delayed start, 13 infection periods occurred in 15 days from 28 Apr-12 May, and 23 infection periods through 31 May. Under these conditions, scab incidence was somewhat reduced on leaves (Table 16), but residual activity of fungicides was tested because wet weather prevented applications during the first two weeks in May. SI fungicide resistance has been present in the area and this was confirmed by lack of improvement in scab control by including Rally with Sulfur (Microthiol Disperss, #1) vs. Sulfur alone (#8). Most treatments gave significant scab suppression on Red Delicious fruit and Golden Delicious leaves and fruit compared to non-treated trees, but were generally less effective on Rome. Kaligreen was among the weakest treatments for scab, significantly increasing foliar scab infection on Golden Delicious and Rome. Mildew conidia were present 16 Mar, and there were 21 dry weather "mildew infection days" from 16 Mar until 5 May, resulting in moderate infection of non-treated trees (Table 16). Under these conditions, all treatments except OxiDate (#3) gave significant control of percent leaves and/or percent leaf area infected with mildew. Including Rally with Sulfur (Microthiol Disperss, #1), significantly improved mildew control vs. Sulfur alone (#8). Rust infection occurred mostly 22 Apr and 1 May- 12 May. Treatments involving Rally (#1 & 2), and Regalia + JMS Stylet-Oil gave the strongest of cedar-apple rust control on foliage and control of cedar-apple and quince rusts under relatively heavy pressure on Rome fruit, which bloomed later and remained susceptible longer than other cultivars (Table 17). Summer disease pressures were moderate and most treatments gave significant control in this test. The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 14 May, was reached as early as 21 Jun (after the 3rd cover application), and this resulted in strong SBFS test conditions (Table 18). Under these conditions, treatments involving Microthiol Disperss (#1, 7 & 8) gave the best SBFS control. Post-storage rots (mostly, bitter rot, white rot, and some Alternaria, Table 19) were best controlled on Red Delicious and Rome by Rally + Microthiol Disperss (#1). Control of rots on Golden Delicious was less than adequate. OxiDate (#3) significantly increased russet of Red and Golden Delicious and opalescence of Red Delicious compared to non-treated fruit, and Regalia + JMS Stylet-Oil (#5) increased opalescence of Red Delicious and Rome (Table 20).

Table 16. Scab and powdery mildew control on Red Delicious, Golden Delicious, and Rome apples, 2016.

		Scab, % leaves or fruit infected					Mildew, % leaves or fruit infected		
		Red Del.	Golden Delicious		Rome		Golden Delicious	Rome	
Treatment and formulated rate/100 gal dilute	Timing	fruit	lvs	fruit	lvs	fruit	lvs	lvs	fruit
0 No fungicide	--	34 c	20 c	50 f	42 bc	57 e	37 e	38 d	36 c
1 Rally 40WSP 1.25 oz + Microthiol Disperss 80% 2.5 lb	Bl-7C	2 a	13 b	6 a	27 a	14 ab	5 a	6 a	3 a
2 Rally 40WSP 1.25 oz + Microthiol Disperss 2.5 lb Rally 40WSP 1.25 oz + OxiDate 2.0 29.1% 1 gal	1,3,5,7,9 2,4,6,8	6 b	16 bc	10 a-c	38 b	22 bc	13 bc	14 b	6 ab
3 OxiDate 2.0 29.1% 1 gal	Bl-7C	14 b	21 c	21 b-d	49 cd	41 de	37 e	39 d	17 bc
4 Regalia 1 pt + JMS Stylet-Oil 1 gal Regalia 1 pt + OxiDate 2.0 29.1% 1 gal	1,3,5,7,9 2,4,6,8	12 b	19 c	21 cd	47 c	23 b-d	22 d	24 c	16 bc
5 Regalia 1 pt + JMS Stylet-Oil 1 gal	Bl-7C	13 b	14 b	32 de	40 bc	32 cd	12 bc	25 c	6 ab
6 Kaligreen 81.9SP 12 oz	Bl-7C	27 c	29 d	42 ef	57 d	55 e	39 e	37 d	14 ab
7 Kaligreen 81.9SP 12 oz + Microthiol Disperss 2.5 lb	Bl-7C	1 a	6 a	10 b	21 a	8 a	12 b	14 b	8 ab
8 Microthiol Disperss 80% 2.5 lb	Bl-7C	1 a	13 b	7 a	25 a	9 a	18 cd	18 bc	14 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 15 Jun (Golden Delicious) or 18 Jul (Rome) or harvest counts of 25-fruit samples picked from each of four single-tree reps 21 Sep (Red Delicious), 27 Sep (Golden Delicious), or 4 Oct (Rome).

Treatments applied dilute to runoff with a single nozzle handgun at 350 psi.
Treatment dates: 20 Apr (Bl, bloom Red Delicious; Bl-PF, petal fall, Golden Delicious; pink, Rome); 29 Apr (petal fall); 1st-7th covers: 18 May, 31 May, 14 Jun, 29 Jun, 14 Jul, 28 Jul, 22 Aug.

Table 17. Control of cedar-apple rust and quince rust on Golden Delicious and Rome Smith apples, 2016.

		Cedar-apple rust % leaves or lesions/leaf				Cedar-apple rust % fruit infected		Quince rust % fruit infected	
		Golden Del.		Rome					
Treatment and formulated rate/100 gal dilute	Timing	% inf.	les/lf	% inf.	les/lf	Gold. Del.	Rome	Gold. Del.	Rome
0 No fungicide	--	48 d	8.3 b	64 f	10.6 b	4 a	35 c	11 a	19 c
1 Rally 40WSP 1.25 oz + Microthiol Disperss 80% 2.5 lb	Bl-7C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
2 Rally 40WSP 1.25 oz + Microthiol Disperss 2.5 lb Rally 40WSP 1.25 oz + OxiDate 2.0 29.1% 1 gal	1,3,5,7,9 2,4,6,8	<1 a	<0.1 a	0 a	0 a	0 a	0 a	0 a	0 a
3 OxiDate 2.0 29.1% 1 gal	Bl-7C	21 c	1.1 a	40 ef	2.6 a	0 a	8 b	0 a	6 b
4 Regalia 1 pt + JMS Stylet-Oil 1 gal Regalia 1 pt + OxiDate 1 gal	1,3,5,7,9 2,4,6,8	3 ab	0.1 a	11 bc	0.5 a	0 a	4 ab	0 a	0 a
5 Regalia 1 pt + JMS Stylet-Oil 1 gal	Bl-7C	1 ab	<0.1 a	2 ab	0.1 a	0 a	1 a	0 a	0 a
6 Kaligreen 81.9SP 12 oz	Bl-7C	3 ab	<0.1 a	9 a-c	0.3 a	0 a	1 a	1 a	0 a
7 Kaligreen 81.9SP 12 oz + Microthiol Disperss 2.5 lb	Bl-7C	9 b	0.5 a	19 cd	1.5 a	0 a	3 ab	0 a	3 ab
8 Microthiol Disperss 80% 2.5 lb	Bl-7C	33 cd	2.4 a	33 de	3.9 a	0 a	8 b	1 a	9 b

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 15 Jun (Golden Delicious) or 18 Jul (Rome) or harvest counts of 25-fruit samples picked from each of four single-tree reps 21 Sep (Red Delicious), 27 Sep (Golden Delicious), or 4 Oct (Rome).

Treatments applied dilute to runoff with a single nozzle handgun at 350 psi.
Treatment dates: 20 Apr (Bl, bloom Red Delicious; Bl-PF, petal fall, Golden Delicious; pink, Rome); 29 Apr (petal fall); 1st-7th covers: 18 May, 31 May, 14 Jun, 29 Jun, 14 Jul, 28 Jul, 22 Aug.

Table 18. Control of sooty blotch and flyspeck by fungicides on Red Delicious, Golden Delicious, and Rome apples, 2016.

			% fruit or fruit area infected, harvest counts											
			Sooty blotch						Flyspeck					
			Red Del.		Golden Del.		Rome		Red Del.		Golden Del.		Rome	
	Treatment and rate/100 gal dilute	Timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0	No fungicide	--	90 c	7 c	100 e	10 e	100 c	16 c	72 d	4 e	99 d	6 d	95 e	7 d
1	Rally 1.25 oz + Microthiol Disperss 2.5 lb	Bl-7C	14 a	<1 a	0 a	0 a	28 a	2 a	3 a	<1 a	0 a	0 a	7 a	<1 a
2	Rally 1.25 oz + Microthiol Disperss 2.5 lb	1,3,5,7,9												
	Rally 40WSP 1.25 oz + OxiDate 2.0 1 gal	2,4,6,8	38 b	3 b	1 a	<1 a	28 a	2 a	12 b	<1 b	2 a	<1 a	20 a-c	1 ab
3	OxiDate 2.0 29.1% 1 gal	Bl-7C	32 b	2 b	12 bc	<1 bc	37 a	3 ab	24 b	1 bc	15 b	<1 b	39 cd	3 ab
4	Regalia 1 pt + JMS Stylet-Oil 1 gal	1,3,5,7,9												
	Regalia 1 pt + OxiDate 2.0 29.1% 1 gal	2,4,6,8	33 b	2 b	10 b	<1 b	35 a	3 ab	23 b	1 c	17 b	1 b	36 cd	2 bc
5	Regalia 1 pt + JMS Stylet-Oil 1 gal	Bl-7C	29 b	2 b	20 cd	1 cd	43 ab	3 ab	41 c	3 d	40 c	2 c	61 d	5 cd
6	Kaligreen 81.9SP 12 oz	Bl-7C	42 b	3 b	23 d	1 d	66 b	5 b	46 c	3 d	43 c	3 c	61 d	5 cd
7	Kaligreen 12 oz + Microthiol Disperss 2.5 lb	Bl-7C	12 a	<1 a	6 b	<1 b	28 a	2 a	4 a	<1 a	14 b	<1 b	30 bc	2 b
8	Microthiol Disperss 80% 2.5 lb	Bl-7C	10 a	<1 a	0 a	0 a	36 a	3 ab	1 a	<1 a	6 ab	<1 ab	12 ab	1 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 15 Jun (Golden Delicious) or 18 Jul (Rome) or harvest counts of 25-fruit samples picked from each of four single-tree reps, 21 Sep (Red Delicious), 27 Sep (Golden Delicious), or 4 Oct (Rome).

Treatments applied dilute to runoff with a single nozzle handgun at 350 psi. Treatment dates: 20 Apr (Bl, bloom Red Delicious; Bl-PF, petal fall, Golden Delicious; pink, Rome); 29 Apr (petal fall); 1st-7th covers: 18 May, 31 May, 14 Jun, 29 Jun, 14 Jul, 28 Jul, 22 Aug.

Table 19. Control of post-harvest fruit rots on Red Delicious, Golden Delicious, and Rome apples, 2016.

		% G. Del. fruit infected rot spots, at harvest	% fruit infected, post storage counts									
			Any rot			Bitter rot			White rot			Alternaria
Treatment and rate/100 gal dilute	Timing		Red Del.	Gold. Del.	Rome	Red Del.	Gold. Del.	Rome	Red Del.	Gold. Del.	Rome	Red Del.
0 No fungicide	--	35 b	18 b	63 a	55 c	4 a	13 b	10 bc	11 b	56 a	49 b	4 a
1 Rally 1.25 oz + Microthiol Disperss 2.5 lb	Bl-7C	10 a	4 a	48 a	15 a	2 a	1 a	0 a	2 a	47 a	15 a	0 a
2 Rally 1.25 oz + Microthiol Disperss 2.5 lb Rally 40WSP 1.25 oz + OxiDate 2.0 1 gal	1,3,5,7,9 2,4,6,8	18 a	9 ab	52 a	20 a	1 a	5 ab	4 ab	8 ab	49 a	16 a	0 a
3 OxiDate 2.0 29.1% 1 gal	Bl-7C	8 a	12 ab	51 a	18 a	3 a	6 ab	6 bc	8 ab	49 a	12 a	1 a
4 Regalia 1 pt + JMS Stylet-Oil 1 gal Regalia 1 pt + OxiDate 2.0 29.1% 1 gal	1,3,5,7,9 2,4,6,8	9 a	16 ab	40 a	27 ab	1 a	3 ab	4 ab	13 b	38 a	23 ab	2 a
5 Regalia 1 pt + JMS Stylet-Oil 1 gal	Bl-7C	13 a	7 ab	63 a	25 ab	2 a	7 ab	4 ab	5 ab	56 a	21 ab	0 a
6 Kaligreen 81.9SP 12 oz	Bl-7C	20 ab	5 ab	43 a	23 ab	0 a	5 ab	4 ab	5 ab	38 a	20 a	0 a
7 Kaligreen 12 oz + Microthiol Disperss 2.5 lb	Bl-7C	13 a	8 ab	43 a	43 bc	0 a	3 ab	17 c	7 ab	40 a	30 ab	1 a
8 Microthiol Disperss 80% 2.5 lb	Bl-7C	19 ab	11 ab	53 a	30 ab	2 a	8 ab	7 bc	10 b	44 a	25 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Post-harvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps. Red Delicious sampled 21 Sep, rated for rots after 20 days incubation at ambient 64-87°F (mean 71.6°F). Golden Delicious sampled 27 Sep, first rated 28 Sep, then rated for rots after 20 days incubation at ambient temperatures 64-82°F (mean 69.8°F). Rome sampled 4 Oct, first rated 5 Oct, then rated for rots after 16 days incubation at ambient temperatures 64-82°F (mean 70.0°F).

Treatments applied dilute to runoff with a single nozzle handgun at 350 psi.
Treatment dates: 20 Apr (Bl, bloom Red Delicious; Bl-PF, petal fall, Golden Delicious; pink, Rome); 29 Apr (petal fall); 1st-7th covers: 18 May, 31 May, 14 Jun, 29 Jun, 14 Jul, 28 Jul, 22 Aug.

Table 20. Fruit finish effects by fungicide treatments on Red Delicious, Golden Delicious, and Rome apples, 2016.

			Fruit finish ratings (0-5)*					Russet ratings, Golden Del.	
			Russet			Opalescence		X-fancy/	US#1 +
	Treatment and rate/100 gal dilute	Timing	Red Del.	Golden Del.	Rome	Red Del.	Rome	Fancy	Utility
0	No fungicide	--	1.9 a	3.8 a-c	0.6 ab	1.1 a	1.2 ab	21 a-c	79 a-c
1	Rally 1.25 oz + Microthiol Disperss 80% 2.5 lb	Bl-7C	2.0 ab	3.3 a	0.4 a	1.3 ab	1.1 ab	33 ab	67 ab
2	Rally 40WSP 1.25 oz + Microthiol Disperss 2.5 lb Rally 40WSP 1.25 oz + OxiDate 2.0 29.1% 1 gal	1,3,5,7,9 2,4,6,8	3.8 e	4.6 e	0.6 ab	2.0 cd	1.1 ab	5 de	95 de
3	OxiDate 2.0 29.1% 1 gal	Bl-7C	3.8 e	4.5 de	0.7 ab	1.6 bc	1.0 a	2 e	98 e
4	Regalia 1 pt + JMS Stylet-Oil 1 gal Regalia 1 pt + OxiDate 2.0 29.1% 1 gal	1,3,5,7,9 2,4,6,8	3.4 d	4.2 c-e	0.6 ab	2.2 d	1.1 ab	10 c-e	90 c-e
5	Regalia 1 pt + JMS Stylet-Oil 1 gal	Bl-7C	2.0 a	3.4 a	0.9 b	2.8 e	2.1 c	28 a-c	72 a-c
6	Kaligreen 81.9SP 12 oz	Bl-7C	1.9 a	4.0 b-d	0.7 ab	1.3 ab	1.2 ab	16 b-d	84 b-d
7	Kaligreen 12 oz + Microthiol Disperss 2.5 lb	Bl-7C	2.5 c	3.3 a	0.8 ab	1.5 ab	1.3 b	41 a	59 a
8	Microthiol Disperss 80% 2.5 lb	Bl-7C	2.4 bc	3.5 ab	0.7 ab	1.2 ab	1.3 b	30 a-c	70 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Harvest counts of 25-fruit samples picked from each of four single-tree replications 21 Sep (Red Delicious), 27 Sep (Golden Delicious), or 4 Oct (Rome).

* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe opalescence or russet, presumed not to be mildew).

Treatments applied dilute to runoff with a single nozzle handgun at 350 psi.
Treatment dates: 20 Apr (Bl, bloom Red Delicious; Bl-PF, petal fall, Golden Delicious; pink, Rome); 29 Apr (petal fall); 1st-7th covers: 18 May, 31 May, 14 Jun, 29 Jun, 14 Jul, 28 Jul, 22 Aug.

APPLE (*Malus domestica* 'Fuji')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Bitter rot; *Colletotrichum* spp.
White rot; *Botryosphaeria dothidea*
Alternaria rot; *Alternaria* spp.
Fruit finish

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Scab and broad spectrum disease control by fungicides first applied at petal fall on Fuji apple, 2016.

Seventeen treatments tested mixing partners and sequential schedules on 21-year-old dwarf Fuji apple trees. The test was designed primarily to evaluate responses of selected treatments for scab control but was continued through the cover sprays for summer disease management as well. Also, it is known that scab strains resistant to SI and QoI fungicides are present in the test area, so combinations of several fungicide classes were tested in an attempt to overcome this situation. Treatments were applied dilute to runoff with a single-nozzle handgun at 250 psi in a randomized block design with four single-tree replications as follows 12 May (PF, petal fall); 1C-7C (1st-7th covers): 20 May, 10 Jun, 24 Jun, 8 Jul, 20 Jul, 3 Aug, 23 Aug. Because of the delay in the initial application, foliar data are based on means of leaves beyond the eleventh leaf on ten shoots per tree 11 Jul. Fruit data are based on 25 fruit per tree picked 7 Oct, first rated 18 Oct and held at ambient temperatures (64-82º F, mean 70.0º F), until the final rot evaluation 26 Oct after 19 days' incubation. Maintenance materials applied to the entire test block included: Admire Pro, Altacor, Assail, Asana XL, Biocover, Beleaf, Delegate, Imidan, and Lannate LV. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Scab pressure was heavy in this test, with lesions from the first infection 22 Apr appearing on unprotected leaves near the time of the first application 12 May. Other pre-treatment scab infection periods occurred 28-29 Apr, 30 Apr-1 May, 1-2 May, 2-3 May, 3-4 May, 4-5 May, 5-7 May, 8 May, 9 May, 10 May, 10-11 May, and 11-12 May. Because of the delay in the first application, foliar evaluations started with the eleventh leaf on the shoot. In spite of the delay, treatments #16 and 17 (Luna Sensation or Merivon in combination with Inspire Super + Captan + Silwet) and several others (#3, 5, 8, and 15) still gave significant reduction in scab on foliage (Table 21). Infection was heavy (79%) on non-treated fruit. The combination of Aprovia + Inspire Super + Captan + Silwet (#15) completely protected against secondary fruit scab infection and Merivon substituted for Aprovia (#16) was also very effective. Other combinations that were good for fruit scab control included combinations Aprovia + Silwet (#4) and A 19649 + Silwet (#6), and rotations of these with Inspire Super (#5 and #7). Inspire Super + Ziram (#11) and combinations of several products (#8, 9 and 17) also gave good fruit scab control. Under these conditions, CX-10370 (#12-14) did not reduce scab on foliage but significantly suppressed it on fruit, comparable to the protective schedule of Manzate + Captan/ Captan + Ziram (#1). Treatments #1-14 included Rally in the petal fall application to suppress cedar-apple rust infection that had also occurred in the previous 10-14 days. These and #15-17, which included Inspire Super, all gave good rust control on later developing leaves and also gave excellent quince rust control compared to non-treated trees (Table 21). The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 14 May, was reached as early as 21 Jun (before the 3rd cover application), resulting in 100% SBFS infection of non-treated fruit. Under these conditions, several treatment schedules resulted in 1% or less of sooty blotch and flyspeck symptoms (Table 22), including Aprovia + Silwet (#4), Aprovia + Inspire Super + Silwet (#8), Inspire Super + Ziram (#11), Aprovia + Inspire Super + Captan + Silwet (#15), Merivon + Inspire Super+ Captan + Silwet (#16), and Luna Sensation + Inspire Super + Captan + Silwet (#17). Post-storage rots included bitter rot, white rot, and Alternaria (Table 23), and excellent control of these was provided by combinations involving Merivon + Silwet (#2), Inspire Super + Ziram (#11), Merivon + Inspire Super+ Captan + Silwet (#16), and Luna Sensation + Inspire Super + Captan + Silwet (#17). CX-10370 (#12-14) gave significant suppression of SBFS, bitter rot, and white rot compared to non-treated trees, but was less effective than the protectant standard (#1), and suppression was not consistently rate-related.

Table 21. Control of scab and rusts by treatments first applied to Fuji apple at petal fall, 2016. Virginia Tech AREC.

			Scab			Cedar-apple rust		Quince
	Treatment and rate/100 gal dilute	Timing	% lvs inf.	lesions/ leaf	% fruit	% lvs infected	% fruit	rust, % fruit inf.
0	No fungicide	---	39 fg	3.1 a-c	79 h	7.5 b	14 b	9 b
1	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Manzate 12 oz + Captan 80WDG 10oz	1C-3C						
	Captan 80WDG 10 oz + Ziram 76DF 12oz	4C-7C	39 fg	3.8 a-c	28 ef	0.9 a	3 a	0 a
2	Rally 12.5 oz + Manzate 12 oz + Captan 80WDG 10oz	PF						
	Merivon 4.18SC 1 oz + Silwet 114 ml	1C-7C	35 d-f	2.9 a-c	26 ef	0.2 a	0 a	0 a
3	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Merivon 4.18SC 1 oz + Silwet 114 ml	1C,3C,5C,7C						
	Inspire Super 2.82EW 3 fl oz	2C,4C,6C	20 a-e	1.5 ab	13 d	0.2 a	0 a	0 a
4	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Aprovia 0.83EC 1.38 fl oz + Silwet 114 ml	1C-7C	29 c-f	2.5 a-c	7 cd	0.2 a	0 a	0 a
5	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Aprovia 0.83EC 1.38 fl oz + Silwet 114 ml	1C,3C,5C,7C						
	Inspire Super 2.82EW 3 fl oz	2C,4C,6C	20 a-e	1.3 ab	4 bc	0 a	0 a	0 a
6	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	A 19649 200SC 0.69 fl oz + Silwet 114 ml	1C-7C	26 b-f	3.4 a-c	7 cd	0 a	0 a	0 a
7	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	A 19649 200SC 0.69 fl oz + Silwet 114 ml	1C,3C,5C,7C						
	Inspire Super 2.82EW 3 fl oz	2C,4C,6C	25 b-f	2.2 ab	8 cd	0 a	0 a	0 a
8	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Aprovia 1.38 fl oz + Inspire Super 3 oz + Silwet 114 ml	1C-7C	21 a-e	1.5 ab	5 bc	0 a	1 a	0 a
9	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Aprovia 0.83EC 1.38 fl oz + Inspire Super 2. 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	1C-7C	17 a-c	1.8 ab	4 bc	0.2 a	0 a	0 a
10	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Inspire Super 2.82EW 3 oz + Captan 80WDG 10 oz	1C-7C	19 a-c	1.6 ab	15 de	0 a	0 a	0 a
11	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	Inspire Super 2.82EW 3 oz + Ziram 76DF 12 oz	1C-7C	26 b-f	1.4 ab	9 cd	0.2 a	0 a	0 a
12	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	CX-10370 0.5 gal	1C-7C	36 ef	2.4 a-c	32 fg	0 a	0 a	0 a
13	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	CX-10370 1 gal	1C-7C	57 g	6.8 c	43 g	0 a	0 a	0 a
14	Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz	PF						
	CX-10370 2 gal	1C-7C	43 fg	5.7 bc	28 fg	0 a	0 a	0 a
15	Aprovia 0.83EC 1.5 fl oz + Inspire Super 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-7C	20 a-d	0.8 a	0 a	0 a	0 a	0 a
16	Merivon 4.18SC 1.37 fl oz + Inspire Super 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-7C	11 ab	0.3 a	2 ab	0 a	0 a	0 a
17	Luna Sensation 500SC 1.37 fl oz+ Inspire Super 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-7C	9 a	0.3 a	7 b-d	0.2 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications, ratings starting with the eleventh leaf on each of 10 shoots/tree, 11 Jul. Fruit ratings were of 25-fruit samples per replication, taken 7 Oct, and held in warm storage until the first evaluation 18 Oct.

Treatment applications: 12 May (PF, petal fall); 1C-7C (1st-7th covers): 20 May, 10 Jun, 24 Jun, 8 Jul, 20 Jul, 3 Aug, 23 Aug.

Pre-treatment scab infection periods: 22-23 Apr, 28-29 Apr, 30 Apr-1 May, 1-2 May, 2-3 May, 3-4 May, 4-5 May, 5-7 May, 8 May, 9 May, 10 May, 10-11 May, 11-12 May.

Table 22. Sooty blotch/flyspeck control on Fuji apple, 2016. Virginia Tech AREC.

		% fruit or fruit area inf. at harvest			
		Sooty blotch		Flyspeck	
Treatment and rate/100 gal dilute	Timing	fruit	area	fruit	area
0 No fungicide	---	100 g	21 f	100 g	13 g
1 Rally 40WSP 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Manzate Pro-Stick 75DF 12 oz + Captan 80WDG 10oz Captan 80WDG 10oz + Ziram 76DF 12oz	PF 1C-3C 4C-7C	7 c-e	<1 cd	10 d	1 de
2 Rally 12.5 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Merivon 4.18SC 1 oz + Silwet 114 ml	PF 1C-7C	3 a-d	<1 a-c	5 cd	<1 b-d
3 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Merivon 4.18SC 1 oz + Silwet 114 ml Inspire Super 2.82EW 3 fl oz	PF 1C,3C,5C,7C 2C,4C,6C	2 a-c	<1 a-c	5 cd	<1 b-d
4 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Aprovia 0.83EC 1.38 fl oz + Silwet 114 ml	PF 1C-7C	0 a	0 a	1 ab	<1 ab
5 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Aprovia 0.83EC 1.38 fl oz + Silwet 114 ml Inspire Super 2.82EW 3 fl oz	PF 1C,3C,5C,7C 2C,4C,6C	4 b-e	<1 b-d	9 d	1 de
6 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz A 19649 200SC 0.69 fl oz + Silwet 114 ml	PF 1C-7C	6 de	<1 cd	6 cd	<1 cd
7 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz A 19649 200SC 0.69 fl oz + Silwet 114 ml Inspire Super 2.82EW 3 fl oz	PF 1C,3C,5C,7C 2C,4C,6C	2 a-c	<1 a-c	4 bc	<1 a-c
8 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Aprovia 1.38 fl oz + Inspire Super 3 oz + Silwet 114 ml	PF 1C-7C	1 ab	<1 ab	1 ab	<1 ab
9 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Aprovia 0.83EC 1.38 fl oz + Inspire Super 3 oz + Captan 80WDG 10 oz + Silwet 114 ml	PF 1C-7C	0 a	0 a	0 a	0 a
10 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Inspire Super 3 oz + Captan 80WDG 10 oz	PF 1C-7C	5 c-e	<1 cd	7 d	<1 cd
11 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz Inspire Super 2.82EW 3 fl oz + Ziram 76DF 12 oz	PF 1C-7C	1 ab	<1 ab	0 a	0 a
12 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz CX-10370 0.5 gal	PF 1C-7C	29 f	2 e	31 f	2 f
13 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz CX-10370 1 gal	PF 1C-7C	11 e	1 d	18 e	1 ef
14 Rally 1.25 oz + Manzate 75DF 12 oz + Captan 80WDG 10 oz CX-10370 2 gal	PF 1C-7C	25 f	1 e	26 ef	1 f
15 Aprovia 0.83EC 1.5 fl oz + Inspire Super 2.82EW 3 oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-7C	0 a	0 a	0 a	0 a
16 Merivon 4.18SC 1.37 fl oz + Inspire Super 2.82EW 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-7C	1 ab	<1 ab	0 a	0 a
17 Luna Sensation 500SC 1.37 fl oz + Inspire Super 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-7C	1 ab	<1 ab	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications, Fruit ratings were of 25-fruit samples per replication, taken 7 Oct, put in warm storage then evaluated 18 Oct.
* Fruit finish rated on a scale of 0-5 (0 = perfect finish, 5 = severe russet or opalescence.

Treatment applications: 12 May (PF, petal fall); 1C-7C (1st-7th covers): 20 May, 10 Jun, 24 Jun, 8 Jul, 20 Jul, 3 Aug, 23 Aug.

Table 23. Control of post-harvest fruit rots evaluated at harvest on Fuji apple, 2016. Virginia Tech AREC.

		% fruit inf., 11 days' incubation			% fruit infected, 19 days' incubation			
Treatment and rate/100 gal dilute	Timing	Any rot	Bitter rot	White rot	Any rot	Bitter rot	White rot	Alternaria
0 No fungicide	---	33 d	15 b	21 d	70 g	34 e	41 e	7 cd
1 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Manzate 12 oz + Captan 80WDG 10oz Captan 80WDG 10 oz + Ziram 76DF 12oz	PF 1C-3C 4C-6C	1 ab	0 a	1 ab	14 b-e	4 a-c	10 bc	0 a
2 Rally 12.5 oz + Manzate 12 oz + Captan 80WDG 10oz Merivon 4.18SC 1 oz + Silwet 114 ml	PF 1C-6C	0 a	0 a	0 a	0 a	0 a	0 a	0 a
3 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Merivon 4.18SC 1 oz + Silwet 114 ml Inspire Super 2.82EW 3 fl oz	PF 1C,3C,5C 2C,4C,6C	0 a	0 a	0 a	6 b-d	5 bc	1 a	0 a
4 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Aprovia 0.83EC 1.38 fl oz + Silwet 114 ml	PF 1C-6c	0 a	0 a	0 a	12 c-e	4 a-c	6 ab	2 a-c
5 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Aprovia 0.83EC 1.38 fl oz + Silwet 114 ml Inspire Super 2.82EW 3 fl oz	PF 1C,3C,5C 2C,4C,6C	3 ab	2 a	1 ab	16 de	9 cd	9 bc	0 a
6 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz A 19649 200SC 0.69 fl oz + Silwet 114 ml	PF 1C-6C	0 a	0 a	0 a	10 b-e	8 cd	1 a	1 ab
7 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz A 19649 200SC 0.69 fl oz + Silwet 114 ml Inspire Super 2.82EW 3 fl oz	PF 1C,3C,5C 2C,4C,6C	2 ab	2 a	0 a	11 b-e	5 a-c	4 ab	2 a-c
8 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Aprovia 1.38 fl oz + Inspire Super 3 oz + Silwet 114 ml	PF 1C-6C	0 a	0 a	0 a	6 b-d	2 a-c	3 ab	1 ab
9 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Aprovia 0.83EC 1.38 fl oz + Inspire Super 2. 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF 1C-6C	0 a	0 a	0 a	7 b-d	1 ab	4 ab	2 a-c
10 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Inspire Super 2.82EW 3 oz + Captan 80WDG 10 oz	PF 1C-6C	6 a-c	1 a	5 ab	20 e	7 cd	10 b	3 bc
11 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz Inspire Super 2.82EW 3 oz + Ziram 76DF 12 oz	PF 1C-6C	0 a	0 a	0 a	5 bc	4 a-c	1 a	0 a
12 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz CX-10370 0.5 gal	PF 1C-6C	0 a	0 a	0 a	16 de	6 cd	9 b	2 ab
13 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz CX-10370 1 gal	PF 1C-6C	8 bc	0 a	8 bc	38 f	16 d	21 cd	4 bc
14 Rally 1.25 oz + Manzate 12 oz + Captan 80WDG 10 oz CX-10370 2 gal	PF 1C-6C	11 c	1 a	10 cd	46 f	17 d	27 de	12 d
15 Aprovia 0.83EC 1.5 fl oz + Inspire Super 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-6C	1 ab	0 a	1 ab	8 ab	0 a	8 ab	1 ab
16 Merivon 4.18SC 1.37 fl oz + Inspire Super 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-6C	0 a	0 a	0 a	5 bc	2 a-c	0 a	3 a-c
17 Luna Sensation 500SC 1.37 fl oz+ Inspire Super 3 fl oz + Captan 80WDG 10 oz + Silwet 114 ml	PF-6C	0 a	0 a	0 a	4 a-c	2 a-c	2 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Post-harvest counts are means of 25-fruit samples picked from each of four single-tree reps. Sampled 7 Oct and placed in warm storage, first rated 18 Oct, then rated for rots 26 Oct after 19 days at ambient temperatures 64-82°F (mean 70.0°F).

APPLE (*Malus domestica* 'Ramey York')
Scab; *Venturia inaequalis*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Bitter rot; *Colletotrichum* spp.
White rot; *Botryosphaeria dothidea*
Fruit finish

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Evaluation of experimental and registered cover spray fungicide combinations for disease control on York apple, 2016.

Seventeen treatments, first applied at petal fall, were compared during the mid-season cover spray period on 16-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by in-row border trees. No fungicides were applied until the first treatment application date 2 May. Dilute treatments were applied to runoff with a single nozzle handgun at 250 psi as first- seventh cover sprays: 2 May (PF, petal fall); 1C-7C, (1st -7th covers): 19 May, 27 May, 10 Jun, 23 Jun, 11 Jul, 27Jul, 22 Aug. All diseases developed from inoculum naturally present in the test area. Foliar data are based on ten shoots per rep 29 Jun. Fruit ratings are based on 25-fruit samples per replication picked 6 Oct and incubated in ambient warm temperatures (64-82º F, mean 69.9º F), first rated 13 Oct and final rating for rots 24 Oct after 18 days' incubation. Maintenance materials applied to the entire test block included: Admire Pro, Altacor, Assail, Asana XL, BioCover, Beleaf, Belt, Danitol, Delegate, Imidan, and Lannate LV. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The test was set up primarily to evaluate the treatments for summer disease control after petal fall, but scab lesions from pre-treatment scab infection periods 22-23 Apr, 28-29 Apr, and 30 Apr-1 May were incubating, and 17 more secondary scab infection periods occurred through May. Also, it is known that scab strains resistant to SI and QoI fungicides are present in the test area, so combinations of several fungicide classes were tested in an attempt to overcome this situation. Under these conditions, combinations involving Inspire Super gave good suppression of scab (Table 24). Aprovia and experimental materials AGR005 and F1757aa also gave significant scab suppression. It is possible that resistance somewhat impacted control by Luna Sensation and other experimental materials. Although scab test pressure was high during the period from petal fall to first cover, treatments involving Aprovia gave excellent fruit scab control as did treatment #17, a combination of Luna Sensation + Inspire Super + Manzate + oil. Cedar-apple rust infection occurred 22 Apr and 1 May and eight more cedar rust infection periods occurred 2 May-12 May. Combinations involving Inspire Super also gave excellent cedar-apple rust control. The protectant treatment, Manzate (#16) was weaker for scab and rust control on foliage, but gave good scab control on fruit. The unidentified "leaf spots" shown in Table 24 were likely related to partially inhibited rust lesions, but did not have any orange coloration to clearly identify them as such. Aprovia + Inspire Super + Manzate + Oil (#15) had the fewest leaf spots and also was among those with the fewest rust lesions. The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 14 May, was reached as early as 21 Jun (before the 3rd cover application), and this resulted in good SBFS test conditions. Under these conditions, all treatment schedules ending with Captan + Ziram gave good SBFS control (Table 25). ARY-0438-005 (#2) and F1757aa (#5) were weak for SBFS and the combination of them at the same rates (#6) was less effective than either compound separately. Control of post-storage rots generally followed the pattern of SBFS control, however the early season schedule through 4th cover affected the post-storage control by treatment #13, Aprovia + Inspire Super, which had significantly more rots than #12 (Aprovia + Oil), #15 (Aprovia + Inspire Super + Manzate + Oil), or #16 (Manzate alone). Luna Sensation + Inspire Super + Manzate + Oil followed by Captan + Ziram (#17) also gave excellent rot control. Experimental treatments other than UBI-4319-01 + F1058ab (#9) did not give adequate control of bitter rot. F1757aa (#5) had significantly more bitter rot than the non-treated control. Several treatments were deleterious to fruit finish. Compared to non-treated fruit, Inspire Super + Manzate (#1) significantly increased russet and opalescence. Significant increases in opalescence also occurred with experimental treatments #2-6, and with combinations of Aprovia + Oil (#12), Aprovia + Inspire Super (#13), Aprovia + Inspire Super + Manzate (#14), and with Aprovia + Inspire Super + Manzate (#15), but not with Inspire Super (#10), Aprovia (#11) or Manzate alone (#16).

Table 24. Control of scab and other early season diseases by treatments first applied at first cover, 2016. Ramey York, VT AREC.

Treatment and rate/100 gal dilute	Timing	Scab % lvs inf.	Scab lesions/ leaf	Scab % fruit	Cedar-apple rust % lvs inf.	Cedar-apple rust lesions/ leaf	Cedar-apple rust % fruit	Quince rust, % fruit inf.	"Leaf spots" % lvs affected
0 No fungicide	---	52 fg	5.0 c	70 g	62 h	12.5 f	6 d	6 d	17 a-e
1 Inspire Super 3 fl oz+ Manzate Pro-Stick 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76Df 12 oz	PF-4C 5C-7C	13 a	0.5 ab	0 a	1 a	<0.1 a	0 a	0 a	13 ab
2 ARY-0438-005 11.3WDG 1.55 oz	PF-7C	55 g	4.8 c	24 ef	19 b-d	0.8 a-c	0 a	0 a	23 b-f
3 AGR005 65WDG 8 oz	PF-7C	26 b-d	0.9 ab	4 bc	24 b-d	1.1 a-c	0 a	0 a	27 d-f
4 ARY-0438-005 11.3WDG 1.55 oz + AGR005 65WDG 8 oz	PF-7C	30 c-e	1.0 ab	2 ab	42 fg	4.5 de	0 a	0 a	26 d-f
5 F1757aa 5SC 1.75 fl oz	PF-7C	27 cd	0.9 ab	18 de	47 gh	2.7 a-d	2 c	0 a	25 b-f
6 ARY-0438-005 11.3WDG 1.55 oz + F1757aa 5SC 1.75 fl oz	PF-7C	20 a-c	0.8 ab	15 de	45 g	3.1 b-d	0 a	2 c	25 b-f
7 UBI-4319-01 4SC 2 fl oz	PF-7C	51 fg	4.4 c	30 f	14 b	0.4 ab	0 a	0 a	24 c-f
8 F1058ab 80WDG 12 oz	PF-7C	42 e-g	1.3 ab	16 de	46 g	6.6 e	0 a	1 b	31 f
9 UBI-4319-01 4SC 2 fl oz + F1058ab 80WDG 12 oz	PF-7C	43 e-g	2.0 b	8 cd	29 d-f	2.0 a-d	1 b	0 a	29 ef
10 Inspire Super 2.82EW 3 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	PF-4C 5C-7C	18 a-c	0.6 ab	8 cd	3 a	0.1 a	0 a	0 a	28 ef
11 Aprovia 0.83EC 1.4 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	PF-4C 5C-7C	23 a-c	0.5 ab	0 a	17 ab	0.7 a-c	0 a	0 a	16 a-d
12 Aprovia 0.83EC 1.4 fl oz + Oil 1qt Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	PF-4C 5C-7C	21 a-c	0.4 ab	0 a	27 c-e	2.3 a-d	0 a	0 a	18 a-e
13 Aprovia 0.83EC 1.4 fl oz + Inspire Super 2.82EW 3 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	PF-4C 5C-7C	14 ab	0.3 a	0 a	2 a	0.1 a	0 a	0 a	14 a-c
14 Aprovia 0.83EC 1.4 fl oz + Inspire Super 2.82EW 3 fl oz + Manzate 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	 PF-4C 5C-7C	13 a	0.2 a	0 a	3 a	0.1 a	0 a	0 a	17 a-e
15 Aprovia 0.83EC 1.4 fl oz + Inspire Super 2.82EW 3 fl oz + Manzate Pro-Stick 75DF 12 oz + Oil 1 qt Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	 PF-4C 5C-7C	13 a	0.2 a	0 a	1 a	<0.1 a	0 a	0 a	9 a
16 Manzate Pro-Stick 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	PF-4C 5C-7C	39 d-f	1.3 ab	3 bc	39 e-g	3.5 cd	0 a	0 a	18 a-f
17 Luna Sensation 1.4 fl oz + Inspire Super 3 fl oz + Manzate Pro-Stick 75DF 12 oz + Oil 1 qt Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	 PF-4C 5C-7C	15 ab	0.3 a	0 a	3 a	<0.1 a	0 a	0 a	20 b-f

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications, ratings of all leaves on each of 10 shoots/tree, 29 Jun. Fruit ratings were of 25-fruit samples per replication, taken 6 Oct, put in warm storage then evaluated 13 Oct.
Dilute rates based on 400 gal/A equivalent. Applied dilute to runoff at 250 psi on the following dates: 2 May (PF, petal fall); 1C-7C, (1st - 7th covers): 19 May, 27 May, 10 Jun, 23 Jun, 11 Jul, 27 Jul, 22 Aug. Pre-treatment scab infection periods: 22-23 Apr, 28-29 Apr, 30 Apr-1 May.

Table 25. Summer disease control and fruit finish on Ramey York apple, 2016. Virginia Tech AREC.

		% fruit or fruit area inf. at harvest				% post-storage rots*			Fruit finish rating (0-5)**	
		Sooty blotch		Flyspeck		Any	Bitter	White		
Treatment and rate/100 gal dilute	Timing	fruit	area	fruit	area	rot	rot	rot	russet	opalescence
0 No fungicide	---	100 f	18 f	100 e	10 e	17 c-g	13 b-g	6 a-e	1.5 a-c	1.0 a
1 Inspire Super 3 fl oz+ Manzate 75DF 12 oz	PF-4C								2.1 d	2.0 d-f
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	0 a	0 a	0 a	0 a	8 b-e	6 a-e	2 a-c		
2 ARY-0438-005 11.3WDG 1.55 oz	PF-7C	20 d	1 d	38 c	2 c	29 gh	21 d-h	9 de	1.9 cd	2.3 f
3 AGR005 65WDG 8 oz	PF-7C	13 d	<1 d	32 c	2 c	27 f-h	21 f-h	6 b-e	1.9 cd	2.0 d-f
4 ARY-0438-005 1.55 oz + AGR005 65WDG 8 oz	PF-7C	2 ab	<1 ab	18 bc	1 bc	28 gh	23 gh	6 c-e	1.6 a-d	1.8 c-f
5 F1757aa 5SC 1.75 fl oz	PF-7C	11 cd	<1 cd	18 bc	1 bc	40 h	31 h	12 e	1.6 a-c	1.7 c-e
6 ARY-0438-005 1.55 oz + F1757aa 5SC 1.75 fl oz	PF-7C	31 e	2 e	55 d	4 d	23 e-h	20 e-h	5 b-e	1.5 a-c	1.6 b-d
7 UBI-4319-01 4SC 2 fl oz	PF-7C	4 ab	<1 ab	19 bc	1 bc	22 e-h	15 c-h	7 b-e	1.6 a-c	1.4 a-c
8 F1058ab 80WDG 12 oz	PF-7C	9 cd	<1 cd	15 b	<1 b	12 c-f	9 a-g	3 a-d	1.2 a	1.2 ab
9 UBI-4319-01 4SC 2 fl oz + F1058ab 80WDG 12 oz	PF-7C	5 bc	<1 bc	4 a	<1 a	6 a-d	5 a-e	1 ab	1.3 ab	1.4 a-c
10 Inspire Super 2.82EW 3 fl oz	PF-4C								1.3 ab	1.2 ab
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	0 a	0 a	2 a	<1 a	11 b-e	8 a-f	3 a-d		
11 Aprovia 0.83EC 1.4 fl oz	PF-4C								1.2 a	1.4 a-c
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	1 ab	<1 ab	2 a	<1 a	10 b-e	6 a-d	4 b-e		
12 Aprovia 0.83EC 1.4 fl oz + Oil 1qt	PF-4C								1.9 cd	2.2 ef
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	0 a	0 a	1 a	<1 a	5 a-c	3 ab	2 a-c		
13 Aprovia 0.83EC 1.4 fl oz + Inspire Super 3 fl oz	PF-4C								1.4 ab	1.6 b-d
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	0 a	0 a	0 a	0 a	19 d-g	17 c-h	2 a-c		
14 Aprovia 0.83EC 1.4 fl oz + Inspire Super 3 fl oz +										
Manzate Pro-Stick 75DF 12 oz	PF-4C								1.6 a-c	1.9 c-f
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	0 a	0 a	0 a	0 a	9 b-e	9 a-g	0 a		
15 Aprovia 0.83EC 1.4 fl oz + Inspire Super 3 fl oz +										
Manzate Pro-Stick 75DF 12 oz + Oil 1 qt	PF-4C								1.7 b-d	2.2 ef
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	0 a	0 a	1 a	<1 a	3 ab	2 ab	1 ab		
16 Manzate Pro-Stick 75DF 12 oz	PF-4C								1.5 a-c	1.4 a-c
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	3 ab	<1 ab	4 a	<1 a	4 a-c	3 a-c	1 ab		
17 Luna Sensation 1.4 fl oz + Inspire Super 3 fl oz +										
Manzate Pro-Stick 75DF 12 oz + Oil 1 qt	PF-4C								1.4 a-c	1.5 a-d
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	5C-7C	0 a	0 a	0 a	0 a	1 a	1 a	0 a		

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications, Fruit ratings were of 25-fruit samples per replication, taken 6 Oct, put in warm storage then evaluated 13 Oct.

* Final rating for rots after 18 days' incubation at ambient temperatures 64-82º F (mean 69.9º F).

** Fruit finish rated on a scale of 0-5 (0 = perfect finish, 5 = severe russet or opalescence).

No fungicides were applied until the first treatment application date. Applied dilute to runoff at 250 psi on the following dates: 2 May (PF, petal fall); 1C-7C, (1st-7th covers): 19 May, 27 May, 10 Jun, 23 Jun, 11 Jul, 27 Jul, 22 Aug.

APPLE (*Malus domestica* 'Idared')
Fire blight; *Erwinia amylovora*

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Suppression of fire blight blossom blight on Idared apple, 2016.

Treatments involving eleven different products were compared to streptomycin (Firewall), alone and in integrated schedules, for blossom blight control and fruit finish effects. The test was established in four randomized blocks on 33-yr-old trees, using single-tree replications with border rows between treatment rows. The test strategy was to make applications in the morning before inoculating in the evening in anticipation of a relatively warm day to follow. Treatments were applied to both sides of the tree with a Swanson Model DA-400 airblast sprayer at 100 gallons per acre as follows: 14 Apr (early bloom, Bl 1, all treatments); 18 Apr (mid bloom, Bl 2, all treatments), 21 Apr (late-bloom, Bl 3, all treatments); 27 Apr (petal fall, PF, all treatments). Four selected branches per tree, each with about 25 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *Erwinia amylovora* cells/ml in the evenings of 14 Apr, 18 Apr and 21 Apr. Trees were not inoculated after the fourth (petal fall) application 27 Apr. Infection data were based on counts of number of blossom clusters present on the inoculated branch at the time of the first inoculation. A cluster was rated as infected if it had at least one blossom with any fire blight symptoms on 5 May. Fruit finish was rated on 25-fruit harvest samples 29 Aug.

Inoculation resulted in strong blossom blight test conditions. Treatments involving the four-application schedule of streptomycin (Firewall, in treatments. #1, 12 and 14-16), performed as expected under these conditions, with significant suppression of cluster infection. Treatment #2, which had the second and third applications omitted from the sequence, was ineffective. Treatments receiving alternative treatments in the second and third applications were not significantly different (p=0.05) from #2 or the non-treated trees, including: Treatment #3 (Fracture), #4 (Serenade Optimum), and #5 (Blossom Protect). Several treatments had complete schedules and fewer clusters infected, but were not significantly different than non-treated trees, including #6 (Blossom Protect), #7 (Kasumin), #8 (F1781aa), #9 (F1781ab), #10 and #11 (Kasumin/ARY-0627), and #13 (HM0303). Four applications of Blossom Protect (#6) significantly increased russet and opalescence compared to non-treated trees, but a schedule that included Blossom Protect only at the second and third applications did not affect fruit finish ratings.

Table 26. Suppression of fire blight blossom blight on Idared apple. 2016. Block 15, Idared. VT-AREC, Winchester.

	Timing				Fire blight		Fruit finish ratings (0-5)*	
	Bloom. #				% clusters	%		
Treatment and rate/A	1	2	3	PF	infected	control	russet	opalescence
0 No treatment	--	--	--	--	50.4 ef	--	1.8 ab	1.0 a
1 FireWall 17 1.5 lb + Regulaid 1 pt/100 gal	X	X	X	X-	21.4 ab	57	2.1 bc	1.3 ab
2 FireWall 17 1.5 lb + Regulaid 1 pt/100 gal	X	--	--	X	51.3 ef	-2	2.0 a-c	1.3 ab
3 FireWall 17 1.5 lb + Regulaid 1 pt/100 gal Fracture 2.12SL 30.4 fl oz	X --	-- X	-- X	X --	38.1 b-f	24	1.9 ab	1.1 ab
4 FireWall 17 1.5 lb + Regulaid 1 pt/100 gal Serenade Optimum 20 oz	X --	-- X	-- X	X --	36.8 a-f	27	1.7 a	1.0 a
5 FireWall 17 1.5 lb + Regulaid 1 pt/100 gal Blossom Protect 20 oz + Buffer Protect 8.75 lb	X --	-- X	-- X	X --	38.6 b-f	23	1.8 a	1.0 ab
6 Blossom Protect 20 oz + Buffer Protect 8.75 lb	X	X	X	X	49.6 ef	2	2.4 c	1.5 b
7 Kasumin 2L 2 qt + Regulaid 1 pt/100 gal	X	X	X	X	33.8 a-e	33	1.8 a	1.1 ab
8 F1781aa 1 qt + Regulaid 1 pt/100 gal	X	X	X	X	47.5 ef	6	2.0 ab	1.2 ab
9 F1781ab 1 qt + Regulaid 1 pt/100 gal	X	X	X	X	41.0 c-f	19	1.8 a	1.1 ab
10 Kasumin 2L 2 qt + ARY-0627-002 14 fl oz + Regulaid 1 pt/100 gal	X	X	X	X	43.3 ef	14	1.9 ab	1.2 ab
11 Kasumin 2L 2 qt + Regulaid 1pt/100 gal ARY-0627-002 14 fl oz + Regulaid 1 pt/100 gal	X --	-- X	X --	-- X	44.3 ef	12	1.9 ab	1.2 ab
12 FireWall 17 1.5 lb	X	X	X	X	23.6 a-c	53	2.0 a-c	1.3 ab
13 HM0303 2 qt	X	X	X	X	53.0 f	-5	1.7 a	1.3 ab
14 FireWall 17 1.5 lb + HM0303 2 qt	X	X	X	X	28.0 a-d	44	1.7 a	1.4 ab
15 FireWall 17 1.5 lb + HM1611 1 qt/100 gal	X	X	X	X	27.9 a-d	45	1.7 a	1.1 ab
16 FireWall 17 1.5 lb + HM0303 2 qt + HM1611 1 qt	X	X	X	X	18.8 a	63	1.8 ab	1.2 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps with border rows between treatment rows.
A cluster was rated as infected if it had at least one blossom with any fire blight symptoms on 5 May.
* Fruit finish was rated on 25-fruit harvest samples 29 Aug using a scale of 0-5 (0=perfect finish; 5=severe russet or opalescence).

APPLE (*Malus domestica* 'Fulford Gala')
Fireblight; *Erwinia amylovora*
Scab; *Venturia inaequalis*

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Test of coppers and biopesticides for the control of fireblight on Gala apple, 2016.

Sixteen treatments were compared for fireblight blossom blight and scab control and fruit finish effects. The test was established on 15-yr-old trees in four randomized blocks using single-tree replications. Our goal was to select treatment days according to the protocol with an inoculation day to be the day before a relatively warm day, which would be as favorable for natural infection as possible. Treatments were applied dilute to run-off on the mornings of: 14 Apr (Pink/early bloom, no inoculation); 18 Apr (B1, bloom, first inoculation), 21 Apr (B2, full bloom, 2nd inoculation); 27 Apr (late bloom, no inoculation); 19 May (Petal Fall-1C, no inoculation). Two selected branches per tree, each with about 25 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *Erwinia amylovora* cells/ml in the evenings of 18 Apr and 21 Apr. Infection data were based on counts of number of blossom clusters present on the inoculated branch at the time of the first inoculation. A cluster was rated as infected if it had at least one blossom with any fire blight symptoms on 4 May. Cover spray fungicide (Captan 80WDG 3.75 lb/A) was applied to the entire test block (including "no treatment") with an airblast sprayer 10 Jun, 23 Jun, 7 Jul, 20 Jul, and 2 Aug. Conventional maintenance insecticides were applied with an airblast sprayer to the entire test block as needed. Scab infection and fruit finish were rated on 25-fruit harvest samples 31 Aug.

Inoculation resulted in strong fire blight test conditions. With considerable variation among replications, only treatment #12, four applications of NU-COP 30HB 4oz, significantly suppressed fire blight compared to non-treated trees (p=0.05). While many other treatments had fewer clusters infected than non-treated trees, they were not significantly different. The first scab infection period occurred during the treatment series 22-23 Apr, and 13 scab infection periods occurred in 15 days 28 Apr to 12 May resulting in heavy scab pressure while the fire blight treatment series was in progress. Covering the entire block, including "no treatment" trees with Captan, allowed opportunity for demonstrating scab control particularly among the fire blight treatments involving NU-COP; however, treatment #11 (NU-COP 30HB 4 oz), which did not include the 19 May petal fall-first cover application, had a greater incidence of fruit scab. Cueva + Double Nickel (#5) also significantly reduced fruit scab, but less so than the NU-COP treatments. Although the NU-COP treatments reduced the amount of scab, they increased the amount of russet. NU-COP 50DF 4 oz treatments #9 and #10 were more prone to fruit russet and opalescence than NU-COP 30HB (#7, 8 and 12).

Table 27. Suppression of fire blight blossom blight and scab on Gala apple. 2016. Virginia Tech-AREC, Winchester.

		Bloom. app. #					Fire blight		Scab infection		Fruit finish ratings (0-5)*	
	Treatment and rate/100 gal	Pk-Bl	1	2	3	PF	% clusters infected	% control	% fruit	lesions /fruit	russet	opalescence
0	No treatment	--	--	--	--	--	43.1 bc	--	89 ef	6.7 d	1.4 a	1.3 a-d
1	FireWall 8 oz	--	X	X	X	X	36.3 bc	16	74 de	4.5 c	1.3 a	1.2 a-c
2	CX-10250 4.5 oz	X	X	X	X	X	29.3 ab	32	80 d-f	4.0 bc	1.5 a	1.2 ab
3	Double Nickel LC 8 fl oz FireWall 8 oz	X --	-- X	X --	-- X	X --	33.1 a-c	23	82 d-f	4.0 bc	1.5 a	1.3 a-d
4	Cueva 1 pt	--	X	X	X	X	41.4 bc	4	75 de	3.7 bc	1.8 a	1.3 a-d
5	Cueva 1 pt + Double Nickel LC 8 fl oz	--	X	X	X	X	37.5 bc	13	68 d	2.6 b	1.4 a	1.1 a
6	Actigard 0.5 oz	--	X	X	X	X	29.8 a-c	31	90 ef	4.6 c	1.4 a	1.4 a-d
7	NU-COP 30HB 3 oz	X	X	X	X	X	38.5 bc	11	24 bc	0.8 a	2.8 b	2.0 ef
8	NU-COP 30HB 3 oz + Double Nickel LC 8 fl oz	X	X	X	X	X	30.0 ab	30	17 ab	0.3 a	2.8 b	1.8 de
9	NU-COP 50DF 4 oz	X	X	X	X	X	36.8 bc	15	7 a	0.1 a	3.6 c	2.4 f
10	NU-COP 50DF 4 oz	--	X	X	X	X	51.5 c	-19	14 ab	0.2 a	3.4 c	2.0 ef
11	NU-COP 50DF 4 oz	--	X	X	X	--	33.1 a-c	23	36 c	0.8 a	2.9 b	1.7 c-e
12	NU-COP 30HB 4 oz	--	X	X	X	X	15.4 a	64	10 a	0.2 a	2.5 b	1.7 b-e
13	FireWall 17 8 oz + Regulaid 1 pt Serenade Optimum 5 oz	--	X --	-- X	X --	-- X	29.2 ab	32	92 f	4.8 c	1.4 a	1.1 a
14	FireWall 17 8 oz + Regulaid 1 pt Serenade Optimum 5 oz	--	X --	X --	-- X	X --	35.2 bc	18	87 ef	5.0 cd	1.7 a	1.6 a-e
15	FireWall 17 8 oz + Regulaid 1 pt	--	X	--	X	--	35.3 bc	18	87 ef	4.8 c	1.6 a	1.2 ab
16	FireWall 17 8 oz + Regulaid 1 pt	--	X	X	--	X	25.5 ab	41	88 ef	3.6 bc	1.4 a	1.2 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications with border rows between treatment rows. Dilute rates based on 400 gal/A.

* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet or opalescence).

Applications: 14 Apr (Pink/early bloom, no inoculation); 18 Apr (B1, bloom, first inoculation), 21 Apr (B2, full bloom, second inoculation); 27 Apr (late bloom, no inoculation); 19 May (PF-1C, follow-up, no inoculation). Two selected branches per tree, each with about 25 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *Erwinia amylovora* cells/ml in the evenings of 18 Apr and 21 Apr. Infection data were based on counts of number of blossom clusters present on the inoculated branch at the time of the first inoculation. A cluster was rated as infected if it had at least one blossom with any fire blight symptoms on 4 May.

PEACH (*Prunus persica* 'Redhaven')
Leaf curl; *Taphrina deformans*
Scab; *Cladosporium carpophilum*
Brown rot; *Monilinia fructicola*
Leaf injury/defoliation

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Disease control and phytotoxicity by treatments applied to Redhaven peach, 2016.

Twelve treatments involving experimental materials were compared to standard programs for broad-spectrum disease control on 5-yr-old trees. Test trees had been non-treated border trees in 2015 to allow the buildup of leaf curl and scab inoculum for the test in 2016. The test was set up in a randomized block design with four replications with non-treated in-row border trees between the test trees. Three brown rot mummies were placed in each test tree at pink stage 24 Mar. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 200-250 psi as follows: 11 Mar (BS, bud swell, treatments #1 and 3-5 only); 23 Mar (pink, all treatments); 30 Mar (full bloom); 13 Apr (PF, petal fall); 27 Apr (SS, shuck split); Covers (1C-4C): 16 May, 31 May, 14 Jun; 29 Jun; 7 Jul (2PH, 2-wk pre-harvest), 18 Jul (1PH, 3 days pre-harvest). Actual harvest date was 21 Jul. Percentage of terminal buds infected with leaf curl were rated on 25 shoot tips per tree 10 May. Defoliation was rated on ten shoots per tree on the east sides of the rows on 11 Jul. To increase brown rot pressure in the test block, on 14 Jul several fruit in each non-treated adjacent border tree were inoculated by dipping the point of a nail in a suspension containing 30,000 *M. fructicola* conidia/ ml and puncturing the fruit. Commercial insecticides were applied to the entire test block at 1-2 week intervals with a commercial airblast sprayer. Samples of 5-20 apparently rot-free fruit per replicate tree were harvested 21 Jul, and rated for scab. Fruit were selected for uniform ripeness and placed on fiber trays. All fruit were incubated in polyethylene bags at ambient temperatures 76-86°F (24-30°C) before rating rot development at the indicated intervals.

Early season rains favored heavy leaf curl infection. Bravo (Treatment #1), showed the importance of the bud swell application 11 Mar, just before an extended wetting event 13-15 Mar as compared to Treatment #2, which was delayed until 23 Mar (pink). NU-COP (#3-5) was also applied at bud swell 11 Mar but did not effectively control leaf curl. In early summer it became apparent that some treatments were causing shothole injury and defoliation of older leaves on the shoots, and this was confirmed by ratings conducted 11 Jul. NU-COP (#3-5) had similar amounts of injury, which was not significantly reduced by including Double Nickel (#5). However, some of the defoliation appeared to be related to leaf curl as indicated by Treatment #9 and #2 vs. #1, which had good leaf curl control and minimal defoliation. Following the shuck split application 27 Apr, rains every day from 28 Apr-12 May resulted in heavy scab pressure prior to the first cover spray 16 May. More than half of the fruit were infected on the best treatments, and better evidence of control is noted in lesions per fruit rather than incidence. The Bravo/Sulfur treatments (#1 and #2) generally resulted in the fewest scab lesions, but one of the GWN-4617/Sulfur treatments also reduced scab lesions. *It should be noted that brown rot suppression in NU-COP (#3-5) was probably related to delayed maturity and reduced sugar levels due to defoliation by the copper treatment.* Among other treatments, the highest rates of GWN-4617 (#8) and GWN-10320 (#10) and OSO (#12) gave brown rot control similar to the Merivon standard (#1 and #2). Significant weaknesses were noted at reduced rates of GWN-4617 (#6) and GWN-10320 (#9).

Table 28. Control of leaf curl and scab and defoliation by treatments on Redhaven peach, 2016.

	Treatment and rate/100 gal dilute	Timing	Leaf curl, % terminal buds inf. 10 May	% defoliation 11 Jul	Scab infection*, % fruit and lesions: % fruit	les/fruit
0	No fungicide	---	49 b	4 a-d	100 b	56.7 c
1	Bravo Weather Stik 6F 1 pt	BS-PF	18 a			
	Microfine Sulfur 90W 3 lb	SS-4C		1 a	52 a	2.5 a
	Merivon 4.18SC 3.25 oz + Induce 8 fl oz	2 & 1PH				
2	Bravo Weather Stik 6F 1 pt	Pink-PF	41 ab			
	Microfine Sulfur 90W 3 lb	SS-4C		6 cd	85 ab	6.7 a
	Merivon 4.18SC 3.25 oz + Induce 8 fl oz	2 & 1PH				
3	NU-COP HB 4 oz	BS-1PH	42 ab	19 e	74 ab	30.4 b
4	NU-COP HB 6 oz	BS-1PH	32 ab	35 f	89 ab	19.8 ab
5	NU-COP HB 6 oz+ Double Nickel LC 8 fl	BS-1PH	28 ab	35 f	70 ab	12.4 ab
6	GWN-4617 0.85SC 3 fl oz + Induce 8 fl oz	Pink-PF	46 ab			
	Microfine Sulfur 90W 3 lb	SS-4C		5 b-d	66 a	7.6 a
	GWN-4617 0.85SC 3 fl oz + Induce 8 fl oz	2 & 1PH				
7	GWN-4617 0.85SC 4.5 fl oz + Induce 8 fl oz	Pink-PF	47 ab			
	Microfine Sulfur 90W 3 lb	SS-4C		3 a-d	92 ab	13.4 ab
	GWN-4617 0.85SC 4.5 fl oz + Induce 8 fl oz	2 & 1PH				
8	GWN-4617 0.85SC 6 fl oz + Induce 8 fl oz	Pink-PF	38 ab			
	Microfine Sulfur 90W 3 lb	SS-4C		3 a-d	80 ab	13.2 ab
	GWN-4617 0.85SC 6 fl oz + Induce 8 fl oz	2 & 1PH				
9	GWN-10320 8 fl oz + Induce 8 fl oz	Pink-PF	57 b			
	Microfine Sulfur 90W 3 lb	SS-4C		7 d	83 ab	17.6 ab
	GWN-10320 8 fl oz + Induce 8 fl oz	2 & 1PH				
10	GWN-10320 16 fl oz + Induce 8 fl oz	Pink-PF	40 ab			
	Microfine Sulfur 90W 3 lb	SS-4C		2 a-c	70 ab	21.5 ab
	GWN-10320 16 fl oz + Induce 8 fl oz	2 & 1PH				
11	OSO 5% SC 3.25 fl oz + Induce 8 fl oz	Pink-2C	40 ab			
	Microfine Sulfur 90W 3 lb	3C-4C		6 cd	91 ab	22.3 ab
	OSO 5% SC 3.25 fl oz + Induce 8 fl oz	2 & 1PH				
12	Bravo Weather Stik 6F 1 pt	Pink-PF	48 b			
	Microfine Sulfur 90W 3 lb	SS-4C		2 ab	72 ab	18.3 ab
	OSO 5% SC 3.25 fl oz + Induce 8 fl oz	2 & 1PH				

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single tree replications.

Four single tree reps with non-treated border trees in row. Dilute application to run-off.

Application dates:

11 Mar (BS, bud swell, trts #1 and 3-5 only); 23 Mar (pink, all trts); 30 Mar (full bloom); 13 Apr (PF, petal fall); 27 Apr (SS, shuck split); Covers (1C-4C): 16 May, 31 May, 14 Jun, 29 Jun, 7 Jul (2PH, 2-wk pre-harvest), 18 Jul (1PH, 3 days pre-harvest). Actual harvest date: 21 Jul.

Leaf curl counted 10 May; defoliation rated on ten shoots, 10 shoots on east side of rows, on 11 Jul.

* Harvest ratings of 5-20 fruit per replication, 21 Jul.

Table 29. Post-harvest brown rot development on Redhaven peach, 2016. VT-AREC, Winchester.

	Treatment and rate/100 gal dilute	Timing	% fruit with brown rot after days incubation 2 day	4 day	6 day	Unrotted fruit, %, 6 days
0	No fungicide	---	51 d	61 e	82 f	5 e
1	Bravo Weather Stik 6F 1 pt	BS-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	Merivon 4.18SC 3.25 oz + Induce 8 fl oz	2 & 1PH	12 bc	14 d	15 cd	25 c-e
2	Bravo Weather Stik 6F 1 pt	Pink-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	Merivon 4.18SC 3.25 oz + Induce 8 fl oz	2 & 1PH	5 a-c	9 d	9 c-e	13 cd
3	NU-COP HB 4 oz	BS-1PH	2 ab	2 ab	2 ab	48 ab
4	NU-COP HB 6 oz	BS-1PH	0 a	0 a	0 a	85 a
5	NU-COP HB 6 oz+ Double Nickel LC 8 fl	BS-1PH	0 a	0 a	1 a	89 a
6	GWN-4617 0.85SC 3 fl oz + Induce 8 fl oz	Pink-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	GWN-4617 0.85SC 3 fl oz + Induce 8 fl oz	2 & 1PH	16 bc	19 d	37 e	17 de
7	GWN-4617 0.85SC 4.5 fl oz + Induce 8 fl oz	Pink-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	GWN-4617 0.85SC 4.5 fl oz + Induce 8 fl oz	2 & 1PH	12 bc	16 d	23 c-e	38 b-d
8	GWN-4617 0.85SC 6 fl oz + Induce 8 fl oz	Pink-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	GWN-4617 0.85SC 6 fl oz + Induce 8 fl oz	2 & 1PH	6 ab	12 cd	12 bc	30 c-e
9	GWN-10320 8 fl oz + Induce 8 fl oz	Pink-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	GWN-10320 8 fl oz + Induce 8 fl oz	2 & 1PH	16 c	16 d	26 de	38 b-d
10	GWN-10320 16 fl oz + Induce 8 fl oz	Pink-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	GWN-10320 16 fl oz + Induce 8 fl oz	2 & 1PH	4 ab	4 a-c	10 c	39 b-d
11	OSO 5% SC 3.25 fl oz + Induce 8 fl oz	Pink-2C				
	Microfine Sulfur 90W 3 lb	3C-4C				
	OSO 5% SC 3.25 fl oz + Induce 8 fl oz	2 & 1PH	8 a-c	15 d	22 c-e	49 bc
12	Bravo Weather Stik 6F 1 pt	Pink-PF				
	Microfine Sulfur 90W 3 lb	SS-4C				
	OSO 5% SC 3.25 fl oz + Induce 8 fl oz	2 & 1PH	0 a	11 b-d	16 c	43 b-d

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Four single tree reps with non-treated border trees in row. Dilute application to run-off.

Application dates:
11 Mar (BS, bud swell, trts #1 and 3-5 only); 23 Mar (pink, all trts); 30 Mar (full bloom); 13 Apr (PF, petal fall); 27 Apr (SS, shuck split); Covers (1C-4C): 16 May, 31 May, 14 Jun, 29 Jun, 7 Jul (2PH, 2-wk pre-harvest), 18 Jul (1PH, 3 days pre-harvest). Actual harvest date: 21 Jul.

Note: Brown rot suppression in Treatments #3-5 is apparently related to delayed maturity and reduced sugar levels due to defoliation by the copper treatment.

Horticulture

Sunburn Management on 'Honeycrisp' at the Hudson Valley Area in 2016

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Introduction

Sunburn is considered to be a serious economic problem in practically all apple-growing regions of the world. Losses of apple fruit due to sunburn can reach 10-30% depending on the year, the region and the apple cultivar. Until recently, sunburn has been perceived as a problem primarily in hot and dry climates, like Australia, South Africa, Spain, Turkey and Washington State (Rackso and Schrader, 2012). However, starting several years ago this problem has emerged as a concern in Eastern New York, more particularly at the Hudson Valley area, especially with the cultivar 'Honeycrisp' (Reig et al., 2016; Schupp et al., 2002).

From results obtained in 2015 by Reig et al. (2016) when they tested spray particle films applied in the latter half of the season, enough information was obtained to design additional trials to 1) test other strategies already used in other parts of the world, such as evaporative cooling (EC) and netting, together with the application of particle films, and 2) test other timings, including season-long applications. EC involves use of an over-tree sprinkler cooling system in order to reduce heat stress. The ameliorative effect of EC manifests primarily in the reduction of fruit surface temperature (FST) through the evaporation of water from the fruit surface (Evans et al., 1995), while the use of nets over the tree canopy for shading purposes reduces both incident sunlight on the fruit surface and FST by reducing the transmission of direct solar radiation through the net, thereby decreasing sunburn injury (Rackso and Schrader, 2012). The threshold FST for 'Honeycrisp' and for each type of sunburn have already been described in Reig et al. (2016) and Rackso and Schrader (2012).

Two trials were set up at the Hudson Valley area in 2016 to study the incidence and the severity of sunburn under different strategies used.

Material and Methods

<u>Study site and plant material</u>

Fruit used in this study were harvested from tall spindle 'Honeycrisp' apple trees grown in two different locations. The first one was at Hudson Valley Research Laboratory (HVRL) experimental orchards near Highland, New York. This experiment is called Experiment 1. The second location (Experiment 2) was at a commercial orchard near Milton, New York.

Trees from Experiment 1 were planted in 2010, grafted on Nic.29, spaced at 3 ft x 14 ft, and grown in loam soil. Irrigation was the same for all the treatments using trickle irrigation, and it was done according to the NEWA irrigation model (http://www.newa.cornell.edu) from the end of May to the end of September. Except for chemical thinning, standard commercial management practices recommended for the area were followed.

Trees from Experiment 2 were planted in 2007, grafted on B.9, spaced at 3.5 ft x 14 ft, grown in Bath-Nassau complex soil, and irrigated with a drip system. Standard commercial management practices recommended for the area were followed including fertilization, plant disease and pest control, and chemical thinning with NAA and carbaryl. Trees in this planting also received 1 gal/acre of Harvista™ on 1 September.

These particular areas of New York State are subjected to periods of high summer temperatures (≥ 86 ºF) and medium to high rainfall (around 12 inches) from June to the end of September.

Treatment characteristics

A completely randomized block design was used in both two experiments, with four blocks assigned to each of the treatments. Each treatment and block consisted of 10 trees, from which three trees per treatment and block were selected and considered as an experimental unit and the rest of the trees were considered buffer trees. Six treatments were applied in both experiments.

In Experiment 1, three different strategies were used to control sunburn: 1. Spray particle films, 2. Netting, and 3. Overhead irrigation. Therefore, the experimental treatments from Experiment 1 consisted of the following: 1) Untreated control; 2) Evaporative cooling; 3) Netting: A light grey polyester net; 4) ScreenDuo-1: ScreenDuo® applied every 10-14 days beginning at petal fall (label recommendation); 5) ScreenDuo-2: ScreenDuo® applied 1-3 days before a heat event (≥ 86 ºF); and 6) Raynox® applied four times during growing season, beginning nine weeks after full bloom (label recommendation). Treatments were applied using an airblast sprayer that delivered 85 gallons per acre with tree/row/volume calculated at 170 gallons per acre. Rates and dates of application are described in Table 1.

In Experiment 2, only spray particle films were used to control sunburn. Therefore, the experimental treatments from Experiment 2 consisted of the following: 1) Untreated control; 2) ScreenDuo-1: ScreenDuo® applied every 10-14 days beginning at petal fall (label recommendation); 3) ScreenDuo-2: ScreenDuo® applied 1-3 days before a heat event (≥86 ºF); 4) Raynox-1: Raynox® applied four times during growing season, beginning nine weeks after full bloom (label recommendation); 5) Raynox-2: Raynox® applied 1-3 days before a heat event (≥ 30 ºC); and 6) Raynox-3: Raynox® applied four times during growing season, beginning nine weeks after full bloom (label recommendation), but only on the west side of the tree. Treatments were applied using an airblast sprayer that delivered 70 gallons per acre with tree/row/volume calculated at 200 gallons per acre. Rates and dates of application are described in Table 1.

Table 1. Treatments, rates and dates of application.

Code	Treatment	Rate	Dates of application
Experiment 1	Control	-	-
	Netting[1]	-	-
	Evaporative cooling[2]	11 gals $hour^{-1}$	6th-8th July 12th July, 15th July, 18th July, 21st-29th July, 5th 8th-9th Aug., 11th-15th Aug. 17th-20th Aug. 24th Aug., 26th-29th Aug., 8th Sept.
	Raynox[3]	2.5 gals $acre^{-1}$	15th June, 22th June, 7th July, and 12th Aug.
	ScreenDuo-1[4]	10 lb $acre^{-1}$	28th May, 7th June, 18th June, 3rd July, 12th July, 26th July, 16th Aug.
	ScreenDuo-2	10 lb $acre^{-1}$	18th June, 3rd July, 12th July, 26th July, 5th Aug., 16th Aug.
Experiment 2	Control	-	-
	Raynox-1	2.5 gals $acre^{-1}$	18th June, 25th June, 16th July, 11th Aug.
	Raynox-2	2.5 gals $acre^{-1}$	18th June, 15th July, 11th Aug.
	Raynox-3	2.5 gals $acre^{-1}$	18th June, 25th June, 16th July, 11th Aug.
	ScreenDuo-1	10 lb $acre^{-1}$	8th June, 18th June, 2nd July, 12th July, 26th July, 3rd Aug., 17th Aug.
	ScreenDuo-2	10 lb $acre^{-1}$	18th June, 12th July, 26th July, 5th Aug., 17th Aug.

[1] From Pak Unlimited Inc. (Georgia, USA).
[2] From TRICKL-EEZ Company (Michigan, USA), Model Nelson R5 Rotator.
[3] From Valent BioSciences Corporation (Ilinois, USA).
[4] From Crop Microclimate Management Inc. (North Carolina, USA).

Sunburn evaluation

The incidence of the three sunburn types (SN: sunburn necrosis; SB: sunburn browning; SP: photo-oxidative sunburn), already described at Reig et al. (2016), for all treatments was evaluated as presence or absence of sunburn in the apple skin, and it was expressed as a percentage.

The severity of sunburn was only assessed for the sunburn browning type on both experiments by adapting the four sunburn browning classes previously described by Felicetti and Schrader (2008) for 'Fuji'. Only two classes were used for this trial on 'Honeycrisp' based on the previous observations in 2015 season (Reig et al., 2016): SB-1: browning or light yellowing spot on the fruit skin (Figure 1); SB-2: strong yellowing spot on the skin (Figure 2).

Figure 1. SB-1 sunburn severity symptom

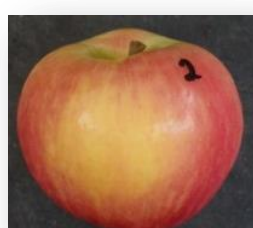

Figure 2. SB-2 sunburn severity symptom

Results and Discussion

'Honeycrisp' is a multi-picking cultivar, so three harvest times (henceforth H1, H2 and H3) were needed to pick all fruits from Experiment 1 (H1: 9/01/2016, H2: 9/08/2016, and H3: 9/21/2016), and 4 harvest times (henceforth H1, H2, H3 and H4) to pick all fruits from Experiment 2 (H1: 9/07/2016, H2: 9/20/2016, H3: 9/28/2016, and H4: 10/10/2016). However, only fruits from H1 and H2 were evaluated for sunburn in both experiments.

Results showed statistically significant differences among treatments in Experiment 1 at each harvest (H1 and H2) (Table 2) and with combined data from both harvests (data not shown). Netting resulted in the lowest incidence of sunburn. Fruits under the netting averaged about 40 % less sunburn compared to the control treatment. However, the netting did not differ significantly from the overhead cooling and Raynox treatment at H1, and from the evaporative cooling and ScreenDuo-1 at H2. With regards to the whole tree harvested, fruits under the netting had the lowest percentage of sunburn (7.9 %), while the rest of the treatments did not differ statistically different among themselves with sunburn incidence around 20% (data not shown). On the other hand, although overhead cooling, Raynox, ScreenDuo-1 treatments did not differ statistically from the control treatment, they tended to show less sunburn than the control (Table 2). 'Honeycrisp' fruits with the ScreenDuo-1 treatment had less sunburn numerically compared to fruit from the ScreenDuo-2 treatment. The omission of two applications at the beginning of the season in the ScreenDuo_2 treatment could explain that. Finally, none of the treatments in this trial provided complete control of the sunburn problem on 'Honeycrisp', which means more research needs to be done in order to understand better this problem.

Table 2. 'Honeycrisp' sunburn evaluation by harvest at Hudson Valley Research Laboratory (Experiment 1).

Harvest	Treatment	*Incidence*				*Severity*	
		% Sunburn[1]	% SP	% SN	% SB	% SB-1	% SB-2
H1	Control	41.5 a	0.0	0.0	41.5 a	74.3	25.7 a
	Netting	18.7 b	0.0	0.0	18.7 b	93.4	6.6 b
	Overhead cooling	33.0 ab	0.0	0.0	33.0 ab	87.5	12.5 ab
	Raynox	32.8 ab	0.2	0.2	32.4 ab	82.2	17.7 ab
	ScreenDuo-1	33.7 a	0.0	0.0	33.7 a	95.2	4.8 b
	ScreenDuo-2	41.1 a	0.0	0.0	41.1 a	89.7	10.3 b
H2	Control	11.0 a	0.2	0.0	10.7 ab	94.4	5.6
	Netting	3.8 b	0.0	0.0	3.8 b	100.0	0.0
	Overhead cooling	10.7 ab	0.0	0.0	10.7 ab	95.8	4.2
	Raynox	10.6 a	0.7	0.0	10.0 a	100.0	0.0
	ScreenDuo-1	9.5 ab	1.4	0.0	8.1 ab	100.0	0.0
	ScreenDuo-2	12.5 a	1.3	0.0	11.2 a	100.0	0.0

[1]All three sunburn types together.

For each treatment, means followed by the same letter in each column are not significantly different at $P \leq 0.05$. No letter means no statistically differences among treatments.

Abbreviations: SB, sunburn browning; SN, sunburn necrosis; SP, photooxidative sunburn.

In terms of sunburn incidence, more than 90% of the sunburn evaluated on all treatments was sunburn browning (SB), as might have been expected. On the other hand, more than 80% showed the lesser severity symptom (SB-1) (Table 2), in contrast with the results found by Reig et al. (2016), where most of the 'Honeycrisp' apples with sunburn had SB-2 symptom. This could be caused by the different timing of application during 2016 season compared to 2015 season.

Table 3. 'Honeycrisp' sunburn evaluation by harvest at Milton Farm (Experiment 2).

Harvest	Treatment	*Incidence*				*Severity*	
		% Sunburn[1]	% SP	% SN	% SB	% SB-1	% SB-2
H1	Control	18.8	0.4	0.0	18.3	89.7	10.3
	Raynox-1	16.8	0.7	0.0	16.1	93.6	6.4
	Raynox-2	20.6	0.0	0.0	20.6	86.9	13.1
	Raynox-3	18.4	0.4	0.0	18.0	93.5	14.3
	ScreenDuo	23.9	0.5	0.0	23.4	89.9	10.1
	ScreenDuo	22.1	0.0	0.0	22.1	83.8	16.2
H2	Control	7.9	1.3	0.0	6.6	100.0	0.0
	Raynox-1	8.1	1.5	0.0	6.6	100.0	0.0
	Raynox-2	8.1	0.7	0.0	7.4	100.0	0.0
	Raynox-3	6.4	0.9	0.1	5.3	96.3	3.7
	ScreenDuo	8.2	1.0	0.0	7.2	96.7	3.3
	ScreenDuo	7.3	0.1	0.0	7.2	100.0	0.0

[1]All three sunburn types together.

For each treatment, means followed by the same letter in each column are not significantly different at $P \leq 0.05$. No letter means no statistically differences among treatments.

Abbreviations: SP, photooxidative sunburn; SN, sunburn necrosis; SB, sunburn browning.

Concerning to Experiment 2, where the only strategy used was spraying particle films (Raynox and ScreenDuo), no statistically differences were found among the treatments in terms of sunburn incidence and sunburn severity (Table 3).

Comparing the percentage of sunburn obtained on both experiments, trees from Milton farm (Experiment 2) experienced less sunburn manly because trees are older and therefore had more foliage to cover the fruits and protect them from the sun exposure.

Summer of 2016 had more days with temperatures equal or higher than 86 ºF as compared to 2015 and as compared to the average maximum temperature over 16 previous years (Figure 3). From June to mid-September of 2016, the Hudson Valley area had 38 days where the maximum temperature was equal or higher than 86 ºF and 10 days were the maximum temperature was equal or higher than 90 ºF. In particular, August 2016 had more days above 90 ºF than any other August on record. The high temperatures recorded this season may explain the lack of statistical differences among spray particle films (Raynox and ScreenDuo) because the hot weather may have exceeded the abilities of these films to protect fruit. These products are still being tested in the East coast of USA, where although we can have high temperatures in the summer as in the west coast, rain, relative humidity, and the type of solar radiation are different than in western production regions. Also, these two products need to be tested more years in season-long spray programs in order to find the right rate to apply. The rates used in this study may not have been appropriate for the summer conditions that we had. In addition, as mentioned for the spray particle films used in this study, the two other strategies evaporative cooling (EC) and netting need more years of data under the eastern conditions, although they seemed to work well on the West coast. In conclusion, the geography and the climatology from the Hudson Valley area is quite different compared to areas on the west coast. Therefore, more years of data will provide eastern growers with a more accurate assessment of which strategy to invest in order to reduce sunburn on 'Honeycrisp'.

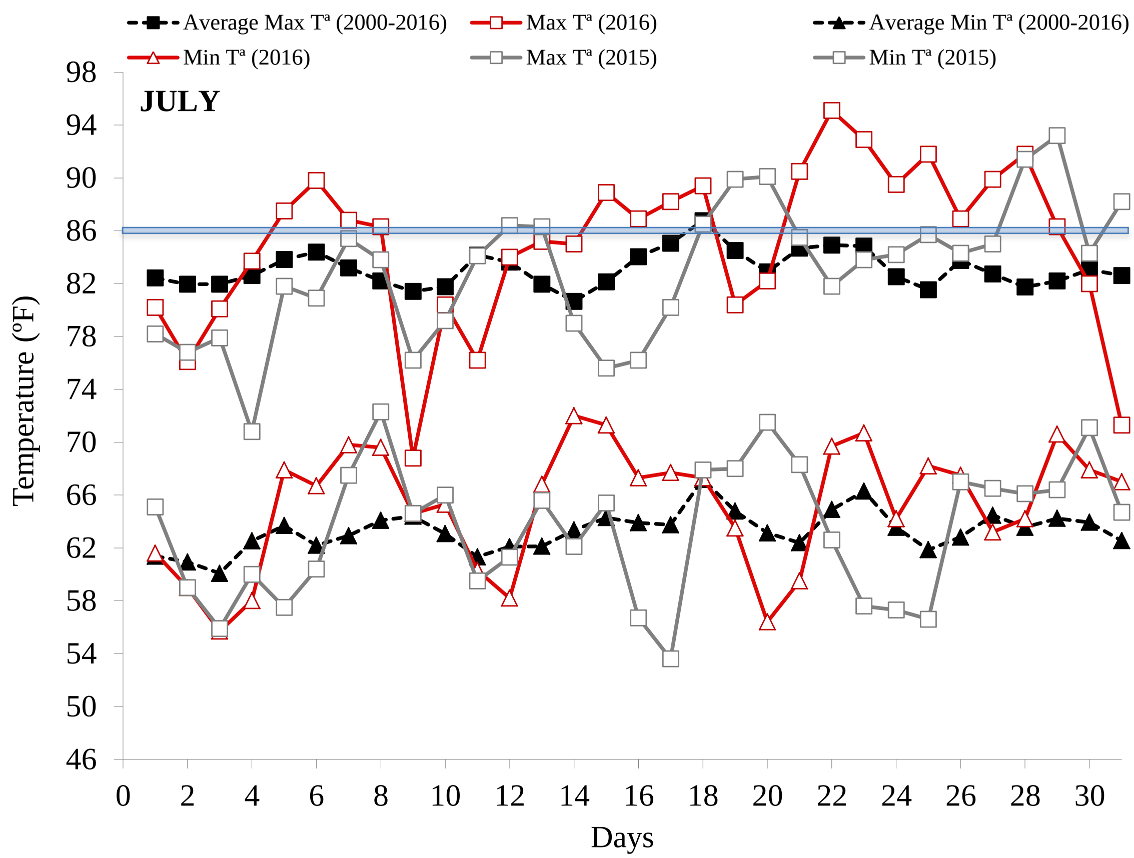

Figure 3. Daily maximum and minimum temperatures over the period 1st July-31st July for the 2015, 2016 season at HVRL, and daily average maximum and minimum temperatures over the period 1st July-31st July from 2000 to 2016.

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MYSTERY BLOTCHES ON PEACH: WHAT WE KNOW DOES NOT CAUSE BRONZING

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Discoloration of peach fruit finish in the form of bronzing has become a major issue for southeastern peach producers and we do not know its cause nor are there management recommendations in place. Symptoms occur as irregular-shaped blotches ranging from a single blotch to covering almost the entire fruit. It is a problem that occurs during ripening especially in years with high rainfall. Symptom severity intensifies during storage. In years with high occurrence of bronzing, losses exceed 60% of the fruit of mid-season varieties, and growers have lost millions of dollars due to significant packout reduction and rejection of entire loads shipped to distributers. In dry years (low incidence years) we see anywhere between 1 and 3% ($400,000 to $1 million) loss in South Carolina alone due to bronzing. With regard to economic significance, the largest shipper of peach fruit in the southeastern US reports average annual losses of $4 million due to bronzing. Bronzing of peach fruit has increasingly affected growers in Georgia, Pennsylvania, Michigan, and New Jersey as well. (**Fig. 1**). Growers across state lines report significant losses in shipped and fresh market fruit and declining customer satisfaction.

MI Peach (Bill Shane, MSU) | PA Peaches (Kari Peter, PSU) | SC Organic Peach (G. Schnabel) | SC Conventional fruit (G. Schnabel)

Fig. 1. Bronzed peaches from Michigan, Pennsylvania, and South Carolina.

In the southeastern United States, vulnerable varieties include 'Julyprince', 'Redglobe', 'Sweet Dream', 'PF23', 'Messina', and 'Scarletprince', all of which are high quality varieties that growers rely on during peak season. They represent the bulk of production in July for many growers. This problem is particularly affecting producers because all costs related to production, postharvest storage, packinghouse, and the cost of shipping the fruit to the distributors cannot be recovered since bronzing renders the fruit unmarketable. Some of these costs also have a significant environmental impact as a remarkable amount of resources are being used in producing fruit that end up being discarded. Besides the direct economic losses to the grower, the reputation of the growers, their brand name, and the sales and reputation of the distributors/retail markets are at stake.

Fig. 2. Bronzed peaches affecting the sales and reputation of both the producer and the store.

Symptoms of bronzing often increase in severity in storage, and although many of the affected fruit is sorted out as cull fruit in the packinghouse, many escape detection and make it to the retail market. The fruit is stamped with the brand name of the farm and reflect on the quality of the produce in the store (**Fig. 2**). Fruit appearance with regard to color is an important attribute for consumer acceptability. Bronzed fruit is not of acceptable quality and will hurt the reputation of the producer and the retail store. In many grocery stores, peaches are advertised as "local", "Southern Peaches", or identify the state where they have been grown. Thus, the presence of bronzed peaches in retail markets also harms the reputation of the state as a whole.

The **cause of bronzing is still unknown**, and investigating underlying causes will help to develop management strategies. Over the last two years we made significant progress on our understanding of the cause of bronzing, which allows formulation of testable hypotheses. Bronzing is initiated in the field prior to harvest, but there was no evidence of fungal pathogen, insect, phytoplasma, or pesticide damage. Rapid cooling and high pH water during postharvest handling exacerbate but do not cause bronzing. It is found in both conventional and organic orchards. New evidence based on symptom patterns suggest that inadequate water supply to the fruit and perhaps associated supply of nutrients is a major predisposing factor to bronzing. We observed that when incidence is of medium severity (more than just a single patch but not so much as to covering large portions of the fruit), patches center around the equatorial plane of the fruit as well as in circles around the very top and the very bottom. Those are the areas of the fruit that expand the fastest during maturation. In some circumstances the entire equatorial plane becomes sunken. We hypothesize that inadequate or excess water supplied to the tree during periods of high transpiration may cause stress in form of water and/or nutrient imbalance to the fastest growing cells of the fruit (equator, top and bottom of fruit) leading to cell collapse. This hypothesis also fits with increased incidence observed in years with above average rainfall patterns. Thus, if water or nutrient management is involved, appropriate management of natural resources such as water or soil fertility may be part of the solution. In addition, certain postharvest treatments such as dips in calcium chloride solutions may help reduce the manifestation/acceleration of symptoms during storage and transport. Other biotic factors such as the presence of viroids might be involved, because skin scarring symptoms were reported in viroid-affected peaches in Japan. But our preliminary research shows that common skin scarring viroids such as peach latent mosaic viroid, apple scar skin viroid, and apple dapple viroid were not present in affected fruit or leaf samples. That does not, however, rule out the involvement of viroids. Thus, an integrated approach is required to examine potential associations between orchard conditions, peach physiology, and perhaps as yet unknown viroids and bronzing.