Proceedings of the
94th Annual
Cumberland-Shenandoah Fruit Workers Conference

November 29-30, 2018

Holiday Inn Winchester SE-Historic Gateway
Winchester, Virginia

(FOR ADMINISTRATIVE USE ONLY)

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Edited by
Michael B. Dimock

Certis USA, L.L.C.
Columbia, Maryland

Table of Contents

Plant Pathology

Current and Past Executive Officers

2019

President:	Kerik Cox (Cornell)
Secretary/Treasurer:	Chris Bergh (Virginia Tech)
President-Elect:	Dean Polk (Rutgers)
Immediate-Past President:	Mike Dimock (Certis USA)

2018

President:	Mike Dimock (Certis USA)
Secretary/Treasurer:	Chris Bergh (Virginia Tech)
President-Elect:	Kerik Cox (Cornell)
Immediate-Past President:	Greg Krawczyk (Penn State)

2017

President:	Greg Krawczyk (Penn State)
Secretary/Treasurer:	Chris Bergh (Virginia Tech)
President-Elect:	Mike Dimock (Certis USA)
Immediate-Past President:	James Walgenbach (NC State)

2018 CSWFC Participants

Name	Affiliation	Name	Affiliation
Abegg, Chelsea	Rutgers University	Leskey, Tracy	USDA-ARS
Aćimović, Srđan	Cornell University	Love, Kenner	Virginia Coop. Extension
Agnello, Arthur	Cornell University	Ludwick, Dalton	USDA-ARS
Akotsen-Mensah, Clement	Rutgers University	Lutton, Elizabeth	USDA-ARS
Allen, Chester	Virginia Tech University	Mackintosh, Bill	Nutrien Ag Solutions
Avila, Nicolas	Rutgers University	Martin, Phillip	Penn State University
Ayer, Katrin	Cornell University	Mathew, Sudeep	Syngenta Crop Protection
Beatty, Daniel	Nutrien Ag Solutions	Nielsen, Anne	Rutgers University
Bergh, Chris	Virginia Tech University	Nita, Mizuho	Virginia Tech University
Biddinger, David	Penn State University	Nixon, Laura	Oakridge Assoc University
Brandt, Nate	USDA-ARS	Nunez, Demian	USDA-ARS
Carper, Lee	USDA-ARS	O'Barr, John	BASF Corp.
Carroll, Juliet	Cornell University	Ogburn, Emily	NC State University
Chandler, Jeffrey	NC State University	Outwater, Cory	Michigan State University
Clavet, Chris	NC State University	Peter, Kari	Penn State University
Collier, Judy	Certis USA	Peterson, Hillary	Penn State University
Cosseboom, Scott	University of Maryland	Plasters, Kevin	Helena Agri Enterprises
Cox, Kerik	Cornell University	Pochubay, Emily	Michigan State University
Crassweller, Robert	Penn State University	Polk, Dean	Rutgers University
Crim, Larry	USDA-ARS	Pollock, Robert	Penn State University
Cullum, John	USDA-ARS	Preston, Carrie	Cornell University
Davis, Linda	Wilbur-Ellis Co.	Quinn, Nicole	Virginia Tech University
Denson, Carrie	Rutgers University	Rice, Henry	Penn State University
Dimock, Michael	Certis USA	Rice, Kevin	University of Missouri
Dobbins, Madison	Michigan State University	Rodriguez-Saona, Cesar	Rutgers University
Donahue, Daniel	Cornell University	Rogers, Greg	Certis USA
Epstein, David	USDA-ARS	Rosenberger, Dave	Cornell University
Estes, Tony	UPI, Inc.	Rouse, Bob	B. Rouse Agriculturalist LLC
Frank, Daniel	West Virginia University	Rucker, Ann	Rutgers University
Fritz, Bradley	Certis USA	Rugh, Tony	USDA-ARS
Ganske, Don	CSFWC, Inc.	Schmitt, Dave	Rutgers University
Gauthier, Nicole	University of Kentucky	Schoof, Steve	NC State University
Gohil, Hemant	Rutgers University	Schupp, Jim	Penn State University
Gutt, Larry	Michigan State University	Schut, Kara	Wilbur-Ellis Co.
Hadden, Whitney	Virginia Tech University	Sears, Beth	UPL
Hannig, Greg	FMC Corp.	Seetin, Mark	US Apple Association
Hitchner, Erin	Syngenta Crop Protection	Seifrit, Donald	Penn State University
Holowid, John	Arysta LifeScience	Shannon, Mark	Shannon Farm Services
Hott, Chris	USDA-ARS	Sherif, Sherif	Virginia Tech University
Hunt, Kathy	University of Maryland	Shipe, Jo	Virginia Tech University
Ibrahim, Aya	Univ. Udine/Fond. E. Mach	Short, Brent	USDA-ARS
Irish-Brown, Amy	Michigan State Univ	Slack, Suzanne	Michigan State University
Janes, Scott	Arysta LifeScience	Smith, Larissa	Syngenta Crop Protection
Jentsch, Peter	Cornell University	Stamm, Greg	CBC America
Johnson, Kendall	NC State University	Steffel, Jim	LAB Services
Kirkpatrick, Danielle	USDA-ARS	Strickland, David	Cornell University
Kon, Tom	NC State University	Sutphin, Mark	Virginia Coop. Extension
Kowalski, Abby	Virginia Tech University	Umlor, Paul	Wilbur-Ellis Co.
Krawczyk, Greg	Penn State University	Urban, Julie	Penn State University
Kreis, Rachel	NC State University	Villani, Sara	NC State University
Lalancette, Norman	Rutgers University	Walgenbach, Jim	NC State University
Lampasona, Tim	Rutgers University	Wallingford, Anna	Univ. of New Hampshire
Landwehr, Anna	Andermatt BioControl	Wallis, Anna	Cornell University
Leach, Heather	Penn State University	Walsh, Chris	University of Maryland
Leahy, Kathleen	Polaris Orchard IPM Cons	Ward, John	Kop-Coat Protection Prod
Leake, Layne	USDA-ARS	Weber, Daniel	Penn State University
Lehman, Brian	Penn State University	Wise, John	Michigan State University
Leon, Chris	FMC Corp.	Yoder, Keith	Virginia Tech University

94^{th} Cumberland – Shenandoah Fruit Workers Conference

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CONFERENCE AGENDA

Thursday, November 29

8:00 – 9:00	Registration
9:00 – 9:10	Call to Order
9:10 – 10:10	Call of the States
10:10 – 10:30	Call of the Industry
10:30 – 10:45	BREAK
10:45 – 12:00	Plenary Session

U.S. Apple Industry 2018-19 - Overview and Outlook.
Mark W. Seetin, Director, Regulatory and Industry Affairs, U.S. Apple Association, Falls Church, VA.

Impacts of Federal Policies and Regulatory (and Court) Actions on Agriculture - What's Happening & Why You Should Be Paying Attention.
David L Epstein, Entomologist, USDA-ARS Office of Pest Management Policy, Washington, DC.

12:15 – 1:00	LUNCH
1:15 – 5:15	Concurrent Sessions Entomology Horticulture Plant Pathology
5:30	MIXER

Friday, November 30:

8:00 – 8:45	CSFWC Business Meeting (all are invited)
9:00 – 12:15	Concurrent Sessions continue

Concurrent Sessions Agenda

ENTOMOLOGY

Thursday, November 29:

1:15 - 1:30 **2018 orchard survey for invasive and exotic pests in New York.**
Juliet Carroll (NYS IPM Program, Cornell Univ.) and Art Agnello (Entomology, Cornell Univ.).

1:30 - 1:45 **Preliminary Trapping Study and Host Range Results for Spotted Lanternfly (*Lycorma delicatula*).**
Danielle Kirkpatrick (USDA-ARS), Heather Leach, Julie Urban (Penn State Univ.), Rodney Cooper (USDA-ARS), Rafael Valentin, Anne Nielsen, Julie Lockwood, Dina Fonseca, (Rutgers Univ.), and Tracy Leskey (USDA-ARS).

1:45 – 2:00 **Filling in the Knowledge Gaps: Update on Studies of Spotted Lanternfly Feeding and Reproductive Biology.**
Julie Urban (Penn State University).

2:00 - 2:15 **Spotted Lanternfly Damage and Phenology in PA Vineyards.**
Heather Leach, Michela Centinari, David Biddinger, and Julie Urban (Penn State University).

2:15 - 2:30 **Residual Control of Spotted Lanternfly Nymphs and Adults with Various Insecticides**,
David Biddinger (Penn State Univ. Fruit Res. & Ext. Ctr., Entomology), Heather Leach, and Julie Urban (Penn State Univ., Entomology).

2:30 - 2:45 **BMSB and SLF - field trials during the 2018 season.**
Greg Krawczyk, Hillary Peterson, Claire Hirt, and Henry Rice (Penn State Univ. Fruit Res. & Ext. Ctr.)

2:45 - 3:00 **Response of adult *Halyomorpha halys* to insecticide-treated netting during its autumn dispersal phase: Results from 2018.**
Chris Bergh, Nicole Quinn, Whitney Hadden, and Jean Engelman (Virginia Tech AHSAREC).

3:00 – 3:15 **BREAK**

3:15 - 3:30 **Prevalence of *Nosema maddoxi* in brown marmorated stink bug (*Halyomorpha halys*) populations in Eastern and Western states in the US.**
Carrie Preston (Cornell University).

3:30 - 3:45 **Big picture, small scale: Why does BMSB population density exhibit site-specific differences?**
Whitney T. Hadden (Virginia Tech AHSAREC), Tracy C. Leskey (USDA-ARS, Kearneysville, WV), and J. Christopher Bergh (Virginia Tech AHSAREC, Winchester, VA).

3:45 - 4:00 **Trapping *Trissolcus japonicus* in Virginia: Habitat and host plant effects.**
Nicole Quinn (Virginia Tech AHSAREC, Winchester, VA), Elijah Talamas (Div. of Plant Industry, FL Dept. of Agric. & Consumer Services, Gainesville, FL), Tracy Leskey (USDA-ARS Appalachian Fruit Res Station, Kearneysville, WV), and Chris Bergh (Virginia Tech AHSAREC, Winchester, VA).

4:00 - 4:15 **Behavioral responses of *Halyomorpha halys* and its egg parasitoid, *Trissolcus japonicus* to host based plant volatiles.**
Clement Akotsen-Mensah and Anne Nielsen (Rutgers University).

4:15 - 4:30 **Parasitoid impact on brown marmorated stink bug under differing management programs: a comparison of egg fates in corn and apple agroecosystems in North Carolina.**
Emily Ogburn and Jim Walgenbach (MHCR&EC, North Carolina State University).

4:30 – 4:45 **Impact of border row applications of insecticides on *Trissolcus japonicus*: an early look at alternative management strategies for integrated pest management.**
Dalton Ludwick (USDA-ARS/Virginia Tech) and Tracy Leskey (USDA-ARS).

Concurrent Sessions Agenda

ENTOMOLOGY

Thursday, November 29 (continued):

4:45 – 5:00 **Foraging Ecology and Predictions of *Trissolcus japonicus* in Fruit Systems.**
Anne L. Nielsen, Anna DiPaola, Clement Akotsen-Mensah, Nicolas Avila (Rutgers University) and Kevin Rice (University of Missouri).

5:00 – 5:15 **Comparing parasitism of brown marmorated stink bug (*Halyomorpha halys* Stål) sentinel egg masses in Pennsylvania fruit orchard landscapes.**
Hillary Peterson (Penn State Univ, University Park, PA), Claire Hirt, and Greg Krawczyk (Penn State University, Biglerville, PA).

Friday, November 30:

9:00 - 9:15 **Can you guess what caused this damage?**
Jim Walgenbach (NC State University) and Bill Mackintosh (Mackintosh Fruit Farm).

9:15 - 9:30 **Protecting Apple Trees from Black Stem Borer, *Xylosandrus germanus*, Using Trunk Injection.**
John Wise and Celeste Wheeler (Michigan State University).

9:30 - 9:45 **Effects of methyl salicylate as a repellent to *Xylosandrus germanus* ambrosia beetle infestations in apple trees.**
Arthur Agnello, David Combs (Cornell University) and Kenneth Lamm (Bowdoin College).

9:45 - 10:00 **Optimizing the sterile insect technique for management of codling moth.**
Larry Gut, Chris Adams, and Rob Curtis (Michigan State University).

10:00 - 10:15 **Colony collapse issues with NJ blueberry pollination.**
Dean Polk, Chelsea Abegg, Cesar Rodriguez-Saona (Rutgers Coop. Ext.), Tim Schuler (NJ Dept. Agric.)

10:15 – 10:30 **BREAK**

10:30 – 10:45 **Tracking *In-Situ* Distribution of Plum Curculio *Contrachelus nenuphar* in Peach and Blueberry Orchards.**
Timothy Lampasona and Anne Nielsen, Rutgers University.

10:45 – 11:00 **Double edge sword: Cultivated blueberries are more susceptible, but less attractive, to spotted wing drosophila than wild blueberries.**
Cesar Rodriguez-Saona (Rutgers University) and Kevin Cloonan (Acadia University).

11:00 – 11:15 **Replacing conventional insecticides with non-nutritive sugars in attracticidal spheres: preliminary studies with spotted wing drosophila and apple maggot fly.**
Laura Nixon and Tracy Leskey (USDA-ARS Appalachian Fruit Research Station).

11:15 - 11:30 **Hummingbird enrichment in berries to encourage predation of spotted wing Drosophila.**
Juliet Carroll (NYS IPM Program, Cornell Univ), Greg Loeb (Entomology, Cornell Univ), Courtney Weber (Horticulture, Cornell Univ), and Laura McDermott (Eastern NY Commercial Hort. Program, Cornell University).

11:30 - 11:45 **Can female vibrational playback increase BMSB trap capture?**
Aya Ibrahim (Univ. of Udine), Gianfranco Anfora (Fondazione Edmund Mach, San Michele all' Adige), Lara Maistrello (Univ. of Modena & Reggio Emilia), and Valerio Mazzoni (Fondazione Edmund Mach, San Michele all' Adige, Italy).

11:45 – 12:00 **Agroecosystem Effects on BMSB Pheromone Trap Capture and Damage in NC Apple Orchards.**
Steve Schoof and Jim Walgenbach (NC State Univ).

12:00 - 12:15 **Optimization of BMSB pheromone doses, ratios, substrates, and traps for monitoring and attract-and-kill.**
Brent Short and Tracy Leskey (USDA-ARS Appalachian Fruit Research Station).

Concurrent Sessions Agenda
HORTICULTURE

Thursday, November 29:

1:15 - 1:30 **Postharvest and Post-Cold Storage Properties of Five New Peach Varieties - Brigantine, Evelynn, Selena, Silverglo and Tiana.**
Hemant Gohil (Rutgers Cooperative Extension, Gloucester County) & Daniel Ward (Rutgers Agricultural Research and Extension Center).

1:30 - 1:45 **Apple Rootstock Trial Results.**
Rob Crassweller and Don Smith (Penn State University).

1:45 – 2:00 **Improving 'Fugachee Fuji' fruit quality with reflective fabrics.**
Chris Clavet and Tom Kon (North Carolina State University).

2:00 – 2:15 **What is the Effect of Preconditioning on Premier Honeycrisp and Honeycrisp Apples Grown in Southern Pennsylvania?**
Chris Walsh, Audra Bissett, Kathy Hunt (Univ of Maryland) and Tara Baugher (Penn State Extension).

2:15 – 2:30 **Effect of This Year's Hot, Wet Harvest Season on Apple Fruit Maturity.**
Chris Walsh, Audra Bissett, Kathy Hunt (Univ of Maryland), Tara Baugher and Norma Young (Penn State Extension).

2:30 - 2:45 **Prohexadione-calcium, Honeycrisp, and Bitter Pit: Selected Results from Three Seasons of Field Research in Eastern New York.**
Daniel Donahue (Cornell Cooperative Extension - ENYCHP).

2:45 - 3:00 **Thinning without carbaryl: Evaluation of multi-step thinning programs in NC and PA.**
Tom Kon (North Carolina State University) and Jim Schupp (Penn State University).

3:00 – 3:15 **BREAK**

3:15 - 3:30 **Evaluating chemicals for apple blossom thinning.**
Sherif Sherif, Chester Allen, and Keith Yoder (Virginia Tech AHSAREC, Winchester, VA).

3:30 - 3:45 **Effect of Single or Split Applications of Prohexadione, With and Without Gibberellin 4+7 on Scarf Skin of Buckeye Gala.**
Jim Schupp, H. Edwin Winzeler, and Melanie Schupp (Penn State Fruit Research and Extension Center).

Concurrent Sessions Agenda

PLANT PATHOLOGY

Thursday, November 29:

1:15 - 1:30 **Characterizing strains of *Erwinia amylovora* across orchards in New York State in 2017 & 2018 using CRISPR elements.**
Anna Wallis, Matthew Siemon, Mei-Wah Choi, and Kerik Cox (Plant Pathology and Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell University, Geneva, NY).

1:30 - 1:45 **The use of prohexadione calcium and a systemic acquired resistance inducer to manage fire blight without antibiotics.**
Anna Wallis (Plant Pathology & Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell Univ, Geneva, NY), Daniel Kaplan (Dept. of Biology, St. John Fisher College, Rochester, NY), Mei-Wah Choi, and Kerik Cox (Plant Pathology & Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell University, Geneva, NY).

1:45 – 2:00 **Effect of flower age and antibiotic treatment on the population dynamics of *Erwinia amylovora* on apple flower stigmas.**
Suzanne Slack, Jeffery Schachterle, Cory Outwater, and George W. Sundin (Michigan State Univ.).

2:00 – 2:15 **Field evaluation of host plant defense inducers for fire blight management and pathogenesis-related protein gene expression in *Malus* x *domestica*.**
Rachel Kreis and Sara Villani (North Carolina State University).

2:15 – 2:30 **Post-Infection Prevention of Fire Blight Cankers with Apogee and Apple Scab Management with Revysol.**
Srđan G. Aćimović, Christopher L. Meredith, and Ricardo D. Santander (Cornell University, Plant Pathology and Plant-Microbe Biology Section, Hudson Valley Research Laboratory, Highland, NY).

2:30 – 2:45 **Characterization of *Colletotrichum* species in KY Orchards and Potential Risks for Cross Infection.**
Nicole Gauthier, Madison McCulloch, and Lisa Vallaincourt (University of Kentucky, Dept. of Plant Pathology).

2:45 – 3:00 **Rotten to the Core: Characterization and fungicide sensitivity of *Colletotrichum* species causing Glomerella leaf spot and fruit rot in NC.**
Kendall Johnson (North Carolina State University), Wayne Jurick (USDA-ARS), Rachel Kreis and Sara Villani (North Carolina State University).

3:00 – 3:15 **BREAK**

3:15 – 3:30 **Bitter rot of apple: What we learned in 2018.**
Phillip Martin, Teresa Krawczyk, Brian Lehman, and Kari Peter (Penn State University).

3:30 – 3:45 **Apple Bagging for Disease and Insect Management: A Low-Input Option for Backyard and Organic Growers.**
Nicole Gauthier (University of Kentucky, Dept. of Plant Pathology).

3:45 – 4:00 **Highlights of 2018 fungicide testing on apples.**
Keith Yoder, Allen Cochran II, William Royston, Jr., Scott Kilmer, and Abby Kowalski (Virginia Tech AREC).

4:00 – 4:15 **Selection for SDHI fungicide resistance: influence of application rate.**
Katrin Ayer, Mei-Wah Choi, and Kerik Cox (Plant Pathology and Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell University, Geneva, NY).

Thursday, November 29 (continued):

4:15 - 4:30 **Timing Fungicide Applications for Improved Control of Apple Powdery Mildew (*Podosphaera leucotricha*).**
David Strickland and Kerik Cox (Plant Pathology and Plant-Microbe Biology Section, School of Integrative Plant Science, Cornell University, Geneva, NY).

4:30 – 4:45 **Using Post Dormant Copper Applications for Fungal Disease Control.**
Brian Lehman and Kari Peter (Penn State University).

4:45 – 5:00 **2018 Pennsylvania Update: RAD, new diseases, promising products.**
Kari Peter (Penn State University)

Friday, November 30:

9:00 – 9:15 **Refinement of Peach Cover Spray Programs for Sustainable Management of Brown Rot.**
Norman Lalancette and Lorna Blaus (Rutgers University).

9:15 – 9:30 **Efficacy of Experimental Fungicides and Biorational Bactericides for Management of Peach Brown Rot and Bacterial Spot.**
Norman Lalancette and Lorna Blaus (Rutgers University).

9:30 – 9:45 **Evaluation of fungicidal products for the control of ripe rot in Maryland vineyards, 2018.**
Scott Cosseboom and Mengjun Hu (University of Maryland).

9:45 – 10:00 **Field trial updates 2018: *Botrytis* gray mold on grapes and bagging trials.**
Mizuho Nita (Virginia Tech University).

10:00 – 10:15 **Effect of high relative humidity on germination of five *Colletotrichum* species isolated from grapes in Virginia.**
Mizuho Nita and Akiko Mangan (Virginia Tech University).

BUSINESS
AND
FINANCIAL REPORTS

BUSINESS MEETING MINUTES

November 30, 2018

Compiled and submitted by Chris Bergh, CSFWC, Inc. Secretary/Treasurer

Mike Dimock (President) called the meeting to order at 8:03 a.m.

Thirty-four members attended the Business Meeting, fulfilling the quorum requirement of 10% (conference attendance = 119)

Minutes of 2017 Business meeting reviewed. Motion to accept by Jim Schupp, seconded by member who was not identified by Secretary. Unanimous approval to accept.

Chris Bergh gave the Treasurer's Report for 2017. Noted record attendance in 2019. Chris Walsh moved to accept, seconded by Dean Polk. Unanimous vote in favor.

Old business: none raised

New business:

Members in attendance discussed the new venue for the 2018 meeting. Dean Polk noted that the venue was good with the exception of excessive noise between the Entomology and Plant Pathology meeting rooms. Mike Dimock noted that this would be resolved for Friday sessions by the hotel staff. The temperature was too high in the rooms at a certain point, but addressed by the hotel staff. Meeting space in hotel considered to be adequate for current size of meeting. Don Ganske indicated that he would explore other options in Winchester in case a new venue was needed going forward (i.e. after 2019). Chris Bergh asked Don if he intended to continue as Executive Director in 2019 and Don replied that he was uncertain about this.

Dates for 2019 meeting discussed. Noted the 2019 dates for Thanksgiving (Nov 28), ESA (Nov 17-20), the NC-140 meeting (Nov 13-14), and the Great Lakes Expo (first week of December). Determined that the only option for CSFWC 2019 were Thursday-Friday, Dec 5-6. Jim Walgenbach moved to schedule the 2019 CSFWC on December 5-6, seconded by Kerik Cox. Unanimous vote in favor.

Mike Dimock raised the issue of nominating the President-Elect. Some members believed that the organization was still on a rotational basis among participating states. Dimock and Bergh reminded the members that when the CSFWC was incorporated, this structure was replaced, for continuity purposes, with the Executive Committee structure, consisting of President, Past President, and President-Elect. There was discussion about the responsibilities of the Executive Committee and of the Executive Director, including handling and posting of the Proceedings. Dean Polk was nominated as President-Elect by Kathleen Leahy and seconded by Chris Walsh.

There was discussion about whether the current membership/registration fee structure and late registration fees were appropriate; general consensus was that they are. Greg Krawczyk raised the possibility that CSFWC, Inc. could provide a reduced registration/membership fee for graduate students and noted that this is common for other conference organizations. It was concluded that this did not need to be implemented for 2019 but that online registration should include a check box to indicate graduate students, to capture this data for determination of financial feasibility.

Dean Polk motioned to return to the same venue in 2019, seconded by Daniel Frank. Unanimous vote in favor.

Chris Walsh asked whether Mizuho could reach out to small fruit researchers to try and encourage more participation in the meeting, noting that lack of representation of small fruit research (especially grapes) was likely due to general lack of relevant meeting content. Chris Walsh noted that this was especially true for the Horticulture session. There was a suggestion that this could be announced at the Hershey meeting.

Art Agnello recognized industry sponsorship of the mixer and Don Ganske for his role as Executive Director. Bergh recognized Mike Dimock and the Executive Committee for an excellent meeting.

Art Agnello motioned to adjourn the meeting, seconded by Chris Walsh and Mike Dimock adjourned the meeting at 8:45 a.m.

Cumberland-Shenandoah Fruit Workers Conference, Inc. Treasurer's Report for 2017
Respectfully submitted on November 30, 2018 by Chris Bergh, Secretary/Treasurer

INCOME		
Registration/memberships (104)		7,180.00
Sponsorships		2,450.00
Interest		NA*
	Total income	**9,630.00**
MEETING EXPENSES		
Facility meeting rooms		844.42
Lunch, coffee, soda		1,908.80
Mixer		2,459.75
Gratuities		795.00
Advance deposit (2016)		150.00
	Total meeting expenses	**6,157.97**
OTHER EXPENSES		
Deposit for 2018 meeting		
Attorney (Owen and Truban, PLC)		1,000.00
Accountant (Rutherford and Johnson, P.C.)		450.00
VA State Corporation Commission		785.00
PayPal		60.00
BB&T		196.49
	Total other expenses	298.71
		2,790.20
SUMMARY		
Income		9,630.00
Meeting expenses		-6,157.97
Other expenses		-2,790.20
	Balance forward	**681.83**
BB&T account balance (Dec. 31, 2017)		17,158.00
PayPal account balance (Dec. 31, 2017)		283.23
	Total balance forward	**18,123.06**

CSFWC, INC. 2017 MEETING BREAKDOWN
(6,157.97/104 attendees)

Facility	844.42	8.12/attendee
Food and non-adult beverages	1,908.80	18.35/attendee
Adult beverages plus all gratuities	3,254.75	31.29/attendee
Total cost/attendee		59.21/attendee
Income		69.04/attendee

*Non-interest bearing account

CALL OF THE STATES

CALL OF THE STATES – MARYLAND 2018

Bob Rouse
Bob Rouse Agriculturalist, L.L.C.

The late winter and early spring weather made strawberry plasticulture production harvest 7 to 14 days late. So when harvest began in mid-May the rains came and made it a very trying season. In short it was a good advertisement for rain tunnels. The 2018 season was wet with 12 to 30 inches above normal rainfall for the year.

Bitter rot which had not been much of a problem in apples in the past was a major issue.

Fall planting of plasticulture strawberries was delayed due to nursery issues and wet fields. So 2019 may not be that great either.

CALL OF THE STATES – NEW JERSEY 2018

David Schmitt, Program Associate; Atanas Atanassov, Program Associate;
Carrie Mansue Denson, Program Associate; Dean Polk, Statewide Agent;
Norm Lalancette, Specialist in Fruit Pathology; Anne Nielsen, Specialist in Fruit Entomology
Rutgers Agricultural Research and Education Center, Bridgeton, NJ 08302

Tree Fruit **-** Tree phenology in 2018 was about a week to 10 days later than normal based on historical observations. Cropping was good in stone fruit despite spring frost events. Fruit quality was affected from freeze events as higher than normal levels of shattered pits were observed throughout harvest. Cropping in pome fruit was lighter than normal probably due to a heavy crop load and poor thinning in 2017. According to the New Jersey State Climatologist (http://climate.rutgers.edu/stateclim), average monthly temperatures were above average for much of the growing season with 4 months: February, May, August and September among the 5 warmest months on record. Overall total precipitation in 2018 was the highest on record dating back to 1895 with May, July, August and September well above average. Precipitation in the months of February and November were among the 5 highest months on record.

Disease control in the field was generally poor. In apples, scab and fruit rots remain troublesome. In 2018 white rot levels were the highest in recent memory with some crop loss above 50% despite frequent fungicide applications. Anthracnose (Bitter Rot) remains difficult to control on some farms. Fire blight was troublesome on some farms in southern counties, however no widespread epidemics were noted. In peach, rot control was challenging. Following a 5 day period in early July with temperatures above 95, "cooked" flesh in stone fruit was observed in ripening fruit and higher than normal rot levels were observed starting midseason due to frequent rains during the harvest period. Streaking on highly colored white peaches and nectarines was particularly troublesome. Bacterial spot control was generally good. Observations made by Dr. Norm Lalancette's team at RAREC indicated that environmental conditions were very favorable for Peach Scab and Brown Rot on fruit. Conditions were not favorable for Brown Rot Blossom Blight probably due to generally cool temperatures during bloom. In apples environmental conditions were favorable for Apple Scab, and summer rots. Conditions were not highly favorable for Sooty Blotch or Flyspeck.

Brown Marmorated Stink Bug populations and damage increased this year compared to the past few seasons. Dr. Anne Neilsen's lab recovered T. japonicas from egg masses in several sites statewide. Codling Moth damage in apples continues to be a challenge but did not significantly increase over last year. CM trap captures continue to increase in numbers and duration across the region regardless of management practices. Field observations indicate significant overlapping of generations during the growing season challenging the current degree day model growers rely on to time insecticide applications. Observations of Ambrosia Beetle damage increased slightly in 2018. Tree loss continues at known infestation sites and significant damage to peach orchards were observed for the first time. This season, active attacks in apples were noted as late as early November. Incidence of San Jose Scale infestations in tree fruit were significantly higher than past seasons. Spotted Lantern Fly was observed for the first time in New Jersey at a homeowner site in the northern part of the state. It was also observed at 2 commercial vineyards, and 1 tree fruit farm.

Grapes - Grape Phenology was about normal in 2018. Disease control was generally good despite frequent late summer rains. Downy Mildew was present in most vineyards, but growers were generally able to suppress it with frequent fungicide applications and good cultural management. Grape Berry moth first generation hatch was observed about a week earlier than the first insecticide application prediction by the MSU model. Growers were alerted and in those vineyards scouted by the Rutgers Fruit IPM Program control was better than in previous years with earlier insecticide applications. Harvest was delayed and fruit quality generally poor due to a very wet August and September. Bird control remains difficult for most growers to manage.

Blueberry – The 2018 New Jersey Blueberry season experienced a slight issue with Anthracnose this year due to weather conditions. The start of the season was a wet one, with May rainfall during bloom well above the 30 year average. Anthracnose observations in the field were higher than normal, as were levels reflected in incubated berries. Loss of fungicide coverage due to weather or field conditions was likely a contributing factor. Even though growers had some disease problems, prices held for most growers throughout the season.

Blueberry maggot (BBM) was first detected the week of June 23rd in an organic field and was later detected in a commercial field the week of July 6th. Spotted Wing Drosophila (SWD) was first detected in Atlantic County on June 13th. This year we incorporated a new red sticky trap in place of cup traps. While sticky boards caught slightly less than cup traps, the reduction in required labor allows for additional trap placement and encourages growers to self-monitor. Our survey included 136 BBM and 67 SWD traps to monitor populations in Atlantic and Burlington Counties. Early detection of these pests allowed for growers to use appropriate management tactics to keep pest populations under control through the season.

Scale crawler traps, 3 in Burlington and 7 in Atlantic County found second generation Putnam scale crawlers in mid-August, resulting in grower treatments shortly thereafter. Sharpnosed leafhopper populations were very low for both generations, but higher in Atlantic County. Weed management in blueberries is still a concern with growers, often with problems in goose grass and nutsedge control, and control ‘running out’ by mid to late August. Lastly, while taking soil fertility samples we detected oriental beetle grubs as a common occurrence. Therefore we are doing an industry wide grub survey, and continue to find beetle larvae in numerous fields.

Tree Fruit Phenology – Southern New Jersey Counties 2018

Pest Event or Growth Stage	**Approximate**	**2018 Observed Date**
1/4" Green Tip Red Delicious	March 31 +/- 13	April 2
Pink Peach (Redhaven)	April 4 +/- 15	April 10
Tight Cluster Red Delicious	April 9 +/- 13	April 16
Full Bloom Peach (Redhaven)	April 9 +/- 14	April 20
Pink Apple (Red Delicious)	April 14 +/- 12	April 30
Full Bloom Apple (Red	April 22 +/- 11	May 3
Petal Fall (Redhaven)	April 22 +/- 10	May 1
Shuck Split (Redhaven)	April 27 +/- 14	May 7
Petal Fall (Red Delicious)	April 30+/- 11	May 7
Pit Hardening – Peach	June 16 +/- 8	June 12

CALL OF THE STATES – NEW YORK 2018

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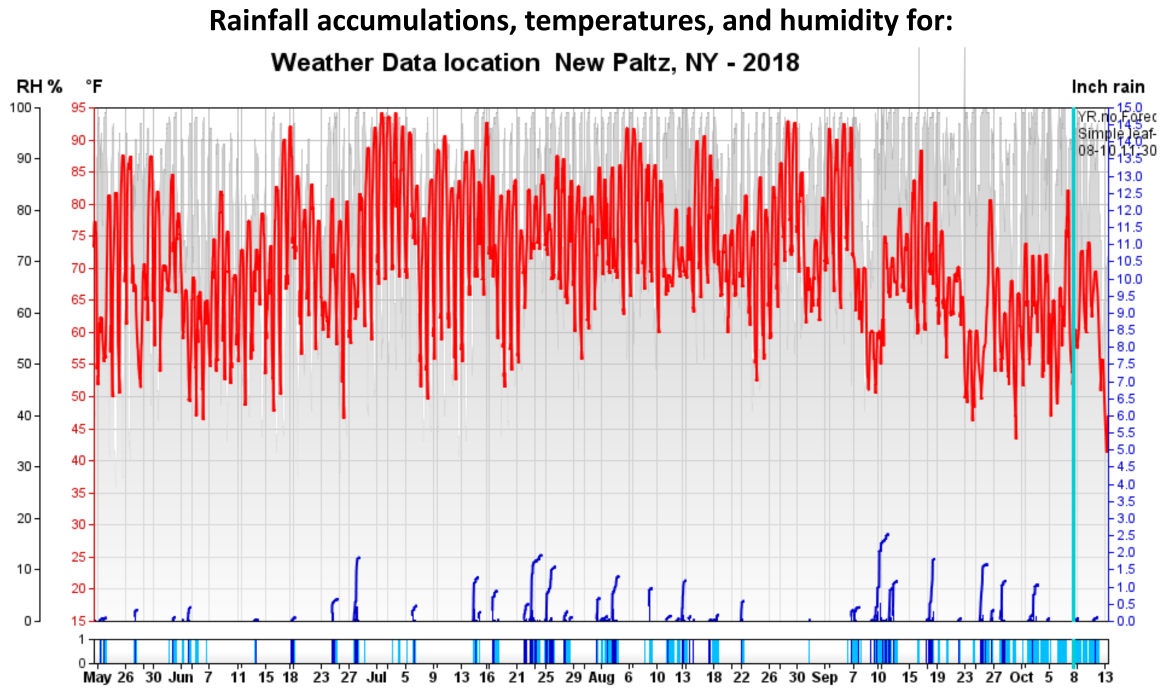
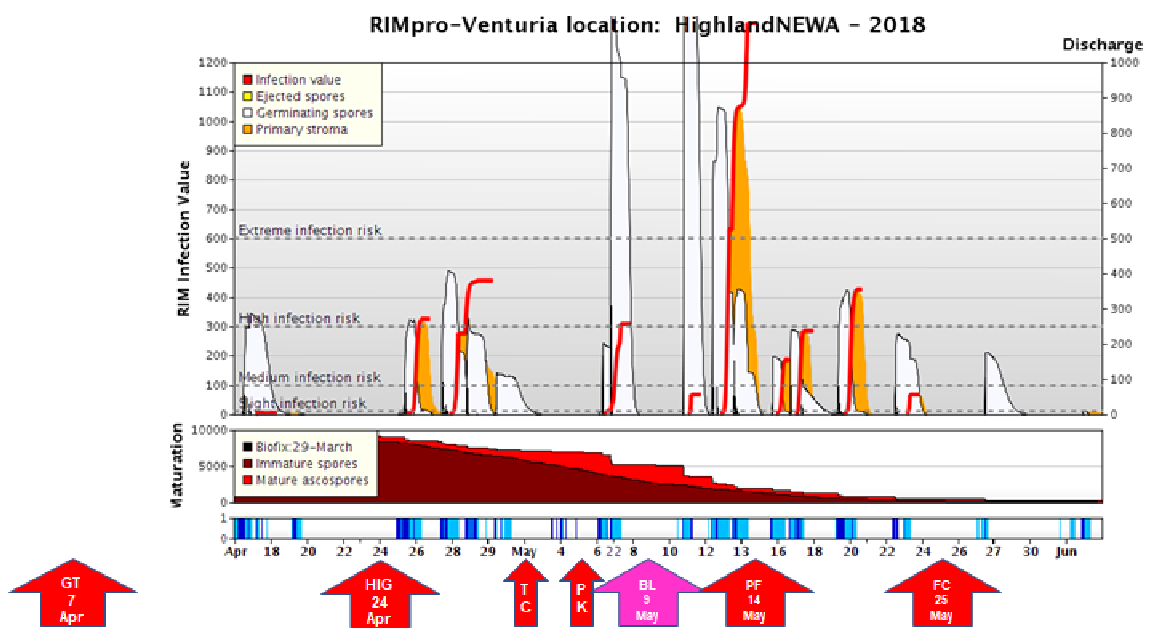
This was another one of those dual-personality growing seasons that New York does so well, and which never fail to irritate those of us who continue to expect the weather to deliver something gradual, normal, not extreme, unremarkable, etc., even though it rarely does so. To start out, the spring took a very long time in arriving, making even the people who are most averse to early warmups show signs of boredom waiting for the trees to start moving. Most of the state reported the latest green tip date on record; it wasn't seen in Geneva until April 30, at which time the degree day accumulations were barely half of the long-term average values. Not until the first week of May did the cold and rainy pattern break somewhat to start pushing moths into the air, and by mid-month there were enough erratic temperature jumps to induce bloom in most tree fruit plantings around the state. June continued the trend of normal- to above-normal temperatures, with sporadic showers failing to prevent a distinct drying out phase, so that most of the state was in moderate drought conditions by the end of the month. Periods of high temperatures and low rainfall persisted through most of July, until finally succumbing to the late-summer pattern of pop-up thunderstorms and muggy heat that continued through September.

The upside of our schizophrenic season was that there was very little in the way of actual drama in either crop or pest development. **Plum curculio** seemed to be addressed adequately and in short order by most growers; outbreaks of European red mite appeared to threaten briefly but then did not amount to much. **Obliquebanded leafroller** was again present as usual, but didn't pose many serious problems in most areas. **Oriental fruit moth** and **codling moth**, the traditional drivers of many insect management programs, occurred generally on schedule and in respectable numbers, continuing to fly at normal and even above-normal levels for the remainder of the season. Trap numbers were impressive through the end of August. First occurrence of **apple maggot** was similarly at a typical timing, thanks to adequate moisture to allow adult emergence from the soil, and they continued to be caught at moderate levels into September. Populations of scale pests, including both **San Jose** and **Prunicola scale**, were noted in several areas of the state, and **woolly apple aphid** infestations lived up to their potential of becoming problematic in some mid-late season varieties, both in western NY as well as in the Hudson Valley.

This seems to have been another notable season for **Japanese beetle**, but 2017's unrelenting assault of **spotted wing drosophila** on tart cherries did not recur this year. Also this season, **brown marmorated stink bug** was unaccountably difficult to find until the middle of September, when numbers shot up in the Hudson Valley sites where it's been a frequent challenge, and continued to cause damaged fruit into the October harvest period. Finally, the perennial **black stem borer** ambrosia beetle, a primary or at least secondary cause of tree decline and death in numerous plantings around the state, continues to be found, and this year exhibited a rare high second brood flight. We are still unable to propose a definitive solution for this pest, and the stress caused by abnormal climatic conditions, as well as other elusive factors, continues to make the case for our attention to how easily these trees can become targets for attack.

Disease Status in Hudson Valley of New York - Hudson Valley Research Laboratory

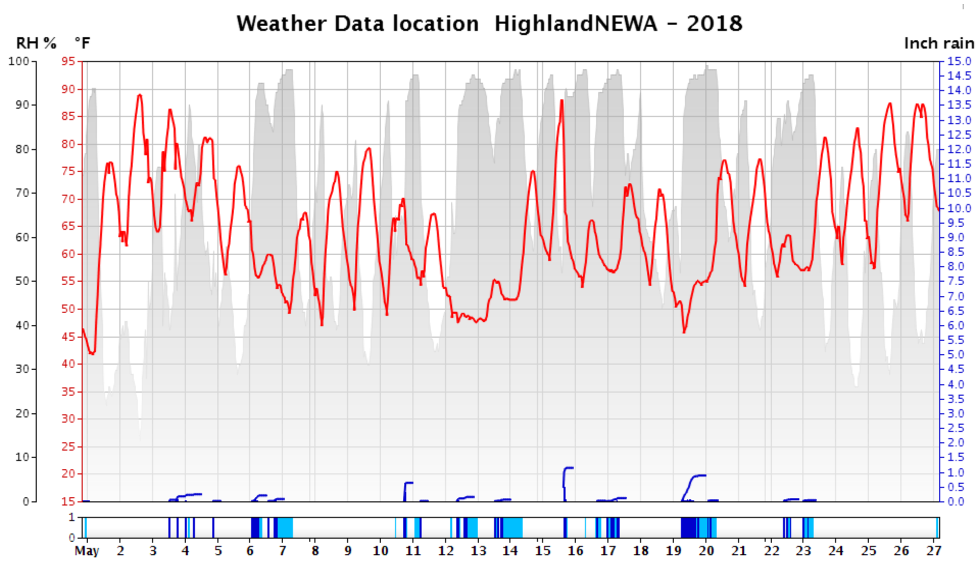


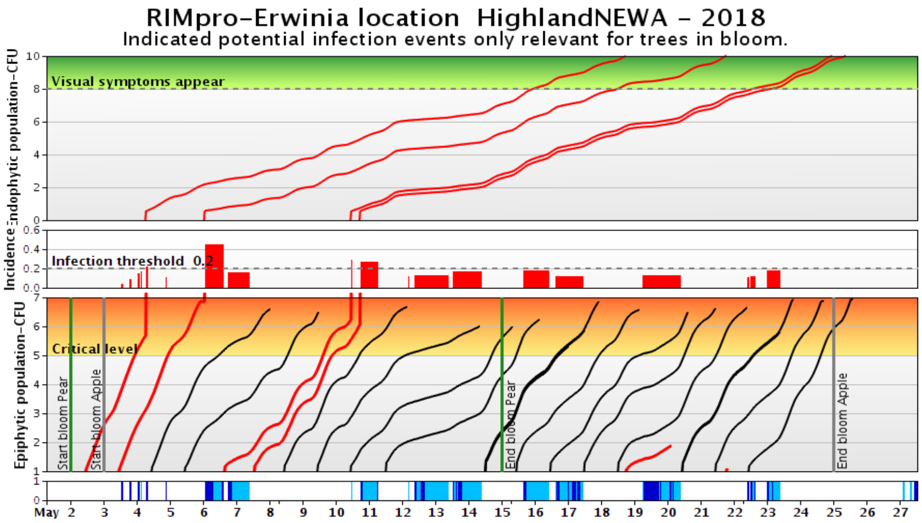


Apple scab had 8 major infection periods based on RIMpro prediction model (image above). Before the first major infection on the 25 April at HIG, one ascospore germination period did not lead to significant infection warranting protection since conditions after rainfall were too cold. Using the scab tower, we found mature ascospores in leaf litter on 31 March in Highland, on 5 April in Rexford, and on 13 April in Peru, NY. From 17 Apr to 21-29 May almost all ascoposres were discharged from pseudothecia according to RIMpro. In Highland we found the first scab symptoms on 11 May on Cortland leaves. This infection were probably initiated on the first major scab infection period of 25 April. First scab symptoms were visible on 7 June in Peru.

Cedar apple rust and quince rust symptoms in Highland NY started showing on apple leaves from May 17 onward. Infection periods for rust were prolonged since there was a lot of rain. Some growers, but especially organic growers, complained to us that rust was an issue in apples in 2018.

Fire blight conditions in Hudson Valley were very favorable. Several streptomycin applications were needed in orchards with fire blight history. Warm and rainy conditions during bloom favored growth of fire blight populations on flowers. In our inoculated trees, we found first fire blight ooze on 27 May on 'Honeycrisp' flowers and first blossom blight symptoms on the 31 May (we rated first blossom blight on 4 June). There were 3-4 major infection periods for fire blight in the Hudson Valley. RIMpro reported infection periods on 4, 6 and 10 May 2018. More southern locations had more than 3 infection periods, while more northern locations 1-2 infection periods.





SBFS - Sooty Blotch & Flyspeck in Hudson Valley were first found on 6 Aug 2018 on 'McIntosh', 'Ginger Gold' and 'Goldern Delicious' fruit. With ample rain we had in 2018, the incubation period requirement of accumulated 190 hr of wetting from PF was fulfilled and/or exceeded on 25 July.

Bitter Rot again was a big problem in the orchards across southern NY State that have not applied fungicide cover sprays on a shorter time interval than usual. We found first natural symptoms of bitter rot on Gala in Milton NY on 14 July. Frequent rains favored this disease. This was a year where all, early and late maturing varieties, required a good fungicide coverage for efficient control and where fungicide deposits on fruit had to be maintained after 2" rainfall.

Marssonina Leaf Spot on apple. Again, as in 2017, **i**n more than several locations in lower Hudson Valley and in south NY typical symptoms of this disease were observed on Rome, Mutsu, Winesap, Northern Spy, Gala and several other cultivars. However, Rome trees were severely affected and defoliation of leaves was noticed when fungicide cover sprays for summer rots and SB&FS were not as frequent as we recommended.

CALL OF THE STATES – PENNSYLVANIA 2018

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Plant Pathology

The 2018 season was later to start than the last two previous years: green tip was in early April and bloom started on May 1. This was an exceptionally rainy year: from March through September, 45.8 inches of rain fell; over 72 inches for the entire year. The average rainfall in Adams County, PA is 42 inches. The warm, very rainy season caused many disease issues for all parts of the tree. Some highlights of the 2018 season include:

Apple and pear diseases: Ideal fire blight weather coincided with bloom during early May and stuck around for the remainder of the season. This was the case for all of Pennsylvania. Fire blight incidence was widespread throughout apple growing regions. An extreme hail event occurred on 10 May in a part of Adams County (PSU FREC was affected), causing catastrophic damage for several growers in some very fire blight susceptible apple blocks. Apple scab was very problematic due to persistent rain events occurring when the apple scab ascospores were peaking in numbers and dispersal. The persistent disease conditions throughout the summer made it more difficult to control apple scab if had become established early in the season. Bitter rot was the most problematic fruit rot. Symptoms were observed on fruitlets as early as late June; Honeycrisp was the most severely impacted cultivar. Bitter rot incidence in some commercial orchards was so high, growers abandoned the crop in some apple blocks. Marssonina leaf blotch caught many growers by surprise this season during September and October. There were reports concerning premature defoliation for some cultivars, particularly Rome. Marssonina leaf blotch was observed for the first time in PA in September 2017. The frequent rain events during September most likely washed off all fungicides leading growers to be vulnerable to issues. Several incidences of Phytophthora root rot were reported, particularly in orchard sites with high clay soils and/or poor drainage. A new apple disease for Pennsylvania was identified in August: Southern blight caused by *Sclerotium delphinii*. To date, five apple orchards located in Adams County, PA have been positively identified for the disease. All rootstocks and tree ages seem to be susceptible to the root rot disease. Incidence within an apple block varied: from one to 50 trees were observed to be affected in an apple block. The fungus favors warm, at capacity soils to cause disease. This was the year for warm, at capacity soils.

Stone fruit diseases: The two biggest issues affecting stone fruit were cherry leaf spot on sour cherries and brown rot on peaches and nectarines. Like apple scab, conditions were extremely favorable for cherry leaf spot. Disease pressure was so severe, defoliation was observed as early as late June in some cherry blocks. Brown rot was an issue on peach and nectarine varieties harvested in August and September due to the frequent rainfall events.

Entomology

Despite warmer than usual weather in March, the biofixes for most common insect pests occurred at dates similar or later than during previous years. The biofix for oriental fruit moth was established on April 18, codling moth on May 12, obliquebanded leafroller on May 30 and tufted apple budmoth on May 17.

Throughout the season, the internal fruit feeders, codling moth and Oriental fruit moth populations were at rather low levels and consequently only about 65 fruit loads with the CM/OFM (split of 40:60) were rejected by PA fruit processors. Frequent rain events during the season created some issues with the insect pest management, as no pesticide can retain active residue after more than 2 inches of rainfall.

The brown marmorated stink bug populations survived winter in good shape however the number of adults in the spring were lower than during past seasons, mainly due to lower BMSB population going to diapause during the fall of 2017. During the fall, not too many PA fruit growers reported injuries on apple cultivars due to the feeding by BMSB adults.

Spotted lanternfly *Lycorma delicatula* (Hemiptera: Fulgoridae) an invasive plant hopper, native to China, India and Vietnam is reported from 13 counties located in SE corner of PA. To reduce the spread and possible eradicate the pest, the PDA imposed quarantine in areas affected by SLF, however the insect appears to continuously it territory from the original area where it was first identified during the late 2014 season. The list of potential host plants is quite extensive and includes grapes, apples and stone fruit trees. At least at this moment, SLF does not appear to represent direct challenge to production of stone and pome fruit. This provisional assessment could change completely, if SLF will be documented to play any role as a vector to any fruit diseases. But as of now, there is no data supporting involvement of this insect in spreading fruit diseases, except for sooty mold developing on the honeydew excreted by SLF nymphs and adults.

CALL OF THE STATES – VIRGINIA 2018

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Horticulture:

We had a decent crop of peaches and sweet cherries this year as a result of not having any severe frost events during the bloom period. However, as reported from GA to PA, a large percentage of peach fruit stopped growing after shuck split, but didn't drop. It is not clear whether this was related to the lack of sun or poor pollination. We can't speak for all areas, but during bloom in VA, most growers experienced temps in the mid-20's with no frost. If frost had formed at those temps, the bloom would have been killed immediately, but since orchards were exposed to freeze instead of frost the injury showed up as a delayed response.

As for the apple crop, some weather-related factors affected the yield to some extent, and fruit quality and size more considerably. Temperatures stayed below 60o F several days during bloom which had a negative impact on bee activity and initial fruit set. This was followed by several days of cloudy, cold and rainy weather during the third and fourth weeks after bloom, which led to natural fruit abscission in many apple varieties. This also caused poor photosynthesis during the early stage of apple development, which negatively affected cell division and consequently fruit size at harvest, especially for Gala. It has been reported that the 2018 conditions resulted in higher quality Honeycrisp apples than usual in VA.
Unusually heavy and frequent rainfall (35" from May-October) encouraged vigorous tree growth and delayed terminal bud set in many scion varieties, which in turn affected fruit coloration, especially in late varieties like Pink Lady and late Fuji. However, such vigorous growth is anticipated to enhance the tree carbohydrate reserve for the next growing season, which may enhance fruit set and fruit size but may have negative impacts on fruit thinning efficiency. Virginia growers are using the carbohydrate thinning model for fruit thinning and crop load management, and the model accurately predicted carbohydrate deficits and natural abscission events in 2018. We tested a version of the pollen tube growth model for blossom thinning on the NEWA website and are generally satisfied with the results of this model, which will be available for the public in 2019.

Pathology:

We have had very little scab in Virginia the past two years, although it seemed that weather was favorable with a lot of rain from mid-May on and all the scab infection periods needed for heavy disease pressure. In commercial situations, we are inclined to credit our in-season fungicide programs, but perhaps benefitted from regular fall nitrogen and early spring copper applications. In our Winchester test plots, cedar apple rust was very heavy on untreated trees and may have had some inhibitory effect on scab development.

Sooty blotch and flyspeck (SBFS) and bitter rot were found in central VA and the Winchester area much earlier than normal. Pre-bloom, bloom and early cover spray fungicide selection made a difference in post-bloom and late-season fruit rot damage, especially from bitter rot. We had about 40” of rain from mid-May through September. There was general agreement that straight protectant programs did not perform well on rots/SBFS, but combination programs at close intervals generally worked well.

Brooks fruit spot was quite common on unprotected fruit this year. It infects fruit about a month after petal fall and, if present in a commercial orchard, would indicate a gap in fungicide coverage around second cover, a month after petal fall.

Due to frequent rain events, many grape growers suffered either downy mildew and/or phytotoxicity from the misuse of phosphite materials. Low light conditions resulted in poor fruit set as well as lack of maturity in many cultivars. Many also had late-season rots such as Botrytis gray mold and ripe rot (equivalent of bitter rot on apples).

Entomology:

The late spring resulted in the latest oriental fruit moth (OFM) biofix since 2000 (April 22), although the codling moth (CM) biofix was within historical norms (May 3). For the first time since 2000, tufted apple budmoth captures were so low that biofix could not be established for it. There were reports of higher CM captures in VA and WV orchards than have been seen in many years. Redbanded leafroller (RBLR) populations were higher than have been seen in recent years; cover sprays for CM and OFM managed other leafroller pests, but not RBLR.

In orchards that had experienced significant western flower thrips injury over several previous years, pressure and injury from this pest was much lower in 2018. We are uncertain as to whether this was weather-related and/or to reduced shoot growth because of prohexadione-calcium applications that were 3 to 4 weeks earlier than normal.

Brown marmorated stink bug captures in pheromone traps were low until late August and showed general reductions overall in the area around Frederick County, although remain substantially higher in other parts of the state, particularly in southwest VA. Detections of Trissolcus japonicus were frequent in Frederick County, but not elsewhere in VA
In central VA, there were reports of unusual injury to apples that appeared similar to that from apple curculio, but the specific cause was not confirmed.

The second spotted lanternfly (SLF) infestation in the USA was detected in northern Winchester in January, 2018, and had likely had been established for at least one year. Initial indications were of a population that was confined to a 1.5-mile x 1.5-mile area. The Virginia Department of Consumer Services (VDACS), VA Cooperative Extension, and Virginia Tech faculty responded with a monitoring/scouting program through summer 2018, including a census of Tree of Heaven (TOH) in the infestation zone. VDACS and USDA initiated a containment program in the fall within a 2 x 2-mile area that involved TOH trunk injections of dinotefuran. In November, there were reports of adult SLF sightings in a number of other locations in and around Winchester, resulting in an expansion of the zone of infestation to 6 x 3 miles. SLF has not been detected in agricultural fields to date, but some detections have been near fruit orchards.

ENTOMOLOGY

Not for Citation or Publication
Without Consent of the Author

EFFECTS OF METHYL SALICYLATE AS A REPELLENT TO *XYLOSANDRUS GERMANUS* AMBROSIA BEETLE INFESTATIONS IN APPLE TREES

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Preventive Trials for Control of Ambrosia Beetles in NY Apple Orchards

The ambrosia beetle *Xylosandrus germanus* has been documented to cause tree death and decline in dozens of NY apple orchards since 2013, mostly in young dwarf apple plantings. Preventive trunk sprays using chlorpyrifos or pyrethroids have not provided acceptable levels of control, nor have topical applications of the repellent verbenone, a component of anti-aggregation pheromone produced by various species of bark beetles that has been found to repel this and related species of scolytines from traps and attractive host trees.

Methods

In 2018, we tested trunk applications of different repellents for *X. germanus* control in potted apple trees (2-yr old 'HH1503' on G.935 rootstock), waterlogged to stress them to produce ethanol, and placed inside wooded areas directly adjacent to orchard sites. Additionally, individual ethanol lures were attached to each tree to increase their attractiveness to the beetles. The preventive treatments included different topical formulations and rates of methyl salicylate (a host defense and signalling compound), alone and combined with verbenone; these were in SPLAT formulations (ISCA Tech), and applied using a caulking gun; Additional treatments were the Systemic Acquired Resistance (SAR) activator Actigard (acibenzolar-S-methyl, Syngenta) and the grower standard insecticide Lorsban (chlorpyrifos, Dow AgroScience). The last two treatments were applied using a Solo AccuPower 416 battery-powered backpack sprayer with a TeeJet 8004 LP flat fan nozzle. Each treatment was replicated on 6 trees, which were arranged in 6-tree groupings at each of the sites, with groups of trees separated by a distance of 10 m (one group per treatment per site). Trunk and tree damage was assessed among the different treatments on 10 Jul, after the end of the first adult flight, and on 23 August, as the second flight was subsiding, to determine what effect these treatments had in preventing attacks by this beetle. On each date, half the trees in each treatment group were uprooted and brought to the lab, where they were dissected to count and characterize the infestation levels.

Results

- Infestation holes: On the 23 Aug evaluation date, all the repellent treatments had fewer infestation sites (holes) than the Untreated (flooded) checks. There was a similar trend on the earlier evaluation date, but not at statistically significant levels. On 10 Jul, Actigard had fewer holes than the Lorsban treatment. The untreated drought-stressed check had the lowest incidence, likely due to insufficient attractiveness of these trees to the beetles.

- Gallery contents, adults: The fewest number of galleries containing adults was seen in the Actigard and all repellent treatments, especially on the 23 Aug evaluation date.

- Gallery contents, brood: No brood was present in galleries on 10 Jul. On 23 Aug, lower numbers were seen in all treatments than in the Check except Lorsban, with zero in all treatments containing methyl salicylate.

- Empty or aborted galleries: The fewest numbers were found in the combination verbenone + methyl salicylate treatments, particularly at the higher rates.

In general, all the repellent treatments had fewer infestation sites (holes) than the Untreated Checks. The combined verbenone+methyl salicylate treatments had the lowest incidences of galleries containing adults or brood; effects were more pronounced according to rate. The combination formulation was more effective than either verbenone or methyl salicylate alone. SAR inducers like Actigard prime the host for stress events by inducing the expression of host defense genes; in apples, these have been used primarily for fire blight control. Only a single application of Actigard was used in these trials, but some trends were still apparent, which suggests the possibility of increased efficacy with multiple applications. We were apparently not able to generate enough stress to attract beetles in simulating drought stress in the trees by sealing off the root zone to exclude all external moisture (Table 1).

Long-Lasting Insecticide Netting as a Preventive Against Ambrosia Beetle Attacks

Recent efforts to prevent *X. germanus* attacks on trees have included proposals to wrap the trunks with a polyethylene long-lasting insecticide netting (LLIN) impregnated with an insecticide (deltamethrin) commonly used as an insect deterrent for livestock and human habitations (D-Terrence, Vestergaard, Lausanne, Switzerland). We conducted a trial to evaluate this tactic using bolts of apple wood soaked in ethanol and placed in wooded sites.

<u>Methods</u>

Bolts (approx. 30 cm x 3 cm) of apple branches were soaked in 95% ethanol for 2–3 weeks, and were deployed starting 25 May in mixed hardwood forests at two sites (Arnot Forest, Van Etten, NY; and Mt. Pleasant, Freeville, NY) with known *X. germanus* populations, to attract the adults and assess their ability to attack and bore into the wood when bolts were wrapped with insecticide-impregnated netting and secured using cable ties. The bolts were hung at a 1-m height from a garden-type shepherd's hook hanger; each netting-wrapped bolt was paired with an unwrapped bolt, placed approximately 1 m away, as a comparison. Treatment pairs were replicated 5 times at each site, separated by approximately 20 m, and were retrieved and replaced on a weekly basis for 7 weeks. Bolts retrieved from the field were returned to the lab and inspected for the presence of attack sites (holes).

Results

Bolts wrapped with deltamethrin netting uniformly had significantly fewer BSB infestations than did the plain bolts (Figs. 8–9). Population pressure was higher at the Arnot Forest site than at Mt. Pleasant, and peak numbers were seen during the first week (ending 1 Jun) at both sites. Virtually no beetles were active during the second week because of a cold snap. Bolts wrapped with LLIN sustained only 0.3–14.3% of the attacks of the unwrapped bolts at Arnot Forest, and 0.0–17.3% at Mt. Pleasant; nearly all of the holes found in the wrapped bolts were at the cut ends of the bolts, which were not protected by the netting. Because of the impracticality of wrapping individual tree trunks with netting (up to the 2-m height at which infestations can often be found), this study should be regarded primarily as a test of the principle of using a physical-chemical barrier as opposed to an argument proposing it as an industry practice, until such time as some more pragmatic way is identified to incorporate this as a management tactic.

Acknowledgements

We wish to thank the following growers for allowing us to conduct these trials on their farms: T. Furber; J. D. Fowler; J. Teeple; W. Hermenet; Scott Palmer; K. Simpelaar; T. C. Chao; R. Lamont; C. Pettit; C. Plummer; M. Zingler; M. Forrence; S. Forrence; G. Bowman; D. Wilson; B. Sullivan; W. Gunnison; J. Toohill; B. Fix; D. Minard, R. Minard. We wish to thank Wafler Nursery for providing the trees and facilities for potting them; Michael Griggs, USDA-Ithaca, for providing technical supplies and support for conducting the research.
This work was supported by the donation of products for testing from ISCA Technologies (Jesse Saroli, Agenor Mafra-Neto), Dow AgroSciences (Alejandro Calixto), Chris Werle (USDA-Poplarville, MS), and funds from the USDA Hatch Program and the NY Apple Research & Development Program.

Table 1. Ambrosia beetle infestations in two-year old potted flooded apple trees treated with a single preventive trunk application of different repellents, Wayne Co. 2018

		Mean #		Mean # galleries with				
		Infestation Sites		Empty Galleries		Adults		Brood
Treatment[a]	Rate	10 Jul	23 Aug	10 Jul	23 Aug	10 Jul	23 Aug	23 Aug
Lorsban	1.5 qt/100 gal	6.3 a	9.2 a	2.8 a	4.0 a	3.6 a	4.1 ab	2.0 ab
Verbenone	10 g/tree	3.7 ab	2.9 b	2.8 a	1.0 bcd	0.9 b	1.6 bc	0.3 bc
MeSa	10 g/tree	2.0 bc	2.7 b	1.2 ab	2.1 abcd	0.8 b	0.8 c	0.0 c
Actigard	0.7 oz/100 gal	1.6 bc	4.7 ab	1.0 ab	3.1 ab	0.6 b	1.2 bc	0.3 bc
Verb+MeSa	1 g/tree	0.8 bc	1.9 b	0.2 b	1.6 bcd	0.6 b	0.3 c	0.0 c
Verb+MeSa	10 g/tree	1.6 bc	1.0 b	1.1 ab	0.9 bcd	0.4 b	0.1 c	0.0 c
Verb+MeSa	35 g/tree	0.0 c	1.3 b	0.0 b	0.7 cd	0.0 b	0.7 c	0.0 c
Control (flooded)	—	3.1 abc	9.8 a	2.6 a	2.8 abc	0.6 b	5.4 a	3.4 a
Control (drought)	—	0.4 bc	0.3 b	0.0 b	0.1 d	0.4 b	0.1 c	0.0 c

Values in a column followed by the same letter not significantly different ($P < 0.05$, Student's t-test.) Data pooled across three replicated orchard sites.
[a] Lorsban, chlorpyrifos; MeSa, methyl salicylate; Verb, verbenone; Actigard, acibenzolar-S-methyl

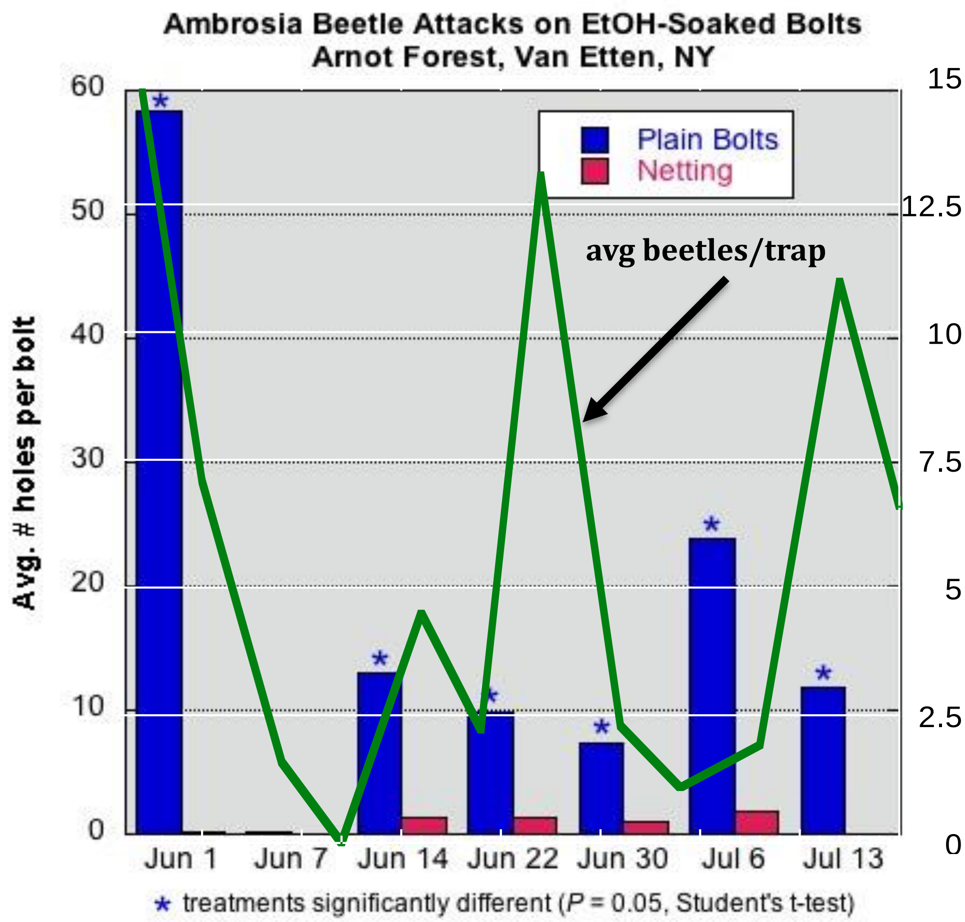

Fig. 1. BSB attacks on bolts wrapped with insecticide-impregnated netting, Arnot Forest.

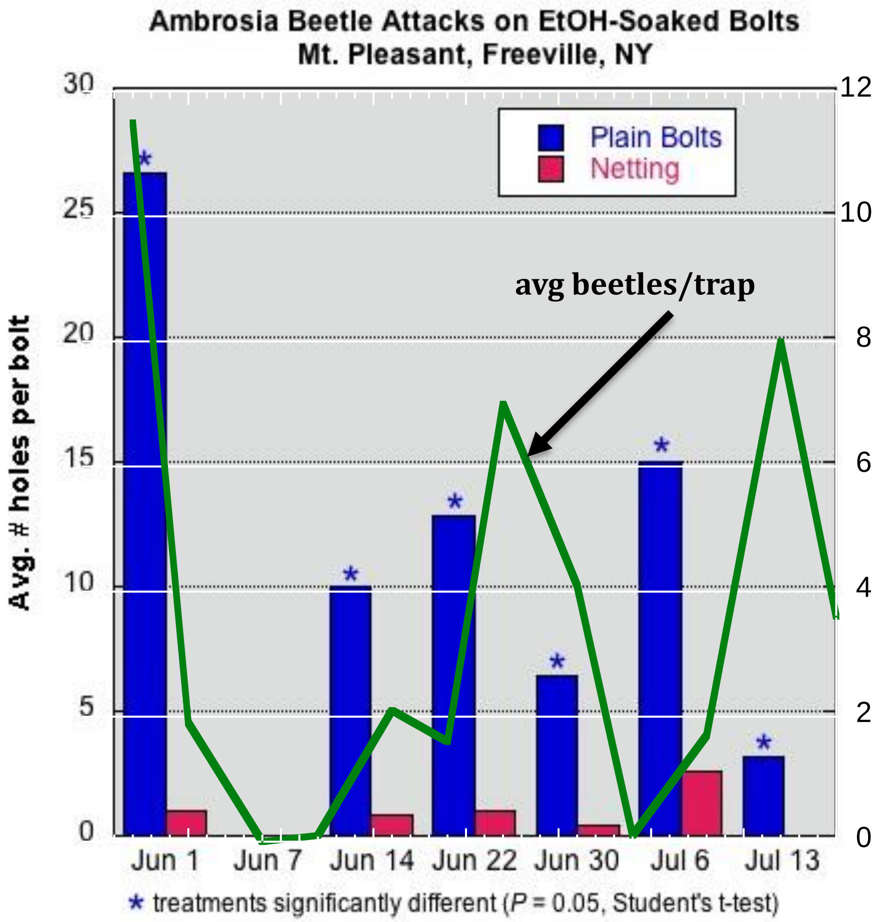

Fig. 2. BSB attacks on bolts wrapped with insecticide-impregnated netting, Mt. Pleasant.

2018 ORCHARD SURVEY FOR INVASIVE AND EXOTIC PESTS IN NEW YORK

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An Orchard Commodity Cooperative Agricultural Pest Survey was conducted for exotic insects and diseases including summer fruit tortrix (SFT), variegated golden tortrix (VGT), velvet longhorned beetle (VLB), spotted lanternfly (SLF), apple proliferation phytoplasma (APP) and latent apple viruses. All the agricultural pests in the survey pose significant threats to NY tree fruit industries.

The USDA APHIS protocols were adjusted for NY orchard and growing season conditions. Survey sites were set up with growers and monitored and scouted for the insects and diseases listed in Table 1, all of which are exotic pests not found in the Northeastern US, except for the latent apple viruses.

Table 1. Target insects and diseases in the 2018 Orchard Survey.

Insect or Disease	Scientific name
summer fruit tortrix	*Adoxophyes orana*
variegated golden tortrix	*Archips xylosteanus*
velvet longhorned beetle	*Trichoferus campestris*
spotted lanternfly	*Lycorma delicatula*
apple proliferation phytoplasma	*Candidatus* Phytoplasma mali
latent apple viruses	

Summer fruit tortrix, variegated golden tortrix, and velvet longhorned beetle: Two traps per insect species (SFT, VGT, VLB) were used at each farm site; paper delta traps for SFT and VGT, and panel traps for VLB. Farms were located in the following counties: Cayuga, Niagara, Onondaga, Ontario, Orleans, Schuyler, Seneca, Tompkins, Wayne, and Yates. Traps were set out in May, mainly in apple orchards, but also in cherry orchards or in hedgerows, depending on the orchard and species, and serviced every one to two weeks until late September. Lures were replaced at the specified intervals in the USDA APHIS protocols. A total of 90 traps were monitored, evenly divided among the three insect species (CBT, VGT, and ECFF), and serviced seven to 11 times during the season. Suspect insect specimens were brought back to our labs for pre-screening. A total of 2237 non-target insects were caught in the traps. A subset of these, which couldn't be ruled out as target species, were sent in for determination by Jason Dombroskie, Insect Diagnostic Laboratoty, Dept. of Entomology, Cornell University.

Spotted lanternfly and Ailanthus altissima: The 15 orchard locations scouted for apple proliferation phytoplasma (APP) were also checked for the presence of *Ailanthus altissima*, tree of heaven, a favored host for spotted lanternfly. We surveyed the entire perimeter of orchard blocks and farms to look for its preferred host, tree of heaven. This tree was found at only two of the orchard survey sites. One location in Macedon, NY, Wayne County (GPS coordinates 43.16444 north and 77.3347 south) had six trees in a cluster near an old stone pile. The other location in Sodus, NY, Wayne County (GPS coordinates 43.28394 north and 77.11348 south) had one male tree. To assist with the threat of invasion this insect poses, we also surveyed for Ailanthus along the roadsides we traveled (data not shown).

Apple proliferation phytoplasma: We scouted for APP in late September. Before scouting we asked for input from the growers in case odd symptoms had been noted on their farms. Apple trees were examined for APP by walking between rows and stopping ten times, every 60 ft., to inspect trees in each row for characteristic disease symptoms. Surveys were conducted in the 15 orchard locations and a total of 1480 trees were examined for APP symptoms. No suspect symptoms were observed and no samples were collected for analysis.

Latent apple viruses: For the apple virus survey, orchards were selected that had trees on the following rootstocks G16, Nic29, M9, and G935. Quadrat sampling was done wherein six leaves were collected from each of four contiguous trees in the row, five quadrats were collected in each row, and every fifth row was sampled in the block. Leaf samples were collected in August and September from ten orchards that had trees on these rootstocks. Apple tissue samples were analyzed for apple stem pitting virus (ASPV), apple stem grooving virus (ASGV), apple mosaic virus (AMV), apple chlorotic leaf spot virus (ACLSV), tomato ringspot virus (ToRSV), and tobacco ringspot virus (TRSV) by Fuchs' lab using enzyme-linked immunosorbent assays (ELISA). Only apple stem pitting virus was confirmed in the quadrat samples and no correlation with rootstock type was found (Table 2), though scion did appear to correlate with the prevalence of ASPV (Table 3).

Table 2. Number of quadrats (n) testing positive for apple stem pitting virus (ASPV) in leaf samples collected from trees on each of the four rootstocks.

Rootstock	Proportion with ASPV	n	n ASPV
G16	0.20	65	13
Nic29	0.07	30	2
M9	0.25	110	27
G935	0.11	18	2
Total	**0.20**	**223**	**44**

Table 3. Number of quadrats (n) testing positive for apple stem pitting virus (ASPV) in leaf samples collected from different cultivars.

Cultivar	Proportion with ASPV	n	n ASPV
Gala	0.13	40	5
Cortland	0.00	5	0
Empire	0.34	65	22
Ginger Gold	0.50	10	5
Honeycrisp	0.02	50	1
Ida Red	0.40	5	2
Kingston Black	0.00	3	0
Linda Mac	0.00	20	0
Ruby Mac	0.35	20	7
SnapDragon	0.40	5	2
Total	**0.20**	**223**	**44**

No invasive or quarantine-level pests, SFT, VGT, VLB, spotted lanternfly or APP, were found by Carroll or Agnello in 2018. The threat of introduction of invasive species of quarantine-level importance is continuous. In 2017 and 2018, respectively, two exotic insects were found in New York State: (1) European cherry fruit fly, *Rhagoletis cerasi*, in Niagara County, now part of a quarantine effort, and (2) spotted lanternfly in eight NY Counties: Albany, Chemung, Delaware, Kings (Brooklyn), Monroe, New York (Manhattan), Suffolk, and Yates, as of 26 November 2018, none resulting in establishing infestations.

Fact sheets on all pest in the orchard, grape, and small fruit commodity surveys are available on the NYS IPM Program web page, nysipm.cornell.edu/agriculture/fruits/invasive-species-exotic-pests.

This work was supported by the New York State Department of Agriculture and Markets.

HUMMINGBIRD ENRICHMENT IN BERRIES TO ENCOURAGE PREDATION OF SPOTTED WING DROSOPHILA

Juliet Carroll, NYS IPM Program; Greg Loeb, Entomology; Courtney Weber, Horticulture; and Laura McDermott, Eastern NY Commercial Horticulture Program
Cornell University

An article in Good Produce, Berry Growers Sharing Great Ideas by Charlie O'Dell, published May 14, 2014, "Unusual Way to Control SWD" highlighted Robert Hays's, Hays Berry Farms at Dumas, MS, use of 25 hummingbird feeders per acre in his six acres of blackberries to attract hummingbirds. He estimated there are more than 500 hummingbirds flying around his fields on picking days and he had not had to spray. When feeding their young, hummingbirds will eat up to 2,000 small insects per day. The diet of an average hummingbird consists mostly of flower nectar and insects – including, but not limited to small beetles, flies, vinegar flies, gnats, mosquitoes, aphids and spiders. In Mississippi there are three species of hummingbirds, but only two are residents during summer. In NY, we have only the ruby throated hummingbird.

Berry growers in NY were interested in whether this technique could work against spotted wing Drosophila (SWD) in raspberry. Many are averse to routinely spraying insecticides or operate U-pick farms, which can make it challenging to manage SWD. Therefore, we established a field experiment to test the technique's effectiveness over four years, two years each in two one-acre fields in which raspberry breeding program selections were grown. In the final year, we recruited two growers to test its feasibility on the farm – in organic blueberry and in raspberry.

Objective 1. Deploy 25 hummingbird feeders per acre and observe associated hummingbird behavior in a raspberry planting. The one-acre plot was split between a treatment zone with feeders and a non-treatment zone without feeders. It took approximately two hours to service and clean feeders. Weekly hummingbird observations found that hummingbirds would spend seconds to several minutes and longer in the planting and at the feeders. They were seen to fly: (a) from within the raspberries to the feeder then into the raspberries; (b) from within the raspberries to the feeder then out of the field; (c) from outside the raspberries to the feeder then into the raspberries; and (d) from outside the raspberries to the feeder then out of the field. Behaviors a, b, and c were most common, indicating the birds were spending the majority of time in the raspberries.

Objective 2. Test the efficacy of hummingbird enrichment in reducing the numbers of SWD in a raspberry planting and in reducing fruit infestation. Rudimentary data analysis in the first two years had shown little to no differences in the SWD numbers or fruit infestation between the treatment zone with feeders and a non-treatment zone without feeders. Adjustments in the experimental design to address the challenges of determining the impact of a flying predator on a flying pest proved beneficial. Final design using SWD traps placed along four transects in the field, each transect containing nine traps, four traps in the feeder zone and five in the non-feeder zone gave better results. Once SWD was caught, berry samples collected along the 36 transect locations were assayed using salt flotation to determine fruit infestation levels (data not shown).

Preliminary data analysis for 2018 showed that in weeks when SWD trap catch numbers were very low (Fig. 1A) or very high (Fig. 1B), there was little to no difference in the number of SWD caught in Scentry traps placed in area of the field with hummingbird feeders compared to those in the area of the field without feeders. However, when numbers were moderate, a difference was found along the transect. The trend was for fewer SWD in the hummingbird feeder zone compared to the no-feeder zone, as shown in Figure 2A and B for data collected on August 2, 2018. Traps 1-4 were in the hummingbird enrichment zone.

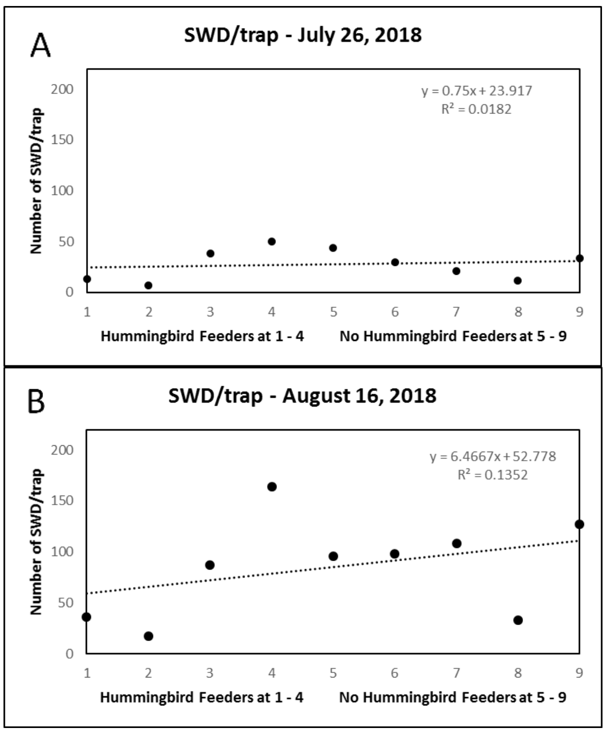

Figure 1. No trend in SWD trap catch associated with the feeder zone (1-4) when SWD catch is low (A) or high (B).

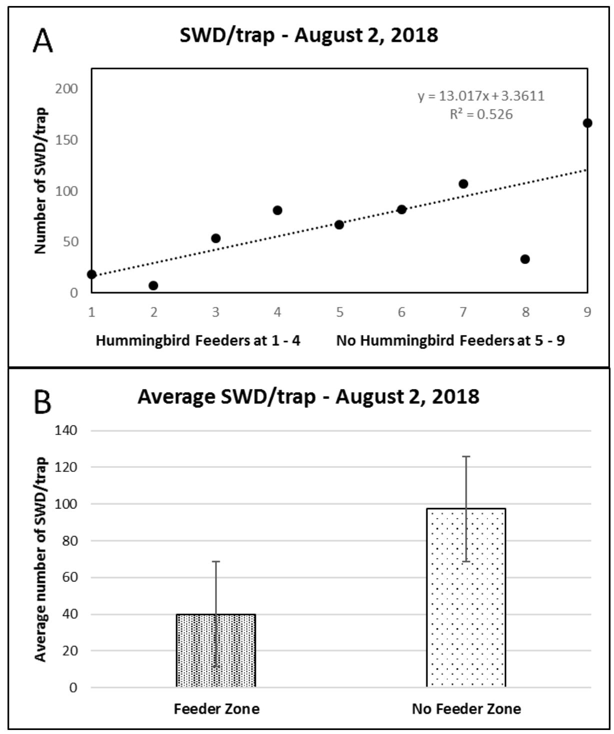

Figure 2. Fewer SWD caught in the feeder zone along the transect (A) or on average with standard error bars (B).

Objective 3. Explore the feasibility of this tactic in grower demonstration trials. We set up two grower demonstration plots, one in organic blueberry in Western NY and one in raspberry in Eastern NY. Both growers were meticulous about management of their plantings, using excellent sanitation, weed management, and pruning practices. The growers were able to maintain the hummingbird feeders in their plantings, indicating this practice is feasible for typical small berry plantings in NY. The organic blueberry grower had lost his entire crop in 2017 to SWD. In 2018, there was no crop loss and only one Entrust spray was applied. Whether this was directly attributable to the hummingbirds visiting the planting was not assessed.

Our results show that it is feasible for growers to deploy hummingbird feeders in berry plantings, that hummingbirds spend time in raspberries, that growers are willing to use this technique, and that enriching a fruit planting with insect predatory hummingbirds shows promise as an alternative technique to pesticides for the management of SWD.

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SPOTTED LANTERNFLY DAMAGE AND PHENOLOGY IN PA VINEYARDS

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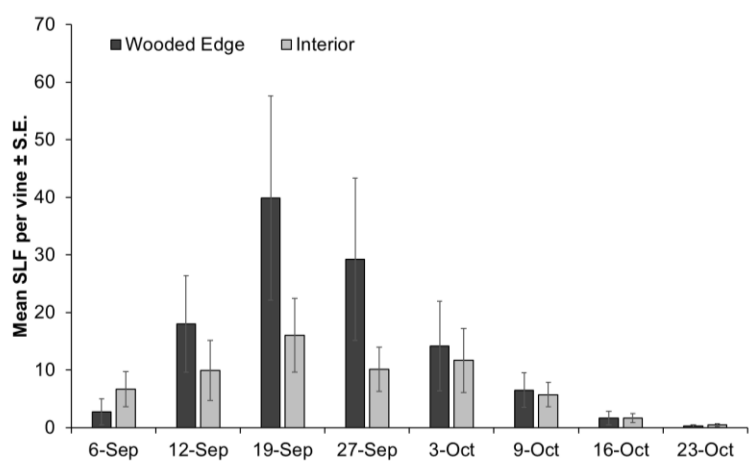
Spotted lanternfly (SLF), the recent invasive insect to the Northeast U.S., poses serious concern to agricultural commodities including specialty fruit crops. Grapes, in particular, seem to be among the preferred hosts for this highly polyphagous insect. SLF is a large insect which feeds on plant phloem. As it feeds, it excretes honeydew which then invites the growth of sooty mold around where SLF feeds. Since SLF has been detected in the U.S., several grape growers have had reduction in yield, failure of vines to set fruit, and in some cases, death of the vine, all thought to be caused by SLF feeding. In 2018, a visual survey for SLF adults was carried out in 8 vineyards in Berks County, PA, within the current state quarantine zone for SLF. At each vineyard, 1-2 transects were established that began at a wooded edge and led to the vineyard interior. Every 3 meters, vines were counted for the number of SLF on the trunk, cordon, and shoots. Honeydew and sooty mold were also monitored weekly.

We found that SLF populations peaked in mid-late September across all vineyards. Up to 365 SLF were observed feeding on a single vine, though the average across the entire vineyard peaked at 39.9 (see figure below). Higher populations of SLF were observed at the vineyard edge, adjacent a woodlot, compared to the vineyard interior. Additionally, while SLF fed on all parts of the vine, the majority of SLF observed were feeding on the shoots throughout the season. As vines began to senesce, more SLF were observed feeding on the trunk and cordons. These data suggest that SLF poses the most significant risk in the late summer and early fall. Building predictability in the phenology of this important new insect will help us manage them in grape and other specialty fruit production systems.



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COLONY COLLAPSE ISSUES WITH NJ BLUEBERRY POLLINATION – WHAT'S AT STAKE BESIDES $ MILLIONS?

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New Jersey blueberry production encompasses 10,500 acres of highbush blueberries concentrated in Atlantic and Burlington Counties. While some varieties are self-fertile, most varieties benefit from cross pollination for optimum production and size. Honey bees are the most common pollinator used in commercial blueberry production, for which recommended hive placement density can vary by variety from .5 hives per acre up to 3-4 hives per acre. A general average for NJ production is 2 hives per acre placed at the start of bloom and lasting for about 1 month. Bloom usually occurs the last week of April through the last week of May, and results in about 20,000 hives being placed in blueberry production during that period. Bees are sourced from both NJ-based and out of state beekeepers, with most hives coming from overwintering sites in Florida and the Southeast, or previous contracts in California almonds. About 8-10 years ago (2010-'12), beekeepers noticed a colony decline that they had not previously experienced, and associated this with contract blueberry pollination. Some beekeepers also observed that the decline was worse when the colonies were used for double pollination i.e. blueberry followed by cranberry pollination. In 2014 beekeeper losses became unsustainable, and they started asking extension professionals for help. During the ensuing period pollination prices have increased from about $60/hive to a projected $130/hive for 2019. Some beekeepers are no longer bringing their colonies into NJ. Since the blueberry growers have an obvious stake in the problem, they are also concerned. Blueberry growers commonly use some insecticides pre-bloom for cranberry weevil and sometimes, plum curculio; several fungicide applications during bloom for anthracnose; and multiple insecticide and fungicide applications starting immediately post bloom.

In 2015 we started to examine brood growth, disease and pesticide residues in various pollination scenarios. In 2018 we examined colony conditions that resulted from 4 pollination treatments: 1) pollination on small blueberry farms surrounded by multiple woodland wild hosts, 2) pollination on large (> 100A) blueberry farms, 3) pollination on large farms followed by cranberry pollination, and 4) no commercial pollination treatments. Treatments were replicated 3 times with 3 hives per replicate (total = 36 hives). Hive weights were taken at the start of the experiment and at the end of each treatment timing. Three frames were marked in each hive and brood coverage assessed during the middle of each pollination period. A pollen trap was set in one hive in each replicate and pollen collected for pesticide residue analyses, and for pollen identification, during the middle of each pollination treatment. Bee bread and wax samples were also collected at the end of each pollination period.

Hive weights are largely a measure of food reserves and general colony health, but can vary throughout the season. We took hive weights at distinct times of the year, once for each treatment. Hive weights generally increased throughout the season, slightly less so when placed on large farms, and decreased after being placed in cranberries, perhaps due to a possible poorer food source and other factors (Figure 1).

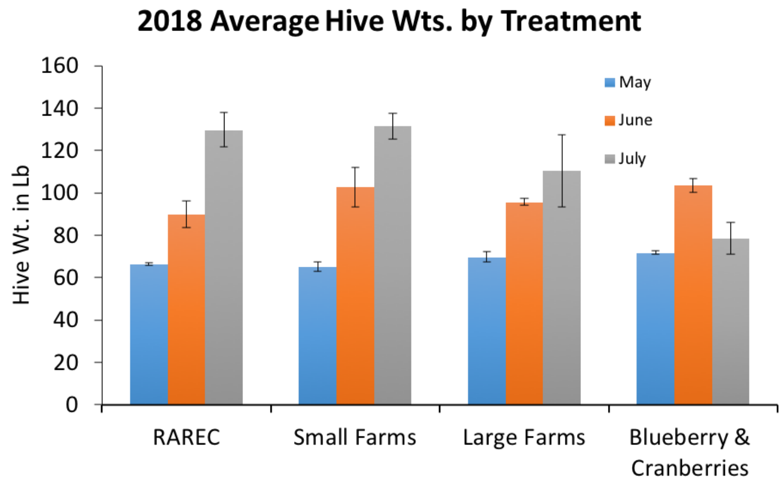

Figure 1. Average hive weights throughout the growing season, showing an increase in all treatments except after placed in cranberries.

Brood growth and change was measured during the middle of each pollination period and again at the end of treatment timings. Three frames were marked in each hive and counted for % brood coverage including egg presence, and uncapped and capped brood. A healthy hive should show a consistent brood increase throughout the season. Our data showed an actual decrease in some of the treatments (Figure 2).

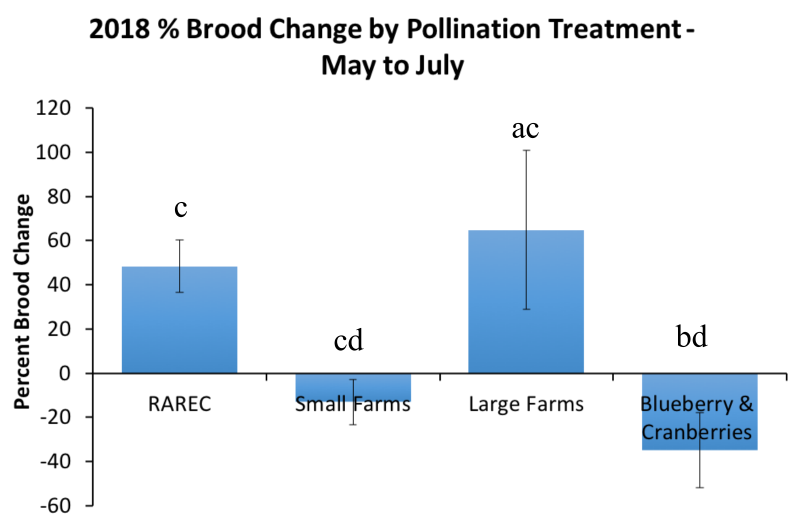

Figure 2. Percent brood change (3 readings) May through July, showing decreases in small farm and after cranberry pollination.

Virus presence was detected among all treatments (UMD BIP laboratory), and did not differ between treatments (Figure 3.)

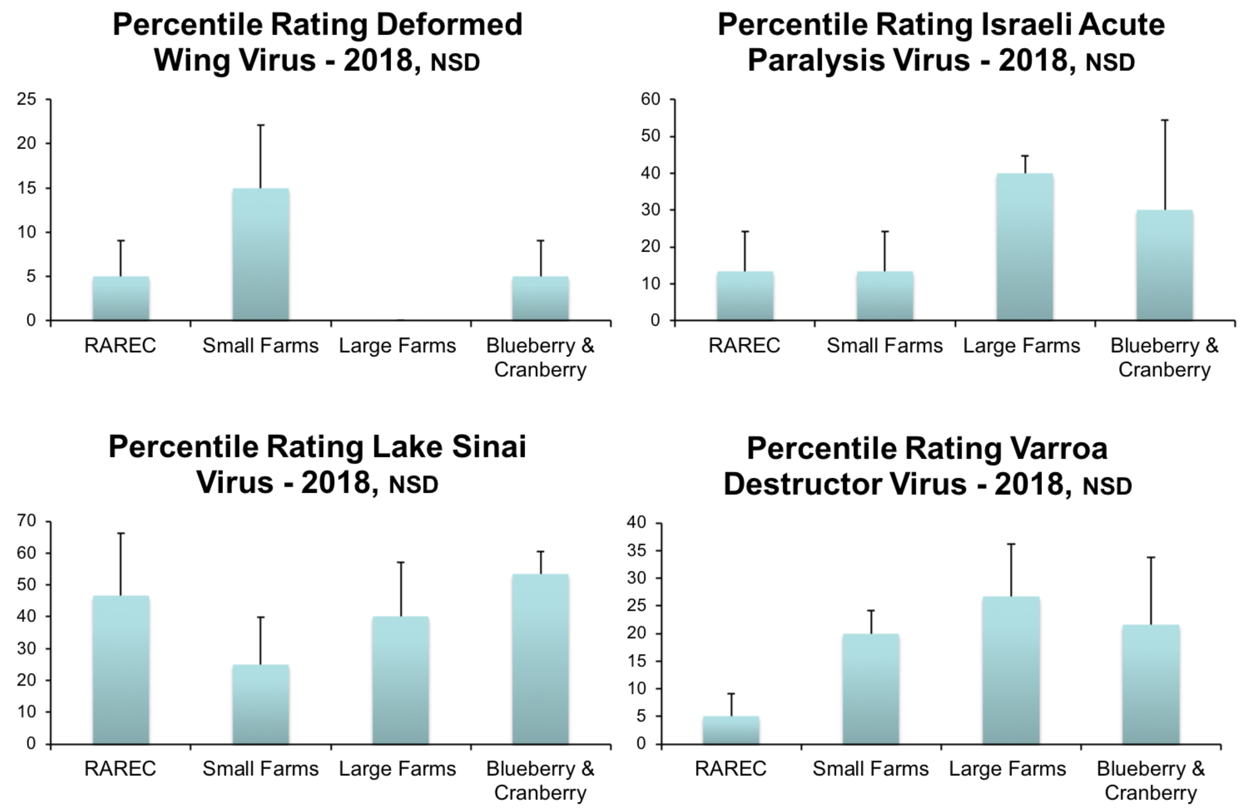

Figure 3. Virus presence in all 4 treatments showed no significant difference in percentile ratings among 4 viruses.

We found over 30 different active ingredient residues in the pollen samples, including 17 insecticide/miticides, 15 fungicides and several herbicides. Insecticide/miticide residues included 5 materials used for varroa control and 12 related to crop protection use. Several insecticides found are known bee toxicants such as carbaryl (Sevin) and chlorpyrifos (Lorsban), but are not used in blueberries. Lorsban is used in cranberries. Other insecticides found may have been used in surrounding crops, forests or residential areas. Abound and Indar fungicide residues were commonly found in a number of samples, but were more commonly found in those hives placed in blueberries followed by cranberries. The effects of fungicides on honey bees is a developing story, and more work in this area needs to be done.

FILLING IN THE KNOWLEDGE GAPS: UPDATE ON STUDIES OF SPOTTED LANTERNFLY FEEDING AND REPRODUCTIVE BIOLOGY

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Lycorma delicatula (Hemiptera: Fulgoridae), commonly known as the Spotted Lanternfly (SLF), is an economically dangerous invasive planthopper first detected in Berks County, Pennsylvania in September, 2014. Since that time, SLF has expanded its range to include 13 counties in eastern Pennsylvania and 3 counties in New Jersey. A second established population has been detected in Virginia. Adults have been detected in Maryland, New York, Delaware, and Connecticut. This insect is univoltine, and overwinters in the egg stage. Hatching begins in late May to early June, and SLF goes through four nymphal instars before eclosing as adults beginning in late July. As adults, SLF appears to feed voraciously on the phloem of multiple species of trees and have not been observed to lay eggs until October to November.

During the several weeks prior to egg laying (the second to fourth weeks of September, 2018), we observed SLF to exhibit greater flight activity and movement onto trees not previously fed upon. We monitored 40 red maple trees from Aug. 29-Oct. 9, and observed from Aug. 29-Sept. 18, the average number of SLF counted per tree was less than 10, but increased to an average of 30 per tree by Oct. 9. Observations of female SLF during this time show a noticeable increase in volume and distension, as their reproductive system matures and eggs become larger prior to egg laying. We dissected multiple female SLF across this period of reproductive maturation and observed and documented changes in the size and placement of reproductive tissues. We also observed changes in the morphology and position of endosymbiont bacteriomes. These structures are organs that house the three obligate bacterial endosymbionts harbored by SLF, and other species within Fulgoridae. Our preliminary findings indicate that in the later stages of adult SLF development in late fall, females exhibit remarkable development of their reproductive tissues and bacteriomes that appears to correspond to transmission of endosymbionts to eggs prior to egg laying. Further characterization of these changes and their timing may provide insight into potential strategies to control SLF through interruption of these processes of endosymbiont transmission.

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HORTICULTURE

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2018 ROOTSTOCK TRIALS AT PENN STATE UNIVERSITY – ROCK SPRINGS

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Penn State University was a founding member of the NC-140 Regional Rootstock Research Project. Rootstocks in apple production are the primary means by which growers can control tree size. In recent years there have been many new rootstock selections released. These new releases are routinely evaluated for their performance. Parameters evaluated include average yield, tree size, efficiency, survival and average fruit size. While the NC-140 project usually features comparisons of new rootstocks for multiple tree fruit crops this paper is meant to provide a preliminary report of the current apple plantings located at the Horticultural Research Farm at Rock Springs in central Pennsylvania.

Materials & Methods:

Currently there are four active rootstock trials underway at Rock Springs. A partial planting of the 2014 NC-140 uniform trial; a local 2016 Scifresh and Royal Red Honeycrisp; a 2016 local trial with the cultivar Regal 10-45 on two rootstocks and a local trial established in 2017/2018 with two strains of Honeycrisp with new rootstock releases from New Zealand. All plantings are laid out in a randomized complete block design.

Since the last trial was fully established just during the 2018 season there is no data to be analyzed. Instead we will describe the known characteristics of the rootstocks. The stocks were bred for producing high yields, tolerance to WAA, *Phytophthora sp.* and fire blight. Cultivars are Royal Red Honeycrisp and Honeycrisp B42 strain. Comparison rootstocks are G.41 and G.890. Trees are planted at a spacing of 4 ft. x 13 ft. (838 trees/A or 2071 trees/ha). Results of this trial will be reported in future years

The oldest planting is a partial planting of the 2014 NC-140 uniform trial. The main purpose of this planting is to evaluate the Vineland series of rootstocks from Canada. The Vineland rootstocks are being tested with both cultivars (Aztec Fuji and Honeycrisp). The standard rootstocks are M9 T337 and M.26EMLA. G.214 is an additional rootstock that is only being trialed in the Fuji planting; while G.890 and G.969 are only being trialed in the Honeycrisp planting. Tree spacing between rows in both plantings is set at 14 feet; in-row spacing varied depending upon cultivar. The Fuji are set at 5 ft. in-row and the Honeycrisp are set at 4ft. in-row. Density therefore is 622 trees/A and 778 trees/A, respectively

The second trial is a planting of Scifresh and Honeycrisp (Royal Red strain) on three rootstocks; M.9T337, G.11 and G.935. The tree spacing for both cultivars is 3 ft. in-row and 12 ft. between rows for a density of 1210 trees/A. The third trial is a planting of Regal 10-45 on two rootstock, M.9 T337 and G.11 They are planted at a spacing of 3 ft x 12 ft for a density of 1210 trees/A.

Results:

2014 NC-140: At the end of the 4th growing season the smallest trees in the Fuji planting were on M.9 T337 but not significantly smaller than G.214 or M.26 (Table 1). The largest trees were on V.6 but were not significantly larger than trees on V.5 or V.7. Annual TCSA growth in 2017 was greatest on V.5 & V.6. There were no differences in the average number of rootsuckers by rootstock. For Honeycrisp, the smallest trees were on M.9 but were not different than trees on either M.26 or G.969. The largest trees as with Fuji were on V.6. Annual trunk growth was least on M.9 but not significantly different from growth on M.26 or G.969. There were differences in average number of rootsuckers by rootstock with G.890 having the greatest number of suckers.

Table 1. Tree size as measured by trunk cross sectional area (TCSA), annual increase in TCSA in 2018 and average number of rootsuckers this past growing season for 2014 NC-140 uniform rootstock trial planting at Rock Springs.

Rootstock	TCSA Fall '17, cm^2	Growth '17, cm^2	# Suckers
Aztec Fuji			
G.214	18.3 ab	5.4 ab	0.2 a
M.26 EMLA	17.6 ab	5.9 abc	0.5 a
M.9 T337	15.5 a	4.7 a	0.0 a
V.1	22.4 bc	7.3 bcd	0.8 a
V.5	25.9 cd	8.4 d	1.0 a
V.6	28.9 d	8.8 d	1.8 a
V.7	26.6 cd	8.0 cd	2.3 a
P-Value	0.0001	0.0001	0.0871
Honeycrisp			
G.890	19.6 bc	4.2 bc	5.8 b
G.969	13.2 a	3.1 ab	1.5 a
M.26 EMLA	12.6 a	3.0 ab	0.4 a
M.9 T337	10.1 a	2.1 a	1.7 a
V.1	17.9 b	5.0 c	2.4 ab
V.5	19.4 b	5.9 c	2.8 ab
V.6	23.1 c	5.8 c	1.4 a
V.7	17.8 b	4.5 bc	3.3 ab
P-Value	0.0001	0.0001	0.0025

Letters refer to Tukey-Kramer mean separation, P – 0.05

The greatest average cumulative number of fruit per tree for Fuji was on the Vineland rootstocks but it was not significantly greater than that on G.214 (Table 2). Cumulative average yield per tree was greatest on the Vineland stocks and G.214. There were no differences in average fruit weight by cultivar on the different rootstocks. Cumulative efficiency for Fuji was greatest on G.214 rootstock. The greatest average cumulative number of fruit per tree for Honeycrisp was for trees on G.890 and least on M.26 rootstocks. Average cumulative yield per tree was greatest for trees on G.890. Cumulative efficiency for Honeycrisp was on trees on G.969 and G.890

Table 2. Cumulative number of fruit per tree, yield/tree average fruit weight and average tree efficiency for 2014 NC-140 uniform rootstock trial planting at Rock Springs, PA

	2014-2017			
Rootstock	# Fruit	Yield, Kg	Avg. Fruit wt, g	Efficiency, kg/cm^2
Aztec Fuji				
G.214	97 c	21.15 b	215 a	1.17 b
M.26 EMLA	48 a	10.66 a	222 a	0.61 a
M.9 T337	60 ab	13.67 a	219 a	0.93 ab
V.1	81 bc	16.70 ab	202 a	0.80 a
V.5	107 c	22.28 b	201 a	0.89 ab
V.6	101 c	21.33 b	204 a	0.79 a
V.7	102 c	21.28 b	202 a	0.84 ab
P-Value	0.0001	0.0001	0.0137	0.0019
Honeycrisp				
G.890	175 d	46.88 d	270 a	2.47 c
G.969	137 cd	33.90 c	255 a	2.61 c
M.26 EMLA	67 a	17.70 a	266 a	1.42 ab
M.9 T337	88 ab	21.44 ab	258 a	2.13 bc
V.1	118 bc	28.40 bc	249 a	1.66 ab
V.5	87 ab	22.55 ab	264 a	1.21 a
V.6	131 c	34.47 c	256 a	1.53 ab
V.7	111 bc	28.21 bc	260 a	1.61 ab
P-Value	0.0001	0.0001	0.1596	0.0001

Letters refer to Tukey-Kramer mean separation, P – 0.05

2016 Scifresh & Honeycrisp Trial: Scifresh tree trunk cross sectional area at the end of the 2017 growing season was not different by rootstock (Table 3). However, for the Honeycrisp trees on G.935 were smaller at planting and after the 2017 growing season.

Average number of flower clusters and density of flowering per tree for Scifresh in 2017 was significantly greater for trees on G.935 rootstock (Table 4). However, there was no influence of rootstock on flowering number or density for trees of Honeycrisp regardless of the rootstock.

Table 3. Tree size at planting, in the fall after planting and in the fall of 2017 for Scifresh and Honeycrisp at Rock Springs.

Scifresh	SP 16 TCSA, cm^2	Fall 16 TCSA, cm^2	Fall 17 TCSA, cm^2
M.9Nic19	1.5 a	3.8 a	9.2 a
G.41	1.8 a	3.7 a	8.9 a
G.935	1.8 a	4.1 a	9.2 a
P - Value	0.1424	0.1619	0.6895
Royal Red Honeycrisp	SP 16 TCSA, cm^2	Fall 16 TCSA, cm^2	Fall 17 TCSA, cm^2
M.9Nic19	1.5 b	2.5 b	5.4 b
G.41	1.5 b	2.3 b	4.6 b
G.935	1.1 a	1.6 a	3.3 a
P - Value	0.0022	0.0010	0.0031

Letters refer to Tukey-Kramer mean separation, P – 0.05

Table 4. Average number of flower clusters and flower cluster density in 2017 within cultivars by rootstocks.

Scifresh	# Flower Clusters	Cluster Density, $\#/cm^2$
M.9Nic19	162 a	43 a
G.41	153 a	41 a
G.935	233 b	56 b
P - Value	0.0002	0.0001
Royal Red Honeycrisp		
M.9Nic19	19 a	7.1 a
G.41	12 a	5.6 a
G.935	12 a	8.7 a
P - Value	0.6771	0.7266

Letters refer to Tukey-Kramer Mean Separation, P=0.05

2016 *Regal 10-45:* At the end of the 2018 season there was no difference in tree size as measured by TCSA based upon rootstock (Table 5). Yields were not significantly different. This suggests that G.11 rootstock in this planting is equivalent to the common strain of M.9 NAKB T337.

Table 5. Tree size (TCSA) at the end of 2018 and cumulative yield parameters for Regal 10-45 on M.9 T337 and G.11 rootstocks at Rock Springs.

		2016-2018			
Rootstock	18 Fall TCSA, cm^2	# Fruit/tree	Yield/tree, kg	Fruit wt., g	Efficiency, kg/cm^2
M.9T337	8.5 a	58.2 a	12.64 a	205 a	1.510 a
G.11	9.8 a	65.0 a	15.56 a	225 a	1.623 a
P-value	0.0536	0.5801	0.3562	0.0738	0.7848

Letters refer to Tukey-Kramer Mean Separation, P=0.05

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POSTHARVEST AND POST-COLD STORAGE PROPERTIES OF FIVE NEW PEACH VARIETIES

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Rutgers Tree Fruit Breeding program continues to release new varieties, giving growers more options to choose from. It also creates an opportunity to fill in any holes in harvest windows. The germplasm (genetic material) from which these varieties were created was sourced from different parts of the world and specifically selected and bred not only for tree health, but also for the extremes of weather, diversity, and market demand. These varieties give growers opportunities to garner more shelf space in retail establishments. New Jersey farmers are growing not only peaches with traditional flavor, but also new, sweet varieties with a sub acid flavor. In addition, there is interest in firmer varieties with different flesh colors and textures. Five varieties were developed after extensive multi-year evaluations at several location in New Jersey, representing different agro-climates. They were released in fall 2016. Fruit and tree characteristics of these new peach and nectarine varieties are described below. Figure 1 and 2 describes the relative harvest timing of these varieties compared to other well-known varieties.

Evelynn (H 7 -47) – Yellow-fleshed peach with semi free stone and firm flesh. It is a low acid peach, which ripens with Redhaven. It has large size and very attractive full scarlet coloring. Smooth low pubescence, retains firmness well. Always productive and low susceptibility of bacterial spot. Three-year average firmness (9.33 lbs.), diameter (2.87 in.), mass (205 g), total titratable acidity (0.76 g/l) and total soluble solids (10.23 °Brix).

Selena (K65-76) – Late season yellow peach with excellent firmness. Ripens between ‘Jersey Queen’ and ‘Encore’. Very large fruited with attractive 50-80% red-on-yellow background. Hangs well on tree and has excellent flavor and coloring. Low susceptibility to bacterial spot and productive. Three-year average firmness (9.85 lbs.), diameter (3.10 in.), mass (244 g), total titratable acidity (5.67 g/l) and total soluble solids (12.07 °Brix).

Tianna (K64-197) – Late season yellow peach with free stone and very firm flesh. Ripens between ‘Cresthaven’ and ‘Encore’. Nice acidic flavor, beautiful coloration, and has an excellent large size. Highly mottled (50-75%) red-on-yellow. Good quality and sweet. Low susceptibility to bacterial spot. Three-year average firmness (11 lbs.), diameter (2.67 in.), mass (271 g), total titratable acidity (5.71 g/l) and total soluble solids (11.72 °Brix)

Brigantine (H21-44) - Yellow-fleshed nectarine with semi freestone. Ripens July 20-25 just before ‘Summer Beaut’ and ‘Redhaven’. It has solid scarlet coloring and a nice acidic flavor and firm melting flesh. Skin clean to blemishes. Very productive tree has low susceptibility to bacterial spot while fruit has moderate susceptibility to bacterial spot. Three-year average firmness (9.05 lbs.), diameter (2.60 in.), mass (172 g), total titratable acidity (1.46 g/l) and total soluble solids (10.05 °Brix).

Silverglo (K54-42) – White-fleshed nectarine with clingstone/semi free stone. It ripens between ‘Artic Sweet’ and ‘Artic Jay’. Its fruits are larger and more attractive than other white nectarines in this season. Nice acidic flavor. Attractive color, lots of pinkish red color and very few skin blemishes. Tree is moderately vigorous with low susceptibility to bacterial spot. Three-year average firmness (10.07 lbs.), diameter (2.67 in.), mass (191 g), total titratable acidity (7.36 g/l) and total soluble solids (10.54 °Brix).

Sincere thanks to industry cooperator, Mr. Robert Fralinger of the Fralinger Farms and to our technical help, Ms. Laura Zuzek and Mr. Jeff Hammerstedt.

EFFECT OF SINGLE OR SPLIT APPLICATIONS OF PROHEXADIONE, WITH AND WITHOUT GIBBERELLIN $_{4+7}$ ON SCARF SKIN OF BUCKEYE GALA

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Scarf skin is a physiological disorder of apple that results in a dull gray appearance. It has recently caused loads of Pennsylvania-grown ‘Gala’ apples to be rejected by retailers, concerned consumers will mistake scarf skin for pesticide residue. The red strains of Gala are particularly susceptible. Scarf skin occurs during the early development of the fruit. Several sprays of GA_{4+7} at 10-day intervals starting at petal fall (PF) are known to reduce the severity of scarf skin.

McArtney, et al., (2006) found that a single application of 250 ppm of the plant growth regulator prohexadione (PCa) at petal fall was additive to GA_{4+7} in reducing scarf skin, but it also reduced fruit size. PCa is active for about two weeks after application, while scarf skin may occur between PF and PF+40d. It is not known if multiple applications of PCa spread over 40d have the desired effect on scarf skin, but multiple sprays of lower doses (62.5 – 125 ppm) of PCa are a strategy for reducing the effects of increased fruit set and reduced fruit size.

Forty uniform ‘Buckeye Gala’/ M.9 apple trees at FREC were selected, and treatments were assigned in a completely random design, with five replications.

Treatments were as follows:

PCa (ppm)	GA_{4+7} (ppm)
0	0
0	20 x 4^x
250 x 1^z	0
250 x 1^z	20 x 4^x
125 x 2^y	0
125 x 2^y	0 x 4^x
62.5 x 4^x	0
62.5 x 4^x	20 x 4^x

^{z}one application at petal fall.
^{y}applications at PF and PF+10d.
^{x}applications at PF, PF+10d, PF+ 20d, and PF+30d.

PCa and GA_{4+7} (kudos® and Novagib 5L®, respectively, Fine Americas, Walnut Creek, CA 94596, USA) sprays were applied at 40 psi by backpack CO_2 sprayer, to drip. No surfactants or water conditioners were used in these sprays.

Fruit set was evaluated on several limbs per tree. The length of 10 terminal shoots per tree will be measured once seasonal growth was complete. Fifty fruits per tree were non-selectively sampled at harvest. Fruit weight was measured, and mean fruit weight calculated. Three individuals rated scarf skin coverage independently, using a visual rating scale of 1= none to a trace to 5= severe scarf skin evident on the shoulder and cheek of the apple (Figure 1).

The treatments had no effect on fruit set, yield, or the number of fruit at harvest (data not presented). GA_{4+7} increased mean fruit weight slightly and increased the fraction of fruit that were ≥2.75 in. in diameter (Figure 2). Prohexadione slightly reduced the fraction of fruit <2.5 in. in diameter. Bloom density while adequate for a full crop, was light in 2018, which may have reduced the potential for PCa to result in heavier fruit set and smaller fruit size, as others have documented (McArtney, et al., 2006). Shoot extension growth was reduced 17% by PCa. However, tree vigor was low even in the untreated control trees, where mean extension shoot length was ~32 cm (just over 12 inches). The PCa treatments were 4-7 cm (1.6 – 2.8 in.) shorter than controls.

Scarf skin ratings were in very close agreement for all three raters, with y intercepts between 0.92 and 1.07, and with r^2 of 0.86, 0.87, and 0.90, respectively. So, our rating scale was consistent and valid as relates to human perception of this disorder. GA_{4+7} reduced scarf skin coverage and the percent of fruit out of grade due to scarf skin (Figs 3 and 4). Prohexadione had no effect on scarf skin in our study. These results contrast with McArtney et al., (2006) who reported that prohexadione reduced scarf skin in two of three experiments, and that this effect was additive with the reductions documented for GA_{4+7}. We evaluated the same single application of prohexadione at 250 ppm used in their studies, as well as multiple sprays of lower rates that more closely match the use patterns that are currently recommended. Scarf skin can develop any time during the first 60 days after bloom, while the growth regulating effects of prohexadione are typically of 14-28 days duration. However, 250 ppm prohexadione, whether applied in total at petal fall, or as split applications spread over 20 or 40 days was not effective for reducing this disorder.

Prohexadione reduces shoot extension growth, which can increase light penetration and foster more rapid drying conditions. Scarf skin is more severe in the lower/ interior sections of canopies, and this has been attributed to lower light and slower drying conditions (Byers, 1977). Our Gala trees were on the dwarfing M. 9 rootstock, and well-pruned to create narrow canopies. The lack of response for scarf skin to prohexadione in our study may suggest that its effect on scarf skin is an indirect effect of its influence on canopy environment. Byers (1977) noted that low tree vigor strongly reduced scarf skin. Scarf skin has been referred to as “smooth russet”, and it is caused when the cuticle and epidermis layers become separated from the highly pigmented layers of cells below. The two disorders are physiologically related and have essentially the same anatomical origin (Weber and Zabel, 2011). Scarf can be considered russet that doesn’t break the surface of the skin. GA_{4+7} is effective for reducing both disorders.

<u>Literature Cited:</u>

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McArtney, S., D. Ferree, J. Schmid, J.D. Obermiller and A. Green. 2006. Effects of prohexadione-Ca and GA_{4+7} on scarf skin and fruit maturity in apple. HortScience 41:1602-1605.

Weber, R.W.S., and D. Zabel. 2011. White haze and scarf skin, two little-known cosmetic defects of apples in northern Germany. Eur. J. Hort. Sci. 76(2):45-50.

Scarf skin score 1 Scarf skin score 2 Scarf skin score 3 Scarf skin score 4 Scarf skin score 5

Figure 1. Scarf skin severity rating classes used in study. Rating scale: 1 = no scarf to a trace of very mild scarf; 2 = trace of scarf to mild scarf, does not detract from commercial value; 3 = moderate (≤15%) scarf, does not detract from commercial value; 4 = prominent scarf, patches of scarf surrounding lenticels leading to a dull grayish appearance, detracts from visual clarity of apple color, distracts from appreciation of apple appearance, is of concern in commercial setting; and, 5 = dominant scarf; a primary visual impression concerns the presence of scarf, detracts from commercial value, is commercially unacceptable in some markets for some varieties. (Photo: H. Edwin Winzeler)

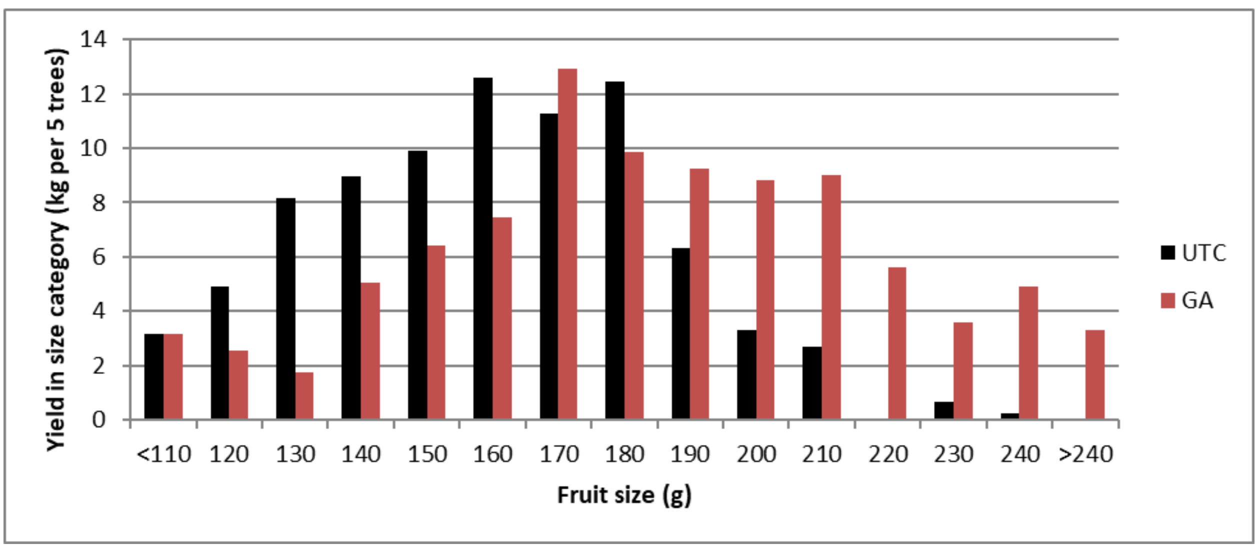

Figure 2. Effect of GA4+7 on fruit size distribution of ‘Buckeye Gala’ in PA, 2018.

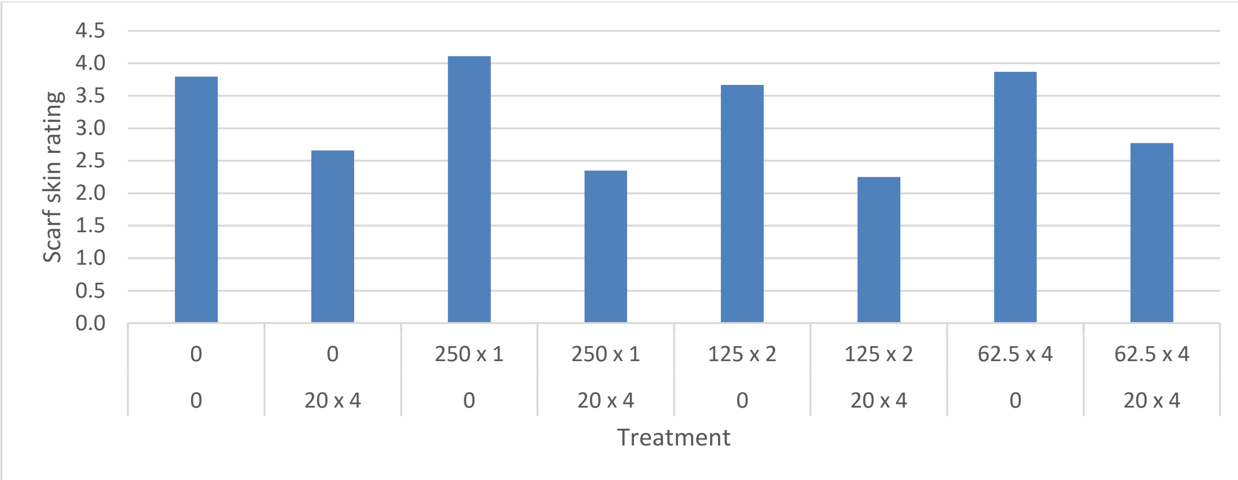

Figure 3. Effect of prohexadione and gibberellin $_{4+7}$ on scarf skin rating of 'Buckeye Gala' apples.

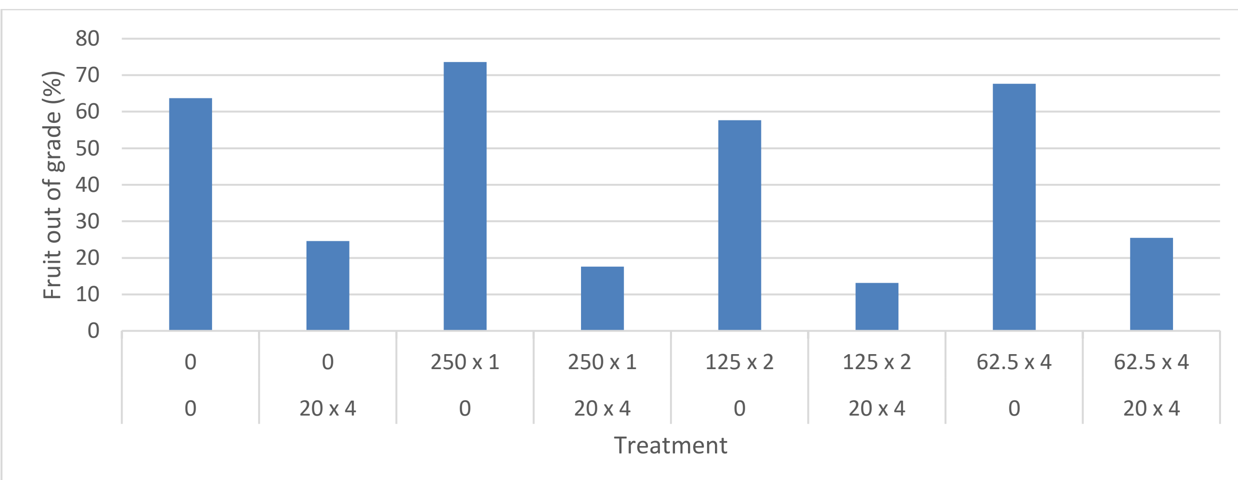

Figure 4. Effect of prohexadione and gibberellin $_{4+7}$ on 'Buckeye Gala' apples out-of-grade for scarf skin (%).

EVALUATING CHEMICALS FOR APPLE BLOSSOM THINNING

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The profitability of apple fruit producers is mainly dependent upon the consistent, high annual yield of quality fruit. In commercial apple production systems, this cannot be achieved without effective crop load management strategies that make a balance between vegetative and fruiting buds, reduce fruit-to-fruit competition, allow fruit enough room to grow, expose fruit to adequate sunlight and enhance return bloom. It is already well-established that crop thinning during bloom produces the largest fruit, the highest return bloom and reduces biennial bearing. However, our knowledge of chemicals and conditions that achieve efficient thinning at bloom stage is still limited, especially in the Eastern US.

The objective of the present study was to evaluate materials for chemical blooms thinning that can achieve proper thinning activity without having negative impacts on fruit quality. To this end, we assessed the thinning efficacy of five chemicals including ammonium thiosulfate (ATS, 1%), potassium thiosulfate (KTS, 0.5%), lime sulfur (1%), Regalia (1%) and potassium bicarbonate (6 kg/acre). All materials were applied alone or in combination with JMS Stylet-Oil (1%) to mature 'Honeycrisp' and 'Pink Lady' trees, using a backpack sprayer (Table 1). The first thinning treatment has been applied when 20% of king blossoms were open and according to the outputs of the PTGM model. All trees, except controls, were subjected to a second thinning application that was determined according to the PTGM model on the NEWA website (Figure 1). The experiment was arranged in a randomized complete block design (RCBD). No post-bloom chemical thinning applications or hand thinning were applied to the examined blocks. Fruit set (%) data were recorded after two, four and six weeks of the first thinning application; and at harvest. Fruits were collected from treated and untreated trees (controls) at harvest to examine the effect of different thinning materials on fruit quality.

As shown in Tables 2-5, our results indicated the following: a) ATS and KTS at low concentrations did not cause fruit russets, but their thinning efficiencies were too low, b) Potassium bicarbonate is a potent blossom thinner; however, lower concentrations should be considered to keep crop losses due to russet at a minimum, c) Potassium bicarbonate-oil mix caused severe damages to harvested fruit, d) Low concentrations of lime sulfur (1%) did not cause fruit injury; however higher concentrations (1.5 %) should be considered for better thinning results, e) Thinning applications combining Regalia and oil showed promising results, f) Natural fruit abscissions that occurred in the third week after bloom diluted the effect of most thinning treatments and g) thinning materials showed minimal impacts on the physical (fruit color, firmness, diameter and mass) and chemical (fruit starch index, titratable acidity, soluble solid content and pH) properties of the 'Honeycrisp' and 'Pink Lady' apples.

Table 1: Blossom thinning materials applied to 'Honeycrisp' and 'Pink Lady' trees in 2018.

Treatments	Supplier	Rate/ Gallon
Control (No thinning treatment)		0
1 % ammonium thiosulfate (ATS)	SimgmaAldrich	38 g/gal
0.5% potassium thiosulfate (KTS)	SimgmaAldrich	19 g/ gal
1% Regalia	Marrone Bio-Innovations	1.28 fl oz/gal
1 % JMS Stylet Oil	JMS FlowerFarms, Inc.	1.28 fl oz/gal
1% Rex Lime Sulfur	OR-CAL, Inc.	1.28 fl oz/gal
1% Lime-Sulfur Solution	NovaSource	1.28 fl oz/gal
Potassium bicarbonate (6 kg/ acre)	GreenCure	60 g/gal
1% ammonium thiosulfate + 1% JMS Stylet Oil	SimgmaAldrich + JMS FlowerFarms, Inc.	38 g/gal 1.28 fl oz/gal
0.5% potassium thiosulfate + 1% JMS Stylet Oil	SimgmaAldrich + JMS FlowerFarms, Inc.	19 g/ gal 1.28 fl oz/gal
1% Regalia + 1% JMS Stylet Oil	Marrone Bio-Innovations + JMS FlowerFarms, Inc.	1.28 fl oz/gal 1.28 fl oz/gal
1 % Rex Lime Sulfur + 1% JMS Stylet Oil	OR-CAL, Inc. + JMS FlowerFarms, Inc.	1.28 fl oz/gal 1.28 fl oz/gal
Potassium Bicarbonate (6 kg/acre) + 1% JMS Stylet Oil	GreenCure + JMS FlowerFarms, Inc.	60 g/gal 1.28 fl oz/gal
1% LLS + 1% JMS Stylet Oil	NovaSource + JMS FlowerFarms, Inc.	1.28 fl oz/gal 1.28 fl oz/gal

Table 2: The effect of blossom thinning materials on fruit set (%) and crop load (fruit/ cm^2 TCSA) of 'Honeycrisp' apples

Treatments /Honeycrisp	Rate (per gal)	Timing Fist spray, Second spray	Fruit set (%) Initial count	Second count	Pre-June drop	Crop load at harvest (fruit/TCSA)	Damaged fruit at harvest (no.)
			(5/14)	(5/31)	(6/8)	(8/20)	(8/20)
Untreated Control	-	-	40.3 a	14.8 a	14.8 a	10.0 ab	0 a
1% Sigma ATS	38 g	30 Apr, 2 May	32.2 a	7.3 ab	5.6 a-c	11.4 a	0 a
0.5% Sigma KTS	19 g	30 Apr, 2 May	31.7 a	8.2 ab	7.9 a-c	14.2 a	0 a
1% Regalia	1.28 fl oz	30 Apr, 2 May	37.5 a	11.4 ab	11.3 ab	10.7 ab	1.3 a-c
1% JMS Stylet Oil	1.28 fl oz	30 Apr, 2 May	26.0 a	7.4 ab	6.4 a-c	9.8 ab	0 a
1% Rex Lime Sulfur	1.28 fl oz	30 Apr, 2 May	33.1 a	6.4 ab	5.3 a-c	9.9 ab	0.3 a
1% NOVA-Liquid Lime Sulfur	1.28 fl oz	30 Apr, 2 May	30.8 a	4.5 ab	4.5 a-c	11.3 a	0 a
Potassium Bicarbonate 6 kg/A	60 g	30 Apr, 2 May	19.7 a	3.7 b	3.6 bc	5.5 ab	3.7 bc
1% Sigma ATS + 1% JMS Stylet Oil	38 g 1.28 fl oz	30 Apr, 2 May	16.8 a	8.3 ab	7.8 a-c	11.4 a	0.3 a
0.5% Sigma KTS + 1% JMS Stylet Oil	19g 1.28 fl oz	30 Apr, 2 May	30.1 a	8.8 ab	8.6 a-c	8.7 ab	1.0 ab
1% Regalia + 1% JMS Stylet Oil	1.28 fl oz 1.28 fl oz	30 Apr, 2 May	38.4 a	10.9 ab	9.9 a-c	9.8 ab	0 a
1% Rex Lime Sulfur + 1% JMS Stylet Oil	1.28 fl oz 1.28 fl oz	30 Apr, 2 May	31.3 a	9.5 ab	8.4 a-c	7.8 ab	0.3 a
Potassium Bicarbonate 6 kg/A + 1% JMS Stylet Oil	60g 1.28 fl oz	30 Apr, 2 May	10.0 a	0.8 b	0.8 c	1.5 b	4.0 c
1% NOVA-Liquid Lime Sulfur + 1% JMS Stylet Oil	1.28 fl oz 1.28 fl oz	30 Apr, 2 May	26.2 a	4.3 ab	4.3 bc	8.0 ab	0 a

Table 3: Physical and chemical properties of 'Honeycrisp' apples after different thinning treatments.

Treatments/ Honeycrisp	Fruit firmness (lbs.)[x]	Fruit diam. (mm)	Fruit wt. (g)	Starch (1-8)	DA index (I_{AD})	pH[y]	Soluble solids (°Brix)	TA (g/L)
Untreated Control	14.4 c	79.3 a	193.9 a	5.3 ab	0.8 a	3.4 a	12.0 b	5.9 b
1% Sigma ATS	15.4 bc	81.2 a	216.2 a	5.3 ab	0.6 a	3.4 a	12.9 ab	5.7 b
0.5% Sigma KTS	15.6 bc	77.5 a	185.9 a	5.4 ab	0.6 a	3.4 a	13.0 ab	6.0 b
1% Regalia	15.7 bc	81.3 a	213.9 a	5.1 ab	0.7 a	3.4 a	13.0 ab	5.6 b
1% JMS Stylet Oil	15.4 bc	80.2 a	209.7 a	5.5 ab	0.6 a	3.3 a	13.0 ab	6.0 b
1% Rex Lime Sulfur	15.0 bc	78.0 a	192.8 a	4.4 ab	0.6 a	3.4 a	12.9 ab	5.9 b
Potassium Bicarbonate 6 kg/A	17.1 ab	79.6 a	204.3 a	3.2 b	0.6 a	3.4 a	13.9 ab	7.6 ab
1% Sigma ATS + 1% JMS Stylet Oil	16.1 bc	78.5 a	203.8 a	4.3 ab	0.8 a	3.3 a	12.8 ab	6.8 ab
0.5% Sigma KTS + 1% JMS Stylet Oil	15.6 bc	78.3 a	188.9 a	4.0 ab	0.7 a	3.4 a	13.0 ab	6.6 b
1% Regalia + 1% JMS Stylet Oil	15.4 bc	79.5 a	196.5 a	5.9 a	0.7 a	3.4 a	12.5 ab	5.9 b
1% Rex Lime Sulfur + 1% JMS Stylet Oil	15.6 bc	80.8 a	212.5 a	4.7 ab	0.7 a	3.4 a	12.6 ab	6.2 b
Potassium Bicarbonate 6 kg/A + 1% JMS Stylet Oil	18.3 a	81.7 a	223.8 a	4.0 ab	0.9 a	3.3 a	14.5 a	8.8 a
1% NOVA-Liquid Lime Sulfur	16.1 bc	76.4 a	181.3 a	4.4 ab	0.7 a	3.3 a	12.9 ab	6.1 b
1% NOVA-Liquid Lime Sulfur + 1% JMS Stylet Oil	16.3 a-c	76.8 a	183.3 a	4.5 ab	0.6 a	3.4 a	13.4 ab	6.0 b

Table 4: The effect of blossom thinning materials on fruit set (%) of 'Pink Lady' apples.

Treatments/Pink Lady	Timing Fist spray, Second spray	Fruit set (%) Initial count (5/14)	Second count (5/31)	Pre-June drop (6/8)	Fruit Set (%) at harvest (10/17)	Damaged fruit at harvest (%) (10/17)
Untreated Control	-	28.85a	21.80a	20.85a	15.88a	0b
% Rex Lime Sulfur	28 Apr, 1 May	18.42a	14.01a	13.55a	12.10a	1b
1% JMS Stylet Oil	28 Apr, 1 May	23.31a	18.81a	18.15a	14.71a	0b
1% Sigma ATS	28 Apr, 1 May	18.52a	16.56a	15.68a	11.87a	0b
Potassium Bicarbonate 6 kg/A	28 Apr, 1 May	23.39a	17.85a	17.03a	13.54a	7b
0.5% Sigma KTS	28 Apr, 1 May	25.53a	20.49a	19.59a	14.92a	0b
1% Regalia	28 Apr, 1 May	27.12a	19.30a	19.30a	13.39a	0b
1% NOVA-Liquid Lime Sulfur	28 Apr, 1 May	16.29a	11.50a	10.61a	8.34a	0b
1% Rex LS + 1% JMS Oil	28 Apr, 1 May	21.58a	17.52a	16.11a	12.08a	0b
1 % ATS + 1% JMS Oil	28 Apr, 1 May	22.84a	14.50a	13.92a	11.88a	0b
1% Regalia + 1% JMS Oil	28 Apr, 1 May	19.12a	15.62a	14.67a	8.93a	0b
Potassium Bicarbonate 6 kg/A + 1% JMS Stylet Oil	28 Apr, 1 May	17.55a	8.01a	7.39a	6.48a	63a
0.5% Sigma KTS + 1% JMS Stylet Oil	28 Apr, 1 May	30.68a	22.07a	21.13a	18.49a	0b
1% NOVA-Liquid Lime Sulfur + 1% JMS Stylet Oil	28 Apr, 1 May	10.76a	7.07a	6.51a	4.88a	0b

Table 5: Physical and chemical properties of 'Pink Lady' apples after different thinning treatments.

Treatments/ Pink Lady	Color delta A (I_{AD})	Firmness (lbs)	Diameter (mm)	Mass (g)	Starch (1-8)	SSC (Brix)	TA (g/L)	pH
Untreated Control	0.6a	21.0ab	67.6a	140.7a	3.1a	13.2a	6.2c	3.47a
1% Sigma ATS	0.6a	22.4ab	66.2a	136.3a	3.6a	13.9a	11.6ab	3.40a-c
0.5% Sigma KTS	0.8a	22.0ab	69.3a	152.7a	3.1a	15.4a	10.5ab	3.42ab
1% Regalia	0.6a	22.8ab	68.9a	148.8a	2.4a	14.6a	11.4ab	3.41a-c
1% JMS Stylet Oil	0.8a	21.5ab	68.4a	145.1a	3.0a	14.3a	10.9ab	3.41a-c
1% Rex Lime Sulfur	0.6a	22.1ab	69.4a	156.0a	3.1a	16.6a	13.1a	3.38bc
Potassium Bicarbonate 6 kg/A	0.9a	21.4ab	68.9a	147.5a	3.0a	14.0a	9.4a-c	3.39a-c
1% Sigma ATS + 1% JMS Stylet Oil	0.7a	20.6ab	67.6a	142.6a	2.9a	15.9a	9.5a-c	3.43ab
0.5% Sigma KTS + 1% JMS Stylet Oil	0.7a	21.6ab	66.6a	133.9a	3.3a	13.5a	10.0a-c	3.41ab
1% Regalia + 1% JMS Stylet Oil	0.7a	21.7ab	66.1a	130.0a	3.1a	15.7a	8.3bc	3.42ab
1% Rex Lime Sulfur + 1% JMS Stylet Oil	0.6a	23.4a	67.7a	148.9a	2.9a	16.6a	11.3ab	3.39bc
Potassium Bicarbonate 6 kg/A + 1% JMS Stylet Oil	0.8a	20.6ab	72.4a	171.3a	3.0a	14.5a	11.6ab	3.36bc
1% NOVA-Liquid Lime Sulfur	0.7a	21.6ab	70.5a	157.3a	2.8a	12.5a	9.6a-c	3.40a-c
1% NOVA-Liquid Lime Sulfur + 1% JMS Stylet Oil	0.6a	22.1ab	67.6a	142.0a	2.5a	14.3a	12.5a	3.33c

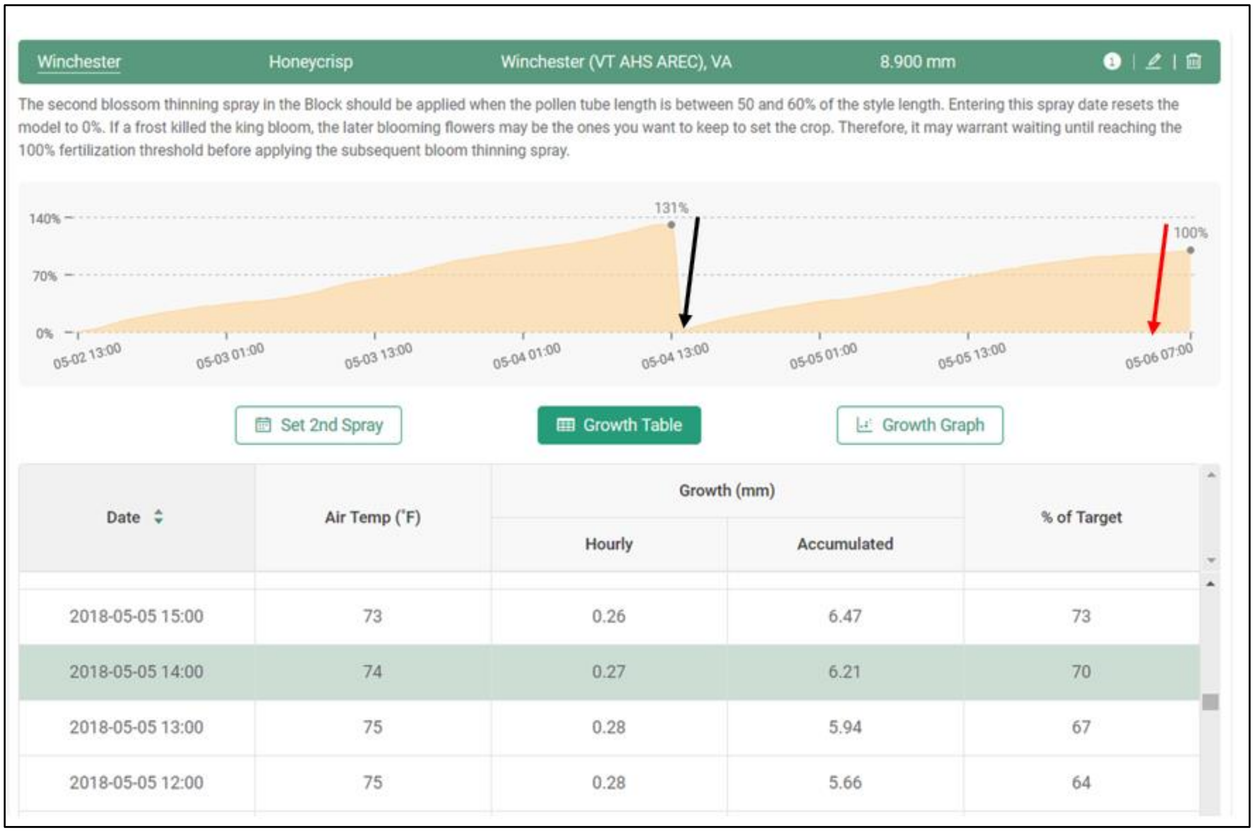

Figure 1: The timing of first and second blossom thinning applications as determined by the PTGM on NEWA website. The black arrow refers to the time of the fist thinning application (100% pollen tube growth), and the red arrow refers to the time of the second thinning application).

PLANT PATHOLOGY

POST-INFECTION PREVENTION OF FIRE BLIGHT CANKERS WITH APOGEE AND APPLE SCAB MANAGEMENT WITH REVYSOL®

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Due to climate change driven possibilities for more frequent early spring weather conditions to favoring fire blight epidemics. we predict that more poorly managed fire blight outbreaks will occur in the cooler regions of Northern U.S. Evaluation of post-infection options for fire blight management used to preserve high-density apple orchards after infection is the top priority for all apple growers in New York.

In a second year repetition of a spray trial with 14 unique treatments applied after shoot inoculations (1-2" size), with different rates and timings of Apogee, used alone or in mix with Regulaid and/or Actigard, we found significant shoot blight severity control on trees treated with 2 X 6 oz Apogee + Regulaid 32 fl oz (50.8%), 2 X 6 oz Apogee + Actigard 2 oz/A + Regulaid 32 fl oz (62.6%), 3 X 6 oz Apogee + Actigard 2 oz/A (72%), 2 X Apogee 12 oz (78.8%) and 1 X Apogee 2 oz (89.5%). We also found significant reduction in percent of canker development and length on perennial branches from the inoculated shoots with 2 X and 1 X Apogee 12oz/100 gal (66.5 - 100%), which can serve as significant inoculum sources for disease renewal. Apple scab can cause up to 100% fruit losses if protective fungicide sprays are not applied. We evaluated efficacy of mefentrifluconazole (Revysol®) a new FRAC 3 i.e. DMI fungicide and compared it to other DMI (Inspire Super, Rally, Rhyme, Indar) and SDHI fungicides (Sercadis, Aprovia, Luna Sensation, Luna Tranquility). The spray trial programs started at tight cluster (TC) and were evaluated under high- pressure disease conditions in 2018.

In 2018, control of apple leaf scab on Jersey Mac was excellent with all the DMI and SDHI fungicide programs, except for Rhyme and Rally. Similar efficacy was recorded on Jersey Mac fruit. Overall, Redcort expressed more leaf scab in comparison to the other two cultivars. All programs showed significant scab control in comparison to the untreated control and Captan covers. Revysol 4 oz and Rhyme allowed more leaf scab to develop in comparison to the other fungicide programs since mancozeb applied at TC at 1.5 lb/A at HIG was too low of a rate to protect the growth from the first two major infections on 25 and 27 April. A contributing factor was a larger green tissue area in Redcort that was targeted by ascospores during these first two infections, as this cultivar unusually preceded both Jersey Mac and Golden Delicious in flower bud development. On 27 April Redcort was at 73% HIG and Jersey Mac at 53% HIG. Fruit scab control on Redcort was excellent in all fungicide programs, except with Rhyme and Rally. Leaf scab control was excellent on Golden Delicious, except in Rhyme and Rally treatments and with slightly more scab developing in Revysol 4 and 5 oz used alone. Fruit scab control on Golden Delicious was excellent with all the DMI and SDHI fungicides. Inspire Super used alone or in mix with Manzate performed very well on all the cultivars, except on Redcort leaves where Inspire Super used alone allowed more scab to establish.

INVESTIGATION OF LATE-SEASON BUNCH ROT AND EFFICACY TRIALS FOR RIPE ROT CONTROL IN MARYLAND VINEYARDS

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Introduction

Late-season bunch rot (LSBR) refers to a variety of bunch rots caused by multiple fungal pathogens and other biotic factors (e.g. insects and bacteria). The issues often occur close to harvest, affecting nearly all varieties grown in Maryland and neighboring states. Examples of LSBRs are *Botrytis* bunch rot (*Botrytis cinerea*), sour rot (disease complex), bitter rot (*Greeneria uvicola*), ripe rot (*Colletotrichum* spp.), and *Cladosporium* rot (*Cladosporium* spp.). Among these LSBRs, ripe rot has been a rising issue and probably a major concern to grape growers. The control of LSBRs largely relies on chemical applications. The objectives of this study were to identify the pathogens causing LSBR in multiple Maryland vineyards and to assess fungicidal products and application timing for ripe rot control.

Materials and Methods

To identify pathogens responsible for LSBRs in the 2018 season, six vineyards within Maryland were sampled for rotten fruit close to harvest. If the fungi were sporulating from the fruit, spores were plated directly onto potato dextrose agar (PDA). If no sporulation was visible, fruit were surface sterilized in 1% sodium hypochlorite for one minute, rinsed in sterile deionized water, then allowed to dry in a laminar flow hood. Small pieces of rotten fruit skin were then plated onto PDA for incubation at 25 °C in darkness. Fungal mycelia recovered from the plates were then transferred to fresh PDA plates to obtain pure cultures. All fungal isolates were identified using both morphological and molecular characteristics.

Previous studies have suggested that grapevines are most susceptible to disease infections during flowering and fruiting stages. The primary purpose of the ripe rot efficacy trial was to evaluate whether targeting the early-season (flowering to veraison) or the late-season (veraison to harvest) is more critical for managing ripe rot. Fungicides with efficacy against *Colletotrichum* (based on in vitro assays or data from previous trials) were applied at early- and/or late-season (Table 1). This trial took place in a commercial vineyard in Maryland in blocks planted with the cultivars ‘Cabernet Franc’, ‘Cabernet Sauvignon’, and ‘Merlot’. One week prior to harvest, disease severity of 160 clusters (40 x 4 replicates) per treatment was assessed as the percentage of cluster symptomatic of ripe rot. In addition, a treatment of the grower standard plus LifeGard®, a biological plant defense activator, was included to assess the efficacy of this product.

Table 1. Ripe rot fungicide efficacy trial treatments.

Appl. Date	Grower standard	Early season	Late season	Early + Late season	Grower standard + LifeGard
29 May	Captan	Captan	Captan	Captan	Captan + *LifeGard*
6 June	Luna Exp	**Inspire Super**	Luna Exp	**Inspire Super**	Luna Exp + *LifeGard*
21 June	Captan	Captan + **Approvia Top**	Captan	Captan + **Approvia**	Captan + *LifeGard*
17 July	Captan	Captan	Captan	Captan	Captan + *LifeGard*
26 July	Captan	Captan	Captan	Captan	Captan
14 Aug	Captan	Captan	Captan + **Aprovia Top**	Captan + **Aprovia**	Captan
30 Aug	Vanguard	Vanguard	**Inspire Super**	**Inspire Super**	Vanguard
12 Sept	Captan	Captan	**Switch**	**Switch**	Captan

Results

Multiple fungi were isolated from grape clusters symptomatic of late season rot. The six most frequently isolated fungi were *B. cinerea, Colletotrichum* spp., *A. japonicus, A. alternata, Fusarium* spp., and *Pestalotiopsis* spp., with 127, 72, 13, 11, 10, and 9 isolates of each, respectively. Vineyards were diverse with their associated pathogens, with multiple pathogens being isolated from some vineyards, while only a single pathogen was isolated from others.

High levels of ripe rot were observed in the efficacy trial plots. The severity of ripe rot did not drastically change between treatments, however there was a large difference between cultivars (Figure 1). Over all cultivars, the treatments late season and early + late season had lower severity than the grower standard and the early season treatments. Compared to the grower standard, the treatment containing Lifegard had more severe ripe rot in 'Cabernet Sauvignon', but less in 'Cab Franc' and 'Merlot'.

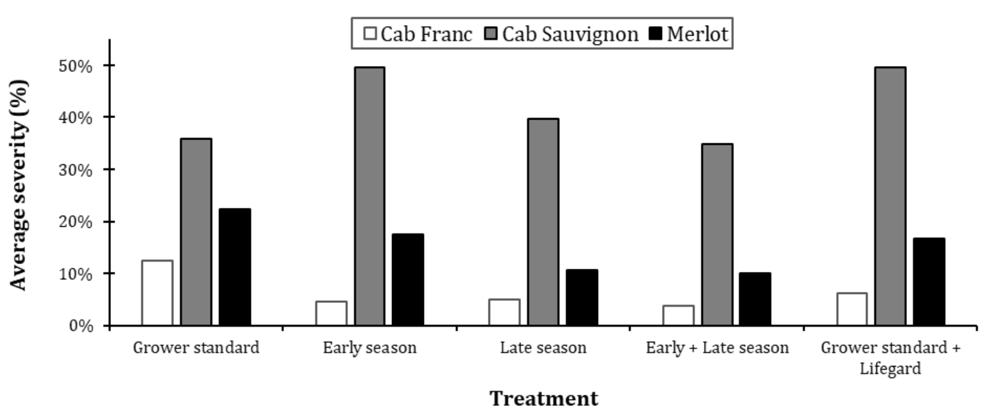

Figure 1. Disease severity evaluated as percentage of grape cluster infected with ripe rot among three cultivars of *Vitis vinifera*.

Discussion

From the LSR survey of rotten grape clusters from Maryland vineyards, multiple pathogens were isolated. By far, *Colletotrichum* spp. and *B. cinerea* were isolated the most frequently, indicating that these are the two most important LSR pathogens in the Mid-Atlantic. The other pathogens are considered to be secondary pathogens, yet their role in LSRs and their pathogenicity potential is not fully understood. Pathogen prevalence was diverse amongst different vineyards, which may be due to differential levels of specific pathogen inoculum, variable harvest dates, or diverse spray programs.

The fungicide efficacy trial demonstrated that a warm and wet period just before harvest can be highly favorable for ripe rot. On average, ‘Cabernet Sauvignon’ had the highest severity of ripe rot, however this may not indicate that this cultivar was more susceptible than others. Fruit maturity has a large effect on disease susceptibility, and at the time of evaluation not all cultivars were at the same maturity. The treatment containing Lifegard had mixed results, however this product has been shown to be effective in other cropping systems. Despite the treatment or cultivar, ripe rot was always present and at a level that could be economically damaging to the grower, and is likely a result of the immense disease pressure in the 2018 season. The results indicate that the late season is the most critical time for ripe rot management. Further research on infection conditions and timing and fungicide sensitivity may provide more insight into ripe rot management.

EVALUATION OF EXPERIMENTAL AND REGISTERED FUNGICIDES FOR MANAGEMENT OF PEACH DISEASES

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The main objective of this field study was to determine and compare the efficacy of several registered and experimental fungicides for management of the fruit rot phase of brown rot. The current available fungicides of interest, which contain SDHI and QoI active ingredients, were Merivon (fluxapyroxad + pyraclostrobin) and Luna Sensation (fluopyram + trifloxystrobin). Efficacy of the SDHI fungicide Fontelis (penthiopyrad), in alternation with the DMI fungicide Indar (fenbuconazole), was also of interest.

Two experimental fungicides, BAS 750 and BAS 752, were also evaluated in the study for management of fruit rot during the preharvest period. BAS 750 has the DMI fungicide revysol as its active ingredient, and was examined in alternation with Merivon. BAS 752, a mixture of revysol and fluxapyroxad, was examined alone, but also in alternation with the QoI fungicide Gem (trifloxystrobin). Finally, a three-chemistry preharvest program consisting of the single active fungicides Gem, Indar, and Fontelis was included for comparison.

A secondary objective was to examine the efficacy of BAS 750, BAS 752, and Luna Sensation applied during the bloom period for management of blossom blight. These materials were alternated with the dicarboximide fungicide Rovral (iprodione). A standard program for blossom blight control was also included, which consisted of the AP fungicide Vangard (cyprodinil) at pink stage followed by Rovral at bloom and petal fall stages.

The third and final objective was to examine BAS 750 and BAS 752 for their ability to manage peach rusty spot, a powdery mildew disease. The apple powdery mildew pathogen *Podosphaera leucotricha* is a known causal agent of rusty spot, although other powdery mildews may also be implicated. The proper timing for control consists of four applications from petal fall through second cover. A standard consisting of the DMI fungicide Rally (myclobutanil) was included for comparison.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2018 growing season. The test block consisted of a 22-year-old 'Encore' 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. To avoid interaction with blossom treatments, a bud-swell application for leaf curl control was not applied; no leaf curl was observed. 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. Rusty spot (*Podosphaera leucotricha*) was evaluated on 20 June by examining 25 fruit per tree. Blossom blight canker (*Monilinia fructicola*) was evaluated on 26-27 June by examining 20 shoots per tree. Scab (*Fusicladium carpophilum*) was evaluated on 21-22 Aug by examining 25 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 10 Sep by examining 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 (Ave: 75°F; Min: 65°F; Max: 85°F). Brown rot and other rots were evaluated at 4- and 7-days postharvest (DPH).

Weather Data. Air temperature 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. Average daily temperatures throughout April were mostly in the 40s and 50s, which were not conducive to both rusty spot and blossom blight disease development (Table 1). This cold weather slowed development of the trees and delayed progression of the epidemics. Typically, shortened epidemics result in lower disease incidence and severity. Somewhat warmer temperatures occurred in early May between PF and SS, but little rain occurred at this time to trigger flower infections. Although conditions were not favorable for disease development early in the season, slight above-average temperatures in June, July, and August were favorable for fruit rot development later in the season (Table 2).

Rainfall totals in 2018 were slightly above normal in April and July and below normal in June and August (Table 2). However, the May rainfall total was 1.5 times greater than the 30-year mean for the month. These rains were fairly frequent throughout the month and, combined with the warmer temperatures, would have provided ample conditions for green fruit infection as well as latent infection by *M. fructicola* prior to pit-hardening (~ mid-June). During the month of May and into early June, eight infection periods having ≥ 0.10 in rainfall were recorded between SS and 1C; two periods between 1C and 2C; and five periods between 2C and 3C (Table 1).

During the preharvest fruit ripening period from 20 Aug through harvest on 10 Sep, only 1 rain period (≥ 0.10 in) occurred between the 21-dph and 12-dph sprays, and between the 12-dph and 4-dph sprays (Table 1). However, 3 rain periods, totaling 4.29 inches, occurred between the final 4-dph spray and harvest. These rainfalls, combined with the high temperatures during this period, provided favorable conditions for brown rot development on fruit. The 0.59 in rainfall on 10 Sep occurred after harvest.

Blossom Blight. Blossom blight disease pressure in the test block was at a near-record low level in 2018. Only 6.3% of non-treated shoots had at least one canker, with an average of 0.06 cankers per shoot (Table 3). The below average cooler conditions in April were most likely the cause for the low disease level; plenty of overwintering mummies were present to provide inoculum.

Given the low disease pressure, only treatments of interest were evaluated (Table 3). The BAS 750 (3), BAS 752 (4), and both Luna Sensation (11, 12) treatments provided control equivalent to the standards (2, 5). However, although disease incidence and severity of these treatments were less than that observed on the non-treated control, none of these treatments had significantly less disease than the control.

In comparison to the low 2018 disease levels, past blossom blight canker incidences on control trees in this same Encore block were 10, 24, 15, 88, 26, 19, 68, 13, and 5% from 2009 through 2017, respectively.

Rusty Spot. On non-treated control trees, only 6% of fruit had rusty spot with an average severity of 0.07 lesions per fruit (Table 4). This low disease pressure was most likely due to the effect of low April temperatures on plant growth. Fruit development was approximately two weeks behind normal, which tends to shorten rusty spot epidemics. In past studies, the moderately susceptible 'Encore' fruit in this block averaged 34% rusty spot fruit infection.

All fungicide treatments had disease incidence and severity levels that were numerically lower than the control (Table 4). However, as expected under low disease pressure, none of the treatments were significantly different from each other or from the non-treated control.

Scab. Conditions were moderately favorable for scab development in 2018. Non-treated trees had 35% infected fruit with 23% of these fruit having 10 or more lesions (Table 5).

The study was not set up for a scab evaluation. Thus, the standard program consisting of Captan at SS followed by Captan cover sprays was employed in all treatments. Most treatments significantly reduced scab incidence and severity (> 10 lesions) and were not different from each other (Table 5). The level of scab control varied from 80 to 100%, excluding trt 10. This latter treatment had one replicate with an unusually high disease incidence level of 68% versus only 5% across the remaining three replicates.

The BAS 750 (3) and BAS 752 (4) treatments included these materials at the critical SS, 1C, and 2C application timings (for rusty spot control). However, these treatments did not have significantly less scab than most other treatments, perhaps because the captan alone was providing sufficient control (Table 5). Nevertheless, it may be worth noting that BAS 750 treatment 3 was the one that provided 100% control.

Brown Rot. Brown rot disease pressure was initially low during the preharvest fruit ripening period, the time when fruit are most susceptible. Only 14% of fruit were infected at harvest (Table 6). In comparison, the 2017 disease incidence at harvest in this block was 31%. This outcome was most likely due to the low frequency of rainfall between the first (21-dph) and final (4-dph) sprays; only two rain periods, 0.94 and 0.12 inches, occurred (Table 1). However, the three rain periods that occurred during the four days between the final spray and harvest provided ample opportunity for infection that appeared in the post-harvest evaluation. At 4-DPH, 58% of non-treated fruit were infected, which increased rapidly to 89% incidence by 7-DPH (Table 6).

All treatment programs significantly reduced brown rot incidence at harvest and at both post-harvest assessments (Table 6). Overall, the treatment with the lowest disease levels across all three assessments was the Merivon / Merivon / Merivon program (5). This program provided 82%, 93%, and 85% control at harvest, 4-DPH, and 7-DPH, respectively. Conversely, the treatment with the highest disease levels was the Gem / BAS 752 / Gem program (9), which yielded only 61%, 45%, and 26% control, respectively.

No significant differences in brown rot were observed at harvest or at 4-DPH between the Merivon / Merivon / Merivon (5), BAS 750 / Merivon / BAS 750 (6), and Merivon / BAS 750 / Merivon (7) treatments (Table 6). However, under higher disease pressure at 7-DPH, treatment 6 had significantly more rot that the solid Merivon (5) program. This outcome indicates that BAS 750 may be less effective than Merivon. Note that treatment 7, which contains only one BAS 750 application, was not significantly different from the solid Merivon program (5).

The Gem / BAS 752 / Gem (9) program had significantly more rot at harvest than the BAS 752 / Gem / BAS 752 (8) program, but was equivalent to the solid BAS 752 program (10) (Table 6). However, at both post-harvest assessments, treatment 9 had significantly more rot than both treatments 8 and 10. The lower efficacy of treatment 9 was most likely due to the lower efficacy of Gem, which is rated as good to very good. Note the other QoI fungicide available on stone fruit, Abound, is also rated similarly. Thus, treatment 8 is preferable to treatment 9 for implementation of a BAS 752 based preharvest program.

The high rate Luna Sensation / Indar / Luna Sensation program (12) had numerically lower disease levels than the low rate program (11) for all three assessments (Table 6). However, the difference between these two treatments was not great enough to be significant. Both of these Luna Sensation programs provided control equivalent to the similar (in terms of chemistries) Merivon / BAS 750 / Merivon program (7) for the harvest and 4-DPH assessments. At these evaluations, the low Luna Sensation treatment (11) yielded 84% and 78% control, while the Merivon / BAS 750 / Merivon treatment (7) provided 71% and 86% control, respectively. Under higher disease pressure at 7-DPH, treatment 7 had significantly less rot than both treatments 11 and 12.

At harvest, the Indar / Fontelis / Indar (3) and Fontelis / Indar / Fontelis (4) programs provided 89% and 71% control of rot, respectively, and their disease levels were statistically equivalent to most other treatments (Table 6). However, at both post-harvest assessments, brown rot incidence was significantly higher for these two programs relative to most other treatments. At 4-DPH, both treatments yielded only 66% control, while at 7-DPH, only 43% and 35% control was observed.

Finally, the Gem / Indar / Fontelis program (2) employing single-active ingredients of all three chemistries performed reasonably well at harvest and at 4-DPH, providing 81% and 83% control, respectively (Table 6). At these two evaluations, the level of rot for this treatment was statistically equivalent to all other treatments except for treatment 9 at 4-DPH (which had significantly more disease). However, as observed for some other preharvest programs, disease control at 7-DPH was diminished; treatment 2 provided only 51% control at this time.

Rhizopus Rot. Little to no Rhizopus rot was observed at harvest or during the 4-DPH postharvest assessment (Table 7). Although rot levels increased to 13% on non-treated fruit by 7-DPH, no significant differences were observed among treatments. Nevertheless, low disease levels observed for treatments 2, 5, 9, 11, and 12 indicate that these programs may have some level of efficacy; further study is needed, preferably under higher disease pressure.

Other Rots. Anthracnose and *Phomopsis* or *Botryosphaeria* spp. fruit rots were observed during the harvest and postharvest assessments. Anthracnose incidence reached 5% by 7-DPH on non-treated fruit, but no significant differences were observed among treatments.

Reference

Burnett, A. L., Lalancette, N., and McFarland, K. A. 2010. Effect of QoI fungicides on colonization and sporulation of *Monilinia fructicola* on peach fruit and blossom blight cankers. Plant Dis. 94: 1000-1008.

Table 1. Weather and spray timings for 2018 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	52	0		1-May	61	0		1-Jun	76	0.36	2nd Cover
2-Apr	42	0.05		2-May	71	0	Petal Fall	2-Jun	76	0.09	
3-Apr	43	0.03		3-May	76	0		3-Jun	61	1.14	
4-Apr	54	0.02		4-May	77	0		4-Jun	63	0.21	
5-Apr	40	0		5-May	67	0		5-Jun	68	0.01	
6-Apr	50	0		6-May	62	0.09		6-Jun	64	0	
7-Apr	46	0		7-May	63	0		7-Jun	66	0	
8-Apr	39	0		8-May	62	0		8-Jun	70	0	
9-Apr	37	0		9-May	62	0		9-Jun	71	0.09	
10-Apr	42	0		10-May	64	0.10		10-Jun	67	0.13	
11-Apr	42	0		11-May	68	0	Shuck Split	11-Jun	60	0.61	
12-Apr	56	0	Pink	12-May	66	0.86		12-Jun	63	0	
13-Apr	68	0		13-May	57	1.05		13-Jun	72	0.05	
14-Apr	69	0		14-May	62	0.37		14-Jun	77	0	
15-Apr	44	0.43		15-May	73	1.07		15-Jun	70	0	3rd Cover
16-Apr	53	2.37		16-May	66	0.39		16-Jun	72	0	
17-Apr	43	0		17-May	63	0.28		17-Jun	76	0	
18-Apr	45	0		18-May	60	0.26		18-Jun	80	0	
19-Apr	48	0.01	Bloom	19-May	60	1.22		19-Jun	81	0	
20-Apr	45	0		20-May	75	0.02		20-Jun	75	0.01	
21-Apr	47	0		21-May	69	0		21-Jun	74	0	
22-Apr	51	0		22-May	64	0.23	1st Cover	22-Jun	68	0.16	
23-Apr	52	0		23-May	72	0		23-Jun	69	0.02	
24-Apr	54	0.08		24-May	71	0		24-Jun	79	0	
25-Apr	61	0.21		25-May	74	0		25-Jun	74	0	
26-Apr	58	0		26-May	80	0		26-Jun	70	0	
27-Apr	56	0.31		27-May	70	0.13		27-Jun	70	0	
28-Apr	59	0.11		28-May	62	0.03		28-Jun	81	0	
29-Apr	50	0.15		29-May	69	0		29-Jun	81	0	4th Cover
30-Apr	52	0		30-May	68	0		30-Jun	82	0	
				31-May	71	0.02					

Table 1 – continued –

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Jul	84	0		1-Aug	80	0.16		1-Sep	73	0	
2-Jul	83	0		2-Aug	80	0.38		2-Sep	76	0	
3-Jul	84	0		3-Aug	77	0.39		3-Sep	80	0	
4-Jul	82	0		4-Aug	78	0.06		4-Sep	82	0	
5-Jul	82	0		5-Aug	80	0		5-Sep	82	0	
6-Jul	80	0.06		6-Aug	80	0		6-Sep	83	0	4-dph
7-Jul	70	0		7-Aug	81	0.01		7-Sep	77	0.35	
8-Jul	70	0		8-Aug	81	0.01		8-Sep	68	1.57	
9-Jul	72	0		9-Aug	78	0.29	7th Cover	9-Sep	60	2.37	
10-Jul	79	0		10-Aug	79	0		10-Sep	65	0.59	Harvest
11-Jul	81	0		11-Aug	77	0.45					
12-Jul	76	0		12-Aug	76	0.21					
13-Jul	74	0	5th Cover	13-Aug	77	0.24					
14-Jul	76	0		14-Aug	73	0.26					
15-Jul	77	0.02		15-Aug	77	0					
16-Jul	82	0		16-Aug	79	0					
17-Jul	80	1.19		17-Aug	82	0					
18-Jul	77	0		18-Aug	79	0.22					
19-Jul	74	0		19-Aug	72	0.01					
20-Jul	73	0		20-Aug	71	0	21-dph				
21-Jul	69	1.35		21-Aug	74	0					
22-Jul	77	0.47		22-Aug	75	0.94					
23-Jul	79	0		23-Aug	70	0					
24-Jul	80	0.02		24-Aug	70	0					
25-Jul	76	0.74		25-Aug	70	0					
26-Jul	78	0.09		26-Aug	74	0					
27-Jul	75	0.77	6th Cover	27-Aug	80	0					
28-Jul	76	0.03		28-Aug	82	0					
29-Jul	74	0		29-Aug	83	0	12-dph				
30-Jul	70	0		30-Aug	82	0					
31-Jul	74	0.02		31-Aug	75	0.12					
								dph = days pre-harvest			

Table 2. Comparison of 2018 Monthly Temperature and Rainfall Data to 30-Year Means.

Month & Year	Average Temp (°F)	Total Rainfall (in)	# Rains ≥ 0.10 in
April 2018	50	3.77	6
April (30-year mean)	52	3.58	---
May 2018	67	6.12	11
May (30-year mean)	62	4.07	---
June 2018	72	2.88	6
June (30-year mean)	71	3.37	---
July 2018	77	4.76	5
July (30-year mean)	76	4.30	---
August 2018	77	3.75	11
August (30-year mean)	75	4.18	---

Table 3. Blossom Blight Canker Incidence and Severity [1]

	Treatment	Rate / A	Timing	% Shoots w. Canker [2]	# Cankers per Shoot [2]
1	Non-treated control	--------	--------	6.3 a	0.06 a
2	**Vangard 75WG** **Rovral 4F** **Rovral 4F + Rally 40WSP** Captan 80WDG + Rally 40WSP Captan 80WDG Gem 500SC Indar 2F Fontelis 1.67SC	**5 oz** **1.5 pt** **1.5 pt + 5 oz** 3 lb + 5 oz 3 lb 3.8 fl oz 9 fl oz 20 fl oz	**P** **B** **PF** SS, 1C, 2C 3C-7C 21 dph 12 dph 4 dph	1.3 a	0.01 a
3	**BAS 750 SC + Induce (PF only)** **Rovral 4F** Captan 80WDG + BAS 750 SC + Induce Captan 80WDG Indar 2F Fontelis 1.67SC	**5 fl oz + 16 fl oz** **1.5 pt** 3 lb + 5 fl oz + 16 fl oz 3 lb 9 fl oz 20 fl oz	**P, PF** **B** SS, 1C, 2C 3C-7C 21, 4 dph 12 dph	2.5 a	0.04 a
4	**BAS 752 SC + Induce (PF only)** **Rovral 4F** Captan 80WDG + BAS 752 SC + Induce Captan 80WDG Fontelis 1.67SC Indar 2F	**6 fl oz + 16 fl oz** **1.5 pt** 3 lb + 6 fl oz + 16 fl oz 3 lb 20 fl oz 9 fl oz	**P, PF** **B** SS, 1C, 2C 3C-7C 21, 4 dph 12 dph	2.5 a	0.05 a
5	**Vangard 75WG** **Rovral 4F** Captan 80WDG Merivon 4.18SC + Induce	**5 oz** **1.5 pt** 3 lb 5 fl oz + 16 fl oz	**P** **B, PF** SS, 1C – 7C 21, 12, 4 dph	2.5 a	0.03 a
6	**Vangard 75WG** **Rovral 4F** Captan 80WDG BAS 750 SC + Induce Merivon 4.18SC + Induce	**5 oz** **1.5 pt** 3 lb 5 fl oz + 16 fl oz 5 fl oz + 16 fl oz	**P** **B, PF** SS, 1C – 7C 21, 4 dph 12 dph	---	---
7	**Vangard 75WG** **Rovral 4F** Captan 80WDG Merivon 4.18SC + Induce BAS 750 SC + Induce	**5 oz** **1.5 pt** 3 lb 5 fl oz + 16 fl oz 5 fl oz + 16 fl oz	**P** **B, PF** SS, 1C – 7C 21, 4 dph 12 dph	---	---
8	**Vangard 75WG** **Rovral 4F** Captan 80WDG BAS 752 SC + Induce Gem 500 SC + Induce	**5 oz** **1.5 pt** 3 lb 6 fl oz + 16 fl oz 3.8 fl oz + 16 fl oz	**P** **B, PF** SS, 1C – 7C 21, 4 dph 12 dph	---	---
9	**Vangard 75WG** **Rovral 4F** Captan 80WDG Gem 500 SC + Induce BAS 752 SC + Induce	**5 oz** **1.5 pt** 3 lb 3.8 fl oz + 16 fl oz 6 fl oz + 16 fl oz	**P** **B, PF** SS, 1C – 7C 21, 4 dph 12 dph	---	---
10	**Vangard 75WG** **Rovral 4F** Captan 80WDG BAS 752 SC + Induce	**5 oz** **1.5 pt** 3 lb 6 fl oz + 16 fl oz	**P** **B, PF** SS, 1C – 7C 21, 12, 4 dph	---	---
11	**Luna Sensation 4.2F** **Rovral 4F** Captan 80WDG Luna Sensation 4.2F Indar 2F	**5 fl oz** **1.5 pt** 3 lb 5 fl oz 9 fl oz	**P, PF** **B** SS, 1C–7C 21, 4 dph 12 dph	3.8 a	0.04 a
12	**Luna Sensation 4.2F** **Rovral 4F** Captan 80WDG Luna Sensation 4.2F Indar 2F	**7.6 fl oz** **1.5 pt** 3 lb 7.6 fl oz 9 fl oz	**P, PF** **B** SS, 1C–7C 21, 4 dph 12 dph	2.5 a	0.03 a

[1] Blossom blight 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).

Table 4. Rusty Spot Incidence and Severity[1]					
Treatment		**Rate / A**	**Timing**	**% Infected Fruit[2]**	**# Lesions per Fruit[2]**
1	Non-treated control	--------	--------	6.0 a	0.07 a
2	Vangard 75WG Rovral 4F Rovral 4F + **Rally 40WSP** Captan 80WDG + **Rally 40WSP** Captan 80WDG Gem 500SC Indar 2F Fontelis 1.67SC	5 oz 1.5 pt 1.5 pt + **5 oz** 3 lb + **5 oz** 3 lb 3.8 fl oz 9 fl oz 20 fl oz	P B **PF** **SS, 1C, 2C** 3C-7C 21 dph 12 dph 4 dph	1.0 a	0.01 a
3	**BAS 750 SC + Induce (PF only)** Rovral 4F **Captan 80WDG + BAS 750 SC + Induce** Captan 80WDG Indar 2F Fontelis 1.67SC	**5 fl oz + 16 fl oz** 1.5 pt **3 lb + 5 fl oz + 16 fl oz** 3 lb 9 fl oz 20 fl oz	P, **PF** B **SS, 1C, 2C** 3C-7C 21, 4 dph 12 dph	2.0 a	0.02 a
4	**BAS 752 SC + Induce (PF only)** Rovral 4F **Captan 80WDG + BAS 752 SC + Induce** Captan 80WDG Fontelis 1.67SC Indar 2F	**6 fl oz + 16 fl oz** 1.5 pt **3 lb + 6 fl oz + 16 fl oz** 3 lb 20 fl oz 9 fl oz	P, **PF** B **SS, 1C, 2C** 3C-7C 21, 4 dph 12 dph	1.0 a	0.01 a
5	Vangard 75WG **Rovral 4F** **Captan 80WDG** Merivon 4.18SC + Induce	5 oz **1.5 pt** **3 lb** 5 fl oz + 16 fl oz	P B, **PF** **SS, 1C, 2C** – 7C 21, 12, 4 dph	4.0 a	0.04 a
6	Vangard 75WG **Rovral 4F** **Captan 80WDG** BAS 750 SC + Induce Merivon 4.18SC + Induce	5 oz **1.5 pt** **3 lb** 5 fl oz + 16 fl oz 5 fl oz + 16 fl oz	P B, **PF** **SS, 1C, 2C** – 7C 21, 4 dph 12 dph	3.0 a	0.03 a
7	Vangard 75WG **Rovral 4F** **Captan 80WDG** Merivon 4.18SC + Induce BAS 750 SC + Induce	5 oz **1.5 pt** **3 lb** 5 fl oz + 16 fl oz 5 fl oz + 16 fl oz	P B, **PF** **SS, 1C, 2C** – 7C 21, 4 dph 12 dph	3.0 a	0.03 a
8	Vangard 75WG **Rovral 4F** **Captan 80WDG** BAS 752 SC + Induce Gem 500 SC + Induce	5 oz **1.5 pt** **3 lb** 6 fl oz + 16 fl oz 3.8 fl oz + 16 fl oz	P B**, PF** **SS, 1C, 2C** – 7C 21, 4 dph 12 dph	2.0 a	0.02 a
9	Vangard 75WG **Rovral 4F** **Captan 80WDG** Gem 500 SC + Induce BAS 752 SC + Induce	5 oz **1.5 pt** **3 lb** 3.8 fl oz + 16 fl oz 6 fl oz + 16 fl oz	P B, **PF** **SS, 1C, 2C** – 7C 21, 4 dph 12 dph	3.0 a	0.03 a
10	Vangard 75WG **Rovral 4F** **Captan 80WDG** BAS 752 SC + Induce	5 oz **1.5 pt** **3 lb** 6 fl oz + 16 fl oz	P B, **PF** **SS, 1C, 2C** – 7C 21, 12, 4 dph	3.0 a	0.03 a
11	**Luna Sensation 4.2F** Rovral 4F **Captan 80WDG** Luna Sensation 4.2F Indar 2F	**5 fl oz** 1.5 pt **3 lb** 5 fl oz 9 fl oz	P, **PF** B **SS, 1C, 2C**–7C 21, 4 dph 12 dph	2.0 a	0.02 a
12	**Luna Sensation 4.2F** Rovral 4F **Captan 80WDG** Luna Sensation 4.2F Indar 2F	7.6 fl oz 1.5 pt **3 lb** 7.6 fl oz 9 fl oz	P, **PF** B **SS, 1C, 2C**–7C 21, 4 dph 12 dph	1.0 a	0.01 a

[1] Rusty spot 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).

Table 5. Scab Incidence and Severity[1]

	Treatment	Rate / A	Timing	% Inf Fruit[2]	% Fruit 1-10 Les[2]	% Fruit >10 Les[2]
1	Non-treated control	--------	--------	35.0 a	12.0 a	23.0 a
2	Vangard 75WG Rovral 4F Rovral 4F + Rally 40WSP **Captan 80WDG + Rally 40WSP** **Captan 80WDG** Gem 500SC Indar 2F Fontelis 1.67SC	5 oz 1.5 pt 1.5 pt + 5 oz **3 lb + 5 oz** **3 lb** 3.8 fl oz 9 fl oz 20 fl oz	P B PF **SS, 1C, 2C** **3C-7C** 21 dph 12 dph 4 dph	1.0 c	1.0 bc	0.0 b
3	BAS 750 SC + Induce (PF only) Rovral 4F **Captan 80WDG + BAS 750 SC + Induce** **Captan 80WDG** Indar 2F Fontelis 1.67SC	5 fl oz + 16 fl oz 1.5 pt **3 lb + 5 fl oz + 16 fl oz** **3 lb** 9 fl oz 20 fl oz	P, PF B **SS, 1C, 2C** **3C-7C** 21, 4 dph 12 dph	0.0 c	0.0 c	0.0 b
4	BAS 752 SC + Induce (PF only) Rovral 4F **Captan 80WDG + BAS 752 SC + Induce** **Captan 80WDG** Fontelis 1.67SC Indar 2F	6 fl oz + 16 fl oz 1.5 pt **3 lb + 6 fl oz + 16 fl oz** **3 lb** 20 fl oz 9 fl oz	P, PF B **SS, 1C, 2C** **3C-7C** 21, 4 dph 12 dph	2.0 c	2.0 bc	0.0 b
5	Vangard 75WG Rovral 4F **Captan 80WDG** Merivon 4.18SC + Induce	5 oz 1.5 pt **3 lb** 5 fl oz + 16 fl oz	P B, PF **SS, 1C, 2C – 7C** 21, 12, 4 dph	4.0 c	2.0 abc	2.0 b
6	Vangard 75WG Rovral 4F **Captan 80WDG** BAS 750 SC + Induce Merivon 4.18SC + Induce	5 oz 1.5 pt **3 lb** 5 fl oz + 16 fl oz 5 fl oz + 16 fl oz	P B, PF **SS, 1C, 2C – 7C** 21, 4 dph 12 dph	2.0 c	2.0 abc	0.0 b
7	Vangard 75WG Rovral 4F **Captan 80WDG** Merivon 4.18SC + Induce BAS 750 SC + Induce	5 oz 1.5 pt **3 lb** 5 fl oz + 16 fl oz 5 fl oz + 16 fl oz	P B, PF **SS, 1C, 2C – 7C** 21, 4 dph 12 dph	3.0 c	3.0 abc	0.0 b
8	Vangard 75WG Rovral 4F **Captan 80WDG** BAS 752 SC + Induce Gem 500 SC + Induce	5 oz 1.5 pt **3 lb** 6 fl oz + 16 fl oz 3.8 fl oz + 16 fl oz	P B, PF **SS, 1C, 2C – 7C** 21, 4 dph 12 dph	7.0 bc	4.0 abc	3.0 b
9	Vangard 75WG Rovral 4F **Captan 80WDG** Gem 500 SC + Induce BAS 752 SC + Induce	5 oz 1.5 pt **3 lb** 3.8 fl oz + 16 fl oz 6 fl oz + 16 fl oz	P B, PF **SS, 1C, 2C – 7C** 21, 4 dph 12 dph	3.0 c	3.0 abc	0.0 b
10	Vangard 75WG Rovral 4F **Captan 80WDG** BAS 752 SC + Induce	5 oz 1.5 pt **3 lb** 6 fl oz + 16 fl oz	P B, PF **SS, 1C, 2C – 7C** 21, 12, 4 dph	21.0 ab	15.0 ab	6.0 b
11	Luna Sensation 4.2F Rovral 4F **Captan 80WDG** Luna Sensation 4.2F Indar 2F	5 fl oz 1.5 pt **3 lb** 5 fl oz 9 fl oz	P, PF B **SS, 1C, 2C–7C** 21, 4 dph 12 dph	1.0 c	1.0 bc	0.0 b
12	Luna Sensation 4.2F Rovral 4F **Captan 80WDG** Luna Sensation 4.2F Indar 2F	7.6 fl oz 1.5 pt **3 lb** 7.6 fl oz 9 fl oz	P, PF B **SS, 1C, 2C–7C** 21, 4 dph 12 dph	6.0 bc	4.0 abc	2.0 b

[1] Scab 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).

Table 6. Brown Rot Harvest and Post-Harvest Incidence [1]						
				% Infected Fruit		
Treatment		Rate / A	Timing	Harvest [2]	4-DPH [2]	7-DPH [2]
1	Non-treated control	--------	--------	14.0 a	58.0 a	89.0 a
2	Vangard 75WG Rovral 4F Rovral 4F + Rally 40WSP Captan 80WDG + Rally 40WSP Captan 80WDG **Gem 500SC** **Indar 2F** **Fontelis 1.67SC**	5 oz 1.5 pt 1.5 pt + 5 oz 3 lb + 5 oz 3 lb **3.8 fl oz** **9 fl oz** **20 fl oz**	P B PF SS, 1C, 2C 3C-7C **21 dph** **12 dph** **4 dph**	2.7 bcd	10.0 cd	44.0 cde
3	BAS 750 SC + Induce (PF only) Rovral 4F Captan 80WDG + BAS 750 SC + Induce Captan 80WDG **Indar 2F** **Fontelis 1.67SC**	5 fl oz + 16 fl oz 1.5 pt 3 lb + 5 fl oz + 16 fl oz 3 lb **9 fl oz** **20 fl oz**	P, PF B SS, 1C, 2C 3C-7C **21, 4 dph** **12 dph**	1.6 cd	20.0 c	51.0 bcd
4	BAS 752 SC + Induce (PF only) Rovral 4F Captan 80WDG + BAS 752 SC + Induce Captan 80WDG **Fontelis 1.67SC** **Indar 2F**	6 fl oz + 16 fl oz 1.5 pt 3 lb + 6 fl oz + 16 fl oz 3 lb **20 fl oz** **9 fl oz**	P, PF B SS, 1C, 2C 3C-7C **21, 4 dph** **12 dph**	4.0 bcd	20.0 c	58.0 bc
5	Vangard 75WG Rovral 4F Captan 80WDG **Merivon 4.18SC + Induce**	5 oz 1.5 pt 3 lb **5 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 12, 4 dph**	2.5 bcd	4.0 d	13.0 h
6	Vangard 75WG Rovral 4F Captan 80WDG **BAS 750 SC + Induce** **Merivon 4.18SC + Induce**	5 oz 1.5 pt 3 lb **5 fl oz + 16 fl oz** **5 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	6.2 b	6.0 d	29.0 efg
7	Vangard 75WG Rovral 4F Captan 80WDG **Merivon 4.18SC + Induce** **BAS 750 SC + Induce**	5 oz 1.5 pt 3 lb **5 fl oz + 16 fl oz** **5 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	4.1 bcd	8.0 d	19.0 gh
8	Vangard 75WG Rovral 4F Captan 80WDG **BAS 752 SC + Induce** **Gem 500 SC + Induce**	5 oz 1.5 pt 3 lb **6 fl oz + 16 fl oz** **3.8 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	0.3 d	7.0 d	27.0 fgh
9	Vangard 75WG Rovral 4F Captan 80WDG **Gem 500 SC + Induce** **BAS 752 SC + Induce**	5 oz 1.5 pt 3 lb **3.8 fl oz + 16 fl oz** **6 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	5.4 bc	32.0 b	66.0 b
10	Vangard 75WG Rovral 4F Captan 80WDG **BAS 752 SC + Induce**	5 oz 1.5 pt 3 lb **6 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 12, 4 dph**	4.2 bcd	5.0 d	26.0 fgh
11	Luna Sensation 4.2F Rovral 4F Captan 80WDG **Luna Sensation 4.2F** **Indar 2F**	5 fl oz 1.5 pt 3 lb **5 fl oz** **9 fl oz**	P, PF B SS, 1C, 2C–7C **21, 4 dph** **12 dph**	2.3 bcd	13.0 cd	41.0 def
12	Luna Sensation 4.2F Rovral 4F Captan 80WDG **Luna Sensation 4.2F** **Indar 2F**	7.6 fl oz 1.5 pt 3 lb **7.6 fl oz** **9 fl oz**	P, PF B SS, 1C, 2C–7C **21, 4 dph** **12 dph**	1.0 d	5.0 d	38.0 def

[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 7. Rhizopus Rot Harvest and Post-Harvest Incidence [1]						
				% Infected Fruit		
Treatment		Rate / A	Timing	Harvest [2]	4-DPH [2]	7-DPH [2]
1	Non-treated control	--------	--------	0.0 a	3.0 a	13.0 a
2	Vangard 75WG Rovral 4F Rovral 4F + Rally 40WSP Captan 80WDG + Rally 40WSP Captan 80WDG **Gem 500SC** **Indar 2F** **Fontelis 1.67SC**	5 oz 1.5 pt 1.5 pt + 5 oz 3 lb + 5 oz 3 lb **3.8 fl oz** **9 fl oz** **20 fl oz**	P B PF SS, 1C, 2C 3C-7C **21 dph** **12 dph** **4 dph**	0.3 a	1.0 a	4.0 a
3	BAS 750 SC + Induce (PF only) Rovral 4F Captan 80WDG + BAS 750 SC + Induce Captan 80WDG **Indar 2F** **Fontelis 1.67SC**	5 fl oz + 16 fl oz 1.5 pt 3 lb + 5 fl oz + 16 fl oz 3 lb **9 fl oz** **20 fl oz**	P, PF B SS, 1C, 2C 3C-7C **21, 4 dph** **12 dph**	1.0 a	7.0 a	13.0 a
4	BAS 752 SC + Induce (PF only) Rovral 4F Captan 80WDG + BAS 752 SC + Induce Captan 80WDG **Fontelis 1.67SC** **Indar 2F**	6 fl oz + 16 fl oz 1.5 pt 3 lb + 6 fl oz + 16 fl oz 3 lb **20 fl oz** **9 fl oz**	P, PF B SS, 1C, 2C 3C-7C **21, 4 dph** **12 dph**	0.0 a	5.0 a	11.0 a
5	Vangard 75WG Rovral 4F Captan 80WDG **Merivon 4.18SC + Induce**	5 oz 1.5 pt 3 lb **5 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 12, 4 dph**	0.0 a	0.0 a	2.0 a
6	Vangard 75WG Rovral 4F Captan 80WDG **BAS 750 SC + Induce** **Merivon 4.18SC + Induce**	5 oz 1.5 pt 3 lb **5 fl oz + 16 fl oz** **5 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	0.3 a	5.0 a	9.0 a
7	Vangard 75WG Rovral 4F Captan 80WDG **Merivon 4.18SC + Induce** **BAS 750 SC + Induce**	5 oz 1.5 pt 3 lb **5 fl oz + 16 fl oz** **5 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	0.3 a	3.0 a	6.0 a
8	Vangard 75WG Rovral 4F Captan 80WDG **BAS 752 SC + Induce** **Gem 500 SC + Induce**	5 oz 1.5 pt 3 lb **6 fl oz + 16 fl oz** **3.8 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	0.0 a	3.0 a	8.0 a
9	Vangard 75WG Rovral 4F Captan 80WDG **Gem 500 SC + Induce** **BAS 752 SC + Induce**	5 oz 1.5 pt 3 lb **3.8 fl oz + 16 fl oz** **6 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 4 dph** **12 dph**	0.0 a	2.0 a	4.0 a
10	Vangard 75WG Rovral 4F Captan 80WDG **BAS 752 SC + Induce**	5 oz 1.5 pt 3 lb **6 fl oz + 16 fl oz**	P B, PF SS, 1C, 2C – 7C **21, 12, 4 dph**	0.3 a	5.0 a	9.0 a
11	Luna Sensation 4.2F Rovral 4F Captan 80WDG **Luna Sensation 4.2F** **Indar 2F**	5 fl oz 1.5 pt 3 lb **5 fl oz** **9 fl oz**	P, PF B SS, 1C, 2C–7C **21, 4 dph** **12 dph**	0.0 a	2.0 a	4.0 a
12	Luna Sensation 4.2F Rovral 4F Captan 80WDG **Luna Sensation 4.2F** **Indar 2F**	7.6 fl oz 1.5 pt 3 lb **7.6 fl oz** **9 fl oz**	P, PF B SS, 1C, 2C–7C **21, 4 dph** **12 dph**	0.0 a	3.0 a	4.0 a

[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).

EVALUATION OF BIORATIONAL BACTERICIDES FOR MANAGEMENT OF PEACH BACTERIAL SPOT

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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 smaller, more numerous, and 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 objective of this study was to examine the ability of the biorational materials Stargus and Regalia to manage bacterial spot on peach. The active ingredient in Stargus consists of *Bacillus amyloliquefaciens* strain 727 cells and spent fermentation media. This rhizobacterium protects plants by colonizing the surface of plant tissues, thereby preventing the establishment of fungal and bacterial plant pathogens. In contrast, the active ingredient in Regalia, an extract of *Reynoutria sachalinensis* (giant knotweed), protects plants by inducing systemic resistance. The bioactive compounds in this extract stimulates the plant to increase phenolics, antioxidants, and strengthen cell walls. Stargus is not currently labeled for use on peach; however, bacterial spot (*Xanthomonas* spp.) is listed as a target disease for fruiting vegetables. Regalia is currently labeled for use on stone fruits; however, bacterial spot is not listed as a target disease, although *Xanthomonas* spp. are listed as targets for a number of other crops.

In this study, Stargus and Regalia treatments were compared to the current copper and antibiotic standards, Kocide 3000 and oxytetracycline (FireLine, Mycoshield). In addition, two “integrated” treatments, which consisted of Stargus and Regalia applications alternating with copper applications, were also examined. Comparisons were made using disease incidence, disease severity, and marketable fruit assessments. All treatments were applied to highly susceptible ‘O’Henry’ peach and susceptible ‘Suncrest’ peach.

An additional treatment consisting of Quintec, with the active ingredient quinoxyfen, was applied in the Suncrest orchard. Athough Quintec is primarily a powdery mildew fungicide, suppression of bacterial spot on pepper (*Xathomonas* spp.) has been observed.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2018 growing season at the Rutgers Agricultural Research and Extension Center. Trees in the O’Henry orchard, which were 12-14 years old, were grafted on Halford or Lovell rootstock. Trees in the Suncrest orchard were 22 years old and grafted on Lovell rootstock. Trees in both orchards were planted at 25 ft x 25 ft spacing. The two orchards were approximately 1000 feet apart.

Treatments. Bactericide treatments were replicated four times in a randomized complete block design within each orchard. Experimental plots in O'Henry consisted of two adjacent trees, while those in the Suncrest orchard consisted of single trees. Treatment plots were surrounded on all sides by non-sprayed buffer trees. Originally, the study was to only be performed in the O'Henry orchard, but low fruit set prompted use of two-tree plots and replication of the entire study in the Suncrest orchard.

A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.5 mph was used for treatment applications. Insecticides were applied as needed using a commercial airblast sprayer. A leaf curl application at budswell was <u>not</u> applied. No fungicides were applied during the course of the study. Applications were initiated at petal fall, one stage earlier than normal, to allow establishment of *B. amyloliquefaciens* and induction of resistance prior to infection. Subsequent application timing was at approximately 7-day intervals. Treatment application dates and phenological timing are shown in Table 1.

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 Kocide 3000, Stargus, and Regalia. This pH correction was not necessary for FireLine or Quintec.

Assessment. The first bacterial spot fruit disease assessment, which consisted of incidence (% infected fruit) and severity (# lesions per fruit) evaluations, was performed on 18 June in both orchards. A second assessment, which consisted of fruit disease incidence, severity, and marketable fruit evaluations, was conducted on 16-17 July in O'Henry and on 19 July in Suncrest. 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 Table 6 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 12-13 July in the O'Henry orchard. The number of missing leaves and infected leaves (with at least one lesion and/or one shot-hole) were counted on each of five vegetative shoots per plot. Results were presented as % infected leaves, % abscised leaves, and % infected and abscised leaves. The latter 'combined" dependent variable provided a measure of total foliar damage or loss. A foliar assessment was not conducted in the Suncrest orchard.

Bacterial spot disease progress on non-treated fruit was also monitored in the O'Henry orchard. Fifteen fruit were tagged in each non-treated control plot. A total of 10 assessments were performed at 7-to-14 day intervals. At each assessment, the total number of infected tagged fruit was recorded, allowing estimation of disease incidence over time.

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 temperatures throughout April were mostly in the 40s and 50s, which was not conducive to disease development (Table 1). This cold weather slowed development of the trees and probably contributed to the delay in onset of the epidemic. Disease on fruit is usually observed mid-May, but was not visible until late May (Fig. 1). However, higher air temperatures (60-70F) in May provided adequate warmth for bacterial multiplication in overwintering cankers, albeit later than usual. Mean air temperatures during April, May, and June were below, above, and near normal, respectively, relative to the 30-year means (Table 2).

Rainfall totals in 2018 were slightly above normal in April and about 0.5 in below normal in June (Table 2). However, the May rainfall total was 2.05 inches above the 30-year mean for the month. These rains were fairly frequent throughout the month and, combined with the warmer temperatures, provided ample conditions for infection (Table 1). A total of 11 rain events having ≥ 0.10 inches occurred in May (Table 2).

Disease Progression. The bacterial spot epidemic was of moderate severity during the 2018 season (Fig. 1). Disease development occurred over approximately a two-month period from onset in late May through the end of June, with only slight increase through July. Although disease incidence increased to 74% fruit infection during this period, lesion sizes were relatively small. In contrast, 92% of fruit were infected in the more favorable 2017 season, and lesion sizes were larger.

The 7-day spray schedule for application of bactericide treatments in 2018 resulted in a total of 11 sprays at 6 to 8 day intervals, with an average interval of 7 days (Table 3). During the critical period from May through mid-June, a total of 16 rain events with ≥ 0.10" rainfall were recorded. Infection periods resulting from these rain events were most likely the cause for rapid rise in disease observed from late May through mid-June (Fig 1). Although treatments were being applied at a fairly tight 7-day schedule, heavy rains during three of these spray intervals (SS-1C, 1C-2C, & 3C-4C) no doubt provided a challenge to residual activity (Table 3).

Standards. At termination of the epidemic in mid-July (assess #2), both the Kocide and FireLine standards provided low but significant reductions in bacterial spot fruit disease incidence. On highly susceptible O'Henry, Kocide provided 40% control while FireLine gave 30% control (Table 4). On less susceptible Suncrest, the level of control by these standards was somewhat better; Kocide yielded 58% control while FireLine provided 47% control (Table 5).

Only Kocide reduced disease severity on O'Henry, lowering lesion density from about 15 lesions / fruit to approximately 7 lesions / fruit (Table 4, assess #2). In contrast, on less susceptible Suncrest, both standards significantly lowered disease severity at both assessments (Table 5). At assessment #2, Kocide provided a 72% reduction in lesions density, while FireLine yielded a 57% reduction.

Stargus. On highly susceptible O'Henry, Stargus failed to provide any significant reduction in fruit disease incidence or severity (Table 4). Even when Stargus was alternated with Kocide, the integrated program failed to provide significant disease control. Results from assessment #2 did show a reduced incidence and severity by the integrated program, presumably due to the Kocide component, but this reduction was not great enough to be statistically significant.

In contrast to the O'Henry results, Stargus performed much better on the less susceptible Suncrest (Table 5). When applied alone, Stargus significantly reduced both disease incidence and severity at both disease assessments. At termination of the epidemic (assess #2), Stargus provided 45% disease control and was equivalent to both the Kocide and FireLine standards.

Unlike Stargus alone, the integrated Stargus / Kocide program yielded mixed results (Table 5). Disease incidence and severity was significantly reduced by this program for assessment #1, but not for assessment #2.

Regalia. A significant reduction in disease incidence was observed for the Regalia treatment at assessment #1 on highly susceptible O'Henry, but this effect was not observed at assessment 2 (Table 4). The Regalia / Kocide program also failed to provide significant control on O'Henry.

As with Stargus, Regalia performed much better on less susceptible Suncrest (Table 5). Disease incidence was significantly reduced at both disease assessments when Regalia was applied alone. However, the integrated Regalia / Kocide program only yielded significant control in mid-June (assess #1), not in mid-July (as observed with the integrated Stargus program).

Quintec. The active ingredient quinoxyfen provided a significant reduction in fruit disease incidence at both assessments on Suncrest peach (Table 5). The level of control was equivalent to that provided by Kocide, FireLine (assess #2 only), Stargus, and Regalia. Numerically lower lesion densities were observed for Quintec, but the reductions were not significant.

Marketable Fruit. A fruit with one or more small lesions is tallied as "infected" for disease incidence purposes. However, this same fruit may still be marketable, contributing to either a grade 2 or even possibly grade 1 fruit category. Thus, unlike disease incidence and severity estimates, marketable fruit data provide a direct indication of saleable fruit. Higher amounts of grade 2 fruit are not necessarily desirable since maximization of this category is not a goal.

Under moderate disease pressure conditions in 2018, many fruit were marketable without implementing disease control. On O'Henry and Suncrest trees, 66% and 70% of non-treated fruit, respectively, were saleable or grades 1+2 (Table 6). Of these saleable non-treated fruit, 44% and 55% were of highest quality (grade 1) for O'Henry and Suncrest, respectively.

Although significant numbers of marketable fruit were available without using disease control measures (see above), the application of bactericides nevertheless improved saleable crop yield. Trees receiving the **Kocide** and **FireLine** standards had significantly greater amounts of saleable (grades 1+2) fruit than the non-treated control on both cultivars (Table 6). On more susceptible O'Henry, Kocide and FireLine provided 85% and 82% saleable fruit, respectively, while these same standards provided 95% and 90% saleable fruit on less susceptible Suncrest.

When applied alone on highly susceptible O'Henry fruit, **Stargus** failed to significantly improve the percentage of grade 1 or grade 1+2 (saleable) fruit (Table 6). In contrast, on less susceptible Suncrest fruit, Stargus significantly increased the percentage of grade 1 (from 55% to 81%) and grade 1+2 (from 70% to 90%) fruit. On this cultivar (Suncrest), Stargus provided grade 1 and saleable fruit levels equivalent to the Kocide and FireLine standards.

As with Stargus, **Regalia** also failed to significantly increase grade 1 and grade 1+2 fruit on highly susceptible O'Henry (Table 6). However, unlike Stargus, Regalia also did not significantly increase total saleable fruit (grades 1+2) on Suncrest, although the amount of grade 1 fruit was significantly greater than the control.

The two **integrated programs**, Stargus / Kocide and Regalia / Kocide, provided results that were opposite to that observed with the disease incidence and severity data (Table 6). Both programs yielded significantly greater amounts of saleable (grade 1+2) fruit on highly susceptible O'Henry. However, on less susceptible Suncrest, both programs failed to improve marketable yield. These outcomes were unexpected given the results of Stargus, Regalia, and Kocide when applied alone.

Quintec increased grade 1 fruit from 55% to 72% and grade 1+2 fruit from 70% to 82% (Table 6). However, neither of these increases were great enough to be statistically significant.

Foliar Infection. By mid-July on non-treated control trees, almost 60% of shoot leaves present were infected and nearly one-fourth had abscised (Table 7). Under this heavy disease pressure encountered (for foliage), none of the treatments significantly reduced foliar infection or defoliation relative to the control. It is not uncommon for bactericides to provide disease control on fruit but not on foliage, as the latter is generally more difficult to manage.

CONCLUSION

Results of this study, particularly the marketable fruit data, indicated that an effective peach bacterial spot control program can be achieved when the biorational material Stargus is used in conjunction with cultivar resistance. On less susceptible Suncrest, Stargus provided control equivalent to the standards.

Results also showed that the level of resistance in the cultivar need not be high. On a scale of 1 to 6, with 1 = highly susceptible and 6 = highly resistant, O'Henry is rated at 1 while the “less” susceptible Suncrest is rated at 2. Most cultivars grown in the eastern U.S. are rated ≥ 2. Highly susceptible cultivars, such as O’Henry, are not recommended to growers.

Additional testing is needed to confirm this IPM approach & provide support for commercial implementation. Combining cultivar resistance with biorational bactericides makes sense.

Table 1. Weather and spray timings for 2018 growing season at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stages. 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	52	0		1-May	61	0	**Petal Fall**	1-Jun	76	0.36	
2-Apr	42	0.05		2-May	71	0		2-Jun	76	0.09	
3-Apr	43	0.03		3-May	76	0		3-Jun	61	1.14	
4-Apr	54	0.02		4-May	77	0		4-Jun	63	0.21	
5-Apr	40	0		5-May	67	0		5-Jun	68	0.01	**4th Cover**
6-Apr	50	0		6-May	62	0.09		6-Jun	64	0	
7-Apr	46	0		7-May	63	0		7-Jun	66	0	
8-Apr	39	0		8-May	62	0		8-Jun	70	0	
9-Apr	37	0		9-May	62	0	**Shuck Split**	9-Jun	71	0.09	
10-Apr	42	0		10-May	64	0.10		10-Jun	67	0.13	
11-Apr	42	0		11-May	68	0		11-Jun	60	0.61	
12-Apr	56	0		12-May	66	0.86		12-Jun	63	0	**5th Cover**
13-Apr	68	0		13-May	57	1.05		13-Jun	72	0.05	
14-Apr	69	0		14-May	62	0.37		14-Jun	77	0	
15-Apr	44	0.43		15-May	73	1.07	**1st Cover**	15-Jun	70	0	
16-Apr	53	2.37		16-May	66	0.39		16-Jun	72	0	
17-Apr	43	0		17-May	63	0.28		17-Jun	76	0	
18-Apr	45	0		18-May	60	0.26		18-Jun	80	0	**1st Assess.**
19-Apr	48	0.01		19-May	60	1.22		19-Jun	81	0	**6th Cover**
20-Apr	45	0		20-May	75	0.02		20-Jun	75	0.01	
21-Apr	47	0		21-May	69	0		21-Jun	74	0	
22-Apr	51	0		22-May	64	0.23		22-Jun	68	0.16	
23-Apr	52	0		23-May	72	0	**2nd Cover**	23-Jun	69	0.02	
24-Apr	54	0.08		24-May	71	0		24-Jun	79	0	
25-Apr	61	0.21		25-May	74	0		25-Jun	74	0	
26-Apr	58	0		26-May	80	0		26-Jun	70	0	
27-Apr	56	0.31		27-May	70	0.13		27-Jun	70	0	**7th Cover**
28-Apr	59	0.11		28-May	62	0.03		28-Jun	81	0	
29-Apr	50	0.15		29-May	69	0		29-Jun	81	0	
30-Apr	52	0		30-May	68	0	**3rd Cover**	30-Jun	82	0	
				31-May	71	0.02					

Table 1 – continued –

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Jul	84	0		12-Jul	76	0		22-Jul	77	0.47	
2-Jul	83	0		13-Jul	74	0		23-Jul	79	0	
3-Jul	84	0	**8th Cover**	14-Jul	76	0		24-Jul	80	0.02	
4-Jul	82	0		15-Jul	77	0.02		25-Jul	76	0.74	
5-Jul	82	0		16-Jul	82	0	**2nd Assess**	26-Jul	78	0.09	
6-Jul	80	0.06		17-Jul	80	1.19	**2nd Assess**	27-Jul	75	0.77	
7-Jul	70	0		18-Jul	77	0		28-Jul	76	0.03	
8-Jul	70	0		19-Jul	74	0	**2nd Assess**	29-Jul	74	0	
9-Jul	72	0		20-Jul	73	0		30-Jul	70	0	
10-Jul	79	0	**9th Cover**	21-Jul	69	1.35		31-Jul	74	0.02	
11-Jul	81	0									

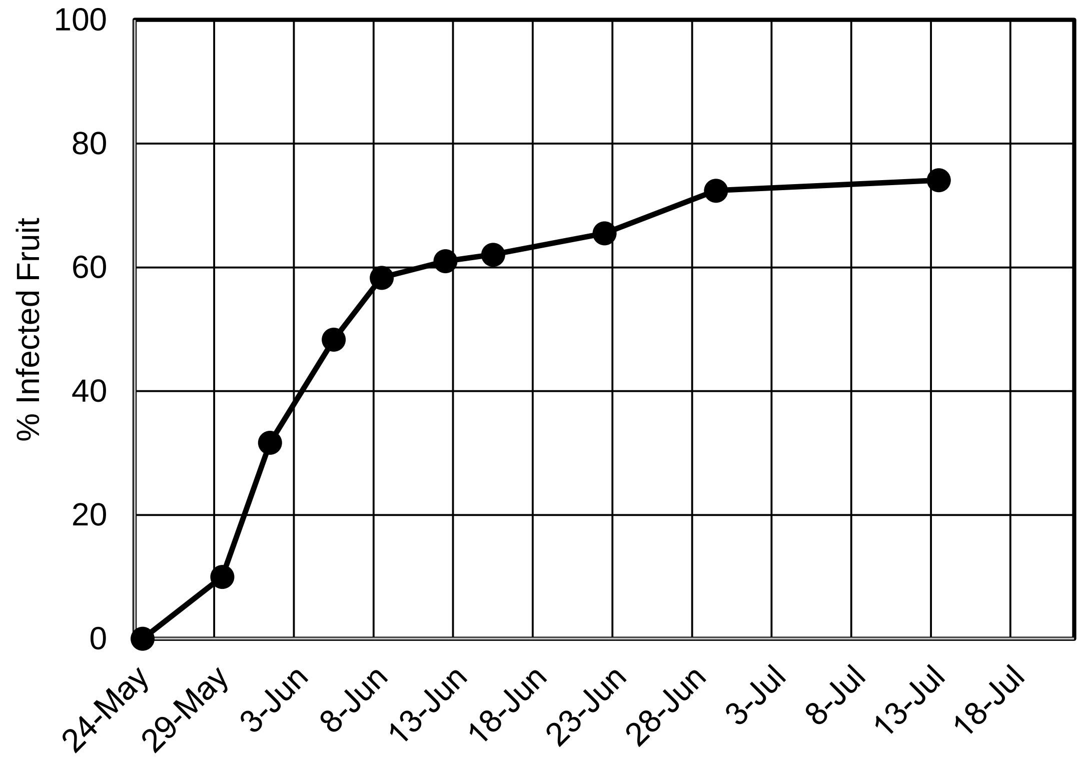

Figure 1. Progression of bacterial spot fruit disease incidence on O'Henry peach during the 2018 epidemic. Data points are means of 15 tagged fruit on four non-treated trees (60 fruit / assessment).

Table 2. Comparison of 2016-18 Monthly Temperature and Rainfall Data, Bridgeton NJ			
Month & Year	**Average Temp (°F)**	**Total Rainfall (in)**	**# Rains ≥ 0.10 in**
April 2018	50	3.77	6
April 2017	58	2.98	8
April 2016	52	2.70	7
April (30-year mean)	52	3.58	---
May 2018	67	6.12	11
May 2017	61	8.30	6
May 2016	61	6.29	15
May (30-year mean)	62	4.07	---
June 2018	72	2.88	6
June 2017	73	2.42	6
June 2016	71	4.98	8
June (30-year mean)	71	3.37	---

Table 3. Average air temperature, rainfall frequency, and total rainfall during bactericide spray intervals resulting from 7-day spray schedule in 2018					
Bactericide Application Interval			**Ave. Temp.**	**# Rains**	**Rainfall**
Spray Dates	**Phenology**	**Length (d)**	**°F**	**≥ 0.10 in**	**Total (in)**
1 May – 9 May	PF - SS	8	67.4	0	0.09
9 May – 15 May	SS – 1C	6	63.2	4	2.38
15 May – 23 May	1C – 2C	8	66.3	6	3.47
23 May – 30 May	2C – 3C	7	71.1	1	0.16
30 May – 5 Jun	3C – 4C	6	69.2	3	1.82
5 Jun – 12 Jun	4C – 5C	7	66.6	2	0.83
12 Jun – 19 Jun*	5C – 6C	7	72.9	0	0.05
19 Jun – 27 Jun	6C – 7C	8	73.8	1	0.19
27 Jun – 3 Jul	7C – 8C	6	80.2	0	0.00
3 Jul – 10 Jul	8C – 9C	7	77.1	0	0.06
10 Jul + 7 days	9C + 7 days	7	77.9	1	1.21
* First fruit assessment on 18 June; second fruit assessment on 16,17 & 19 July					

Table 4. Bactericial Spot Incidence and Severity on O'Henry Fruit				
			Assess #1 (18 June)	**Assess #2 (16-17 July)**

Treatment	Rate / A	Timing	% Infected Fruit [1]	# Lesions / Fruit [1]	% Infected Fruit [1]	# Lesions / Fruit [1]
			CONTROL			
Non-treated control	--------	------	60.0 a	2.3 ab	77.0 a	14.7 b
			COPPER AND ANTIBIOTIC STANDARDS			
Kocide 3000 30DF [2]	1.7 oz	PF, SS, 1C-9C	45.6 abc	1.3 b	46.0 c	6.9 c
FireLine 17WP	1.5 lb	PF, SS, 1C-9C	42.0 bc	2.0 ab	53.8 bc	11.0 bc
			BIORATIONAL AND INTEGRATED TREATMENTS			
Stargus (MBI-110AF5) [2]	64 fl oz	PF, SS, 1C-9C	57.0 ab	3.5 a	73.0 ab	26.5 a
Regalia (MBI-10612) [2]	32 fl oz	PF, SS, 1C-9C	37.0 c	1.0 b	56.0 abc	10.5 bc
Stargus (MBI-110AF5) [2] Kocide 3000 30DF [2]	64 fl oz 1.7 oz	PF, 1C, 3C, 5C, 7C, 9C SS, 2C, 4C, 6C, 8C	51.0 abc	2.4 ab	55.0 abc	7.5 bc
Regalia (MBI-10612) [2] Kocide 3000 30DF [2]	32 fl oz 1.7 oz	PF, 1C, 3C, 5C, 7C, 9C SS, 2C, 4C, 6C, 8C	52.0 abc	3.0 a	60.0 abc	13.0 bc

[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 5. Bacterial Spot Incidence and Severity on Suncrest Fruit						
			Assess #1 (18 June)		**Assess #2 (19 July)**	
Treatment	**Rate / A**	**Timing**	**% Infected Fruit [1]**	**# Lesions / Fruit [1]**	**% Infected Fruit [1]**	**# Lesions / Fruit [1]**
CONTROL						
Non-treated control	--------	------	44.0 a	1.3 a	57.0 a	17.8 a
COPPER AND ANTIBIOTIC STANDARDS						
Kocide 3000 30DF [2]	1.7 oz	PF, SS, 1C-9C	23.0 bc	0.5 bc	24.0 d	5.0 d
FireLine 17WP	1.5 lb	PF, SS, 1C-9C	17.0 c	0.3 c	30.0 cd	7.7 bcd
BIORATIONAL AND INTEGRATED TREATMENTS						
Stargus (MBI-110AF5) [2]	64 fl oz	PF, SS, 1C-9C	28.0 b	0.6 bc	31.0 cd	6.7 cd
Regalia (MBI-10612) [2]	32 fl oz	PF, SS, 1C-9C	30.0 b	0.7 bc	36.0 bcd	11.9 ab
Stargus (MBI-110AF5) [2] Kocide 3000 30DF [2]	64 fl oz 1.7 oz	PF, 1C, 3C, 5C, 7C, 9C SS, 2C, 4C, 6C, 8C	21.0 bc	0.6 bc	51.0 ab	15.5 a
Regalia (MBI-10612) [2] Kocide 3000 30DF [2]	32 fl oz 1.7 oz	PF, 1C, 3C, 5C, 7C, 9C SS, 2C, 4C, 6C, 8C	16.0 c	0.3 c	44.0 abc	13.8 a
CONVENTIONAL FUNGICIDE TREATMENT						
Quintec 2.08SC	7.0 fl oz	PF, SS, 1C-9C	29.0 b	1.0 ab	32.0 cd	9.5 abc

[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 6. Marketable Fruit (16-17 July)

Treatment	Rate/A	Timing	O'Henry % Fruit in Category [1,2]			Suncrest % Fruit in Category [1,2]		
			Market Grade 1	Market Grade 2	Grades 1 + 2	Market Grade 1	Market Grade 2	Grades 1 + 2
CONTROL								
Non-treated control	--------	------	44.0 bc	22.0 a	66.0 bc	55.0 d	15.0 ab	70.0 c
COPPER AND ANTIBIOTIC STANDARDS								
Kocide 3000 30DF [3]	1.7 oz	PF, SS, 1C-9C	72.0 a	13.0 a	85.0 a	86.0 a	9.0 ab	95.0 a
FireLine 17WP	1.5 lb	PF, SS, 1C-9C	68.6 ab	13.2 a	81.8 a	83.0 a	7.0 b	90.0 ab
BIORATIONAL AND INTEGRATED TREATMENTS								
Stargus (MBI-110AF5) [3]	64 fl oz	PF, SS, 1C-9C	40.0 c	14.0 a	54.0 c	81.0 ab	9.0 ab	90.0 ab
Regalia (MBI-10612) [3]	32 fl oz	PF, SS, 1C-9C	58.0 abc	22.0 a	80.0 ab	73.0 abc	8.0 b	81.0 bc
Stargus (MBI-110AF5) [3] Kocide 3000 30DF [3]	64 fl oz 1.7 oz	PF, 1C-9C odd SS, 2C-8C even	71.0 ab	13.0 a	84.0 a	57.0 cd	17.0 a	74.0 c
Regalia (MBI-10612) [3] Kocide 3000 30DF [3]	32 fl oz 1.7 oz	PF, 1C-9C odd SS, 2C-8C even	66.0 abc	15.0 a	81.0 a	65.0 bcd	10.0 ab	75.0 c
CONVENTIONAL FUNGICIDE TREATMENT								
Quintec 2.08SC	7.0 fl oz	PF, SS, 1C-9C	-----	-----	-----	72 abcd	10.0 ab	82.0 abc

[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).

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

Table 7. Bacterial spot incidence and defoliation on O'Henry Foliage (12-13 July)					
Treatment	**Rate / A**	**Timing**	**% Infected Leaves [1, 2]**	**% Abscised Leaves [1, 2]**	**% Infected & Abscised Leaves [1, 2]**
CONTROL					
Non-treated control	--------	------	59.9 ab	22.3 a	67.4 a
COPPER AND ANTIBIOTIC STANDARDS					
Kocide 3000 30DF [3]	1.7 oz	PF, SS, 1C-9C	78.1 a	31.0 a	83.4 a
FireLine 17WP	1.5 lb	PF, SS, 1C-9C	64.0 ab	23.1 a	70.4 a
BIORATIONAL AND INTEGRATED TREATMENTS					
Stargus (MBI-110AF5) [3]	64 fl oz	PF, SS, 1C-9C	53.7 b	31.8 a	67.6 a
Regalia (MBI-10612) [3]	32 fl oz	PF, SS, 1C-9C	53.3 b	34.6 a	68.2 a
Stargus (MBI-110AF5) [3] Kocide 3000 30DF [3]	64 fl oz 1.7 oz	PF, 1C, 3C, 5C, 7C, 9C SS, 2C, 4C, 6C, 8C	80.6 a	29.6 a	85.2 a
Regalia (MBI-10612) [3] Kocide 3000 30DF [3]	32 fl oz 1.7 oz	PF, 1C, 3C, 5C, 7C, 9C SS, 2C, 4C, 6C, 8C	75.4 ab	35.6 a	83.4 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.

Not for Citation or Publication
Without Consent of the Author

USING POST DORMANT COPPER APPLICATIONS FOR FUNGAL DISEASE CONTROL

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An experiment was conducted at the Penn State Fruit Research and Extension Center that studied how copper could be incorporated into an alternative disease management program. Different copper products were applied starting at petal fall and alternated with Captan during the cover sprays. The treatments were applied to Golden Delicious trees on Bud 9 rootstocks at 10-14 day intervals starting on 14 May (petal fall) and ending on 16 Aug. Treatments consisted of, Nordox 30/30, Previsto, Badge SC, Cueva, and Mastercop. In addition, Nordox, Previsto, Badge, and Mastercop were also applied with hydrated lime. All coppers were adjusted to a 2 oz metallic copper rate per acre. Treatment applications were made with a backpack mist blower at the equivalent of 100 gallons per acre. The experiment was arranged in a completely randomized block design with four replications. Leaves were assessed for apple scab incidence in July. Fruit finish was assessed by estimating the percent severity of russeting at the end of August. Fruit were assessed for scab, sooty blotch and flyspeck, and rot incidence in September.

Record amounts of precipitation occurred during the growing season in 2018, particularly in July when 11 inches of rainfall was recorded. Temperatures during the growing season were generally moderate. Apple scab pressure on leaves was high with the incidence on the leaves of the control treatment reaching approximately 75% (figure 1). Scab incidence on fruit of the control treatment was 100%. All the copper treatments significantly reduced the incidence of scab on leaves, with most of the coppers reducing scab by 50% over the control (table 1). Scab incidence on the fruit was reduced by two-thirds or more by all coppers. Although sooty blotch, flyspeck, and rot incidence was generally low, all coppers significantly reduced the incidence compared to the control. Russeting on fruit (fruit finish), rated as a percent, ranged from 8-40% on all copper treatments with the control being less than 5%. On the copper treatments alone, Nordox 30/30 had the significantly less russeting than other coppers. Hydrated lime reduced russeting on all coppers by 50% or more*. Hydrated lime did not significantly affect disease control. This study shows that incorporating copper into a disease management program with Captan has the potential to reduce disease severity while adding lime can potentially limit russeting.

*Cueva was not tank-mixed with hydrated lime because the label specifically says not to tank-mix it

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Figure 1. Apple scab incidence on leaves

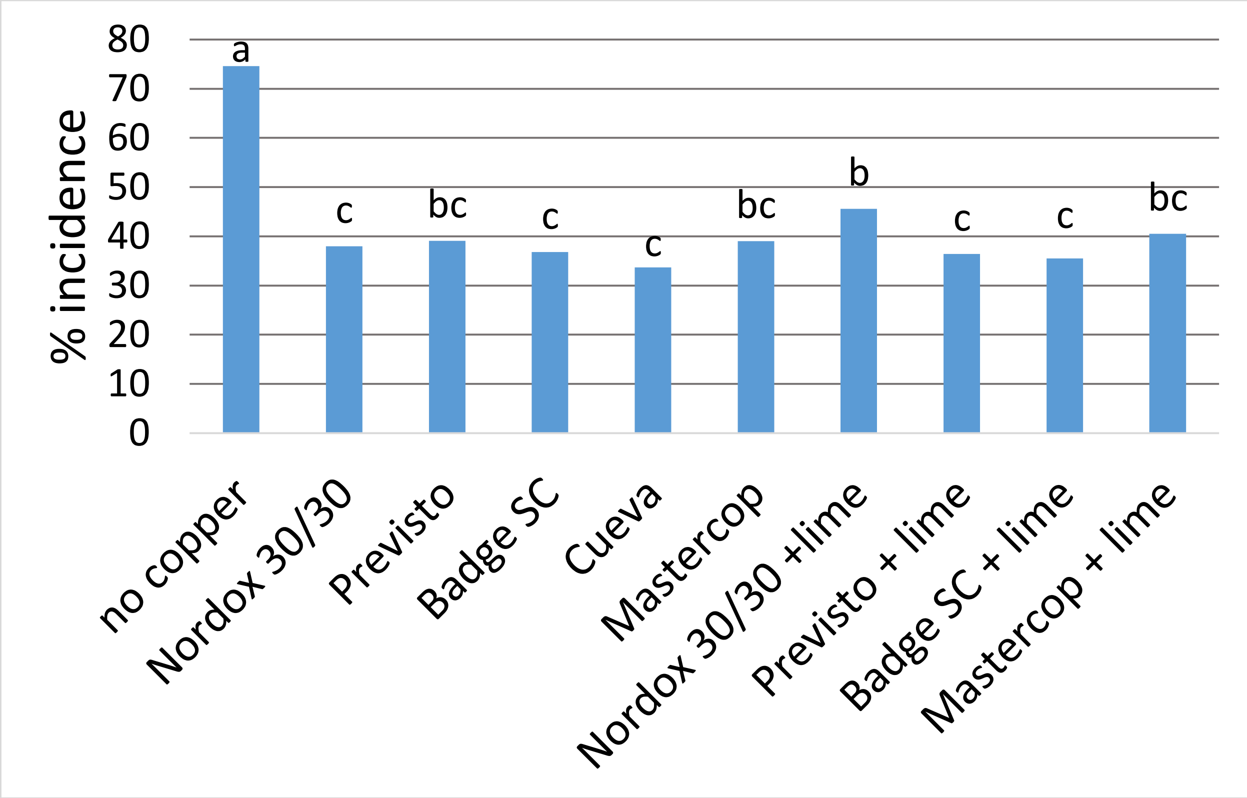

Table 1. Disease incidence and russet severity on fruit

Treatment & amount/A	scab	sooty blotch	flyspeck	rots	Russet (% severity)
Untreated	100 a	5 a	8.0 a	12 a	3.8 a
Nordox 30/30 @ 20 oz	21 b	0 b	1 b	1 b	12.8 c
Previsto @ 2.66 fl oz	19 b	0 b	0 b	0 b	32.7 g
Badge SC @ 6.8 fl oz	27 b	0 a	2 b	1 b	20.9 f
Cueva @ 58.2 fl oz	21 b	0 b	2 b	3 b	15.8 de
Mastercop @ 7.1 fl oz	33 b	0 b	0 b	0 b	38.9 h
Nordox 30/30 @ 20 oz + hydrated lime @ 1 lb	30 b	0 b	0 b	0 b	8.1 b
Previsto @ 2.66 fl oz + hydrated lime @ 1 lb	20 b	0 b	3 b	1 b	16.2 e
Badge SC @ 6.8 fl oz + hydrated lime @ 1 lb	23 b	0 b	0 b	2 b	8.32 b
Mastercop @ 7.1 fl oz + hydrated lime @ 1 lb	21 b	0 b	0 b	1 b	9.96 bc

BITTER ROT OF APPLE: WHAT WE LEARNED IN 2018

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In recent years Pennsylvania has seen increased losses from bitter rot of apple. Management of bitter rot is complicated because the causal fungal species, all in the genus *Colletotrichum*, have a hemibiotrophic disease cycle, where an early infection can lie dormant or quiescent until close to or after harvest when classic rotten symptoms are observed. Timing of fungicide applications and other management practices are dependent on knowing the timing of initial apple infections, as well as knowing whether spores are coming from within the orchard or blown in from nearby forests.

To answer these questions, a series of field experiments were conducted at the Penn State Fruit Research and Extension Center (FREC) on various orchard blocks that included 'Honeycrisp', 'Gala', Delicious,' and 'Golden delicious' apples, and in a nearby forest. The two-pronged approach focused on determining the timing and quantity of spore dispersal in the orchard and forest using spore trapping and q-PCR, and the timing and incidence of quiescent infection in immature apples with freezing and incubation.

Detection of dispersed spores focused in the species *C. fioriniae*, as previous surveys showed that to be the dominant species isolated from bitter rot apples at FREC (Peter Lab 2017, unpublished). As a member of the *C. acutatum* species complex, *C. fioriniae* predominantly produces asexual conidiospores that are rain-splashed dispersed (Sutton 2014). Conidia were trapped with rain-traps within and beneath the tree canopies in orchard blocks and beneath the tree canopy in a nearby forest. Orchard block treatments included inoculation with bitter rot infected apples and no fungicide treatments, no inoculation and no fungicides, and no inoculation and standard fungicide applications. Collections were taken from full bloom to harvest after significant rain events. Rain-traps were built with plastic Corning 225ml centrifuge tubes (Thermo Fisher Scientific, Waltham, MA) with holes drilled in the cap, to which plastic funnels were glued. After a rain the centrifuge tubes were unscrewed from the funnels, capped, and centrifuged at ~ 4,000 g for 20 – 30 minutes to pellet the spores and debris. DNA was extracted from the pellet with a NucleoSpin Soil DNA extraction kit (Macherey-Nagal, Bethlehem PA). *C. fioriniae* DNA was quantified with q-PCR using primers from Debode et al. (2009) as modified by Samuelian et al. (2011). The q-PCR master mix was SsoAdvanced™ Universal SYBR® Green Supermix (Bio-Rad, Hercules, CA), primers were synthesized by Integrated DNA Technologies (Skokie, IL), and the PCR plates and optically clear strip caps were from VWR (Radnor, PA). Amplification was to 40 cycles followed by a melt curve to check for non-specific amplification. A standard curve that equated cycle number to conidia number was made by quantifying a suspension of conidia with a hemocytometer, extracting DNA from a known number of conidia via the method described above, serially diluting it, and detecting the known conidiospore numbers with q-PCR.

Non-specific DNA amplification was observed in some samples. For future analysis, more specific detection will be attempted using Taq-Man probes. However, to get an initial (albeit incomplete) picture of spore dispersal, samples from six time points were analyzed for non-specific amplification, and all samples with non-specific amplification were excluded from further analysis. The graph of the remaining samples showed that spores were already being dispersed by the first week of May during full bloom, and that the quantity of spores being dispersed in the forest was as high or higher as in orchard blocks, including the inoculated untreated block (Figure 1).

Since spores were being dispersed early in the season, we hypothesized that infections were also occurring early. To detect quiescent infections, immature apples were picked, surface disinfested with 1% bleach for 40s, 70% ethanol 20s, rinsed, placed in a -20C freezer overnight to kill the apple, then incubated in a humid container at room temperature for about 2 weeks and observed for orange conidia production characteristic of *C. fioriniae*. We found 50% of the apples from the inoculated untreated block had quiescent infections by May 26, with near 100% incidence by June 11 (Figure 2). The June 26 sample was frozen twice, which may have effected bitter rot incidence. The decline by July 17 may indicate that not all early quiescent infections persist throughout the season, but more study is needed to confirm that hypothesis.

The high quantities of *C. fioriniae* conidia being dispersed in the forest adjacent to the orchard were unexpected. To support the q-PCR results and to determine where in the forest the conidia might me coming from, asymptomatic leaves of various forest understory plants were gathered, surface disinfested, frozen, and incubated as described for immature apples. Abundant orange conidial sporulation was observed on many leaves, most prominently on leaves of wild grape, Amur honeysuckle, and poison ivy. This supported the q-PCR results and raised additional questions of whether forest or fence row plants serve as spore sources for orchards.

In summary, we have developed a trapping and quantification method for *C. fioriniae* conidia being dispersed in the environment, which, while still needing a few tweaks, offers distinct advantages over culturing based methods. We show that conidia are already being dispersed in orchards and forests during apple full bloom, and increase in quantity later in the season. We show that immature apples can have quiescent bitter rot infections by late May, and that many asymptomatic forest understory plant leaves harbor *C. fioriniae*. These results show that early season infection periods need to be considered when designing bitter rot management programs, and that forests and fencerows adjacent to orchards need to be considered as potential inoculum sources.

Acknowledgements

We wish to thank Gabrielle Crouse and Gabriella Scolpino for their assistance in this work. This research was supported by the State Horticultural Association of Pennsylvania and the USDA National Institute of Food and Agriculture and Smith-Lever Appropriations.

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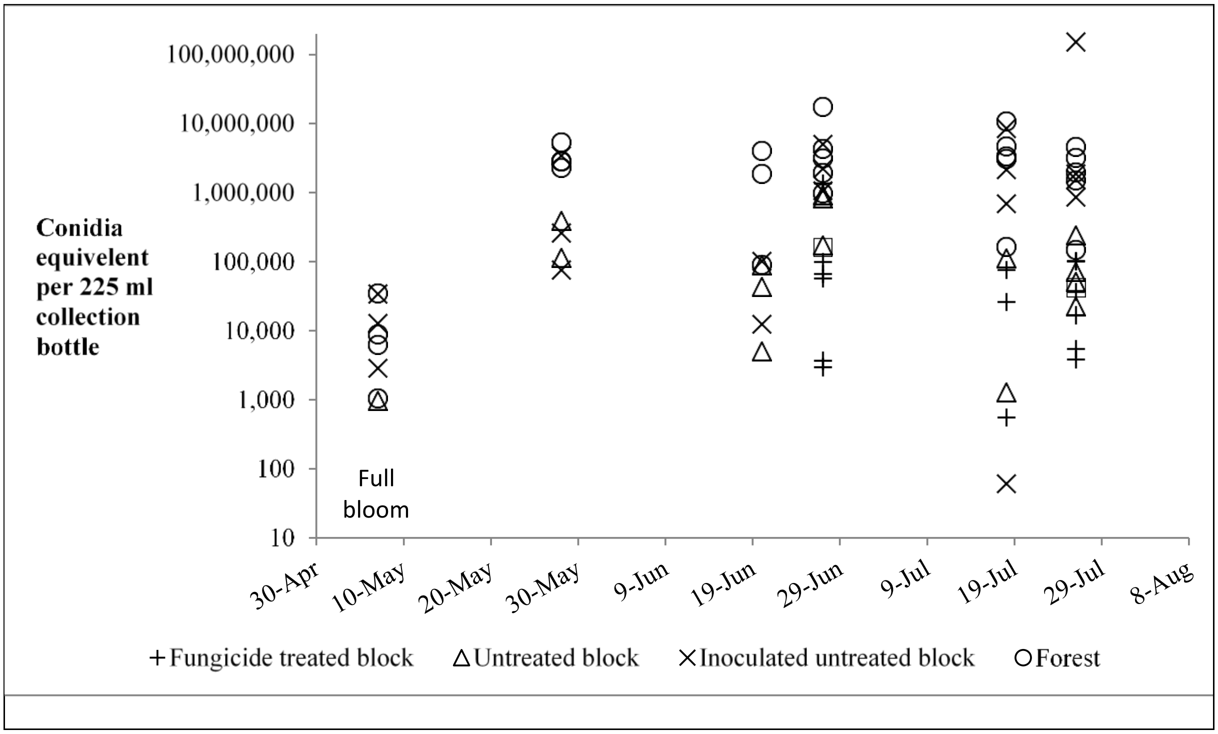

Figure 1: *C. fioirnae* conida equivalent detected per rain-trap collection bottle at 6 time points throughout 2018 in orchard apple blocks under 3 different management conditions and in a nearby forest.

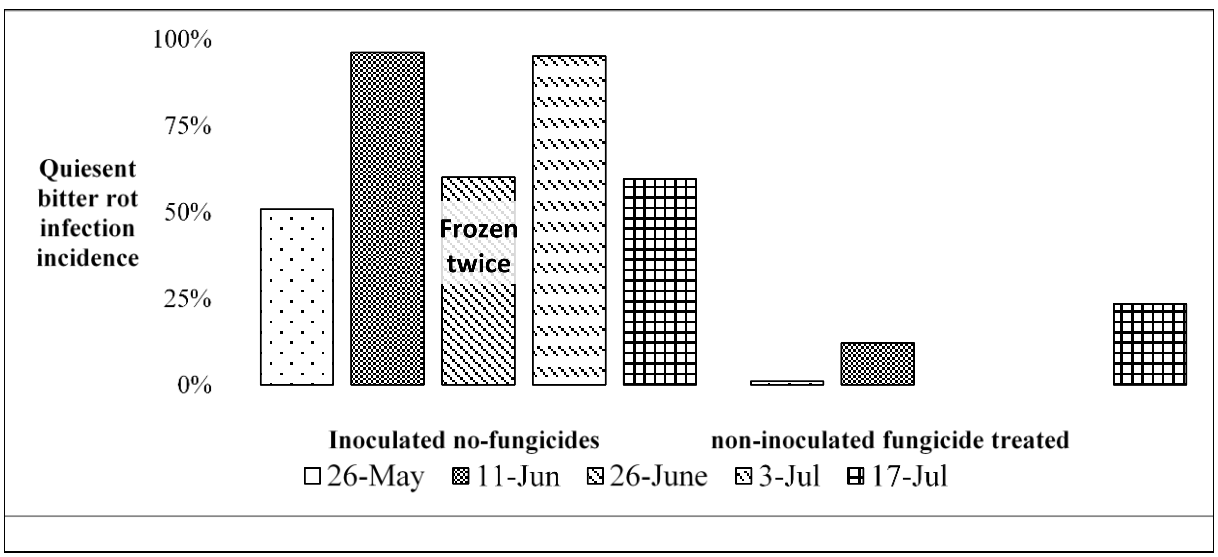

Figure 2: Incidence of quiescent bitter rot infections in a bitter rot inoculated orchard block with no fungicide treatments, and a non-inoculated fungicide treated orchard block, at 4 time points throughout the growing season. The 26-June sample was frozen twice, which may have effected bitter rot incidence.

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FIELD TRIAL UPDATES 2018: BOTRYTIS GRAY MOLD ON GRAPES AND BAGGING TRIALS

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The trial was conducted in 'Chardonnay' grapevines planted in 2009, trained to a vertical shoot positioning system with bilateral cordons, with a spacing of 5 ft between vines and 10 ft between rows. Plots consisted of three consecutive vines and were arranged in a randomized complete block design with four blocks. Treatments were applied with a 4-gal backpack hand-pumped air sprayer, regulated to 21 psi by a Gate CFValve system through a single boom with a TeeJet 8003VS flat fan nozzle. All vines were treated with: Dithane 75DF (3 lb/A) and Microthiol Disperss (Microthiol D; 3 lb/A) on 8 May, 15 May, and 6 Jun; Dithane, Microthiol D, and Prophyt (3 qt/A) on 23 May, 31 May, and 15 Jun; Dithane, Microthiol D, Prophyt, and Quintec (4.8 fl oz/A) on 21 Jun; captan (2 lb/A), Microthiol D, Rally (3.2 oz), and Vivando (9.6 fl oz) on 28 Jun; Captan and Microthol D on 11 Jul; and captan, Prophyt and Microthiol D on 25 Jul, 9 Aug, and 22 Aug. The trial started on 1 Jun, and treatments were applied on a 10- to 13-day interval based on grape's growth stages: prebloom (1 Jun), at bloom (10 Jun), fruit set (23 Jun), and pea-size berry (30 Jun). Experimental design was a randomized complete block design with four blocks. Each treatment consisted of two consecutive vines in the same row. Botrytis and sour rot were visually assessed on 10 Sept and 23 Aug, respectively. Twenty clusters per block were arbitrary selected and assessed. The estimated percentage of infected area (disease severity) per leaf or per cluster and presence or absence of diseased tissue per leaf or cluster (disease incidence) were recorded. The generalized linear mixed model (glmer and lmer in the package "lme4') in R ver. 3.5 (R core development team) was used to conduct the analysis of variance. Treatment was considered a fixed effect, and block and subsample were considered random effects. When treatment effect was found to be significant, ad hoc multiple comparison was conducted using Fisher's LSD with alpha = 0.05.

Bud break of Chardonnay at Winchester was on 20 Apr. We received more than typical precipitation in 2018, the total rainfall in the month of April, May, June, July, and Aug., was 3.4, 9.3, 10.1, 5.6, and 4.8. Thus, maintenance fungicide applications were more frequent than a typical year. Bloom (50%) was on 2 June. Despite of the very frequent rain events, the development of Botrytis gray mold was not as strong as we expected. Cluster incidence of Botrytis gray mold among different treatments ranged from 0.6% to 7.1% and disease severity varied from 0.03% to 1.1%. Treatment effect on both disease incidence ($\chi 2 = 20$, $P < 0.01$) and severity ($F = 3.6$, $P < 0.01$) was significant. Fervent (8.5 fl oz) resulted in the highest mean disease incidence and severity, and was not different from Intuity (6.0 fl oz/A) alternated with Vangard (10.0 fl oz/A) in both mean incidence and severity. The result from Intuity treatment was not surprising since QoI fungicide resistance among Botrytis isolates is wide spread in VA. Miravis Prime (13.5 fl oz) resulted in significantly lower disease incidence and severity (P <

0.05) than both Fervent and Intuity alt. with Vangard. Since both Miravis Prime and Fervent contains an SDHI, the partner material (a DMI for Fervent and PP for Miravis) might have contributed to the difference. Sour rot cluster disease incidence and severity per treatment ranged from 0.6% to 5.8% and 0.09% to 0.47%, respectively. The effect of treatment was not significant with disease incidence ($\chi 2 = 6.8$, $P = 0.2$), but significant with disease severity ($F = 2.3$, $P = 0.047$). Miravis Prime applied at 11.4 fl oz per acre resulted in significantly lower sour rot cluster severity than untreated check and Intuity alternated with Vanguard. Miravis Prime (13.5 fl oz/A) and Fervent (8.5 fl oz/A) resulted in significantly lower sour rot cluster severity than Intuity treatment.

Treatment and amount/A[z]	Days after 1[st] application[y]	Botrytis gray mold on the cluster		Sour rot on the cluster	
		Incidence (SE)[x]	Severity (SE)[x]	Incidence (SE)[x]	Severity (SE)[x]
Mancozeb alt. with Captan (Check)	28, 56, 94 108	9.4(2.3) AB	1.0(0.3) AB	2.5(1.2)	0.17(0.13) AB
Luna Experience (8 fl oz) alt. Pristine (10 fl oz)	28 94	7.5(2.1) AB	0.8(0.3) AB	5.0(1.7)	0.36(0.13) ABC
Miravis Prime(11.4 fl oz)	28, 56, 94, 108	5.6(1.8) AB	0.4(0.2) AB	0.6(0.6)	0.6(0.13) C
Miravis Prime (13.5 fl oz)	28, 56, 94, 108	2.5(1.2) A	0.1(0.1) A	3.1(1.4)	0.13(0.13) BC
Intuity (6.0 fl oz) alt. Vangard (10 fl oz)	28, 94 56	15.0(2.8) B	1.1(0.2) B	5.8(1.9)	0.47(0.13) A
Fervent (8.5 fl oz)	28, 56, 94	13.7(2.7) B	1.3(0.4) B	3.8(1.5)	0.09(0.13) BC

[z] All rates are calculated on a per-acre basis using 100 gal of water, all treatments were tank-mixed with an adjuvant (Hefty 2 pt/A).

[y] The first application of experimental treatments (= maintenance application of Dithane + Microthiol D) was made on 8 May 2018 (= day 0), approximate grape phenology was bloom, bunch closure, veraison, and pre-harvest for 28, 56, 94, and 108 days after the first application, respectively.

[x] Numbers presented are least square mean percentage per treatment. Numbers in the parenthesis are standard errors. Numbers followed by the same letter were not significantly different (LSD with alpha = 0.05).

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EFFECT OF HIGH RELATIVE HUMIDITY ON GERMINATION OF FIVE *COLLETOTRICHUM* SPECIES ISOLATED FROM GRAPES IN VIRGINIA

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In 2016, we have constructed a small “moist chamber” that enable us to monitor rate of spore germination while keeping relative humidity in the chamber consistent throughout the duration of the experiment. One of challenges were to find a sensor that can measure high relative humidity. Our initial trials using a common temperature/RH sensor resulted in very poor results at high RH conditions. E.g., the sensor will produce error message or simply stop working. We identified two (HTU21D-F from Adafruit.com, and Honeywell’s HIH-4030 from Sparkfun.com) sensors (as a breakout board to be able to use it with our system) worked very well. HTU21D-F sensor, which has a typical accuracy of ±2% with an operating range that's optimized from 5% to 95% RH, worked better with our system.

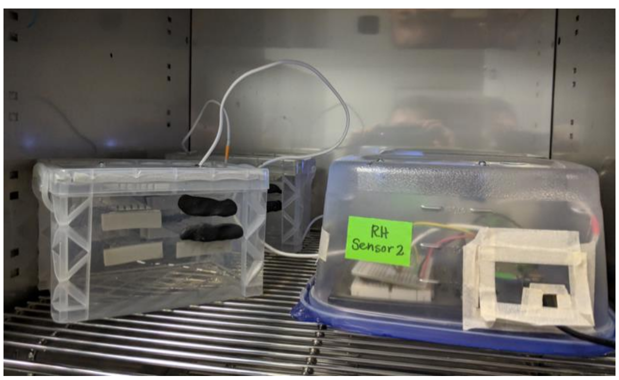

Figure 1. Experimental set up. Clear box on the left contains solution, slides with spores, and temp/RH sensor, and the box on the right contains Arduino microcontroller board and data logger.

The other challenge was to determine how to adjust relative humidity in the moist chamber. There were several literatures from the past, but many used sensors that were not able to accurately measure the range of relative humidity. Thus, we had to conduct a series of experiments to determine the ratio of glycerol and water that can provide the target relative humidity. The chart below shows the results from our trials which were conducted in 2016-2017. Each run took three days to complete, and at each temperature and % glycerol: water combination, there were two runs. To our surprise, the effect of temperature was very small, probably because of the small size of the chamber (approximately 3 x 5 x 4 inches).

In order to determine the effect of relative humidity on spore germination of *Colletotrichum* species, we selected five *Colletotrichum* species that are commonly found in previously conducted VA statewide survey. These are *C. aenigma, C. fioriniae*, *C. alienum*, *C. fructicola*, and *C. nymphaeae*. All are isolated from wine grape berries samples in VA. We initially tested the glass microscope slide as a surface for spore germination, but we found the very erratic results. Thus, we have used cellulose membrane, which will provide more “natural” surface topography than very flat glass surface. A 4mm circles of Cellulose Membrane (CM), also known as dialysis tubing was cut using a single hole punch. The CM circles were boiled in two changes of distilled water with a drop of surfactant (Tween 20). Then these CM circles were autoclaved at 121C for 25min in distilled water. At the same time 30% solution of agar in distilled water was autoclaved. Then a CM circle was adhered using the autoclaved agar to a microscope slide.

Figure 2. A microscope slide with CM circles.

Spores of *Colletotrichum* isolates were prepared as following. An isolate derived from a single spore (to ensure genetic uniformity) was grown on amended-PDA. Nine to fourteen days old culture was then flooded with distilled water. The surface of the amended-PDA was gently rubbed with a sterilized glass rod to promote the release of spores. Suspension was filtered with two layers of Miracloth to remove mycelium. The spore suspension was then adjusted to 1 x 10^5 spores/mL with a use of hemacytometer. On the CM circle, four drops of the spore suspension (20 μL) was placed. The plate with the CM circle was dried under a laminar flow hood for one hour, so that there won't be no free water on the surface of the CM circle. Then 100 spores were visually inspected under a microscope (Nikon Eclipse E200) for the rate of germination before the experiment.

The moist chamber is prepared with a predetermined ratio of water and glycerol solution as indicated above. The moist chamber was placed in an incubator (Fisher Scientific Isotemp Incubator) to achieve target temperature. The inside of the chamber was kept dark to minimize the influence of light. It is prepared 24 hours prior to the placement of the microscope with the CM circle to achieve the target relative humidity prior to the start of the experiment. The microscope slides with the CM circle and four drops of the spore suspension were placed in the moist chamber, and then removed at 24, 48, 72, 96, and 120 hours. At each time point, 25 spores per drop were examined for the rate of germination and of appressoria, which is a fungal structure used for penetration of plant tissue, production under the microscope. For each temperature, relative humidity, and time point, there were two to four replications of microscope slides. The number varied due to uneven rate of spore production.

Our plan was to test three different temperatures, 20, 25, and 30 ℃. Many *Colletotrichum* species are active on these temperature ranges. We are also testing relative humidity of 100%, 96-98%, 93-95%, and 90%. Our preliminary results showed that with less than 90% relative humidity, there were no spore germination even after 120 hours. As of 23 Oct 2018, we have finished 30 ℃ and 100% and 96-98% RH. The results are shown below.

We observed only a few germinated spores after 24 hours; however, at 48 hours, 60 % on average of *C. aenigma* spore germinated. At 72 hours, *C. fioriniae* and *C. fruticola* germinated. *C. nymphaeae* resulted in high germination rate after 96 hours, while *C. alienum* took until 120 hours to germinate.

Both *C. aenigma* and *C. fructicola* were able to produce as many appressorium as 125 on average after 120 hours of 100% relative humidity. The number can be more than 100 because one spore can produce more than one appressorium. Appressorium is a structure the fungus produces to aid penetration of plant cuticle tissue, thus, formation of it is a good indication that these isolates were germinating and recognized the cellulose membrane as a host surface.

When relative humidity was dropped to 98-96% range, the rate of germination was greatly reduced for all isolates. There were a few spores germinated with *C. aenigma, C. fiorinae, and C. nymphaeae* at 38 hours and *C. fructicola* at 72 hours, but we conclude that these isolates were most likely not able to germinate when relative humidity is less than 100%.

As expected, only a few appressorium was produced at 96-98% relative humidity condition. This further confirms that these isolates were not active if relative humidity is less than 100%. The experiments above were conducted from January 2018 to Oct. 2018. We are currently conducting 25 C experiments. Each experimental run needs five days, and at each time point, it takes 1-2 hours to measure spores, thus, the whole process is very time consuming.

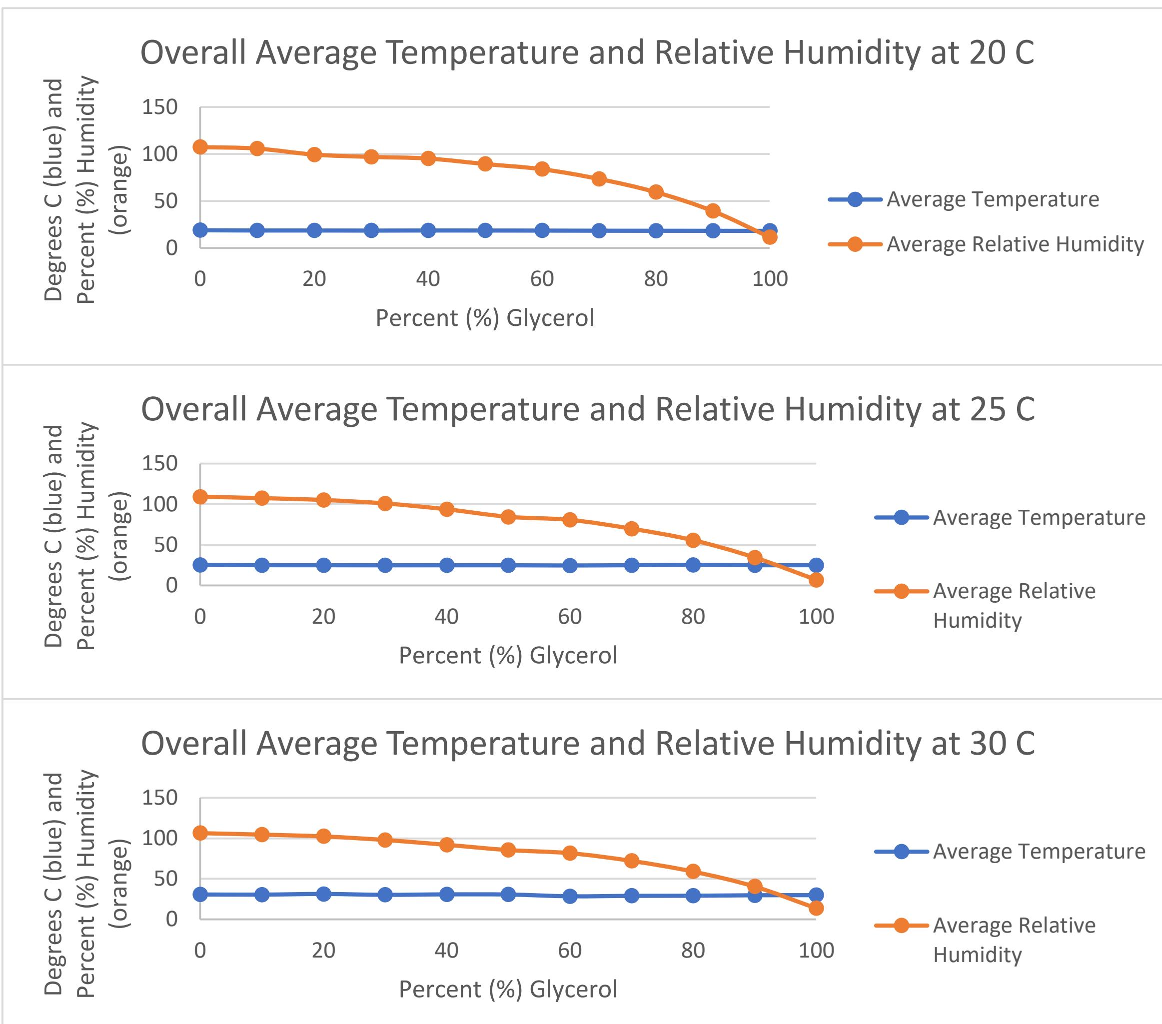

Figure 3. The effect of relative humidity to spore germination

2018 PENNSYLVANIA UPDATE: RAD, NEW DIESASES, PROMISING PRODUCTS

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2018 Rapid Apple Decline Update in Pennsylvania

An unusual phenomenon of many young, dwarf apple trees suddenly dying in apple block has been affecting growers in Pennsylvania as early as 2013. The quest for understanding the underlying cause of Rapid Apple Decline in Pennsylvania continues. RAD was named by Pennsylvania Department of Agriculture due to the rapid or sudden collapse of apple trees from the time the first symptoms appear (chlorotic leaves) to tree death. The graft union appears to be the where necrosis starts, ultimately girdling the tree and leading to death. The typical culprits have been ruled out to date (Phytophthora, fire blight, tomato ringspot virus, phytoplasma, nematodes). Tree stress appears to play a role in susceptibility to the decline; however, we do not know what the initial stressor is, ultimately leading to decline. In 2016, we identified a new apple virus in declining trees at the Penn State Fruit Research and Extension Center, named apple luteovirus 1. Unfortunately, this discovery created more questions than answers. From 2014 – 2017, 16 orchards were evaluated, with a total of 380 samples collected. From the 380 samples, 80 samples tested positive for ALV1 (7 orchards, 4 counties). We have also learned the virus can be unevenly distributed within a tree, such that trees testing negative may be positive. In 2018, we sampled rootstock sources and 2017 budded trees at a local nursery. The M9 rootstock from one source tested positive for ALV1, whereas other rootstock sources for M9 did not. Using this information, we started the process for testing pathogenicity of ALV1 and budded trees where there was only one source for the virus, either from the scion or from the rootstock: +ALV1 scion/ - ALV1 rootstock (100 trees grafted); - ALV1 Scion/+ALV1 rootstock (200 trees). These were budded in August 2018; they will be ready for planting in 2020.

New disease for PA tree fruit growers in 2017 - 2018: Marssonina leaf blotch on apple (*Marssonina caronaria)*

During late September 2017, we first observed Marssonina leaf blotch (MLB) in an untreated apple plot at PSU FREC. Concurrently, there had been confirmed reports of MLB in NY, CT, and NJ. Leaf symptoms included dark lesions surrounded by dark green areas and chlorosis. Eventually, the entire leaf yellowed and fell off the tree. Significant defoliation can occur in a short period of time. During the latter half of the 2018 season (September through October), there were widespread reports of premature defoliation of apple trees (predominantly for the Rome cultivar) throughout PA and MD. The increase in incidence was most likely due to the amount of rainfall received in the region during this period. Based on our observations at PSU FREC, this is an easy disease to control with conventional fungicides, if they are not washed off. In subsequent years, sanitation will be critical in limiting disease spread in orchards since this disease is perpetuated year to year by spores overwintering in fall leaves.

New disease for PA tree fruit growers in 2018: Southern Blight in apple trees *(Sclerotium delphinii*)

Another side effect of the very rainy 2018 season… During late July 2018, there were reports of significant tree death of 2018 planted Crimson Crisp/B9 trees in a commercial orchard. The affected trees had chlorotic leaves and the trees ultimately died. By August, 10-15% of the mixed planting of 2017 and 2018 trees in this same orchard was affected. When inspecting the apple blocks at PSU FREC, we identified four additional apple blocks with similar symptoms: 2018 Gala/M9; 2016 Golden Delicious/M9; 2007 Camo/B9; 2011 Crimson Crisp/B9. There was no rhyme or reason about the pattern of affected trees: a tree here and there or several in the same tree row. Upon close inspection of the trees for all affected sites, there was white mycelial “webbing” wrapped around the crown at the soil line. There was also many light brown microsclerotia present on the soil around the crown, as well as growing on the myeclia on the crown. When digging up the tree to inspect the roots, there was white mycelia with small globules attached to the mycelia throughout the roots and soil. For trees that were dead or dying, the rootstock was necrotic. Upon isolating the fungus and sequencing with ITS primers, it was discovered the infecting fungus was *Sclerotium delphinii*, which is a causal agent of Southern blight on apple in the south. (Note: In the literature, the pathogen used to be called *S. rolfsii* var. *delphinii*; upon further study, the pathogen became its own species.) The pathogen prefers warm, “at capacity” soils. In the United States, there are limited controls once the pathogen is identified in the orchard. Overseas, there has been research soil on drenching asymptomatic trees using fluazinam. The commercial product in the U.S. is Omega (Syngenta); however, Omega is not labeled for soil applications on apples; however, foliar applications for apple is on the label. The product is labeled to control Southern blight on carrot (*S. rolfsii*). Soil solarization is also an option where affected trees are dug up and removed, black plastic is secured over the affected area, and the soil is subsequently “cooked” to kill the pathogen. We are currently working with Syngenta to have a 24c (additional use) for Omega on apple.

2018 Efficacy trials: Highlights

Potassium bicarbonate (Kaligreen) full season

- Commonly used in Europe and Canada.
- Reduced scab by at least 50%.
- Because of scab reduction, we view this as a potential fungicide resistance management tool.
- May be a potential substitute for EBDC or other conventional products early in the season (prior to apple ascospore peak).
- Was not effective on summer diseases (sooty blotch and flyspeck, fruit rots).

OxiDate 2.0

- We substituted broad spectrums (early: mancozeb; covers: captan) with OxiDate (1:300) within a conventional program to evaluate disease control for scab and summer diseases.

- We chose to use Flint Extra (Bayer; trifloxystrobin) during the peak scab ascospore release (bloom through petal fall). We knew there was strobilurin resistance among our scab population in this block.
- Under the conditions we observed in 2018 in a block with known fungicide resistance, a conventional broad spectrum was necessary. We observed Oxidate was not an effective substitute for a broad spectrum for scab control.
- Results were not conclusive when substituting OxiDate for captan to control summer diseases (there was no significant differences among treatments).
- Additional studies are needed with other fungicides and different disease pressure situations.

LifeGard

- In PA, we did not observe any efficacy for fire blight control, whether it was used during bloom time, or to manage shoot blight.
- When we used LifeGard in rotation with captan, we did observe some efficacy for sooty blotch and fruit rot control; however, not for flyspeck. Additional studies are needed.

Nu-Cop XLR and Badge SC

- There was one application of copper (Nu-Cop XLR or Badge SC) that was substituted for a conventional fungicide/bactericide during bloom time. The idea was to determine if one copper application during bloom could control both fire blight and apple scab.
- We observed significant reduction in both diseases, suggesting this could be a potential substitute (particularly for hard cider growers who do not mind fruit finish issues).

Acknowledgements

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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*

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BROAD SPECTRUM DISEASE CONTROL BY EXPERIMENTAL AND REGISTERED FUNGICIDE SCHEDULES ON GOLDEN DELICIOUS AND IDARED APPLES, 2018.

Fifteen experimental or registered combination treatment schedules were compared on two-tree sets of 18-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 2017, which allowed mildew inoculum pressure to stabilize on 2018 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: 18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink), 8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug. Treatments #10-14 were parallel, with the test fungicide applied only in two applications, at open cluster and petal fall, and these were alternated with Inspire Super at bloom and first cover. Treatment #15 did not receive the two applications at open cluster and petal fall, only Inspire Super at bloom and first cover. No fungicide was applied to treatments #10-15 at second cover, then they were all covered with Captan + Ziram 3rd through 8th cover. Inoculum placed over each Golden Delicious test tree included cedar-apple rust galls, wild blackberry canes with the sooty blotch and flyspeck fungi, and bitter rot mummies 10 May. Other diseases developed from inoculum naturally present in the test area, including additional cedar-apple rust inoculum from red cedars in the vicinity. Maintenance sprays, applied to the entire test block included Altacor, Assail, Avaunt, BioCover, Closer, Delegate, Sivanto and Voliam Flexi. Foliar data are from counts of ten shoots per replicate tree: 19 Jun (Golden Delicious) and 31 Jul (Idared), and fruit data represent postharvest counts of 25 fruit per replicate tree. Idared fruit were sampled and placed in cold storage 14 Aug, moved to ambient temperatures (62-94ºF, mean 78.8ºF) 27 Aug, and first rated 29 Aug, then final rot rating 11 Sep after 15 days' incubation at ambient temperatures. Golden Delicious fruit were sampled and placed in cold storage 6 Sep; moved 27 Sep to ambient temperatures (57-85ºF, mean 72.4ºF), and first rated 1 Oct, then final rot rating 12 Oct after 15 days' incubation at ambient temperatures. Percentage data were converted by the square root arcsin transformation for statistical analysis.

This was intended to be a scab test, but with a delay in primary scab infection, it became a strong cedar-apple rust test with inoculum and weather conditions leading to extremely heavy pressure (Tables 1 and 2). Groups of parallel treatments provided opportunity to observe significant rust control by different components of the treatment schedule. Among treatments #1-5 alternated with Inspire Super + Manzate, BAS 752 was the most effective, followed by

Sercadis, Merivon, and Luna Sensation + Manzate (Table 1). When alternated with Merivon, BAS 750 + Manzate was as effective as Inspire Super + Manzate. Luna Sensation (Trt #8), Merivon (#9) and GWN-10411 were among the least effective treatments for rust control. EcoSwing gave a significant rate response in combination with GWN-10411 (Tables 1 and 2). Inspire Super gave only partial control in treatments #10-15, and all companion products in these treatments significantly improved rust control, but Aprovia and S-2399 were the most effective of this group. In general, rust control on Idared was comparable to Golden Delicious. “Leaf spots” in Tables 1 and 2 are probably related to inhibited rust lesions, although this could not be ascertained visually. Mildew conidia were available 10 Apr and there were 37 dry weather infection days through mid-June, leading to moderately heavy powdery mildew pressure. Nearly all treatments gave control of primary and secondary mildew, and fruit infection (Table 3), but overall, Merivon (#9) was the most effective. From mid-May through June, 17 inches of rain brought heavy summer disease pressures. All treatments gave significant control of Brooks spot under moderately heavy pressure (Table 4). Schedules involving Merivon (#2), Sercadis (#3) or BAS 752 (#4), alternated with Inspire Super + Manzate gave excellent Brooks spot control; Luna Sensation (#8) was less effective than Merivon (#9) when applied through 2C. Considering that treatments #12-14 did not receive a 2C application, Luna Sensation, Aprovia and Sercadis, all in combination with Silwet, gave good control of Brooks spot; S-2399 was somewhat weaker. GWN 10411 was also weaker for Brooks spot, but was significantly improved by the higher rate of EcoSwing on Golden Delicious. The 250 accumulated wetting hour threshold for sooty blotch and flyspeck (SBFS) was reached 10 Jun. All treatments gave significant control under heavy SBFS pressure (Table 5). Merivon alternated with BAS 750 + Manzate (#4) was the most effective SBFS treatment overall, especially on flyspeck on Golden Delicious. Other highly effective treatments were Luna Sensation + Manzate (#1) and Merivon (#2), both alternated with Inspire Super + Manzate. GWN 10411 was also weaker for SBFS, but was significantly improved by the higher rate of EcoSwing applied through 2C. Bitter rot pressure was the heaviest in many years, leading to early fruit drop and early collection of samples (Tables 6 and 7). Many fruit that were noted as having “rot spots” at harvest developed bitter rot with further incubation, and only Luna Sensation + Manzate (#1) and Merivon (#2), both alternated with Inspire Super + Manzate and followed by Captan + Ziram, gave significant control after incubation of Idared fruit; on Golden Delicious only #2 gave significant control after incubation. No treatment deleteriously affected fruit finish (Table 8), and several treatments improved it compared to non-treated fruit.

Table 1. Control of cedar-apple rust, "leaf spots" and quince rust on Golden Delicious apple, 2018.

	Treatment and rate/acre	App. number (timing)	Cedar-apple rust % lvs infected	Cedar-apple rust lesions/ leaf	"Leaf spots" * % lvs affected	"Leaf spots" * lesions/ leaf	Quince rust, % fruit
0	Non-treated control	---	59 h	24.3 c	17 cd	0.6 a-c	5 c
1	Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7					
	Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6	19 e	2.0 a	19 cd	1.2 b-e	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C					
2	Merivon 4.18SC 5 fl oz	#1,3,5,7					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6	12 d	1.9 a	19 cd	2.4 gh	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C					
3	Sercadis 3.5 fl oz	#1,3,5,7					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6	4 c	<0.1 a	20 c-e	2.1 fg	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C					
4	Merivon 4.18SC 5 fl oz	#1,3,5,7					
	BAS 750 07F 5 fl oz + Manzate 75DF 3 lb	#2,4,6	13 de	0.9 a	21 c-e	1.7 d-g	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C					
5	BAS 752 02F 7 fl oz	#1,3,5,7					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6	<1 a	<0.1 a	5 a	0.1 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C					
6	GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C	17 de	1.3 a	25 e-g	3.5 i	0 a
	GWN-10411 20SC 5 fl oz	3C-8C					
7	GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C	44 g	6.6 b	22 d-f	1.7 e-g	2 b
	GWN-10411 20SC 3 fl oz	3C8C					
8	Luna Sensation 500SC 5 fl oz	Pk-2C	36 fg	2.7 a	12 b	0.8 a-d	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					
9	Merivon 4.18SC 5 fl oz	Pk-2C	38 g	8.2 b	16 bc	0.9 a-e	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					
10	S-2399 2.84SC 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	<1 a	<0.1 a	7 a	0.1 a	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					
11	S-2399 2.84SC 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	1 ab	<0.1 a	12 b	0.4 ab	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					
12	Luna Sensation 500SC 5 fl oz + Silwet 235 ml	Pk, PF	6 c	0.7 a	29 g	3.0 hi	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					
13	Aprovia 0.83EC 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	<1 a	<0.1 a	17 cd	1.3 c-f	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					
14	Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	3 bc	0.1 a	19 cd	2.4 gh	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					
15	Inspire Super 2.82SC 12 fl oz	Bl, 1C	28 f	7.4 b	28 fg	3.7 i	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C					

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications, 10 shoots/tree rated 19 Jun.

Fruit data represent a 25-fruit sample taken and placed in cold storage 6 Sep; then moved 27 Sep to ambient temperatures (57-85ºF, mean 72.4ºF), and rated 1 Oct.

*"Leaf spots" refers to an unidentified symptom; could be inhibited cedar-apple rust, frogeye leaf spot or an injury response.

Treatment rows were used as non-treated border rows in 2017 to stabilize mildew inoculum pressure for 2018. Applied airblast at 100 gpa to both sides of the row on each application date: 18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink), 8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug.

Table 2. Control of cedar-apple rust and "leaf spots" on Idared, 2018. Block 30, VT-AREC, Winchester.

	Treatment and rate/A	App. number (timing)	Cedar-apple rust % lvs infected	Cedar-apple rust lesions/ leaf	Cedar-apple rust % fruit inf.	"Leaf spots" * % lvs infected	"Leaf spots" * lesions/ leaf	Quince rust, % fruit inf.
0	Non-treated control	---	42 j	8.4 d	3 b	33 g	3.4 e	16 d
1	Luna Sensation 5 fl oz + Manzate 3 lb	#1,3,5,7	10 d-f	0.7 ab	0 a	10 a-c	0.4 a-c	0 a
	Inspire Super 12 fl oz + Manzate 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 3 lb	#8-8C						
2	Merivon 4.18SC 5 fl oz	#1,3,5,7	14 ef	2.3 a-c	0 a	14 b-d	0.8 a-c	0 a
	Inspire Super 12 fl oz + Manzate 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 3 lb	#8-8C						
3	Sercadis 3.5 fl oz	#1,3,5,7	3 a-c	<0.1 a	0 a	13 bc	0.5 a-c	0 a
	Inspire Super 12 fl oz + Manzate 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 3 lb	#8-8C						
4	Merivon 4.18SC 5 fl oz	#1,3,5,7	9 de	0.4 ab	0 a	12 bc	0.5 a-c	0 a
	BAS 750 07F 5 fl oz + Manzate 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 3 lb	#8-8C						
5	BAS 752 02F 7 fl oz	#1,3,5,7	1 a	<0.1 a	0 a	9 ab	0.4 ab	0 a
	Inspire Super 12 fl oz + Manzate 3 lb	#2,4,6						
	Captan 80WDG 30 oz + Ziram 3 lb	#8-8C						
6	GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C	18 fg	2.1 a-c	0 a	23 e-g	1.6 cd	2 b
	GWN-10411 20SC 5 fl oz	3C-8C						
7	GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C	36 ij	5.6 cd	2 ab	24 e-g	1.5 b-d	6 c
	GWN-10411 20SC 3 fl oz	3C8C						
8	Luna Sensation 500SC 5 fl oz	Pk-2C	24 gh	1.5 ab	0 a	21 d-f	0.7 a-c	1 ab
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						
9	Merivon 4.18SC 5 fl oz	Pk-2C	30 hi	4.0 bc	1 a	14 b-d	0.7 a-c	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						
10	S-2399 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	2 ab	<0.1 a	0 a	6 a	0.1 a	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C						
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						
11	S-2399 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	3 ab	<0.1 a	0 a	10 ab	0.1 a	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C						
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						
12	Luna Sensation 5 fl oz + Silwet 235 ml	Pk, PF	4 b-d	0.2 a	0 a	14 b-d	0.4 a-c	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C						
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						
13	Aprovia 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	5 b-d	0.1 a	0 a	11 a-c	0.3 a	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C						
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						
14	Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	6 b-d	0.3 a	0 a	17 c-e	0.7 a-c	0 a
	Inspire Super 2.82SC 12 fl oz	Bl, 1C						
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						
15	Inspire Super 2.82SC 12 fl oz	Bl, 1C	9 c-e	1.7 ab	0 a	28 fg	2.1 d	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	3C-8C						

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications, 10 shoots/tree rated 31 Jul.

Treatment rows were used as non-treated border rows in 2017 to stabilize mildew inoculum pressure for 2018. Applied airblast at 100 gpa to both sides of the row on each application date: 18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink), 8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug.

*"Leaf spots" refers to an unidentified symptom; could be inhibited cedar-apple rust, frogeye leaf spot or an injury response.

Table 3. Powdery mildew control on Idared and Golden Delicious apples, 2018. Block 30, VA Tech-AREC.

		Mildew infection					
	App.	Idared				Golden Delicious	
	number	Primary	%	% leaf	%	%	% leaf
Treatment and rate/A	(timing)	rating*	leaves	area	fruit	leaves	area
0 Non-treated control	---	1.3 g	52 i	23 g	20 d	24 g	3 g
1 Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7	3.7 c-e	6 a-c	2 a-d	1 ab	2 b-d	1 c-e
Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
2 Merivon 4.18SC 5 fl oz	#1,3,5,7	3.8 c-e	4 ab	1 ab	5 c	2 bc	<1 b-e
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
3 Sercadis 3.5 fl oz	#1,3,5,7	4.5 b-d	10 b-e	2 a-d	0 a	4 c-f	<1 b-e
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
4 Merivon 4.18SC 5 fl oz	#1,3,5,7	5.2 b	4 ab	1 ab	0 a	3 b-d	<1 b-d
BAS 750 07F 5 fl oz + Manzate 75DF 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
5 BAS 752 02F 7 fl oz	#1,3,5,7	4.2 b-e	5 ab	1 a	3 a-c	5 c-f	1 b-e
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
6 GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C	3.2 ef	10 b-d	2 a-d	2 a-c	2 a-c	<1 bc
GWN-10411 20SC 5 fl oz	3C-8C						
7 GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C	3.4 de	18 ef	3 b-d	1 ab	3 c-e	1 b-e
GWN-10411 20SC 3 fl oz	3C8C						
8 Luna Sensation 500SC 5 fl oz	Pk-2C	4.8 bc	8 bc	2 a-c	3 a-c	1 ab	<1 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
9 Merivon 4.18SC 5 fl oz	Pk-2C	6.7 a	3 a	1 a	1 ab	<1 a	<1 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
10 S-2399 2.84SC 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	3.5 de	19 f	4 de	1 ab	6 d-f	1 c-e
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
11 S-2399 2.84SC 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	4.1 b-e	33 gh	5 e	3 a-c	7 ef	2 e-g
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
12 Luna Sensation 500SC 5 fl oz + Silwet 235 ml	Pk, PF	4.3 b-e	12 c-e	2 a-d	1 ab	3 b-d	<1 b-d
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
13 Aprovia 0.83EC 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	3.4 d-f	22 fg	3 c-e	1 ab	8 f	2 d-f
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
14 Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	4.8 bc	17 d-f	3 c-e	0 a	3 bc	<1 bc
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
15 Inspire Super 2.82SC 12 fl oz	Bl, 1C	2.2 fg	41 hi	9 f	6 bc	20 g	3 fg
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications, 10 shoots/tree rated 19 Jun (Golden Delicious) or 31 Jul (Idared). Harvest counts of 25 fruit per tree picked 14 Aug; placed in cold storage until 27 Aug then rated 29 Aug.

* Suppressive effect rated on six primary mildew shoots/tree 13 Jun, scale: 1-10 (1= none; 10= excellent effect).

Treatment rows were used as non-treated border rows in 2017 to stabilize mildew inoculum pressure for 2018. Applied airblast at 100 gpa to both sides of the row on each application date: 18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink), 8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug.

Table 4. Scab and Brooks spot control on Idared and Golden Delicious apples, 2018.

	App. number	Scab infection (%)				Brooks spot, % fruit	
		Idared		Golden Delicious			Golden
Treatment and rate/acre	(timing)	leaves	fruit	leaves	fruit	Idared	Delicious
0 Non-treated control	---	3.9 a	15 b	0.5 ab	16 c	52 g	31 e
1 Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7	0.5 a	0 a	0 a	2 ab	4 a-c	0 a
Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
2 Merivon 4.18SC 5 fl oz	#1,3,5,7	0.2 a	1 a	0.4 ab	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	#8-8C						
3 Sercadis 3.5 fl oz	#1,3,5,7	0.7 a	0 a	0.1 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	#8-8C						
4 Merivon 4.18SC 5 fl oz	#1,3,5,7	1.4 a	0 a	0.3 a	1 ab	0 a	0 a
BAS 750 07F 5 fl oz + Manzate 75DF 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
5 BAS 752 02F 7 fl oz	#1,3,5,7	0.7 a	0 a	0 a	0 a	1 ab	0 a
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C						
6 GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C	3.1 a	0 a	0 a	3 ab	18 ef	8 c
GWN-10411 20SC 5 fl oz	3C-8C						
7 GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C	0.4 a	1 a	0 a	1 ab	26 f	15 d
GWN-10411 20SC 3 fl oz	3C8C						
8 Luna Sensation 500SC 5 fl oz	Pk-2C	1.4 a	2 a	0.5 a	4 b	10 c-e	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
9 Merivon 4.18SC 5 fl oz	Pk-2C	0.5 a	1 a	1.2 b	1 ab	1 ab	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
10 S-2399 2.84SC 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	0.4 a	0 a	0 a	0 a	12 de	2 b
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
11 S-2399 2.84SC 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	0.5 a	0 a	0 a	0 a	14 ef	0 a
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
12 Luna Sensation 500SC 5 fl oz + Silwet 235 ml	Pk, PF	0.4 a	1 a	0 a	0 a	6 a-d	0 a
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
13 Aprovia 0.83EC 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	0.6 a	0 a	0 a	2 ab	5 b-d	0 a
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
14 Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	0.1 a	1 a	0.1 a	1 ab	8 c-e	1 ab
Inspire Super 2.82SC 12 fl oz	Bl, 1C						
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						
15 Inspire Super 2.82SC 12 fl oz	Bl, 1C	0.6 a	0 a	0 a	0 a	17 ef	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C						

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications, 10 shoots/tree rated 19 Jun (Golden Delicious) or 31 Jul (Idared). Harvest counts of 25 fruit per tree. Idared picked 14 Aug; placed in cold storage until 27 Aug then rated 29 Aug. Golden Delicious fruit picked and placed in cold storage 6 Sep, then moved 27 Sep to ambient temperatures (57-85ºF, mean 72.4ºF), and rated 1 Oct.

Treatments applied airblast at 100 gpa to both sides of the row on each application date: 18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink), 8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug.

Table 5. Sooty blotch and flyspeck on Idared and Golden Delicious apples, 2018. Block 30, Virginia Tech AREC.

		% fruit or fruit area infected							
	App.	Idared				Golden Delicious			
	number	Sooty blotch		Flyspeck		Sooty blotch		Flyspeck	
Treatment and rate/acre	(timing)	fruit	area	fruit	area	fruit	area	fruit	area
0 Non-treated control	---	100 h	19 i	100 e	15 c	100 g	34 i	100 h	17 g
1 Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7								
Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	13 ab	1 ab	7 a	<1 a	2 a	<1 a	31 bc	2 ab
2 Merivon 4.18SC 5 fl oz	#1,3,5,7								
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	16 a-c	1 a-c	4 a	<1 a	11 ab	<1 a-d	46 c-e	3 b-d
3 Sercadis 3.5 fl oz	#1,3,5,7								
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	26 a-e	1 a-e	11 ab	<1 ab	10 ab	<1 a-c	40 cd	2 bc
4 Merivon 4.18SC 5 fl oz	#1,3,5,7								
BAS 750 07F 5 fl oz + Manzate 75DF 3 lb	#2,4,6								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	11 a	1 a	1 a	<1 a	2 a	<1 a	10 ab	1 a
5 BAS 752 02F 7 fl oz	#1,3,5,7								
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	25 a-e	2 a-e	8 a	<1 a	6 a	<1 ab	10 a	1 a
6 GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C								
GWN-10411 20SC 5 fl oz	3C-8C	55 fg	4 fg	44 c-d	2 cd	68 f	5 g	88 g	8 ef
7 GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C								
GWN-10411 20SC 3 fl oz	3C8C	94 h	10 h	96 e	8 e	99 g	15 h	100 h	18 g
8 Luna Sensation 500SC 5 fl oz	Pk-2C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	61 g	5 g	63 d	4 d	47 ef	4 fg	82 fg	10 f
9 Merivon 4.18SC 5 fl oz	Pk-2C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	38 c-g	3 d-g	29 bc	2 bc	40 de	3 e-g	63 d-f	7 de
10 S-2399 2.84SC 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF								
Inspire Super 2.82SC 12 fl oz	Bl, 1C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	41 d-g	3 c-g	37 c	2 c	19 bc	1 b-e	73 fg	5 de
11 S-2399 2.84SC 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF								
Inspire Super 2.82SC 12 fl oz	Bl, 1C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	34 b-g	2 b-f	31 c	2 c	23 b-d	1 b-e	66 ef	5 c-e
12 Luna Sensation 500SC 5 fl oz + Silwet 235 ml	Pk, PF								
Inspire Super 2.82SC 12 fl oz	Bl, 1C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	33 b-f	2 b-f	35 c	2 c	36 c-e	2 d-f	66 e-g	6 de
13 Aprovia 0.83EC 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF								
Inspire Super 2.82SC 12 fl oz	Bl, 1C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	18 a-d	1 a-d	29 c	2 c	32 c-e	2 d-f	67 e-g	6 de
14 Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF								
Inspire Super 2.82SC 12 fl oz	Bl, 1C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	35 b-g	2 b-f	38 cd	2 cd	28 c-e	2 c-f	65 d-f	5 cd
15 Inspire Super 2.82SC 12 fl oz	Bl, 1C								
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	50 e-g	3 e-g	32 c	2 c	48 ef	3 e-g	71 fg	6 de

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications. Harvest counts of 25 fruit per tree. Idared picked 14 Aug; placed in cold storage until 27 Aug then rated 29 Aug. Golden Delicious fruit picked and placed in cold storage 6 Sep, then moved 27 Sep to ambient temperatures (57-85ºF, mean 72.4ºF), and rated 1 Oct.

Applied airblast at 100 gpa to both sides of the row on each application date: 18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink), 8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug.

Table 6. Post-harvest rot control on Idared apples, 2018. Block 30, VA Tech-AREC, Winchester.

	Treatment and rate/A	App. number (timing)	% fruit infected: Harvest counts, 29 Aug: "Rot spots"	Harvest counts, 29 Aug: Bitter rot	Bitter rot after 15 days warm storage
0	Non-treated control	---	86 g	59 a-c	81 c
1	Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7			
	Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	30 a-c	28 ab	41 ab
2	Merivon 4.18SC 5 fl oz	#1,3,5,7			
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	11 a	24 a	36 a
3	Sercadis 3.5 fl oz	#1,3,5,7			
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	9 a	44 a-c	58 a-c
4	Merivon 4.18SC 5 fl oz	#1,3,5,7			
	BAS 750 07F 5 fl oz + Manzate 75DF 3 lb	#2,4,6			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	22 ab	42 a-c	56 a-c
5	BAS 752 02F 7 fl oz	#1,3,5,7			
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	30 a-c	51 a-c	64 a-c
6	GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C			
	GWN-10411 20SC 5 fl oz	3C-8C	48 b-e	68 c	81 c
7	GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C			
	GWN-10411 20SC 3 fl oz	3C8C	82 fg	64 a-c	84 c
8	Luna Sensation 500SC 5 fl oz	Pk-2C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	38 b-d	59 a-c	77 c
9	Merivon 4.18SC 5 fl oz	Pk-2C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	51 c-e	53 a-c	74 bc
10	S-2399 2.84SC 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF			
	Inspire Super 2.82SC 12 fl oz	Bl, 1C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	62 d-f	50 a-c	71 bc
11	S-2399 2.84SC 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF			
	Inspire Super 2.82SC 12 fl oz	Bl, 1C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	69 e-g	43 a-c	58 a-c
12	Luna Sensation 500SC 5 fl oz + Silwet 235 ml	Pk, PF			
	Inspire Super 2.82SC 12 fl oz	Bl, 1C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	50 b-e	76 c	85 c
13	Aprovia 0.83EC 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF			
	Inspire Super 2.82SC 12 fl oz	Bl, 1C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	42 b-e	62 bc	76 c
14	Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF			
	Inspire Super 2.82SC 12 fl oz	Bl, 1C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	24 a-c	55 a-c	66 a-c
15	Inspire Super 2.82SC 12 fl oz	Bl, 1C			
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	70 e-g	54 a-c	78 c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications, 25 fruit per tree picked and placed in cold storage 14 Aug; moved 27 Aug to ambient temperatures (62-94ºF, mean 78.8ºF). First rated 29 Aug, then final rot rating 11 Sep after 15 days' incubation at ambient temperatures.

Treatments applied airblast at 100 gpa to both sides of the row on each application date:
18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink),
8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug.
Note: no 2c application for treatments #10-15.

Table 7. Post-harvest rots control on Golden Delicious apple, 2018.

Treatment and rate/acre	Application number	% fruit infected: Harvest counts 1 Oct: "Rot spots"	Harvest counts 1 Oct: Bitter rot	Rot incidence after 15 days incubation: Any rot	Rot incidence after 15 days incubation: Bitter rot	Rot incidence after 15 days incubation: White rot
0 Non-treated control	---	55 h	68 c	92 cd	89 b-d	8 a
1 Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7					
Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	13 a-c	33 a	58 a	54 ab	7 a
2 Merivon 4.18SC 5 fl oz	#1,3,5,7					
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	4 a	37 ab	53 a	53 a	0 a
3 Sercadis 3.5 fl oz	#1,3,5,7					
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	18 c-f	66 c	86 bc	86 b-d	1 a
4 Merivon 4.18SC 5 fl oz	#1,3,5,7					
BAS 750 07F 5 fl oz + Manzate 75DF 3 lb	#2,4,6					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	6 ab	57 a-c	71 ab	70 a-c	1 a
5 BAS 752 02F 7 fl oz	#1,3,5,7					
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C	5 ab	70 c	91 bc	90 c-e	3 a
6 GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C					
GWN-10411 20SC 5 fl oz	3C-8C	25 e-g	82 c	95 cd	94 de	2 a
7 GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C					
GWN-10411 20SC 3 fl oz	3C8C	31 fg	80 c	100 d	100 e	2 a
8 Luna Sensation 500SC 5 fl oz	Pk-2C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	5 ab	75 c	88 bc	87 b-d	1 a
9 Merivon 4.18SC 5 fl oz	Pk-2C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	23 d-g	68 c	90 cd	89 c-e	1 a
10 S-2399 2.84SC 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF					
Inspire Super 2.82SC 12 fl oz	Bl, 1C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	14 b-e	67 c	86 bc	85 b-d	5 a
11 S-2399 2.84SC 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF					
Inspire Super 2.82SC 12 fl oz	Bl, 1C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	9 a-d	67 c	92 cd	89 b-d	6 a
12 Luna Sensation 500SC 5 fl oz + Silwet 235 ml	Pk, PF					
Inspire Super 2.82SC 12 fl oz	Bl, 1C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	22 d-g	65 cc	88 bc	86 b-d	4 a
13 Aprovia 0.83EC 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF					
Inspire Super 2.82SC 12 fl oz	Bl, 1C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	32 fg	65 c	88 cd	83 b-d	6 a
14 Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF					
Inspire Super 2.82SC 12 fl oz	Bl, 1C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	38 gh	63 bc	86 bc	83 b-d	4 a
15 Inspire Super 2.82SC 12 fl oz	Bl, 1C					
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C	25 e-g	58 a-c	74 a-c	74 a-d	3 a

Mean separation by Waller-Duncan K-ratio t-test ($p=0.05$). Four paired-tree replications, 25 fruit per tree picked and placed in cold storage 6 Sep; moved 27 Sep to ambient temperatures (57-85ºF, mean 72.4ºF). First rated 1 Oct, then final rot rating 12 Oct after 15 days' incubation at ambient temperatures.

Treatments applied airblast at 100 vgpa to both sides of the row on each application date:
18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink), 8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 Aug.
Note: no 2c application for treatments #10-15.

Table 8. Fruit finish on Golden Delicious and Idared apples, 2018. Block 30, Virginia Tech AREC.

		Fruit finish rating or % USDA grade			
		Fruit finish ratings (0-5)*			G. Delicious, % fruit Ex. Fancy & Fancy
		Idared		Golden Delicious	
Treatment and rate/acre	App. number (timing)	russet	opal-escence	russet	
0 Non-treated control	---	2.2 c	1.6 d	2.9 bc	38 bc
1 Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7	1.6 a-c	0.9 a-c	1.6 a	84 a
Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C				
2 Merivon 4.18SC 5 fl oz	#1,3,5,7	1.6 a-c	0.6 a	2.1 a-c	73 ab
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C				
3 Sercadis 3.5 fl oz	#1,3,5,7	1.4 a	0.7 ab	1.3 a	93 a
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C				
4 Merivon 4.18SC 5 fl oz	#1,3,5,7	1.5 ab	0.7 ab	1.6 a	86 a
BAS 750 07F 5 fl oz + Manzate 75DF 3 lb	#2,4,6				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C				
5 BAS 752 02F 7 fl oz	#1,3,5,7	1.9 a-c	0.9 a-c	1.4 a	91 a
Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-8C				
6 GWN-10411 5 fl oz + EcoSwing 2.0 pt	Pk-2C	1.9 a-c	1.1 a-d	1.9 ab	75 ab
GWN-10411 20SC 5 fl oz	3C-8C				
7 GWN-10411 5 fl oz + EcoSwing 1.5 pt	Pk-2C	2.1 bc	1.3 cd	2.2 a-c	68 a-c
GWN-10411 20SC 3 fl oz	3C8C				
8 Luna Sensation 500SC 5 fl oz	Pk-2C	1.6 a-c	0.8 a-c	1.7 a	76 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				
9 Merivon 4.18SC 5 fl oz	Pk-2C	1.8 a-c	1.2 b-d	2.0 a-c	65 a-c
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				
10 S-2399 2.84SC 3.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	1.7 a-c	1.0 a-c	1.9 ab	81 a
Inspire Super 2.82SC 12 fl oz	Bl, 1C				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				
11 S-2399 2.84SC 2.0 fl oz + Silwet 235 ml/100 gal	Pk, PF	2.0 a-c	1.0 a-c	1.9 ab	77 ab
Inspire Super 2.82SC 12 fl oz	Bl, 1C				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				
12 Luna Sensation 500SC 5 fl oz + Silwet 235 ml	Pk, PF	1.7 a-c	1.0 a-c	2.1 a-c	69 a-c
Inspire Super 2.82SC 12 fl oz	Bl, 1C				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				
13 Aprovia 0.83EC 5.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	2.0 a-c	0.9 a-c	1.8 ab	81 a
Inspire Super 2.82SC 12 fl oz	Bl, 1C				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				
14 Sercadis 3.5 fl oz + Silwet 235 ml/100 gal	Pk, PF	1.7 a-c	0.9 a-c	1.8 ab	81 a
Inspire Super 2.82SC 12 fl oz	Bl, 1C				
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				
15 Inspire Super 2.82SC 12 fl oz	Bl, 1C	2.1 bc	1.1 a-d	3.1 c	37 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-8C				

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree replications. Harvest counts of 25 fruit per tree. Idared picked 14 Aug and placed in cold storage until 27 Aug then rated 29 Aug. Golden Delicious picked 6 Sep and placed in cold storage until 27 Sep then rated 1 Oct.

Treatment rows applied airblast at 100 gpa to both sides of the row on each application date:
18 Apr (Pk, Idared pink; Golden Delicious open cluster); 26 Apr (Bl, Idared bloom; Golden Del. pink),
8 May (PF, petal fall); first – eighth covers (1C-8C): 21 May, 1 Jun, 12 Jun, 29 Jun, 11 Jul, 26 Jul, 9 Aug, 24 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* '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

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CONTROL OF POWDERY MILDEW AND OTHER DISEASES BY MIXED FUNGICIDE SCHEDULES ON IDARED APPLE, 2018.

Fifteen 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 37-yr-old trees using single-tree replications with border rows between treatment rows. 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: 26 Apr (bloom); 2 May (bloom); 14 May (petal fall); first-seventh covers: 22 May, 1 Jun, 12 Jun, 26 Jun, 11 Jul, 26 Jul, 6 Aug. Maintenance materials applied to the entire test block with the same equipment included: Altacor, Assail, Avaunt, BioCover, Closer, Delegate, Sivanto, and Voliam Flexi. Inoculum over each Idared test tree included rust galls, wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies placed 3 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 2 Jul. Apparent suppressive effect on appearance of primary mildew was rated on six primary mildew shoots per tree, 27 Jun using a scale of 1-10 (1= none; 10= excellent effect). Post-harvest fruit counts are means of 25 fruit per tree picked 14 Aug placed in cold storage until 23 Aug, then rated as "at harvest" 27 Aug and again as "post-storage" 6 Sep after 14 days' incubation at ambient temperature, 64-94°F (mean 80.5°F). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew conidia were present 10 Apr, and there were 37 dry weather "mildew infection days" from 10 Apr until mid-June, resulting in moderately heavy infection of non-treated trees (Table 9). Treatments #1 and #8-11 were parallel, with the test fungicide applied in applications #1, 3, 5 and 7, and these were alternated with Inspire Super + Manzate in applications #2, 4 and 6 and followed by Captan + Ziram as the late cover sprays. Treatments #2-4 compared Merivon, Luna Sensation and Luna Tranquility in combination with Manzate in the first two applications, followed by Inspire Super + Manzate in applications #3-5 and by Captan + Ziram at 3C-5C, then finishing the cover sprays with Merivon or Luna Sensation. Treatments #5-7 were season-long applications of single products. Treatments #12-15 compared Pyraziflumid and Gatten through 4C. The higher rate of Gatten + Silwet (Trt #15) had the strongest suppressive effect on primary mildew, and this effectiveness was also evident on foliar secondary mildew control where most treatments gave acceptable control of mildew on foliage. In general, alternating treatments gave better control of mildew russetting than single products through 4C. Under moderate cedar-apple rust pressure (Table 10), all treatments that included Inspire Super (Trts #1-4 and 8-11) gave excellent rust control. A19649 (#5), A15457 (#6), Luna Sensation (#7), Pyraziflumid (Trts #12-13) and Gatten (#14-15) all gave significant rust suppression, but control was somewhat less effective. The unidentified "leaf spots" shown in Table 10 were likely related to partially inhibited rust lesions, but did not have any orange coloration to clearly identify them as such. Scab infection was light on leaves and fruit (Table 11). All treatments gave good control of Brooks spot under moderate pressure, with only Pyraziflumid and Gatten showing any weakness (Table 11). Bitter rot pressure was the heaviest in many years, leading to early fruit drop and forcing early collection of samples (Table 11), and many "rot spots" at harvest developed into bitter rot during post-storage incubation. The schedule with the higher rate of Pyraziflumid + Manzate + Silwet/ Inspire Super + Manzate/ Captan + Ziram (#10) stood out for rot spot/bitter rot control in all post-harvest ratings, while the extended schedules of A19649 (#5), A15457 (#6), Luna Sensation (#7), Pyraziflumid (Trts #12-13) and Gatten (#14-15), all lacking Manzate, were significantly weaker. The 250 accumulated wetting hour threshold for sooty blotch and flyspeck (SBFS) development was reached 10 Jun, and all treatments gave significant control under heavy SBFS pressure (Table 12). Treatments #1-5 and 8-11 generally gave acceptable commercial control of SBFS, while #6, 7 and 12-15 were significantly weaker. In the season-long schedules A19649 (#5) and A15457 (#6), were significantly weaker than Luna Sensation (#7) for rot spot/bitter rot control (Table 11), but A19649 was significantly stronger than A15457 and Luna Sensation for sooty blotch control (Table 12). There were no significant treatment effect on russet, but Pyraziflumid (#13) and Gatten (#14) slightly increased the amount of opalescence compared to non-treated fruit.

Table 9. Powdery mildew and scab control on Idared, 2018. Block 15, Virginia Tech-AREC, Winchester.

			Mildew infection				
	Treatment and rate/A	App. #	Primary rating*	% leaves	% leaf area	% fruit	% fruit area
0	Non-treated control	---	1.5 f	33 f	5.5 e	54 f	7.4 g
1	Merivon 4.18SC 5 fl oz	#1,3,5,7					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6	4.7 b-d	2 b-d	0.5 bc	10 a-c	0.8 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C					
2	Merivon 4.18SC 5 fl oz + Manzate 75DF 3 lb	#1,2					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5	4.7 b-d	4 de	1.0 cd	11 a-d	1.1 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C					
	Merivon 4.18SC 5 fl oz	6C-7C					
3	Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,2					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5	4.4 c-e	3 c-e	0.7 b-d	9 a	0.6 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C					
	Luna Sensation 500SC 5 fl oz	6C-7C					
4	Luna Tranquility 11.2 fl oz + Manzate 75DF 3 lb	#1,2					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5	3.4 e	6 e	1.2 d	12 a-d	1.4 a-e
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C					
	Luna Sensation 500SC 5 fl oz	6C-7C					
5	A19649 200SC 3.42 fl oz	All apps.	5.0 b-d	2 b-d	0.5 bc	23 c-e	2.1 b-f
6	A15457 100EC 5.5 fl oz	All apps.	5.1 bc	6 e	1.2 d	19 b-e	2.0 c-f
7	Luna Sensation 500SC 5 fl oz	All apps.	5.0 b-d	0 a	0 a	23 c-e	2.4 d-f
8	Luna Sensation 500SC 5 fl oz	#1,3,5,7					
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6	5.1 bc	2 bc	0.4 bc	13 a-d	1.5 a-f
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C					
9	Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7					
	Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6	4.4 c-e	1 ab	0.2 ab	10 ab	0.7 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C					
10	Pyraziflumid 4.65 fl oz + Manzate 3 lb + Silwet 1 pt	#1,3,5,7					
	Inspire Super 2.82SC 12 fl oz + Manzate 75DF 3 lb	#2,4,6	5.8 b	2 bc	0.4 b	6 a	0.6 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C					
11	Pyraziflumid 3.1 fl oz + Manzate 3 lb + Silwet 1 pt	#1,3,5,7					
	Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6	3.7 de	2 b-d	0.6 b-d	8 ab	0.7 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C					
12	Pyraziflumid 3.1 fl oz + Silwet 1 pt/100 gal	#1-4C	5.6 bc	1 a-c	0.2 ab	9 ab	1.0 a-d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C					
13	Pyraziflumid 3.1 fl oz	#1-4C	4.8 b-d	2 b-d	0.5 bc	17 a-d	1.9 c-f
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C					
14	Gatten 0.423EC 6.0 fl oz + Silwet 1 pt/100 gal	#1-4C	5.3 bc	1 ab	0.3 ab	33 e	3.3 f
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C					
15	Gatten 0.423EC 8.0 fl oz + Silwet 1 pt/100 gal	#1-4C	7.8 a	1 bc	0.4 b	26 de	3.3 ef
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C					

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots per tree rated 2 Jul. Applied airblast at 100 gpa to both sides of the row on each application date.

* Suppressive effect rated on six primary mildew shoots/tree 27 Jun, scale: 1-10 (1= none; 10= excellent effect).

Treatments applied airblast at 100 gpa to both sides of the row on each application date: 26 Apr (bloom); 2 May (bloom); 14 May (petal fall); first-seventh covers: 22 May, 1 Jun, 12 Jun, 26 Jun, 11 Jul, 26 Jul, 6 Aug.

Table 10. Control of cedar-apple rust and "leaf spots" on Idared, 2018. VT-AREC, Winchester.

	Treatment and rate/A	App. #	Cedar-apple rust % lvs infected	Cedar-apple rust lesions / leaf	"Leaf spots"* % lvs affected	"Leaf spots"* lesions / leaf
0	Non-treated control	---	25 f	1.1 b	20 d	0.5 a
1	Merivon 4.18SC 5 fl oz	#1,3,5,7	<1 ab	<0.1 a	7 a-c	0.1 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C				
2	Merivon 4.18SC 5 fl oz + Manzate 75DF 3 lb	#1,2	0 a	0 a	5 a	0.1 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C				
	Merivon 4.18SC 5 fl oz	6C-7C				
3	Luna Sensation 500SC 5 fl oz + Manzate 75DF 3 lb	#1,2	0 a	0 a	9 a-d	0.2 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C				
	Luna Sensation 500SC 5 fl oz	6C-7C				
4	Luna Tranquility 11.2 fl oz + Manzate 75DF 3 lb	#1,2	<1 a-c	<0.1 a	9 a-c	0.4 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C				
	Luna Sensation 500SC 5 fl oz	6C-7C				
5	A19649 200SC 3.42 fl oz	All apps.	1 a-d	<0.1 a	16 b-d	0.4 a
6	A15457 100EC 5.5 fl oz	All apps.	1 b-d	<0.1 a	9 a-d	0.2 a
7	Luna Sensation 500SC 5 fl oz	All apps.	3 d	<0.1 a	9 a-d	0.2 a
8	Luna Sensation 500SC 5 fl oz	#1,3,5,7	<1 a-c	<0.1 a	6 ab	0.1 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C				
9	Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7	<1 ab	<0.1 a	9 a-d	0.1 a
	Inspire Super 2.82SC 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C				
10	Pyraziflumid 4.65 fl oz + Manzate 3 lb + Silwet 1 pt	#1,3,5,7	<1 a-c	<0.1 a	12 a-d	0.3 a
	Inspire Super 2.82SC 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C				
11	Pyraziflumid 3.1 fl oz + Manzate 3 lb + Silwet 1 pt	#1,3,5,7	<1 ab	<0.1 a	9 a-d	0.2 a
	Inspire Super 2.82SC 12 fl oz + Manzate 75DF 3 lb	#2,4,6				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C				
12	Pyraziflumid 3.1 fl oz + Silwet 1 pt/100 gal	#1-4C	2 cd	<0.1 a	9 a-d	0.2 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C				
13	Pyraziflumid 3.1 fl oz	#1-4C	8 e	0.2 a	15 a-d	0.3 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C				
14	Gatten 0.423EC 6.0 fl oz + Silwet 1 pt/100 gal	#1-4C	8 e	0.2 a	19 cd	0.4 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C				
15	Gatten 0.423EC 8.0 fl oz + Silwet 1 pt/100 gal	#1-4C	8 e	0.2 a	18 cd	0.5 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C				

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots per tree rated 2 Jul.

*"Leaf spots" refers to an unidentified symptom; could be inhibited cedar-apple rust, frogeye leaf spot or an injury response.

Treatments applied airblast at 100 gpa to both sides of the row on each application date: 26 Apr (bloom); 2 May (bloom); 14 May (petal fall); first-seventh covers: 22 May, 1 Jun, 12 Jun, 26 Jun, 11 Jul, 26 Jul, 6 Aug.

Table 11. Scab and summer disease control on Idared apple, 2018. Block 15, VT-AREC, Winchester.

	Treatment and rate /A	App. #	Scab, % lvs inf.	% fruit infected at harvest: fruit scab	Brooks spot	"Rot spots"	Bitter rot	Post-storage rot: Bitter rot (%)	White rot (%)
0	Non-treated control	---	0.4 a	1 ab	16 d	94 g	53 b	90 g	5 b
1	Merivon 4.18SC 5 fl oz	#1,3,5,7	0.5 a	0 a	0 a	21 a-c	8 a	12 ab	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C							
2	Merivon 4.18SC 5 fl oz + Manzate 75DF 3 lb	#1,2	0 a	0 a	0 a	35 cd	15 a	20 bc	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C							
	Merivon 4.18SC 5 fl oz	6C-7C							
3	Luna Sensation 5 fl oz + Manzate 75DF 3 lb	#1,2	0.2 a	0 a	0 a	21 a-c	5 a	23 bc	0 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C							
	Luna Sensation 500SC 5 fl oz	6C-7C							
4	Luna Tranquility 11.2 fl oz + Manzate 75DF 3 lb	#1,2	0 a	0 a	0 a	22 bc	5 a	15 a-c	1 a
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#3,4,5							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	3C-5C							
	Luna Sensation 500SC 5 fl oz	6C-7C							
5	A19649 200SC 3.42 fl oz	All apps.	0.2 a	0 a	0 a	71 f	48 b	65 ef	0 a
6	A15457 100EC 5.5 fl oz	All apps.	0.2 a	0 a	0 a	70 ef	46 b	68 ef	0 a
7	Luna Sensation 500SC 5 fl oz	All apps.	0 a	1 ab	0 a	36 cd	14 a	34 cd	0 a
8	Luna Sensation 500SC 5 fl oz	#1,3,5,7							
	Inspire Super 12 fl oz + Manzate 75DF 3 lb	#2,4,6	0 a	0 a	0 a	9 ab	8 a	18 bc	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C							
9	Luna Sensation 500SC 5 fl oz + Manzate 3 lb	#1,3,5,7							
	Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6	0 a	0 a	0 a	12 ab	6 a	9 ab	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C							
10	Pyraziflumid 4.65 fl oz + Manzate 3 lb + Silwet 1 pt	#1,3,5,7							
	Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6	0 a	0 a	0 a	8 ab	4 a	6 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C							
11	Pyraziflumid 3.1 fl oz + Manzate 3 lb + Silwet 1 pt	#1,3,5,7							
	Inspire Super 2.82SC 12 fl oz + Manzate 3 lb	#2,4,6	0.4 a	0 a	0 a	7 a	6 a	11 ab	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#8-7C							
12	Pyraziflumid 3.1 fl oz + Silwet 1 pt/100 gal	#1-4C	0.2 a	0 a	0 a	62 ef	33 b	60 ef	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C							
13	Pyraziflumid 3.1 fl oz	#1-4C	0.3 a	1 ab	2 b	73 f	52 b	78 fg	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C							
14	Gatten 0.423EC 6.0 fl oz + Silwet 1 pt/100 gal	#1-4C	0.4 a	3 b	6 c	52 d-f	38 b	69 ef	1 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C							
15	Gatten 0.423EC 8.0 fl oz + Silwet 1 pt/100 gal	#1-4C	0.6 a	0 a	3 b	49 de	42 b	52 de	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-7C							

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots per tree rated 2 Jul, or harvest counts of 25 fruit per tree picked 14 Aug placed in cold storage until 23 Aug, then rated as "at harvest" 27 Aug and again as "post-storage" 6 Sep after 14 days' incubation at ambient temperature, 64-94°F (mean 80.5°F).

Treatments applied airblast at 100 gpa to both sides of the row on each application date: 26 Apr (bloom); 2 May (bloom); 14 May (petal fall); first-seventh covers: 22 May, 1 Jun, 12 Jun, 26 Jun, 11 Jul, 26 Jul, 6 Aug.

Table 12. Sooty blotch and flyspeck and fruit finish of Idared apple, 2018. Block 15, VT-AREC, Winchester.

		Fruit infection (%)				Fruit finish*	
		Sooty blotch		Flyspeck			opal-
Treatment and rate/A	App. #	% fruit	% area	% fruit	% area	russet	escence
0 Non-treated control	---	83 g	8.0 g	51 d	2.8 d	1.3 a	1.0 ab
1 Merivon 4.18SC 5 fl oz 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-7C	10 a-c	0.6 a-d	0 a	0 a	1.1 a	1.0 ab
2 Merivon 4.18SC 5 fl oz + Manzate 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb Merivon 4.18SC 5 fl oz	#1,2 #3,4,5 3C-5C 6C-7C	9 a-d	0.5 a-d	0 a	0 a	1.1 a	1.0 a-c
3 Luna Sensation 5 fl oz + Manzate 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb Luna Sensation 500SC 5 fl oz	#1,2 #3,4,5 3C-5C 6C-7C	4 ab	0.2 ab	4 a-c	0.2 a-c	1.3 a	0.9 a
4 Luna Tranquility 11.2 fl oz + Manzate 3 lb Inspire Super 12 fl oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb Luna Sensation 500SC 5 fl oz	#1,2 #3,4,5 3C-5C 6C-7C	6 a-c	0.4 a-d	1 ab	0.1 ab	1.1 a	0.7 a
5 A19649 200SC 3.42 fl oz	All apps.	8 a-c	0.4 a-c	0 a	0 a	1.2 a	0.8 a
6 A15457 100EC 5.5 fl oz	All apps.	25 d-f	1.6 ef	1 ab	0.2 ab	1.4 a	0.8 a
7 Luna Sensation 500SC 5 fl oz	All apps.	42 f	3.1 f	1 ab	0.2 ab	1.4 a	0.9 a
8 Luna Sensation 500SC 5 fl oz 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-7C	4 ab	0.3 ab	0 a	0 a	1.1 a	0.8 a
9 Luna Sensation 5 fl oz + Manzate 3 lb Inspire Super 2.82SC 12 fl oz + Manzate 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 #8-7C	16 b-e	0.8 b-e	0 a	0 a	1.3 a	0.9 a
10 Pyraziflumid 4.65 fl oz + Manzate 3 lb + Silwet 1 pt Inspire Super 2.82SC 12 fl oz + Manzate 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 #8-7C	2 a	0.1 a	0 a	0 a	1.3 a	0.9 a
11 Pyraziflumid 3.1 fl oz + Manzate 3 lb + Silwet 1 pt Inspire Super 2.82SC 12 fl oz + Manzate 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1,3,5,7 #2,4,6 #8-7C	7 a-c	0.4 a-d	0 a	0 a	1.2 a	0.9 a
12 Pyraziflumid 3.1 fl oz + Silwet 1 pt/100 gal Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-4C 5C-7C	19 c-f	1.2 de	1 ab	0.2 ab	1.4 a	1.3 b-d
13 Pyraziflumid 3.1 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-4C 5C-7C	27 ef	1.8 ef	6 c	0.3 c	1.7 a	1.3 cd
14 Gatten 0.423EC 6.0 fl oz + Silwet 1 pt/100 gal Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-4C 5C-7C	20 c-e	1.3 c-e	4 bc	0.2 bc	1.7 a	1.6 d
15 Gatten 0.423EC 8.0 fl oz + Silwet 1 pt/100 gal Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-4C 5C-7C	15 b-e	0.8 b-e	3 a-c	0.2 a-c	1.6 a	1.0 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; harvest counts of 25 fruit per tree picked 14 Aug placed in cold storage until 23 Aug, then rated 27 Aug.

Treatments applied airblast at 100 gpa to both sides of the row on each application date: 26 Apr (bloom); 2 May (bloom); 14 May (petal fall); first-seventh covers: 22 May, 1 Jun, 12 Jun, 26 Jun, 11 Jul, 26 Jul, 6 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* 'Fuji')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Brooks spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Bitter rot; *Colletotrichum* spp.
White rot; *Botryosphaeria dothidea*
Fruit finish

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BROAD SPECTRUM DISEASE CONTROL BY FUNGICIDES FIRST APPLIED TO FUJI APPLE AT PETAL FALL, 2018.

Fourteen treatments tested mixing partners, biofungicides and experimental treatments. Treatments were intentionally delayed to allow early season scab infection to occur. The first infection occurred 15-16 Apr and lesions were present for secondary infection 10-11 May and during later infection periods. Pre-treatment scab infection periods occurred 15-16 Apr, 24-25 Apr, and 5-7 May. Post-treatment infection periods through mid-June were:10-11 May, 14-15 May, 15-19 May, 22 May, 22-23 May, 27-28 May, 31 May-1 Jun, 1-2 Jun, 2-3 Jun, 10-11 Jun, 11-12 Jun. Scab lesions were observed on basal shoot leaves 15 May, probably from infection 15-16 Apr. NEWA model showed that all of the ascospores had been discharged by 12 May. The 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: 9 May (petal fall); first to sixth covers: 22 May, 5 Jun, 18 Jun, 3 Jul, 20 Jul, and 9 Aug. Because of the delay in the initial application, foliar data are based on means of leaves beyond the seventh leaf on ten shoots per tree 17 Jul. Fruit data are based on 25 fruit per tree picked 13 Sep and held in cold storage until they were moved 9 Oct to ambient temperatures (57-82°F, mean 70.1°F), first rated 10 Oct, then rated 23 Oct after 14 days incubation at ambient temperatures. Maintenance products, applied with an airblast sprayer, included: Altacor, Assail, BioCover, Closer, Delegate, Sivanto, Streptomycin and Voliam Flexi. Percentage data were converted by the square root arcsin transformation for statistical analysis.

This was intended to be a scab test, but in spite of frequent wetting periods in May, with the delay in primary scab infection scab incidence was quite light and variable (Table 13). No treatments were significantly better than non-treated trees for foliar scab control, and only treatment #9 gave significant control of fruit scab. By contrast, cedar-apple rust incidence was high with heavy inoculum and weather conditions leading to heavy pressure (Table 14), and Inspire Super + Ziram (#1) and Ziram (#2) gave significant control. Several treatments controlled cedar-apple rust on fruit, and all controlled quince rust. The unidentified "leaf spots" shown in Table 14 were likely related to partially-inhibited rust lesions, but did not have any orange coloration to clearly identify them as such. Under relatively light disease pressure, most treatments suppressed powdery mildew incidence, with ProPhyt + Captan + Induce l(#9) and ProPhyt + Microthiol Disperss (#10) being the most effective (Table 13). In general, summer disease pressure was moderately heavy (Table 15). All treatments controlled Brooks spot. The

250 accumulated wetting hour threshold for sooty blotch and flyspeck (SBFS) was reached by 10 Jun and more than 30 inches of rain fell from May through August. All treatments gave significant control under heavy SBFS pressure (Table 15). ProPhyt-related treatments (#8-10) were among the most effective for SBFS; VA-2 was also effective on sooty blotch. The high rate of ProPhyt + Captan + Induce (#9) effectively controlled fruit rots at harvest and after storage incubation (Table 16). LifeGard (#4) and #8 (the lower rate of ProPhyt + Captan + Induce) gave significant reduction in the "any rot" category. There were several examples of phytotoxicity in this test. Both rates of experimental treatment VA-1 (#13 and 14) caused leaf injury and defoliation by mid-season and a significant amount of opalescence of fruit (Table 14). Nearly all other treatments caused some increase in russet and / or opalescence compared to non-treated fruit.

Table 13. Control of scab and powdery mildew by treatments first applied at petal fall. Fuji apple, 2018. Block 8, VT-AREC.

			Scab infection				Powdery Mildew, % leaves or leaf area	
			% lvs. or les./leaf		% fruit or les./fruit			
	Treatment and rate/100 gal dilute	Timing	leaves infected	lesions/ leaf	fruit infected	lesions/ fruit	leaves	leaf area
0	No fungicide	---	8 a-d	0.2 ab	16 b	0.4 a	13.7 d	2.4 e
1	Inspire Super 3 fl oz + Ziram 76DF 1.5 lb Ziram 76DF 1.5 lb	PF 1C→	7 a-c	0.1 a	4 ab	0.1 a	3.4 a-c	0.8 b-d
2	Ziram 76DF 1.5 lb	PF-6C	8 a-d	0.2 ab	9 ab	0.4 a	5.6 c	1.1 c-e
3	VA-2 1.5 lb	PF-6C	18 d	0.6 b	6 ab	0.2 a	3.6 bc	0.6 b-d
4	LifeGard 4.5 oz	PF-6C	8 b-d	0.2 ab	7 ab	0.4 a	3.5 bc	0.8 b-d
5	LifeGard 4.5 oz Ziram 76DF 1.5 lb	PF,2,4,6C 1C,3C,5C	18 cd	1.1 c	18 b	1.0 a	4.4 bc	1.0 de
6	OSO 5 % 1.63 fl oz	PF-6C	4 ab	<0.1 a	2 ab	0.2 a	2.2 a-c	0.5 a-d
7	OSO 5 % 1.63 fl oz + Induce 8 fl oz	PF-6C	6 ab	0.2 ab	7 ab	0.5 a	2.3 a-c	0.4 a-c
8	ProPhyt 4L 11.4 fl oz + Captan 80WDG 10 oz + Induce 8 fl oz	PF-6C	2 ab	<0.1 a	3 ab	<0.1 a	2.1 a-c	0.4 a-d
9	ProPhyt 4L 15.2 fl oz + Captan 80WDG 15 oz + Induce 8 fl oz	PF-6C	3 a	<0.1 a	0 a	0 a	0.2 a	0.1 a
10	ProPhyt 4L 4 fl oz + Microthiol Disperss 8 oz	PF-6C	8 a-c	0.2 ab	1 ab	0.2 a	1.7 ab	0.4 ab
11	ProPhyt 4L 4 fl oz + Ziram 76DF 1.5 lb	PF-6C	4 ab	<0.1 a	4 ab	<0.1 a	5.1 bc	1.0 de
12	ProPhyt 4L 4 fl oz	PF-6C	7 a-c	0.1 a	10 ab	0.6 a	6.1 cd	1.2 de
13	VA-1 1 pt	PF-6C	5 a-c	0.2 ab	7 ab	0.7 a	4.1 bc	0.8 b-d
14	VA-1 4 fl oz	PF-6C	7 a-d	0.2 ab	5 ab	0.2 a	6.4 cd	1.2 de

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps, 10 shoots/tree 17 Jul, rated from leaf #8 or 25 fruit/tree 13 Sep and rated 10 Oct.

Applied dilute to runoff at 250 psi as follows: 9 May (petal fall); first to sixth covers: 22 May, 5 Jun, 18 Jun, 3 Jul, 20 Jul, 9 Aug.

Pre-treatment scab infection periods: 15-16 Apr (18 hr wetting at 41-47°, with 1.77 in. rain; 24-25 Apr (30 hr at 47-56°, with 0.6 in. rain); 5-7 May (split wetting, 37 hr at 51-60° with 0.95 in. rain). Scab lesions were observed on basal shoot leaves 15 May, probably from infection 15-16 Apr.

Scab history, extended wetting periods after first application (to mid-June):
NEWA model showed that all of the ascospores had been discharged by 12 May. 10-11 May (15 hr at 62° with 0.05 in. rain); 14-15 May (13 hr at 66° with 1.11 in. rain); 15-19 May, 89 hr, 63° with 5.2 in. rain; 22 May, 11 hr at of 67° with 0.24 in. rain; 22-23 May, 7 hr at 71° with 0.02 in. rain; 27-28 May, 16 hr at 69° with 0.14 in. rain; 31 May - 1 Jun, 15 hr at an 70° with 0.65 in. rain; 1-2 Jun, 11 hr at 68° with 1.47 in. rain; 2-3 Jun, 28 hr at 65° with 1.95 in. rain; 10-11 Jun, 15 hr at 59° with 0.51 in. rain; 11-12 Jun, 15 hr at 59° with 0.01 in. rain.

Table 14. Cedar-apple rust, quince rust, "leaf spots" and fruit finish by treatments first applied at petal fall. Fuji apple, 2018.

	Treatment and rate/100 gal dilute	Timing	% leaves or lesions/leaf infected: Cedar-apple rust: leaves	Cedar-apple rust: lesions/ leaf	"Leaf spots"*: leaves	"Leaf spots"*: lesions/ leaf	% fruit infected: Cedar rust	% fruit infected: Quince rust	Fruit finish ratings (0-5)**: Russet	Fruit finish ratings (0-5)**: Opal- escence
0	No fungicide	---	34 cd	10.7 f	44 d	3.6 cd	10 c	10 c	1.3 a	0.8 a
1	Inspire Super 3 fl oz + Ziram 76DF 1.5 lb Ziram 76DF 1.5 lb	PF 1C→	5 a	0.2 a	21 a	0.4 a	0 a	0 a	1.9 ab	1.5 c-e
2	Ziram 76DF 1.5 lb	PF-6C	19 b	1.4 ab	25 ab	0.5 a	3 a-c	0 a	2.0 b	1.2 b-d
3	VA-2 1.5 lb	PF-6C	28 bc	3.6 bc	29 a-c	0.8 ab	3 a-c	0 a	1.9 ab	1.6 de
4	LifeGard 4.5 oz	PF-6C	41 d	7.0 de	46 d	3.7 cd	4 a-c	2 ab	1.9 ab	1.1 a-c
5	LifeGard 4.5 oz Ziram 76DF 1.5 lb	PF,2,4,6C 1C,3C,5C	35 cd	6.3 c-e	37 b-d	2.6 b-d	6 bc	1 ab	2.1 b	1.3 b-d
6	OSO 5 % 1.63 fl oz	PF-6C	32 cd	3.3 cd	41 cd	3.0 cd	1 ab	1 ab	2.3 bc	1.0 ab
7	OSO 5 % 1.63 fl oz + Induce 8 fl oz	PF-6C	35 cd	4.7 cd	49 d	2.7 b-d	2 ab	0 a	2.8 c	2.1 f
8	ProPhyt 4L 11.4 fl oz + Captan 80WDG 10 oz + Induce 8 fl oz	PF-6C	34 cd	6.0 c-e	39 b-d	2.1 a-c	3 a-c	2 ab	2.1 bc	1.4 b-e
9	ProPhyt 4L 15.2 fl oz + Captan 80WDG 15 oz + Induce 8 fl oz	PF-6C	25 bc	3.4 bc	40 cd	1.8 a-c	0 a	0 a	2.0 b	1.3 b-d
10	ProPhyt 4L 4 fl oz + Microthiol Disperss 8 oz	PF-6C	36 cd	7.2 de	42 cd	2.3 a-c	0 a	2 ab	2.2 bc	1.8 de
11	ProPhyt 4L 4 fl oz + Ziram 76DF 1.5 lb	PF-6C	35 cd	5.6 c-e	39 b-d	2.1 a-c	6 bc	3 b	1.8 ab	1.1 a-c
12	ProPhyt 4L 4 fl oz	PF-6C	40 d	8.5 ef	46 d	3.3 cd	6 bc	3 ab	2.1 b	1.1 a-c
13	VA-1 1 pt	PF-6C	27 bc	5.3 cd	63 e	7.6 e	4 a-c	2 ab	1.7 ab	1.4 b-e
14	VA-1 4 fl oz	PF-6C	27 bc	4.8 cd	50 de	4.6 d	2 ab	0 a	1.6 ab	1.6 de

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps, 10 shoots/tree 17 Jul, rated from leaf #8 or 25 fruit/tree picked 13 Sep and rated 10 Oct.

Applied dilute to runoff at 250 psi as follows: 9 May (petal fall); first to sixth covers: 22 May, 5 Jun, 18 Jun, 3 Jul, 20 Jul, 9 Aug.

*"Leaf spots" refers to an unidentified symptom; could be inhibited cedar-apple rust, frogeye leaf spot or an injury response.

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

Table 15. Control of summer diseases by treatments first applied at petal fall. Fuji apple, 2018.

	Treatment and rate/100 gal dilute	Timing	% fruit or fruit area infected, at harvest: Brooks spot, fruit	Sooty blotch fruit	Sooty blotch area	Flyspeck fruit	Flyspeck area
0	No fungicide	---	7 b	100 g	43 h	100 e	16 e
1	Inspire Super 3 fl oz + Ziram 76DF 1.5 lb	PF					
	Ziram 76DF 1.5 lb	1C→	0 a	37 b-d	3 b-e	79 d	7 d
2	Ziram 76DF 1.5 lb	PF-6C	1 a	35 b-d	3 a-d	72 d	5 cd
3	VA-2 1.5 lb	PF-6C	0 a	21 a-c	1 a-c	45 bc	3 a-c
4	LifeGard 4.5 oz	PF-6C	0 a	72 ef	6 fg	76 d	6 d
5	LifeGard 4.5 oz	PF,2,4,6C					
	Ziram 76DF 1.5 lb	1C,3C,5C	0 a	43 c-e	3 c-f	70 cd	6 d
6	OSO 5 % 1.63 fl oz	PF-6C	0 a	57 d-f	4 d-g	75 d	7 d
7	OSO 5 % 1.63 fl oz + Induce 8 fl oz	PF-6C	0 a	50 c-e	4 d-g	69 cd	6 cd
8	ProPhyt 4L 11.4 fl oz + Captan 80WDG 10 oz + Induce 8 fl oz	PF-6C	2 a	25 a-c	2 a-d	25 ab	2 ab
9	ProPhyt 4L 15.2 fl oz + Captan 80WDG 15 oz + Induce 8 fl oz	PF-6C	0 a	14 a	1 a	18 a	1 a
10	ProPhyt 4L 4 fl oz + Microthiol Disperss 8 oz	PF-6C	0 a	16 ab	1 ab	21 ab	1 a
11	ProPhyt 4L 4 fl oz + Ziram 76DF 1.5 lb	PF-6C	1 a	36 b-d	3 c-f	40 ab	3 bc
12	ProPhyt 4L 4 fl oz	PF-6C	1 a	31 a-d	2 a-d	36 ab	3 ab
13	VA-1 1 pt	PF-6C	0 a	70 ef	6 e-g	72 d	5 cd
14	VA-1 4 fl oz	PF-6C	0 a	81 f	6 g	85 d	8 d

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 reps 13 Sep and held in cold storage until 9 Oct, then first rated 10 Oct.
Application dates: 9 May (petal fall); first to sixth covers: 22 May, 5 Jun, 18 Jun, 3 Jul, 20 Jul, and 9 Aug.

Table 16. Control of rot diseases on Fuji apple, 2018. Virginia Tech AREC.

	Treatment and rate/100 gal dilute	Timing	% fruit inf. at harvest: "Rot spots"	Bitter rot	White Rot	Post-storage rots (%)*: Any rot	Bitter rot	White rot	Alter-naria
0	No fungicide	---	61 fg	27 bc	1 a	58 d	42 b-d	15 ab	9 c
1	Inspire Super 3 fl oz + Ziram 76DF 1.5 lb	PF							
	Ziram 76DF 1.5 lb	1C→	32 b-e	29 bc	0 a	54 cd	47 cd	9 ab	1 ab
2	Ziram 76DF 1.5 lb	PF-6C	36 c-e	11 ab	0 a	51 b-d	31 b-d	22 b	4 a-c
3	VA-2 1.5 lb	PF-6C	15 b-d	13 a-c	0 a	32 b-d	25 b-d	12 ab	1 ab
4	LifeGard 4.5 oz	PF-6C	18 b-d	12 ab	0 a	22 a-c	17 a-c	4 ab	1 ab
5	LifeGard 4.5 oz	PF,2,4,6C							
	Ziram 76DF 1.5 lb	1C,3C,5C	36 d-f	33 bc	0 a	50 b-d	44 cd	8 ab	2 ab
6	OSO 5 % 1.63 fl oz	PF-6C	18 b-d	16 a-c	1 a	50 b-d	38 b-d	12 ab	5 bc
7	OSO 5 % 1.63 fl oz + Induce 8 fl oz	PF-6C	13 a-c	16 ab	0 a	33 b-d	24 a-c	10 ab	1 ab
8	ProPhyt 11.4 fl oz + Captan 10 oz + Induce 8 fl oz	PF-6C	15 ab	13 ab	0 a	20 ab	15 ab	5 ab	0 a
9	ProPhyt 15.2 fl oz + Captan 15 oz + Induce 8 fl oz	PF-6C	5 a	2 a	0 a	5 a	3 a	1 a	1 ab
10	ProPhyt 4L 4 fl oz + Microthiol Disperss 8 oz	PF-6C	20 b-e	25 a-c	1 a	45 b-d	40 b-d	8 ab	1 ab
11	ProPhyt 4L 4 fl oz + Ziram 76DF 1.5 lb	PF-6C	26 b-e	23 a-c	0 a	33 b-d	27 b-d	5 ab	1 ab
12	ProPhyt 4L 4 fl oz	PF-6C	31 b-e	18 a-c	1 a	36 b-d	27 b-d	14 ab	1 ab
13	VA-1 1 pt	PF-6C	62 g	46 c	2 a	60 d	56 d	4 ab	1 ab
14	VA-1 4 fl oz	PF-6C	43 e-g	20 a-c	1 a	39 b-d	32 b-d	6 ab	2 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts of 25-fruit samples picked from each of four single-tree reps 13 Sep and held in cold storage. Moved 9 Oct to ambient warm temperatures (57-82°F, mean 70.1°F) and first rated ("at harvest") 10 Oct.
* Post-storage rots rated 23 Oct after 14 days incubation at ambient temperatures.
Application dates: 9 May (petal fall); first to sixth covers: 22 May, 5 Jun, 18 Jun, 3 Jul, 20 Jul, 9 Aug.

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

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BROAD SPECTRUM DISEASE CONTROL BY FUNGICIDES FIRST APPLIED TO GALA APPLE AT PETAL FALL, 2018.

Twelve treatments tested mixing partners, biofungicides and experimental treatments. The test was established on 17-yr-old trees in four randomized blocks using single-tree replications. Treatments were intentionally delayed to allow early season scab infection to occur. The first infection occurred 15-16 Apr and lesions were present for secondary infection 10-11 May and during later infection periods. Pre-treatment scab infection periods occurred 15-16 Apr, 24-25 Apr, 5-7 May and 10-11 May. Post-treatment infection periods through mid-June were: 14-15 May, 15-19 May, 22 May, 22-23 May, 27-28 May, 31 May-1 Jun, 1-2 Jun, 2-3 Jun, 10-11 Jun, 11-12 Jun. Scab lesions were observed on basal shoot leaves 15 May, probably from infection 15-16 Apr. NEWA model showed that all of the ascospores had been discharged by 12 May. The 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: 11 May (PF, petal fall); first- 6th covers (1C-6C): 24 May, 7 Jun, 21 Jun, 5 Jul, 26 Jul, 9 Aug. Foliar data are based on means of all leaves on ten shoots per tree 9 Jul. Fruit data are based on 25 fruit per tree picked 31 Aug and held in cold storage until 4 Sep when they were moved to ambient temperatures (62-94°F, mean 74.3°F), first rated 5 Sep, then rated 19 Sep after 15 days incubation at ambient temperatures. Maintenance products, applied with an airblast sprayer, included: Altacor, Assail, Avaunt, BioCover, Delegate, Sivanto, and Voliam Flexi. Percentage data were converted by the square root arcsin transformation for statistical analysis.

With the delay in the first application until petal fall, scab incidence was moderately heavy (Table 17). Only one treatment (#6, the high rate of experimental material VA-1) was significantly better than non-treated trees for foliar scab control. That effect was likely due to a phytotoxic response that caused some defoliation by the higher rate, possibly resulting in loss of some scab-infected leaves and reduction in secondary inoculum. Interestingly, all treatments *except* #6 gave significant control of scab on fruit, with #8 (Syllit/Badge X2) being the most effective. Under relatively light disease pressure, all treatments suppressed powdery mildew incidence and leaf area effected, with #12 (Apogee combination/Ziram) being the most effective and significantly more effective than Ziram alone (#3). Cedar-apple rust incidence was high, with heavy inoculum and infection periods 24 Apr and 5 May before the treatment series began (Table 18). Under these conditions Regalia + JMS Stylet-Oil/Badge X2 (#9) provided the most control, followed by Ziram (#3) The unidentified "leaf spots" shown in Table 18 were likely related to partially-inhibited rust lesions, but did not have any orange coloration to clearly identify them as such. Treatments #6-11 significantly increased leaf spot incidence, and some of that may have been a phytotoxic response, especially as noted above for #6. All treatments suppressed the incidence of quince rust and cedar-apple rust on fruit. All treatments except VA-1 (#6 and 7) controlled Brooks spot (Table 18). Summer disease pressure was generally heavy (Table 19). The 250 accumulated wetting hour threshold for sooty blotch and flyspeck (SBFS) was reached by 10 Jun and more than 30 inches of rain fell from May through August. Under heavy SBFS pressure, most treatments gave significant control (Table 19). Ziram-related treatments (#2 and 3) were the most effective for SBFS and VA-1 (#6 and 7) was least effective. Rot incidence was heavy, especially bitter rot (Table 19), and only two Badge-related treatments significantly reduced the percent of fruit with "any rot" after incubation. No treatments deleteriously affected fruit finish compared to non-treated fruit; Ziram (#3) improved russet (Table 17).

Table 17. Control of scab and mildew on Gala apple with treatments first applied at petal fall, 2018. Block 30-W, Virginia Tech AREC.

			Scab infection				Powdery Mildew		Fruit finish (0-5)*	
			% leaves	lesions/	% fruit	lesions/	% leaves	% lf area		
	Treatment and rate/100 gal	Timing	infected	leaf	infected	fruit	infected	infected	russet	opalescence
0	No fungicide	---	64 b	9.5 ab	97 f	11.6 e	39 d	6.1 c	1.7 bc	1.4 a-c
1	FireWall 8 oz Ziram 76DF 24 oz	PF 1C-6C	65 b	15.9 b	73 b-d	6.7 cd	15 ab	2.4 ab	1.2 ab	1.1 a-c
2	FireWall 8 oz + Ziram 76DF 24 oz Ziram 76DF 24 oz	PF 1C-6C	57 ab	7.4 ab	58 ab	3.6 ab	27 c	3.3 ab	1.2 ab	1.0 ab
3	Ziram 76DF 24 oz	PF-6C	53 ab	7.0 ab	64 bc	3.0 ab	28 cd	3.9 bc	1.0 a	0.9 a
4	Cueva 1 pt	PF-6C	43 ab	5.7 ab	76 cd	8.0 cd	18 a-c	2.8 ab	2.0 c	1.8 c
5	Cueva 1 pt + Double Nickel LC 8 fl oz	PF-6C	62 b	10.6 ab	74 b-d	5.5 bc	25 bc	3.6 ab	1.5 a-c	1.4 a-c
6	VA-1 1 pt	PF-6C	30 a	2.7 a	92 ef	8.7 de	22 a-c	2.9 ab	1.8 bc	1.3 a-c
7	VA-1 4 fl oz	PF-6C	50 ab	7.2 ab	82 de	7.4 cd	24 a-c	3.3 ab	1.6 a-c	1.7 bc
8	Syllit FL 6 fl oz Badge X2 4 oz	PF 1C-6C	37 ab	2.8 a	42 a	1.9 a	25 bc	3.0 ab	1.4 a-c	1.2 a-c
9	Regalia 12 1pt + JMS Stylet-Oil 2 qt Badge X2 4oz	PF 1C-6C	30 ab	7.5 ab	61 a-c	3.5 ab	16 ab	2.3 ab	1.6 bc	1.4 a-c
10	FireWall 8 oz + Badge X2 4oz Badge X2 4 oz	PF 1C-6C	57 ab	8.7 ab	76 b-d	5.2 bc	18 a-c	2.6 ab	1.7 bc	1.4 a-c
11	Badge X2 4 oz	PF-6C	45 ab	4.5 a	61 a-c	4.9 bc	22 a-c	3.3 ab	1.7 bc	1.6 a-c
12	Apogee 6 oz + Choice 1 qt + LI-700 1 pt + FireWall 8 oz + Ziram 76DF 24 oz Ziram 76DF 24 oz	 PF 1C-6C	50 ab	3.8 a	62 a-c	3.2 ab	14 a	2.2 a	1.6 a-c	1.5 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. 10 shoots/tree, 9 Jul, all leaves rated. Fruit counts represent 25 fruit per tree, sampled 31 Aug and rated 5 Sep.

Applied dilute to runoff with a single nozzle handgun at 250 psi: 11 May (PF, petal fall); first- 6th covers: 24 May, 7 Jun, 21 Jun, 5 Jul, 26 Jul, 9 Aug.

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

Pre-treatment scab infection periods: 15-16 Apr: Wetting event of 18 hr at 41-47°, with 1.77 in. rain; 24-25 Apr: 30 hr at 47-56°, with 0.6 in. rain; 5-7 May: split wetting totaling 37 hr at 51-60° with 0.95 in. rain; Scab lesions were observed on basal shoot leaves 15 May, probably from infection 15-16 Apr.

Post-treatment extended wetting periods to mid-June: 10-11 May (15 hr at 62° with 0.05 in. rain); 14-15 May (13 hr at 66° with 1.11 in. rain); 15-19 May, 89 hr, 63° with 5.2 in. rain; 22 May, 11 hr at of 67° with 0.24 in. rain; 22-23 May, 7 hr at 71° with 0.02 in. rain; 27-28 May, 16 hr at 69° with 0.14 in. rain; 31 May - 1 Jun, 15 hr at an 70° with 0.65 in. rain; 1-2 Jun, 11 hr at 68° with 1.47 in. rain; 2-3 Jun, 28 hr at 65° with 1.95 in. rain; 10-11 Jun, 15 hr at 59° with 0.51 in. rain; 11-12 Jun, 15 hr at 59° with 0.01 in. rain.

Table 18. Effect on rusts, leaf spots and Brooks fruit spot on Gala apple, 2018. Block 30-W, Virginia Tech AREC.

		Cedar-apple rust		"Leaf spots"*		% fruit infected		Brooks spot	
Treatment and rate/100 gal	Timing	% leaves infected	lesions/ leaf	% leaves affected	lesions/ leaf	Cedar-apple rust	Quince rust	% fruit infected	lesions/ fruit
0 No fungicide	---	66 c	12.0 f	8 a	0.1 a	7 b	10 b	31 d	1.0 c
1 FireWall 8 oz	PF								
Ziram 76DF 24 oz	1C-6C	57 bc	6.0 a-c	14 a-c	0.4 a	2 a	1 a	10 a-c	0.2 a
2 FireWall 8 oz + Ziram 76DF 24 oz	PF								
Ziram 76DF 24 oz	1C-6C	52 a-c	7.1 bc	6 a	0.1 a	0 a	1 a	10 ab	0.2 a
3 Ziram 76DF 24 oz	PF-6C	47 ab	6.1 a-c	6 a	0.1 a	2 a	1 a	5 a	0.1 a
4 Cueva 1 pt	PF-6C	52 a-c	7.0 bc	11 ab	0.5 a	1 a	1 a	5 a	0.1 a
5 Cueva 1 pt + Double Nickel LC 8 fl oz	PF-6C	56 bc	10.5 d-f	6 a	0.4 a	0 a	2 a	9 a-c	0.2 a
6 VA-1 1 pt	PF-6C	53 a-c	10.3 ef	35 e	4.0 b	0 a	0 a	21 cd	0.5 b
7 VA-1 4 fl oz	PF-6C	60 bc	9.0 c-f	21 b-d	1.0 a	0 a	0 a	17 b-d	0.4 ab
8 Syllit FL 6 fl oz	PF								
Badge X2 4 oz	1C-6C	53 a-c	4.8 ab	23 c-e	1.0 a	1 a	2 a	11 a-c	0.1 a
9 Regalia 12 1pt + JMS Stylet-Oil 2 qt	PF	38 a	3.0 a	21 bc	1.7 ab	0 a	0 a	7 ab	0.1 a
Badge X2 4oz	1C-6C								
10 FireWall 8 oz + Badge X2 4oz	PF	59 bc	7.4 b-d	32 de	2.9 ab	1 a	0 a	4 a	0.1 a
Badge X2 4 oz	1C-6C								
11 Badge X2 4 oz	PF-6C	55 a-c	8.5 c-e	23 cd	1.6 ab	1 a	1 a	7 ab	0.2 ab
12 Apogee 6 oz + Choice 1 qt + LI-700 1 pt +									
FireWall 8 oz + Ziram 76DF 24 oz	PF								
Ziram 76DF 24 oz	1C-6C	54 a-c	6.4 bc	7 a	0.2 a	0 a	1 a	11 a-c	0.2 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. 10 shoots/tree, 9 Jul, all leaves rated. Four single-tree replications; 10 shoots/tree, 9 Jul, all leaves rated. Fruit counts represent 25 fruit per tree, sampled 31 Aug and rated 5 Sep.

*"Leaf spots" refers to an unidentified symptom; could be inhibited cedar-apple rust, frogeye leaf spot or an injury response. Application dates: 11 May (PF, petal); first- 6th covers: 24 May, 7 Jun, 21 Jun, 5 Jul, 26 Jul, 9 Aug.

Table 19. Summer disease control on Gala apple, 2018. Block 30-W, Virginia Tech AREC.

		% fruit or fruit area infected				% fruit with rot at harvest			Post storage rots				
		Sooty blotch		Flyspeck		Any	Bitter	White	Any	Bitter	White	Blue	Alternaria
Treatment and rate/100 gal	Timing	fruit	area	fruit	area	rot	rot	rot	rot	rot	rot	mold	rot
0 No fungicide	---	95 e	15.1 e	99 h	17.6 g	52 ab	51 ab	5 ab	82 bc	69 ab	22 ab	0 a	0 a
1 FireWall 8 oz	PF												
Ziram 76DF 24 oz	1C-6C	14 b	0.9 bc	35 bc	2.5 bc	26 a	25 a	3 ab	61 ab	33 a	32 b	0 a	0 a
2 FireWall 8 oz + Ziram 76DF 24 oz	PF												
Ziram 76DF 24 oz	1C-6C	3 a	0.2 a	8 a	0.4 a	39 a	38 a	1 ab	66 ab	52 a	19 ab	2 a	1 ab
3 Ziram 76DF 24 oz	PF-6C	2 a	0.1 a	22 ab	1.2 ab	27 a	27 a	0 a	59 ab	46 a	15 ab	0 a	0 a
4 Cueva 1 pt	PF-6C	12 b	0.6 b	54 c-e	3.9 c-e	40 a	37 a	6 ab	78 a-c	57 ab	23 ab	2 a	7 bc
5 Cueva 1 pt + Double Nickel LC 8 fl oz	PF-6C	14 bc	0.8 bc	69 ef	5.6 ef	36 a	36 a	0 a	74 a-c	62 ab	16 ab	1 a	1 ab
6 VA-1 1 pt	PF-6C	35 d	2.0 d	90 gh	7.2 f	77 b	76 b	8 b	95 c	83 b	18 ab	1 a	0 a
7 VA-1 4 fl oz	PF-6C	27 cd	1.7 cd	86 fg	7.3 f	51 ab	49 ab	2 ab	83 bc	64 ab	22 ab	11 b	4 c
8 Syllit FL 6 fl oz	PF												
Badge X2 4 oz	1C-6C	12 b	0.6 b	39 b-d	2.3 bc	17 a	17 a	0 a	40 a	33 a	9 a	1 a	0 a
9 Regalia 12 1pt + JMS Stylet-Oil 2 qt	PF												
Badge X2 4oz	1C-6C	13 b	0.7 bc	60 de	5.8 ef	25 a	24 a	1 ab	59 ab	42 a	17 ab	6 ab	0 a
10 FireWall 8 oz + Badge X2 4oz	PF												
Badge X2 4 oz	1C-6C	23 b-d	1.6 b-d	36 bc	2.5 b-d	17 a	17 a	0 a	46 a	37 a	12 ab	3 a	2 a-c
11 Badge X2 4 oz	PF-6C	16 bc	1.0 bc	63 e	5.2 d-f	29 a	28 a	1 ab	62 ab	52 a	12 ab	2 a	0 a
12 Apogee 6 oz + Choice 1 qt + LI-700 1 pt													
+ FireWall 8 oz + Ziram 76DF 24 oz	PF												
Ziram 76DF 24 oz	1C-6C	12 b	0.8 b	24 ab	1.9 ab	39 a	38 a	2 ab	66 a-c	52 a	22 ab	1 a	1 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications; Fruit counts represent 25 fruit per tree.

Applied dilute to runoff with a single nozzle handgun at 250 psi: 11 May (PF, petal petal); first- 6th covers: 24 May, 7 Jun, 21 Jun, 5 Jul, 26 Jul, 9 Aug.

The 250-hr wetting threshold for sooty blotch/flyspeck was reached 9 Jun.

Fruit samples were picked 31 Aug and held in cold storage until 4 Sep when they were moved to ambient temperatures (62-94°F, mean 74.3°F), first rated 5 Sep, then rated 19 Sep after 15 days incubation at ambient temperatures.

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

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EVALUATION OF COPPERS AND MIXTURES FOR BROAD SPECTRUM DISEASE CONTROL ON IDARED APPLES, 2018.

Fifteen combination treatments were tested on 32-yr-old trees. The test, intended to focus on secondary fire blight and summer diseases, was conducted in a randomized block design with four single-tree replicates. Fungicide treatments applied dilute to runoff with a single nozzle handgun at 300 psi: Treatments #1-12: 1 May (Bl, Bloom), 7 May (PF, petal fall), first to seventh covers, 1C-7C: 21 May, 1 Jun, 12 Jun, 29 Jun, 13 Jul, 27 Jul, 10 Aug. A water spray was applied to untreated trees (#0) with other treatments on 1 May and 7 May, when wetting would have been the only factor needed to trigger fire blight blossom blight infection. Treatments #13-15 received only fourth-seventh cover sprays 29 Jun, 13 Jul, 27 Jul, 10 Aug. Maintenance materials applied airblast to the entire test block included: Altacor, Assail, Avaunt, BioCover, Closer, Delegate, Rhyme, Sivanto, Torino, and Voliam Flexi. Torino and Rhyme were included as part of the maintenance program to suppress mildew. Fire blight inoculations were done on five blossom clusters in the top of each tree 26 Apr (Trts #0-12), using a "Grabber" equipped with nails for wounding and a sponge pad, using an *E. amylovora* suspension at 10^7 cells/ml. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 22 Aug. Fire blight shoot strikes per tree were counted 31 Aug. Post-harvest fruit counts are means of 25-fruit samples picked from each of four single-tree replications, picked 14 Aug, held in cold storage until 12 Sep, then moved to warm storage and first rated 19 Sep. Final rot ratings were 26 Sep after 14 days' ambient temperature incubation 60-82°F (mean 71.1°F). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Although initial inoculations resulted in nearly 100% infection of inoculated blossom clusters, there were only occasional secondary fire blight strikes of shoots (Table 20). Heavy mildew carryover led to moderate infection in the presence of Torino and Rhyme, which were included as part of the maintenance program to suppress mildew. Under these conditions, only treatments involving Ziram gave significant control of foliar mildew compared to non-treated trees. NU-COP HB (Trt #8), Badge (#9), and Regalia + JMS Stylet-Oil followed by Badge suppressed mildew infection of fruit. Apple scab was slow to develop and, in spite of having 9.5 inches of rainfall in May, incidence was light on foliage and fruit. All treatments applied during the early cover spray period gave significant control of Brooks spot (Table 20). With more than 30 inches of rain May-August, summer disease pressure was extremely heavy. The 250-hr wetting threshold for sooty blotch and flyspeck (SBFS) activity was reached by 9 Jun, and under heavy disease pressure, all treatments applied through all cover sprays gave significant control

(Table 22). There was significant flyspeck suppression by treatments delayed until fourth cover (Trts #13-15), and a significant rate difference by ET-F treatments #13 and 14. “Rot spot” and bitter rot infection were heavy, with most full schedule treatments giving significant control; Cueva (#6), NU-COP HB (#8), and treatments involving Badge (#9-11) were among the most effective for bitter rot control. Several treatments significantly increased fruit russet compared to non-treated trees, including GWN-10120, NU-COP XLR and HB, and Badge. Substituting Regalia + JMS Stylet-Oil for Badge in the bloom and petal fall applications significantly reduced russet compared to Badge alone (Table 21, #10 vs. 9).

Table 20. Shoot blight, powdery mildew scab and Brooks spot data on Idared, 2018. Block 13, VT-AREC, Winchester.

	Treatment and rate/100 gal dilute	App. #	Fire blight shoot strikes per tree	Mildew infection % lvs infected	Mildew infection % area infected	Mildew infection % fruit infection	Mildew infection % fruit area	Scab infection % leaves	Scab infection % fruit	Brooks spot, % fruit inf.
0	Non-treated control*	---	0.5 a	30 a	8 ab	36 c-e	6 gh	0 a	2 a	39 d
1	FireWall 8 oz Ziram 76DF 24 oz	Bl-PF 1C-7C	0.3 a	38 ab	8 a-c	42 ef	6 e-h	0 a	1 a	1 ab
2	FireWall 8 oz + Ziram 76DF 24 oz Ziram 76DF 24 oz	Bl-PF 1C-7C	0 a	32 ab	5 a	33 c-e	5 d-g	0 a	1 a	2 a-c
3	Ziram 76DF 24 oz	Bl-7C	0.8 a	28 a	4 a	27 c-e	4 c-e	0.2 a	0 a	1 ab
4	GWN-10120 0.3L 1 pt	Bl-7C	0.5 a	34 ab	6 ab	28 c-e	4 b-d	0 a	0 a	4 bc
5	GWN-10120 0.3L 1.5 pt	Bl-7C	0.8 a	36 ab	4 a	29 c-e	5 d-g	0 a	0 a	5 a-c
6	Cueva 1 pt	Bl-7C	1.0 a	37 ab	7 ab	53 f	8 h	0.4 a	0 a	6 c
7	Nu-Cop XLR 4 fl oz	Bl-7C	0.5 a	32 ab	5 a	27 c-e	3 b-d	0 a	0 a	2 a-c
8	Nu-Cop HB 4 oz	Bl-7C	0.3 a	40 ab	6 ab	14 ab	2 a-c	0 a	0 a	1 ab
9	Badge SC 4 fl oz	Bl-7C	1.0 a	33 ab	5 a	13 a	2 ab	0 a	0 a	2 a-c
10	Regalia 12 1pt + JMS Stylet-Oil 2 qt Badge SC 4 fl oz	Bl-PF 1C-7C	0.5 a	30 ab	4 a	13 a	2 a	0.5 a	0 a	2 a-c
11	FireWall 8 oz + Badge SC 4 fl oz Badge SC 4 fl oz	Bl-PF 1C-7C	0.3 a	34 ab	5 a	23 a-c	3 a-d	0.2 a	0 a	5 c
12	Apogee 6 oz + Choice 1 qt + LI-700 1 pt + FireWall 8 oz + Ziram 76DF 24 oz FireWall 8 oz + Ziram 76DF 24 oz Ziram 76DF 24 oz	Bl PF 1C-7C	0.3 a	35 ab	5 a	31 c-e	4 c-f	0 a	0 a	0 a
13	ET-F 5% Cu 8 fl oz (0.4 oz Cu)	4C-7C	0 a	37 ab	12 b-d	27 b-d	5 d-g	0 a	1 a	56 e
14	ET-F 5% Cu 4 fl oz (0.2 oz Cu)	4C-7C	0 a	43 ab	16 d	38 d-f	6 f-h	0 a	0 a	55 e
15	NU-COP XLR 3.2 fl oz (0.4 oz Cu)	4C-7C	0 a	46 b	14 cd	33 c-e	5 d-h	0 a	2 a	55 e

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications; foliar counts of 10 shoots per tree 22 Aug or 25 fruit per replicate tree picked 14 Aug, held in cold storage until 12 Sep, moved to warm storage, then rated 19 Sep.

Inoculation 26 Apr: Five clusters in the top of each tree (Trts #0-12) inoculated with Grabber equipped with nails for wounding and a sponge pad, using an *E. amylovora* suspension at 10^7 cells/ml. Fire blight shoot strikes per tree were counted 31 Aug.

*Water spray was applied to untreated trees with other treatments on 1 May and 7 May, (when wetting would have been the only factor needed to trigger fire blight blossom blight infection).

Treatments applied dilute to runoff with a single nozzle handgun at 300 psi: 1 May (Bl, Bloom), 7 May (PF, petal fall), first to seventh covers, 1C-7C: 21 May, 1 Jun, 12 Jun, 29 Jun, 13 Jul, 27 Jul, 10 Aug.

Table 21. Control of rusts and "leaf spots" and treatment effect on fruit finish of Idared apples, 2018. Block 13, VT-AREC, Winchester.

	Treatment and rate/A	Timing	Cedar-apple rust % leaves infected	Cedar-apple rust lesions / leaf	"Leaf spots" ** % leaves affected	"Leaf spots" ** lesions / leaf	Quince rust, % fruit	Fruit finish ratings (0-5)*** Russet	Fruit finish ratings (0-5)*** Opalescence
0	Non-treated control *	---	7 a-d	0.3 a	72 c	4.7 d	6 a	1.7 cd	1.4 a-d
1	FireWall 8 oz Ziram 76DF 24 oz	Bl-PF 1C-7C	11 b-e	0.3 a	61 bc	3.2 bc	2 a	1.2 ab	1.2 ab
2	FireWall 8 oz + Ziram 76DF 24 oz Ziram 76DF 24 oz	Bl-PF 1C-7C	13 b-e	0.3 a	44 a	1.4 a	0 a	1.2 ab	1.1 a
3	Ziram 76DF 24 oz	Bl-7C	11 a-e	0.4 a	38 a	1.1 a	0 a	1.1 a	1.0 a
4	GWN-10120 0.3L 1 pt	Bl-7C	10 a-e	0.3 a	64 c	3.7 cd	3 a	2.8 ef	1.7 c-f
5	GWN-10120 0.3L 1.5 pt	Bl-7C	8 a-e	0.2 a	68 c	3.4 cd	2 a	2.9 fg	1.8 d-f
6	Cueva 1 pt	Bl-7C	9 a-e	0.2 a	63 bc	3.4 cd	2 a	1.6 cd	1.0 a
7	Nu-Cop XLR 4 fl oz	Bl-7C	17 de	0.4 a	61 bc	3.1 bc	1 a	2.7 ef	1.5 a-e
8	Nu-Cop HB 4 oz	Bl-7C	16 c-e	0.5 a	64 c	3.1 bc	0 a	3.5 h	1.9 ef
9	Badge SC 4 fl oz	Bl-7C	4 ab	<0.1 a	60 bc	3.5 cd	1 a	3.2 gh	2.2 f
10	Regalia 12 1pt + JMS Stylet-Oil 2 qt Badge SC 4 fl oz	Bl-PF 1C-7C	4 a-c	0.1 a	64 c	3.8 cd	0 a	1.9 d	1.1 a
11	FireWall 8 oz + Badge SC 4 fl oz Badge SC 4 fl oz	Bl-PF 1C-7C	20 e	0.5 a	63 c	3.5 cd	0 a	2.6 e	1.6 b-e
12	Apogee 6 oz + Choice 1 qt + LI-700 1 pt + FireWall 8 oz + Ziram 76DF 24 oz FireWall 8 oz + Ziram 76DF 24 oz Ziram 76DF 24 oz	 Bl PF 1C-7C	10 a-e	0.2 a	50 ab	2.0 ab	3 a	1.6 cd	1.3 a-d
13	ET-F 5% Cu 8 fl oz (0.4 oz Cu)	4C-7C	2 a	<0.1 a	65 c	3.5 cd	3 a	1.6 cd	1.3 a-c
14	ET-F 5% Cu 4 fl oz (0.2 oz Cu)	4C-7C	9 a-e	0.2 a	61 bc	3.5 cd	6 a	1.8 cd	1.2 a-c
15	NU-COP XLR 3.2 fl oz (0.4 oz Cu)	4C-7C	8 a-e	0.2 a	68 c	4.4 cd	2 a	1.5 bc	1.1 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications; foliar counts of 10 shoots per tree 22 Aug or 25 fruit per replicate picked 14 Aug, held in cold storage until 12 Sep, moved to warm storage, then rated 19 Sep.

* Water spray was applied to untreated trees with other treatments on 1 May and 7 May, (when wetting would have been the only factor needed to trigger fire blight blossom blight infection).

**"Leaf spots" refers to an unidentified symptom; could be inhibited cedar-apple rust, frogeye leaf spot or an injury response.

*** 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 300 psi: 1 May (Bl, Bloom), 7 May (PF, petal fall), first to seventh covers, 1C-7C: 21 May, 1 Jun, 12 Jun, 29 Jun, 13 Jul, 27 Jul, 10 Aug.

Table 22. Sooty blotch, flyspeck and rot control on Idared apples, 2018. Block 13, VT-AREC, Winchester.

	Treatment and rate/100 gal dilute	App. #	Sooty blotch % fruit	Sooty blotch % area	Flyspeck % fruit	Flyspeck % area	% infection, first rating "Rot Spots"	% infection, first rating Bitter rot	% infection, first rating White rot	% infection, post-storage* Bitter rot	% infection, post-storage* White rot	% infection, post-storage* Blue mold
0	Non-treated control**	---	100 h	16 g	83 h	6 h	100 g	69 de	1 a	85 de	1 a	0 a
1	FireWall 8 oz	Bl-PF										
	Ziram 76DF 24 oz	1C-7C	25 b	2 b	1 ab	<1 ab	79 d-f	68 de	1 a	75 c-e	0 a	0 a
2	FireWall 8 oz + Ziram 76DF 24 oz	Bl-PF										
	Ziram 76DF 24 oz	1C-7C	8 a	<1 a	4 bc	<1 bc	75 c-f	67 c-e	1 a	72 c-e	1 a	0 a
3	Ziram 76DF 24 oz	Bl-7C	5 a	<1 a	0 a	0 a	69 b-e	62 b-e	0 a	70 b-d	0 a	0 a
4	GWN-10120 0.3L 1 pt	Bl-7C	48 cd	4 bc	10 cd	<1 cd	85 d-f	50 a-d	0 a	62 a-d	1 a	0 a
5	GWN-10120 0.3L 1.5 pt	Bl-7C	30 bc	2 bc	16 de	<1 c-e	75 c-f	42 ab	1 a	57 a-c	1 a	0 a
6	Cueva 1 pt	Bl-7C	68 ef	7 de	20 ef	1 ef	87 d-f	39 ab	0 a	57 a-c	0 a	0 a
7	Nu-Cop XLR 4 fl oz	Bl-7C	63 de	5 cd	28 f	2 f	80 d-f	45 a-d	2 a	53 a-c	1 a	0 a
8	Nu-Cop HB 4 oz	Bl-7C	26 b	2 b	5 bc	<1 bc	50 a-c	37 ab	1 a	45 ab	1 a	0 a
9	Badge SC 4 fl oz	Bl-7C	34 bc	2 b	5 bc	<1 bc	47 ab	37 a	0 a	40 a	0 a	0 a
10	Regalia 12 1pt + JMS Stylet-Oil 2 qt	Bl-PF										
	Badge SC 4 fl oz	1C-7C	41 b-d	4 bc	16 d-f	<1 d-f	40 a	30 a	0 a	38 a	0 a	0 a
11	FireWall 8 oz + Badge SC 4 fl oz	Bl-PF										
	Badge SC 4 fl oz	1C-7C	45 b-d	3 bc	25 ef	2 f	62 a-d	42 a-c	0 a	63 a-d	0 a	1 a
12	Apogee 6 oz + Choice 1 qt + LI-700 1 pt +											
	FireWall 8 oz + Ziram 76DF 24 oz	Bl										
	FireWall 8 oz + Ziram 76DF 24 oz	PF										
	Ziram 76DF 24 oz	1C-7C	4 a	<1 a	1 ab	<1 ab	97 fg	70 de	0 a	84 de	0 a	0 a
13	ET-F 5% Cu 8 fl oz (0.4 oz Cu)	4C-7C	91 gh	12 fg	58 g	3 g	86 e-g	53 a-d	1 a	68 b-d	1 a	0 a
14	ET-F 5% Cu 4 fl oz (0.2 oz Cu)	4C-7C	94 gh	13 g	79 h	5 h	100 g	80 e	1 a	92 e	0 a	0 a
15	NU-COP XLR 3.2 fl oz (0.4 oz Cu)	4C-7C	88 fg	9 ef	48 g	3 g	96 fg	78 e	1 a	86 de	1 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications; counts of 25 fruit per replicate tree picked 14 Aug, held in cold storage until 12 Sep, then moved to warm storage and first rated 19 Sep.

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