Proceedings of the

97th Annual

Cumberland-Shenandoah Fruit Workers Conference

December 1st-3rd, 2021

Virtual Conference

(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the
Cumberland-Shenandoah
Fruit Workers Conference
97th Annual Meeting

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Edited by
Tom Kon

North Carolina State University
Mills River, North Carolina

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Current and Past Executive Officers

2022

President:	Dan Donahue (Cornell)
Secretary/Treasurer:	Srdjan Acimovic (Virginia Tech)
President-Elect:	Mengjun Hu (Maryland)
Immediate-Past President:	Tom Kon (NC State)

2021

President:	Tom Kon (NC State)
Secretary/Treasurer:	Srdjan Acimovic (Virginia Tech)
President-Elect:	Dan Donahue (Cornell)
Immediate-Past President:	Dean Polk (Rutgers)

2020

President:	Dean Polk (Rutgers)
Secretary/Treasurer:	Chris Bergh (Virginia Tech)
President-Elect:	Tom Kon (NC State)
Immediate-Past President:	Kerik Cox (Cornell)

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)

2021 CSWFC Participants

Name	Organization
Alice Wise	Cornell Cooperative Extension
Alina Harris	The Xerces Society/NRCS Partner
Alyssa Kloos	USDA-ARS AFRS
Andrew Bierer	USDA-ARS AFRS
Ann Rucker	Rutgers University
Anna Wallingford	University of New Hampshire
Anna Wallis	Michigan State University Extension
Anne Nielsen	Rutgers University
Annie Vogel	NC State University
Bill MacKintosh	Nutrien Ag Solutions/MacKintosh Fruit Farm
Brent Short	Trécé, Inc
Breyn Evans	USDA-ARS AFRS
Brian Lehman	Penn State University
Byron Phillips	Wilbur Ellis
Caitlin Barnes	USDA-ARS AFRS
Carrie Denson	Rutgers University
Carrie Fitzpatrick	Wilbur Ellis
Catherine Doheny	University of New Hampshire
Cesar Rodriguez-Saona	Rutgers University
Cheryl Vann	USDA-ARS AFRS
Chris Bergh	Virginia Tech
Chris Clavet	NC State University
Chris Gottschalk	USDA-ARS AFRS
Chris Hott	USDA-ARS AFRS
Chris Kropf	Gowan
Dan Birnstihl	University of New Hampshire
Dan Donahue	Cornell University
Dana Acimovic	Virginia Tech
Daniel Beatty	Nutrien Ag Solutions
Daniel Kunkel	AMVAC
Danielle Kirkpatrick	Trécé, Inc
Dave Schmitt	Rutgers Fruit IPM Program
David Rosenberger	Cornell Hudson Valley Laboratory
Dean Polk	Rutgers Cooperative Extension
Doug Pfeiffer	Virginia Tech
Doug Raines	USDA-ARS AFRS
Emily Ogburn	NC State University
Emma Waltman	Rutgers University
Erin Hitchner	Syngenta
Fatemah Khodadadi	Virginia Tech

Name	Organization
Greg Clarke	Valent
Greg Hannig	FMC
Greg Krawczyk	Penn State FREC
Gregory Rogers	Certis Biologicals
Guido Schnabel	Clemson University
Harold Root	USDA-ARS AFRS
Heather Bryant	University of New Hampshire
Holly Bartholomew	USDA-ARS Food Quality Laboratory
Jaime Cummings	Syngenta
Jake Newcombe	Rutgers University
James Larson	NC State University
Janet Van Zoeren	Cornell Cooperative Extension
Jared Dyer	Virginia Tech
Jason Bielski	Virginia Tech
Jason Tyler	Kutztown University
Jeff Chandler	NC State University
Jeremey Delisle	University of New Hampshire
Jeremy Glassford	USDA-ARS AFRS
Jim Hepler	USDA-ARS AFRS
Jim Krupa	University of Massachusetts
Jim Schupp	Penn State FREC
Jim Steffel	LABServices
Jim Walgenbach	NC State University
Johanna Elsensohn	USDA-ARS AFRS
Johanny Castro	Penn State University
John Cullum	USDA-ARS AFRS
John O'Barr	BASF Corporation
Jon Clements	UMass Extension
Julie Urban	Penn State University
Juliet Carroll	Cornell University
Karen Powers	Michigan State University
Kari Peter	Penn State University
Katarzyna (Kasia) Madalinska	Rutgers University
Kathleen Leahy	Polaris Orchard Management
Keith Yoder	Virginia Tech
Kenneth Savia	Virginia Tech
Kevin Webb	USDA-ARS AFRS
Larissa Smith	Syngenta
Laura Mellot	Penn State FREC
Laura Nixon	USDA-ARS AFRS
Lee Carper	USDA-ARS AFRS

Name	Organization
Linda Davis	Wilbur Ellis
Lindsey Milbrath	USDA-ARS
Lisa Tang	USDA-ARS AFRS
Logan Rothestein	USDA-ARS AFRS
Mark Sutphin	Virginia Cooperative Extension
Mason Broderick	USDA-ARS AFRS
Megan Wilson	Rutgers University
Michael Basedow	CCE ENYCHP
Mikey Miller	USDA-ARS AFRS
Mizuho Nita	Virginia Tech
Monique Rivera	Cornell University
Nate Brandt	Virginia Tech
Nikki Rothwell/Jennifer Zelinski	Michigan State University
Norman Lalancette	Rutgers University
Peter Jentsch	Poma Consulting
Philip Martin	Lehigh Agricultural and Biological Services (LABServices)
Phillip Brannen	University of Georgia
Rachel Douglas	NC State University
Rebecca Magron	Rutgers University
Ricardo Delgado Santander	Cornell University
Ryan Bounds	Syngenta
Sam Wilson	CBC America
Sara Villani	NC State University
Sarah Henderson	Penn State University
Scott Cosseboom	University of Maryland
Sean Gresham	NC State University
Sherif Sherif	Virginia Tech
Srdjan Acimovic	Virginia Tech
Stephen Boushell	University of Maryland
Steve Bogash	Marrone Bio Innovations
Steve Schoof	NC State University
Tami Collum	USDA-ARS AFRS
Tim Johnson	Marrone Bio Innovations
Tim Lampasona	Rutgers University
Tom Kon	NC State University
Tony Li	USDA-ARS AFRS
Tony Rugh	USDA-ARS AFRS
Tracy Leskey	USDA-ARS AFRS
Veronica Campos	Rutgers University
Wayne Jurick	USDA-ARS Food Quality Laboratory
Whitney Hadden	Syngenta

97th Cumberland-Shenandoah Fruit Workers Conference
December 1 - 3, 2021
Virtual Meeting, Hosted by Virginia Tech, AHSAREC, Winchester, VA

CONFERENCE AGENDA
All times listed are EST

Wednesday, December 1:

8:45 AM – 9:00 AM	Zoom Link Open
9:00 AM – 9:10 AM	Call to Order, Welcome, and Housekeeping
9:10 AM – 10:10 AM	Call of the States
10:10 AM – 10:30 AM	Call of the Industry
10:30 AM – 11:15 AM	Plenary Session **Challenges and Solutions (?) in PNW Tree Fruit Production** Byron Phillips, Key Account Manager, Wilbur-Ellis
11:15 AM – 11:30 AM	BREAK
11:30 AM – 12:15 PM	Business Meeting
12:15 PM – 1:25 PM	Lunch Break
1:25 PM – 5:15 PM	Horticulture Session

Thursday, December 2:

8:25 AM – 2:45 PM	Entomology Session

Friday, December 3:

8:25 AM – 2:15 PM	Plant Pathology Session

Horticulture Session
Wednesday, December 1st

1:25 – 1:30 PM	**Welcome and housekeeping** *Moderator: Tom Kon, NC State University*
1:30 – 1:45 PM	**The future of the Appalachian Fruit Research Station's pome fruit breeding program** *Christopher Gottschalk. USDA-ARS Appalachian Fruit Research Center*
1:45 – 2:00 PM	**Addressing herbicide trunk deposition in high density apple systems** *Janet van Zoeren and Michael Basedow. Cornell Cooperative Extension.*
2:00 – 2:15 PM	**A quantitative weed IPM program for New Jersey blueberries** *Carrie Denson and Dean Polk. Rutgers University*
2:15 – 2:30 PM	**Effect of timing and air output of pneumatic defoliation on canopy light distribution and red color of apple** *Jim Schupp and Melanie Schupp. Penn State Fruit Research and Extension Center*
2:30 – 2:45 PM	**Effects of ReTain and Harvista on the pre-harvest drop and cracking of 'Gala' apple** *Sherif Sherif, Jianyang Liu, and Tabibul Islam. Virginia Tech AHSAREC.*
2:45 – 3:00 PM	**Assessing the efficacy of GA_{4+7} products for the control of stem-end splitting in 'Gala' apples** *Sherif Sherif, Tabibul Islam, and Jianyang Liu. Virginia Tech AHSAREC.*
3:00 – 3:30 PM	**Additional questions / Targeted discussion: Fruit finish and cracking**
3:30 – 3:45 PM	**Break**
3:45 – 4:00 PM	**Bloom thinning with the PTGM in Northern NY** *Michael Basedow. Cornell Cooperative Extension: ENYCHP*
4:00 – 4:15 PM	**A RECIPE for predicting fruit set using the fruitlet growth rate model: tested in 2021** *Jon Clements. UMass Extension*
4:15 – 4:30 PM	**Vis/NIR Spectroscopy is a promising tool to predict apple fruitlet abscission** *Jimmy Larson and Tom Kon. NC State University*
4:30 – 4:45 PM	**Evaluation of the new materials ACC and Metamitron for chemical thinning of 'Gala' apples** *Anna Wallis. MSU Extension*
4:45 – 5:00 PM	**Effects and interactions of blackberry genotype and PGRs on vegetative growth** *Tom Kon, Chris Clavet, and Ann Piotrowski. NC State University*
5:00 – 5:15 PM	**Additional questions and open discussion**

Entomology Session
Thursday, December 2nd

8:25 – 8:30 AM **Welcome and housekeeping** *Moderator: Steve Schoof, NC State University*

8:30 – 8:45 AM **Distribution of 17-year periodical cicada nymphal exuviae and oviposition injury in Mid-Atlantic apple orchards**
Chris Bergh[1], Jared Dyer[1], Nate Brandt[1], John Cullum[2], Laura Nixon[2], Tracy Leskey[2], and Mizuho Nita[1]. Virginia Tech AHSAREC[1] and USDA-ARS Appalachian Fruit Research Center[2]

8:45 – 9:00 AM **Management impacts on secondary orchard pests and beneficial insects under mating disruption**
Jake Newcombe and Anne Nielsen. Rutgers University

9:00 – 9:15 AM **Mating disruption in small apple plots: Does it work?**
Tracy C. Leskey, John Cullum, Chris Hott, and Lee Carper. USDA-ARS Appalachian Fruit Research Station

9:15 – 9:30 AM **In-situ distribution of plum curculio *Conotrachelus nenuphar* in peach and blueberry farms**
Timothy Lampasona, Anne Nielsen, and Cesar Rodriguez-Saona. Rutgers University

9:30 – 9:45 AM **Assessing the impact of ruby-throated hummingbird predation on spotted-wing drosophila in raspberry**
Juliet Carroll, Percival Marshall, Nicole Mattoon, Courtney Weber, Greg Loeb. Cornell University

9:45 – 10:00 AM **Effects of buckwheat strips on abundances of beneficial and pest insect species in experimental peach orchards**
Emma Waltman and Anne Nielsen. Rutgers University

10:00 – 10:15 AM **Additional Questions and open Discussion**

10:15 – 10:30 AM **BREAK**

10:30 – 10:45 AM **Monitoring BMSB revisited - research and practice**
Greg Krawczyk and Edwin Winzeler. Penn State University Fruit Research and Extension Center

10:45 – 11:00 AM **Does trap location matter? Comparing captures of *Trissolcus japonicus* in mid- and lower canopy yellow sticky cards**
Jared Dyer[1], Elijah Talamas[2], Tracy Leskey[3], and Christopher Bergh[1]. Virginia Tech AHSAREC[1], Florida Department of Agriculture and Consumer Services[2], USDA-ARS Appalachian Fruit Research Station[3]

11:00 – 11:15 AM **Conventional and molecular assessment of parasitism in stink bug sentinel egg masses**

	James R. Hepler[1]*, Kacie Athey*[2]*, David Enicks*[3]*, Paul K. Abram*[4]*, Tara D. Gariepy*[4]*, Elijah J. Talamas*[5]*, and Elizabeth Beers*[3]*. USDA-ARS Appalachian Fruit Research Station*[1]*, University of Illinois at Urbana Champaign*[2]*, Washington State University TFREC*[3]*, Agriculture and Agri-Food Canada*[4]*, and Florida Department of Agriculture and Consumer Services*[5]
11:15 – 11:30 AM	**What to do about BMSB on Granny Smith apples?** *Jim Walgenbach, Steve Schoof, and Emily Ogburn. NC State University*
11:30 – 11:45 AM	**Is Attract-and-Kill a viable option for brown marmorated stink bug control in NC apples?** *Steve Schoof and Jim Walgenbach. North Carolina State University*
11:45 – 12:00 PM	**Additional questions / Open discussion**
12:00 – 1:00 PM	**Lunch**
1:00 – 1:15 PM	**Incipient invasion of spotted lanternfly into Northern Virginia vineyards** *Johanna Elsensohn. USDA-ARS Appalachian Fruit Research Station*
1:15 – 1:30 PM	**Spotted lanternfly, Lycorma delicatula, enters Virginia vineyards** *Doug Pfeiffer*[1]*, Jason Bielski*[1]*, and Mark Sutphin*[2]*. Virginia Tech*[1] *and Virginia Cooperative Extension*[2]
1:30 – 1:45 PM	**Spotted lanternfly phenology in New Jersey** *Katarzyna Madalinska and Anne L. Nielsen. Rutgers University*
1:45 – 2:00 PM	**Update on female spotted lanternfly reproductive development in eastern Pennsylvania** *Julie Urban and Dennis Calvin. Penn State University*
2:00 – 2:15 PM	**Management of overwintering spotted lanternfly (*Lycorma delicatula*) egg masses with the entomopathogenic fungus, *Beauveria bassiana*** *Jason Bielski, Douglas Pfeiffer, and Stefan Jaronski. Virginia Tech*
2:15 – 2:30 PM	**Season-long effects of spotted lanternfly infestation on young apple and peach trees: Short-term effects and long-term plans** *Laura J. Nixon, Lisa Tang, Caitlin Barnes, Tony Rugh, and Tracy C. Leskey. USDA-ARS Appalachian Fruit Research Station*
2:30 – 2:45 PM	**Additional questions and open discussion**

Plant Pathology Session
Friday, December 3rd

8:25 – 8:30 AM	**Welcome and housekeeping** *Moderator: Sara Villani, NC State University*
8:30 – 8:45 AM	**Summary of peach disease control using biorational materials** *<u>Norman Lalancette</u> and Lorna Blaus. Rutgers University*
8:45 – 9:00 AM	**Investigation of alternative fungicides for preharvest peach brown rot control** *<u>Guido Schnabel</u>, William Gura, and Jeff Hopkins. Clemson University*
9:00 – 9:15 AM	**Edging out the competition: The blue mold fungus uses patulin to exclude other fungi at the food infection court** *<u>Holly Bartholomew</u>, Michael Bradshaw, Otilia Macarisin, Verneta Gaskins, Jorge Fonseca, and Wayne Jurick II. USDA-ARS Food Quality Lab*
9:15 – 9:30 AM	**Using leaf wetness and temperature to predict *Colletotrichum* infection of grapes** *Scott Cosseboom and Mengjun Hu. University of Maryland.*
9:30 – 9:45 AM	**Fungicide field trials: Grape powdery mildew and downy mildew, Winchester, VA 2021** *<u>Mizuho Nita</u> and Kenneth Savia. Virginia Tech AHSAREC*
9:45 – 10:00 AM	**Fungicide field trials: Grape late season rots and protective materials, Winchester, VA 20**21 *<u>Mizuho Nita</u> and Kenneth Savia. Virginia Tech AHSAREC*
10:00 – 10:15 AM	**Additional Questions / Open Discussion**
10:15 – 10:30 AM	**BREAK**
10:30 – 10:45 AM	**Spring snow cover and apple scab pseudothecial development** *<u>Juliet Carroll</u>, Wayne Wilcox, Ron Neville, Judy Nedrow, and Percival Marshall. Cornell University*
10:45 – 11:00 AM	**Control of shoot blight and cankers on pear with Regalia and the effect of Gatten® and Parade® on apple powdery mildew** *<u>Srđan Aćimović</u>[1], Christopher Meredith[2], Andrew Davis[1], and Vivien Wong[1]. Virginia Tech AHSAREC[1] and Cornell University[2].*
11:00 – 11:15 AM	**Tackling the role of environmental and host factors in *Erwinia amylovora* survival and long-term persistence in fire blight cankers** *<u>Ricardo Delgado Santander</u>[1], Christopher Meredith[1], Fatemeh Khodadadi[2], Jon Clements[3], and Srđan Aćimović[2]. Cornell University[1], Virginia Polytechnic Institute and State University[2], and University of Massachusetts Amherst[3]*
11:15 – 11:30 AM	**Plant pathogens associated with ambrosia beetles attacking apple trees: Hitchhikers, bed-fellows, or beacons for beetle attack?**

	Sean Gresham, Jim Walgenbach, and Sara Villani. North Carolina State University
11:30 – 12:00 PM	**Additional questions and targeted discussion: A challenging year for bitter rot?**
12:00 – 1:00 PM	**Lunch**
1:00 – 1:15 PM	**Exploring the effects of spray tactics on selection for fenhexamid resistance in *Botrytis cinerea*** *Stephen Boushell and Mengjun Hu. University of Maryland*
1:15 – 1:30 PM	**Apple chlorotic leaf spot virus on cv. Pristine in New England orchards** *Kathleen Leahy. Polaris Orchard Management*
1:30 – 1:45 PM	**Apple blotch (Marssonina Leaf Blotch) disease caused by *Diplocarpon coronariae*: A rising problem in the Mid-Atlantic, US** *Fatemeh Khodadadi[1], Phillip Martin[2], Kari Peter[2], Daniel J. Donahue[3], and Srđan Aćimović[1]. Virginia Tech AHSAREC [1], Penn State University[2], and Cornell Cooperative Extension[3].*
1:45 – 2:00 PM	**Unraveling *Colletotrichum* species causing Glomerella leaf spot and bitter rot on apple in NC** *Sara Villani[1], Rachel Douglas[1], Kendall Johnson[2], Michael Bradshaw[3], and Wayne Jurick[4]. NC State University[1], University of Georgia[2], Harvard University[3], and UDSA-ARS Beltsville[4].*
2:00 – 2:15 PM	**Additional questions and open Discussion**

BUSINESS MEETING MINUTES

December 1st, 2021

Compiled and submitted by Srdjan Acimovic, CSFWC Inc. Secretary/Treasurer

Tom Kon (President) called the virtual meeting to order at 11:35 a.m.

41 members attended the Business Meeting, fulfilling the quorum requirement of 10% (conference attendance = 120).

The Minutes of 2020 Business meeting compiled by Chris Bergh were put to motion. There was no discussion of the minutes. Motion to accept the minutes by Srdjan Acimovic, seconded by Tracy Leskey and the motion carried.

New Secretary/Treasurer Srdjan Acimovic was introduced. The outgoing Secretary/Treasurer Chris Bergh was acknowledged for years of his dedicated service to CSFWC Inc.

Old business:

Summary of a poll was sent middle-summer 2021 to vote for new members of the CSFWC Board of Directors has to maintain 5 members, Executive Committee (Donahue, Acimovic, Peter, Sherif, Villani, Nielsen). Srdjan Acimovic accepted role of Secretary/Treasurer, Brent Short selected as Executive Director.

Status of the 2020 CSFWC Proceedings: have not been posted yet. Dean Polk updated on this topic: abstracts sent have been in small number coming intermittently and slow. 50-60 pages of abstracts so far exists, most Plant Pathology, little Entomology. Submission hesitation due to planned peer-reviewed publications. Extension specialists go back to Proceedings and use them.

New business:

The members discussed the next 2022 meeting: assumed it will be in person, tentative dates: Dec. 1-2, 2022. Conflicts on these dates were not voiced by membership and the proposed dates were put to motion. Donahue made motion Sherif seconded. Voting of members was in favor with no opposed. Tentatively reserve the venue Holliday Inn in Winchester VA with $1,000 deposit for CSFWC 2022. Due to pandemic the 2020 provided deposit has been retained by the Holliday Inn for presumed use in 2021 in person meeting which has again been held virtually. Therefore, the deposit is confirmed by the Holliday Inn as carried over to 2022 in person meeting organization. The selection of this venue was put to vote, motion made by Nielsen, Sherif seconded. Membership voted in favor, there were no opposed. Registration fees were discussed ($50 for virtual vs. $70 in person). Members were presented with previously discussed awards to encourage participation of graduate students and postdocs, as well as to establish an award for service to CSFWC. Opened for discussion to all membership for consensus. Dean Polk in favor of this award program and commented on advantages for student practice in writing. Sherif commented on would program be discipline oriented (equal awards for each discipline winner), he raised should registration fee cost be raised to accommodate award program. Donahue warned taking inflation into account for registration fees for next year. Nielsen noted that there will need to be judges for the award competition in each session or this will be a general fruit science award across all disciplines and award them at the plenary session. Polk noted decision is needed on session-specific award or a general award type due to concurrent sessions. Nielsen suggested non-discipline fruit science award at the plenary session or depending on budget afford session-specific awards. Bergh commented on VT process of student awarding based on CV and scoring metrics and value weighing. Committe is needed to do this scoring process. Kon noted that likely the session-specific awards are the best way to go and that registration fees should fund the award amounts. Registrations should increase to make awards happen and the awards should be meaningful to the awardees monetarily. Since interest exists Kon proposed to name a chair who will propose to form committee and develop program for awarding and summarize ideas to get a direction for awarding. Bergh will share scoring document for students at VT, which is elaborate, objective, quantitative and detailed. Sherif agreed to take a lead role of a chair for forming the awarding the committee. Voting initiated by Kon for establishing an awarding committee, Bergh made a motion, and Leskey seconded it. Votes all in favor. No one was opposed.

Nomination and vote of the president (chair) elect to replace Dean Polk, Kon will become past president, Donahue will become president. Named president elect will later become president in 2023, also the time for the 100th Anniversary of the CSFWC. One party was interested: Dr. Mengjun Hu, Assistant Professor of small fruit pathology at the University of Maryland. Sara Villani, in absence, nominated Dr. Hu, Kon conveyed. Other nominees were not suggested by the members or the Executive committee. Kon puts to motion that Mengjun Hu becomes president elect for the CSFWC Inc. Peter makes a motion, Sherif seconded, voted all in favor, no opposed.

Bergh reminds that reserving the venue and the dates of 1 and 2nd Dec for 2022 CSFWC and to sign the preliminary contract with Holiday In. Suggestion is to physically visit the venue and sign a contract.

Proceedings were discussed with a significant drop of the abstract contributions being a concern. The discussion was on what can be done to encourage the submissions of do we need proceedings as the part of this meeting if no one is using them. Kon opened up this topic for discussion. Polk claims that people are using the Proceedings, as the Proceeding book was asked for. Sherif agreed as call of the states and new diseases/phenomenon is used by him and is important for future readers. Berg commented that Proceedings are a good repository for the Business Meetings notes as well as the Treasurers report. Members need access to this information as CSFWC is an Inc. Donahue asked if Proceedings require (sub)Committee to promote participation in abstract submission. Kon summarized the process, timeline, and benefits in abstract submission. Polk stated that Proceedings are the main venue of sharing the recommendations (tests) in managing pest problems. Extension specialists who make recommendations could go to one place like Proceedings, besides other sources to get information. Kon summarizes that members need to more active in submitting abstracts. Bergh notes that efficacy trials are largely not presented in Entomology session. His question is are Proceedings reflecting solely content of presentations delivered at CSFWC or they can be results other then what was presented at the conference. Polk noted this has been done already (one test presented, more tests submitted to the Proceedings). Yoder noted that during presentations they handed over the handouts with more tests than presented. All those are later in PDMRs but are subscription based and not easy accessed. Proceedings are beneficial as a record of tests, diseases and growth stage records. Committee will not be formed. Kon encouraged to submit abstracts and state reports.

Srdjan Acimovic gave the Treasurer's Report for 2021. Treasurer's report was presented by Acimovic with no ability to access the information on the available balance present in the BB&T bank account due to change of Treasurer's bank log in e-mail from Bergh's, former treasurer, to Acimovic's current treasurer. The PayPal account balance was accessible only. Since the BB&T balance was not available and presented due to account log in and password switch, as per Bergh's suggestion the treasurer's report was not put to vote during the Zoom business meeting until the bank balance was made known to CSFW members. An E-mail vote has been suggested by Bergh to be conducted at a later time.

Acimovic updated the Treasurer's report with the missing balance from BB&T bank and full report was presented via e-mail to the members and BOD on Wednesday, December 1, 2021 at 1:25 PM. Following the voting rules outlined by Kon in the e-mail from December 3, 2021 12:53 PM, to approve Treasurer's report, Bergh has made the motion to approve the Treasurer's report. Kon seconded it, and the motion carried. No e-mails by members were sent opposing the report, indicating that members voted in approval of the report.

The 100th Anniversary of CSFWC was discussed with Philip Martin posing a question if there would be interest to digitize and post to website the PDFs of the proceedings from previous CSFWC meetings 1938 to 1980s? These were made freely accessible to Martin after Penn State Fruit Research and Extension Center Library's cleanup. Summary of the topics could be presented for each year (historical trends on what was studied in the past years/decades). Executive Committee can have an opportunity to present this summary on the 100th Anniversary of CSFWC conference. Library could maybe do that work. Bergh suggested a group photograph on the 100th Anniversary of CSFWC the should be made of all CSFWC attendees. Yoder mentioned that this was not done in the past.

Bergh concluded that from the Treasurer's Report from 2020 the balance at BB&T on Dec 31, 2019 was $27,329.83. With the PayPal balance Acimovic presented, he asserted that the total balance of the CSFWC account with BB&T should be over $30,000. Acimovic confirmed this balance after the business meeting an the exact balance was $31,643.59.

Kon proposed to adjourn the business meeting. Nielsen made a motion, Bergh seconded. Meeting was adjourned and lasted 51 min and 16 sec.

CSFWC, Inc. Treasurer's Report for 2020

Respectfully submitted on December 1, 2021 by Srdjan Acimovic, Secretary/Treasurer

Income	
Registration/memberships (4 comp) (109)	4,360.00
Sponsorships	NA
Interest	NA
	4,360.00
Meeting Expenses (Virtual meeting)	
Meeting rooms	NA
Lunch, coffee, soda	NA
Mixer set-up and bartender	NA
Mixer	NA
Gratuities	NA
Advance deposit (2019) (To be applied to 2022 meeting)	1,000.00
	0.0
Other Expenses	
Deposit for 2021 meeting ($1,000 on file since 2019)	NA
Attorney	218.50
VA State Corporation registration	25.00
PayPal	159.74
	403.24

Summary

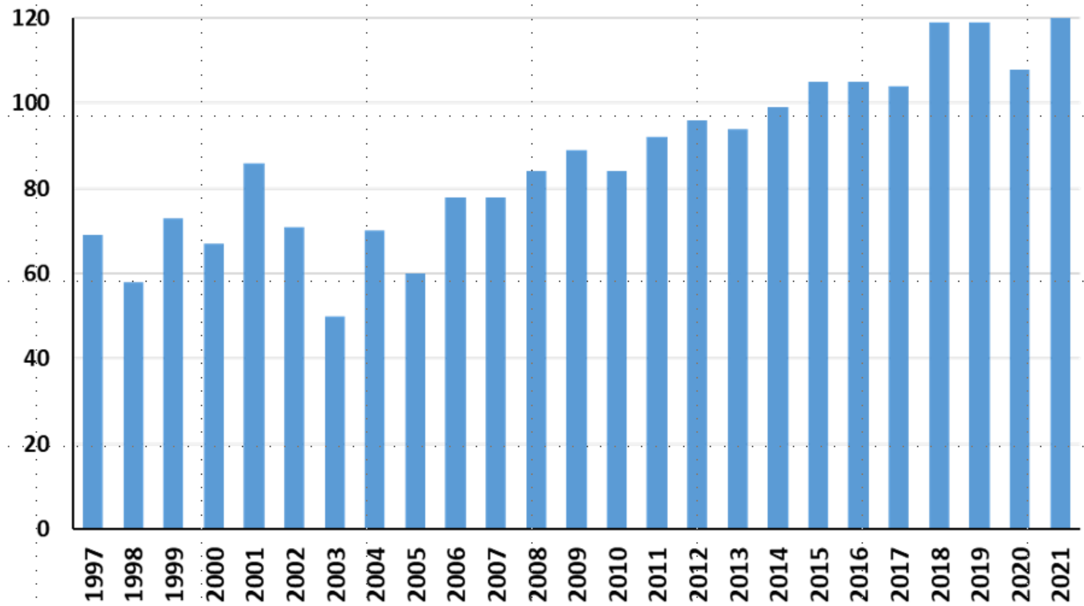
Registrations/memberships (109)	4,360.00
Sponsorships	NA
Meeting expenses	NA
Other expenses	403.24
Balance forward	3,986.76
Account balances as of Dec. 31, 2020	
BB&T	$27,126.33
PayPal	$4,517.26
	$31,643.59

CSFWC, Inc. 2020 Meeting Cost Breakdown

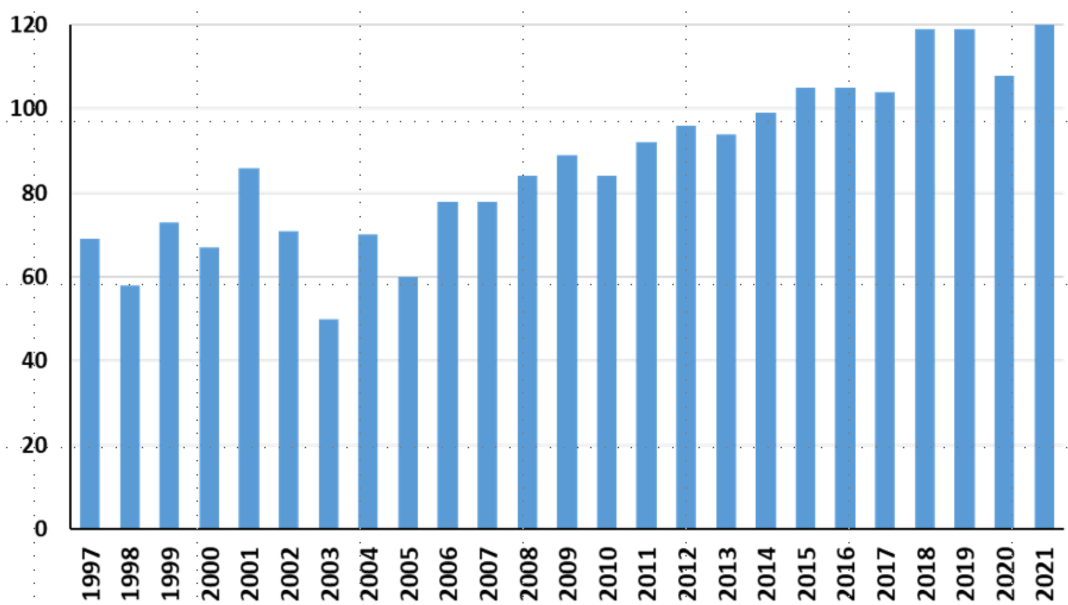
Total meeting cost = 0.0

Facility	0.0
Food and non-adult beverages	0.0
Adult beverages plus all gratuities	0.0
Total cost per attendee	0.0
Income per attendee	40.00

Attendance records (1997 – 2021)



Attendance records (1997 – 2021)



CALL OF THE STATES

CALL OF THE STATES – NEW JERSEY

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

Covid Mitigation – In 2020 we implemented Covid-19 pandemic protocols for both NJ growers and our extension program. We did have extension programming with minimal grower contact, still doing field work, but using cell phones and emailed .pdf files for field data and grower recommendations. In 2021 these protocols were continued, although vaccinations allowed for more in person grower contact.

Climate Observations (Statewide) - According to the [NJ State Climatologist](http://climate.rutgers.edu/stateclim/) (http://climate.rutgers.edu/stateclim/), monthly temperatures were about normal during the growing season with August among the top 5 warmest on record. Overall total precipitation in 2020 was about normal with July and August well above average. No record precipitation was recorded in any month.

Tree Fruit – Tree fruit phenology in 2021 was about normal based on historical observations. Cropping was excellent in stone fruit with no little damaging freeze events during bloom. Apple cropping was also prolific. Both crops required heavy thinning. Peach development accelerated in August with harvest finishing up by Labor Day. Apple harvest was about normal but growers let fruit hang late because warm temperatures in late summer made for poor color.

Disease control in the field was about average. In apples, fruit rots remain troublesome and increased despite more than adequate control measures. Fire Blight was almost nonexistent in southern counties. In peach, Bacterial Spot control remains difficult however fruit infection levels were the lowest seen in years, presumably because the leaf infections did not reach epidemic levels until well after pit hardening. Dr. Lalancette reports the following from his work on non-sprayed control trees at the Rutgers Agricultural Research and Education Center in Upper Deerfield, NJ:

"Peach **blossom blight** infection and canker formation was high across the test orchards, ranging from 21% to 50% of flowering shoots having at least one canker. A dry period of little rain from 26-April through 25-May favored development of peach **rusty spot** but prevented development of the bacterial spot epidemic. On rusty spot susceptible Autumnglo, 83% of non-treated fruit were infected. However, on highly susceptible O'Henry, only 15% of control fruit had bacterial spot lesions with an average of 0.42 lesions per fruit. Consequently, at harvest, 94% of fruit were rated "grade 1" with 98% saleable (grades 1 + 2).

Sufficient rains prior to and after the dry period provided plenty of opportunity for infection by *Fusicladiuim carpophilum*, the causal agent of peach **scab**. Consequently, scab incidence and severity was very high with 98% of fruit infected and 79% having >10 lesions. Frequent rains during the preharvest fruit ripening period, along with high levels of inoculum from the blossom blight cankers, resulted in high levels of rot. At harvest, **brown rot** development on control trees ranged from 58% to 66% across the test blocks, with 78% to 94% rotted at 6 to 7 days postharvest. Little to no ***Rhizopus***, **anthracnose**, or ***Phomopsis*** were observed during the harvest and postharvest assessments."

CM trap captures were very low this year compared to recent years. Codling Moth damage in New Jersey was lower than past years, however control measures were needed through August and into September because of above threshold trap captures extending later than normal. Plum Curculio control was more difficult than most years because of prolonged cool spring conditions. Observations of Ambrosia Beetle damage were slightly higher than 2019. Tree loss continues at known infestation sites. Incidence of San Jose Scale infestation in tree fruit remained significantly higher than past seasons. White Peach Scale was also observed at increased levels in a number of orchards. Scale insects remain difficult to manage. This year however control was better than past years in southern counties because good conditions in the delayed dormant period allowed for excellent oil coverage. This was not the case in northern counties because several freeze events prevented growers from getting timely oil applications out. In 2021 Spotted Lantern Fly adults were observed feeding on apple twigs and exuding excessive levels of honeydew resulting in sooty mold development on fruit.

In 2019, leaf damage from peach root weevils (Oedophrys hilleri) was obvious and up to ~25-50% on one farm in Salem County. In 2021 weevils remained a nuisance throughout southern counties. We also had a report of Asiatic garden beetle feeding on new plantings. In 2021 high trap captures of first generation Tufted Apple Budmoth were again observed. Soon after a biofix was set in early May flight increased drastically and was stable over the whole flight period from late May through the first week of July. On some farms weekly pheromone trap captures exceeded one hundred males per trap. Codling Moth treatments successfully controlled TABM, however on farms with CM mating disruption two or three specific TABM treatments were needed. Brood X of 17-year periodical cicada appeared in high numbers in a few counties and required several treatments to successfully suppress shoot flagging.

Grapes - Grape Phenology was about normal in 2021. Disease control was very good in southern counties however downy mildew was troublesome on highly susceptible varieties, and sour rot infected many white varieties due to a wet August. Grape Berry Moth populations were very low and little damage was noted even where controls were not implemented. Harvest was about normal for most early fruit but delayed for midseason and late varieties due to higher than normal rainfall. Spotted Lantern Fly reports increased greatly in 2021 with reports coming in statewide. Northern county vineyard observations remain significantly higher than southern counties as of this report. Southern county vineyards experienced the first widespread outbreaks. Spotted Wing Drosophila populations required weekly insecticide applications after veraison, however trap captures were lower than past years presumably due to increased insecticide applications targeting SLF near harvest.

Blueberry- New Jersey Blueberry season was a quick one. The grower prices per flat remained high throughout the season. The season started out wet, just alone during bloom period average precipitation for the month of May was 4.07 in. Observations for anthracnose and botrytis were low, most likely because of well-timed fungicides. In the past two years blueberry scorch virus seemed to be a problem in some of our fields but scorch symptoms did not appear this year. However, aphid counts were high. On-farm demonstration trials with Movento and Sivanto gave better aphid control than the traditional neonicotinoids, Actara, Assail and imidacloprid. For other insects this year, our first catch of male spotted wing drosophila, SWD was the week ending May 29th and blueberry maggot, BBM first catch was the week ending July 9th, which was the only catch of BBM for the season. Blueberry maggot, which once had been a major blueberry pest, and the 'driver' of the insecticide program, has been in a decreasing trend since the arrival of SWD. Plum curculio numbers were also low this year. Gypsy moth populations were variable, and some growers did have to treat. A few growers did show concern about the early 'Duke' quality and plant health, and blamed air pollution. However in the end, the plants recovered, harvest was good and prices were high. Weed management in blueberries is still a concern with growers, this year we did some observation on 5 problematic weeds that growers have. From the data collected we plan to incorporate a weed component into our IPM program. Overall, the New Jersey blueberry season turned out to be especially well.

Tree Fruit Phenology – Southern New Jersey Counties 2021

Pest Event or Growth Stage	Approximate Date	2021 Observed Date
Bud Swell (Redhaven)	March 23 +/- 15 Days	March 29
1/4" Green Tip Red Delicious	March 31 +/- 13 Days	March 27
Pink Peach (Redhaven)	April 4 +/- 15 Days	April 4
Tight Cluster Red Delicious	April 9 +/- 13 Days	April 6
Oriental Fruit Moth Biofix	April 9 +/- 13 Days	April 8
Full Bloom Peach (Redhaven)	April 9 +/- 14 Days	April 10
Pink Apple (Red Delicious)	April 14 +/- 12 Days	April 11
Codling Moth Biofix	April 27 +/- 13 Days	May 2
Green Peach Aphid Observed	April 16 +/- 16 Days	April 26
Full Bloom Apple (Red Delicious)	April 22 +/- 11 Days	April 20
Petal Fall (Redhaven)	April 22 +/- 10 Days	April 24
Petal Fall (Red Delicious)	April 27 +/- 14 Days	May 7
Shuck Split (Redhaven)	April 30+/- 11 Days	April 29
First PC Oviposition Scars Observed	May 3 +/- 18 Days	April 29
Tufted Apple Bud Moth Biofix	May 4 +/- 10 Days	May 3
San Jose Scale Crawlers	June 2 +/- 8 Days	Not observed
White Peach Scale Crawlers	May 26 +/- 11 days	Not observed
Pit Hardening Peach	June 16 +/- 8 Days	June 14

CALL OF THE STATES – NEW YORK

Michael R. Basedow[1], Janet Van Zoeren[2], Dr. Juliet Carroll[3], Daniel J. Donahue[1]

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Weather Overview for the 2021 NYS Tree Fruit Growing Season

Winter and early spring weather conditions across New York State were unremarkable for tree fruit, no wide temperature swings, or early season freezes. For McIntosh, 50% green tip occurred on 4-Apr in the Hudson Valley, 2-4 days later in both Western New York and the Champlain Valley. While the Hudson Valley date was 5-days later than the 20 yr. median, the WNY date was approximately a week earlier, with the Champlain Valley being two weeks earlier than normal. McIntosh full bloom in the Hudson Valley occurred on 5-May, five days later than the median date, with the Champlain Valley at May 11, continuing to be substantially earlier than normal. A prolonged cold snap swept across New York from the west, resulting in prolonged pink and bloom stages in WNY. The Hudson Valley was affected by unseasonable cold through the petal fall and early thinning window. Temperatures were warm and dry across the state in June but turned very wet in July. The higher-than-normal rainfall patterns continued across the state from July and through the harvest season. Rainfall amounts varied by location, but 2-4X was not uncommon. November was unseasonably warm throughout the state.

Horticultural Overview for the 2021 NYS Tree Fruit Growing Season

An above-average crop in the Hudson Valley for 2021, average in the Champlain Valley and below-average for Western New York. Biennial varieties such as Honeycrisp and Fuji suffered issues with return bloom, most critically in WNY. Chemical thinners were generally found to be effective with carbaryl performing especially well in the challenging cool early thinning conditions. Fruit size was larger than average, attributable to the excessive rainfall everywhere and the light crop in some regions. Bitter pit of Honeycrisp was a major problem in all regions, with our Hudson Valley reference orchards recording an average of 31% incidence after cold storage. Wet conditions also resulted in fruit finish issues for sensitive varieties. Lack of good coloring weather pre and during harvest was also a challenge. Overall, it was common to observe fruit firmness to be down 1 lb., and soluble solids off by 1 point. Too early to determine at the time of the CSFW conference, but we're anticipating postharvest quality issues with this crop later in the storage season. On the brighter side, FOB pricing and movement have been good so far. The unseasonably warm November weather has triggered concerns about delayed cold hardening before seasonal winter temperatures set in.

Pest Management Overview for the 2021 NYS Tree Fruit Growing Season

Tree Fruit Diseases

Apple Scab, Powdery Mildew and Cedar Apple Rust: Apple scab was well-controlled in NYS apple orchards this past season. Considering the unusually wet July and August, Powdery Mildew was surprisingly easy to find. Cedar Apple Rust is a perennial issue in the Hudson Valley but remained under good control in 2021.

Fire Blight: In WNY, high inoculum in many orchards left over from the 2020 bad fire blight year. However, most orchards seemed to get through most of bloom without any significant blossom blight symptoms, although a few late-blooming varieties were affected by a May15 infection event. Despite low levels of blossom blight infection, we did see significant and problematic levels of shoot blight across many orchards in WNY. There was no noticeable pattern to where those occurred (i.e. in both high density and low density plantings, in nursery and older trees, in orchards with tight fungicide programs, in orchards without any sign of blossom blight this summer, etc.). Some orchards were entirely decimated by fire blight, despite grower's best efforts to control it through the summer. In addition, a warm fall with continual rain events lead to fresh growth and fresh shoot blight strikes into late September. Fire Blight was not a major issue in the Hudson and Champlain Valley's for 2021.

Other diseases: Powdery Mildew was more prevalent in many orchards than usually seen under 2021's wet summer conditions. Occasional instances of fruit powdery mildew symptoms were seen on processing blocks. However, these did not reach economically problematic levels, for the most part. Summer rots, especially bitter rot, were also more prevalent than usual, likely due to the warm wet late summer and fall. Rots were mainly seen in low-spray orchards, and in some cases reached economically problematic levels.

Tree Fruit Insects & Arthropods

Lymantria dispar (previously known as gypsy moth) was abundant across WNY. Some low-spray apple orchards were hit hard early in the season, but were mainly well controlled later in the season once growers realized what was causing the damage. Blueberries were also hit hard by L. dispar in the WNY region.

Common pest species: 2021 was not a banner year for insect pests in NYS. Plum curculio and apple maggot continue to be overall well controlled across NYS, although in isolated farms do reach problematic levels. Apple maggot is most prevalent in central NYS, near Syracuse/Oswego. Plum curculio is a pest predominantly of organic and low-spray growers. European Red Mite and Two-Spotted Spider Mite populations were not problematic this season, possible due to our above-average rainfall in July and August. The same could be said for the Brown Marmorated Stink Bug (BMSB), a damaging pest in some Hudson Valley locations with an increasing presence in other regions. Dogwood Borer management has become more challenging with the loss of chlorpyrifos trunk sprays in NYS.

Spotted Wing Drosophila (SWD): The fruit fly arrived early, but steady trap catches were not observed until mid- to late June. This was the tenth year of the monitoring network and this year had first catch occurring now 76 days earlier than in 2012, when it had first arrived in NY. SWD monitoring in tart cherry in Western NY found the Lake Ontario microclimate was not expressing this spring – bloom occurred at about the same date in all sites and first catch of SWD wasn't significantly earlier near the Lake. Please reference the following internet links for more information. Statewide SWD monitoring network, https://blogs.cornell.edu/swd1/ and https://fruit.cornell.edu/spottedwing/distribution/.

European Cherry Fruit Fly Quarantine: The 2021 quarantine was expanded into all of Wayne County. The ECFF has been found from Niagara County, along Lake Ontario and into the western Wayne County. A systems approach is in place informing insecticide applications, which protects fruit from infestation and allows shipment outside of the quarantine zone.

CALL OF THE STATES – PENNSYLVANIA

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Plant Pathology

The southern half of Pennsylvania experienced budbreak around 23 March; we had a cold snap the week of April 17 with snow showers on April 22. After that period, it became more seasonable. We had enough rain early in the season to get scab established for our research; however, the rain occurred outside the peak period for scab, so this wasn't an issue for growers. Powdery mildew was a problem for some folks due to the many dry days we had. It was hot and dry during peach season, so brown rot wasn't a problem; bacterial spot wasn't too bad either. The rain came late August through September, and this is where problems crept up… Bitter rot became a problem for varieties harvested September and later. Apple blotch (AKA Marssonina blotch) is also becoming increasingly concerning, so much so it was difficult to find scabby leaves to monitor for scab maturity next year. It doesn't take much rain, so the bursts we had kicked things off in July and, by mid-September, I saw susceptible cultivars like Rome, Fuji, and Honeycrisp quite defoliated. If anyone stopped spraying at the end of August/beginning of September – it was problem… We probably should be doing postharvest sprays to keep this disease in check to prevent premature defoliation.

As far as the apple decline problem, it is a mixed bag in PA right now…There are several issues going on with tree decline with one of those issues being RAD, which seems to be primarily connected to the M9 rootstocks. There are other problems, such as trees dying due to tomato ringspot and/or tobacco ringspot virus. We looked for nematodes in several locations across the state, especially those in RAD blocks, and we're finding a lot of the dagger nematodes. The final tree decline issue on my radar
for 2021 is Southern blight on apple. We identified *Sclerotium delphinii* (or *Sclerotium rolfsii* pv. *delphinii)* causing southern blight in 2018 in Adams County. The disease is still occurring, even with lack of precipitation, trees are still succumbing to southern blight. This seems to be localized to the south-central part of the state (so far).

Entomology

The biofixes for most common pests occurred at dates similar to previous years. The first moths in pheromone traps during the 2021 season for Oriental fruit moth were observed on April 06, codling moth on April 29, obliquebanded leafroller on May 31 and tufted apple budmoth on May 05.

With warm weather in April but one of the coldest weather in May (5th coldest on the record) despite early biofixes for OFM and CM the first generation flights for both species were greatly extended and moth of this early generations were still present in June. Combining this with one of the hottest summer weather on the record, the management of both species was challenging and a number of fruit loads were again rejected by our only still operating fruit processor, Knouse Food. The total number of rejected loads was 164 loads (458 during the 2020 season), with **codling moth** and **Oriental fruit moth** split of roughly about 75:25.

Other pest probably also benefitting from the unusual weather pattern in the spring was plum curculio with many commercial orchards reporting high levels of injured fruit in 2021. The brood X of periodical cicada was present in most of PA fruit growing regions however no significant damage in orchards were reported. The unintended results of cicada control included higher than normal populations of wooly apple aphid and phytophagous mites.

The brown marmorated stink bug populations were relatively low, mainly due to lower BMSB population going to diapause during the fall of 2020. Suitable weather conditions during the summer contributed to a rebound in the numbers of BMSB during August and September. During the fall, some PA fruit growers reported again injuries on late apple cultivars due to the intensive feeding by BMSB adults. The parasitic wasp *Trissolcus japonicus* was credited with overall lowering in the numbers of BMSB across the State.

Spotted lanternfly *Lycorma delicatula* (Hemiptera: Fulgoridae) an invasive plant hopper, native to China, India and Vietnam is officially reported from almost all southern and south central counties of Pennsylvania, but not from Adams County which is not under quarantine declared by PDA. All states surrounding Pennsylvania are also declared at least partial quarantine restrictions in some of their counties. In contrast to sever injuries on grapes, no injuries on fruit trees caused by the spotted lanternfly were reported in Pennsylvania during 2021 season.

CALL OF THE STATES – VIRGINIA

Horticulture (Sherif): On April 3, most apple cultivars were at the ‘tight cluster’, whereas peach and sweet cherry cultivars were at the “pink” and “first white” bud developmental stage. Four temperature data loggers at different locations at the Winchester research and extension center indicated frost events on April 2, 3, and 22 that coincided with the bloom and petal fall of most stone and pome fruit cultivars. On April 3, trees were impacted by temperatures as low as 21 degrees for more than 30 minutes, which was enough to kill 93% of sweet cherry flowers. Apple flower bud mortality ranged from 5% to 65% among different cultivars, with 'Honeycrisp' and ‘Zestar’, respectively, showing the lowest and highest damage. Surprisingly, our peach cultivars exhibited less than 25% flower bud mortality, despite being at the pink stage. Despite these frost events in 2021, growers in northern and central Virginia had a full crop of apples and peaches, but sweet cherries were almost entirely lost. For Roanoke and southwestern VA, frost/freeze injury reduced apple production by at least 50%, with some growers experiencing essentially a total loss of their crop. However, overall apple production in 2021 broke Virginia records; a couple of ‘Gala’ blocks in VA recorded an unbelievable 2000 bushels per acre. The efficacy of chemical thinning of apple fruitlets varied between Winchester and central Virginia, and was more successful in the latter region. In Winchester, thinning treatments at petal fall and later in the season (e.g. fruit size 15-18 mm) were more effective than those applied at fruit size 7-13 mm. The year was not exceptional in the incidence of bitter pit, but we did witness a massive incidence of fruit cracking and splitting in almost all apple cultivars.

Tree fruit pathology (Acimovic): Apple scab in northern and central Virginia showed three major infections that required management with fungicides, on March 31, April 14, and May 3. These were in commercial orchards which had no visible scab in 2020. Primary scab season was over on May 29. First apple flowers began opening in northern Virginia around 12 April and full bloom was on 20 April. Mild to cool weather during this period did not favor fire blight infections, but warm weather in late April fueled severe infection events on apple cultivars that were still in bloom, with cider varieties being most affected. Wetting events allowed severe infections in northern Virginia on April 8 in pears, on April 28, 29, and 30 (petal fall) in apples, and on May 3, 4, and 5 on any cider cultivars that were still in bloom at that time. Fire blight symptoms were first visible from May 14 to 21, but were detected on June 4 in central Virginia. In south central and southwest Virginia, where apple bloom started earlier, fire blight infections occurred on April 8. The small amount of rain in June, July, and August led to first visible bitter rot infections on August 2. Abundant rain in September led to severe bitter rot infections in apple orchards with reduced fungicide schedules. The combination of missed spray applications before severe rain events, longer spray intervals, and alternate row middle sprays lead to severe fruit losses on some farms in northern and central Virginia, ranging from 47 to 83%. Sooty Blotch and Flyspeck were first visible on July 22 in central Virginia and on August 5 in northern Virginia, while Marssonina Leaf Blotch was first visible between July 22 in central Virginia and July 26 in northern Virginia. Aside from bacterial canker on cherries and peaches, which were favored by near frost and frost events that occurred early in the spring, no major disease outbreaks were reported on stone fruit.

Grape pathology (Nita): Southwestern Virginia began the season with a frost event and some growers lost up to 70% of their grape crop, with several cultivars affected. In northern Virginia, the beginning of the season was relatively dry, with 0.5 to 1 inch less than average precipitation in April, May, and June. Later, in September, we received more than 6.8 inches of rain. Since many growers left their crop on the vine due to the lack of development, late-season rots, especially ripe rot and Botrytis gray mold, were very common. In addition, late-season downy mildew was also common among growers in northern Virginia. Conversely, central Virginia experienced near-drought conditions for most of the season, and no major fungal disease outbreaks were reported. However, probably because of the dry conditions and a relatively mild winter, many growers in central Virginia reported the development of Pierce's disease. Overall, the season was better for early season white cultivars, and late-season red cultivars might have been affected by the rain, especially in northern Virginia.

Entomology (Bergh): Biofix dates for oriental fruit moth (April 4) and codling moth (May 2) recorded at the Winchester research and extension center, were both within historical norms since 2000. Bill Mackintosh, a northern Virginia-based crop consultant who scouts much acreage in this region, reported that pressure from both oriental fruit moth (OFM) and codling moth (CM) in Virginia was extremely low. He indicated that no cover sprays were needed for OFM after petal fall and fewer sprays were needed for second generation CM than in previous years. However, because of low CM counts in pheromone traps in August and September, growers who stretched their sprays to 3-week intervals during that period experienced increased injury from stink bugs. Bill reported that woolly apple aphid continued to be problematic in apple orchards treated with pyrethroids for stink bug control, but that in blocks in which pyrethroids have not been used for two consecutive years, woolly apple aphid outbreaks were no longer an issue. Finally, Bill noted that scale has also increased in areas where pyrethroids have been used for several years and where pre-bloom insecticides against it were not applied, but that scale was easily managed when delayed dormant sprays of effective scale products were used. The only unusual/unexpected circumstance in 2021 were numerous reports of Japanese maple scale infestations on apple trees. These were detected during winter pruning and were often substantial. As expected, Brood X of the 17-year periodical cicada emerged in northern Virginia and neighboring states to the north and east, causing the expected oviposition injury to small branches on both young and old apple trees. Spotted lanternfly (SLF) continued to spread in and around Frederick county, Virginia, and the quarantine zone was expanded accordingly. A small, isolated population SLF was also detected near Lynchburg, Virginia. To date, there have not been reports of SLF impacting either fruit orchards or vineyards in Virginia. There were indications of lower brown marmorated stink bug (BMSB) populations in Virginia than in previous years, based on captures in pheromone traps and reports from homeowners in the fall, although as mentioned previously, some growers did find stink bug injury at harvest. The BMSB egg parasitoid, *Trissolcus japonicus* (samurai wasp), continues to persist in Frederick county, and shows indications of increasing abundance and wider distribution in that area. However, the establishment of *T. japonicus* across nine sites from Fauquier county (northern Virginia) to Carroll county (southwest Virginia) at which it was released in 2018 and 2020 has been very slow to develop. In 2021, it was detected in low numbers at four of these nine sites, including a first detection at one site in central Virginia.

ENTOMOLOGY

MANAGEMENT OF OVERWINTERING SPOTTED LANTERNFLY *LYCORMA DELICATULA* EGG MASSES WITH THE ENTOMOPATHOGENIC FUNGUS *BEAUVERIA BASSIANA*

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Abstract

The spotted lanternfly [Hemiptera: Fulgoridae: *Lycorma delicatula* (White)] is a planthopper indigenous to eastern Asia and was first detected in Pennsylvania, United States, in 2014. In its nonnative range, *L. delicatula* is a pest in vineyards and negatively impacts many sectors of commerce. The management of *L. delicatula* primarily focuses on the adult life stage with various insecticides. In vineyards, the quantity of insecticide applications required to manage *L. delicatula* has increased. The entomopathogenic fungus, *Beauveria bassiana* GHA, has been field-tested in the USA with some efficacy against *L. delicatula* nymph and adult populations. We examined the effectiveness of multiple formulations of *B. bassiana* GHA, at different seasonal timings, against hatching *L. delicatula*. Results demonstrated that infectious exposure to hatching *L. delicatula* occurred with both formulations of *B. bassiana* GHA and at all seasonal timings, with the most significant efficacy observed in applications closest to *L. delicatula* hatch. We also investigated the survivability of *B. bassiana* GHA spores on overwintering *L. delicatula* egg masses when applied during winter settings. We found that the winter freeze-thaw cycles negatively influenced *B. bassiana* GHA spore survivability, although germination still occurred at reduced rates. This research demonstrates that applications of *B. bassiana* GHA applied before *L. delicatula* hatch can impact early populations and may have a role in integrated pest management.

Introduction

The spotted lanternfly (abbreviated SLF hereafter) is a visually stunning planthopper native to the eastern regions of Asia (Lee et al. 2019). This Fulgorid has developed an infamous reputation due to its propensity for hitchhiking in the past few decades. Nonnative populations of SLF were first detected in Berks County, Pennsylvania, USA, by the Pennsylvania Department of Agriculture in 2014 (Barringer et al. 2015). Before their introduction to the USA, SLF rapidly spread throughout Korea and Japan, where they have been problematic for both tree fruit and vineyards (Han et al. 2008, Tomisawa et al. 2013). In the USA, SLF have caused the most significant impacts in vineyards. Economic analysis in Pennsylvania suggests that SLF already caused the annual loss of hundreds of jobs and over $50 million to the state, with financial losses projected to drastically increase as the SLF spreads (Harper et al. 2019).

In their native ranges, SLF does not pose many economic disturbances. Conversely, in their nonnative ranges, SLF have been observed to prefer grapevines (Lee et al. 2009, Barringer et al. 2015). All life stages of SLF are commonly seen aggregating in dense populations. In vineyards, intense feeding has been documented to influence vine hardiness negatively and significantly reduce vegetative growth, yield, and bud set (Urban 2019, Leach and Leach 2020). Typical of phloem-feeding insects, SLF produces copious quantities of honeydew, resulting in the growth of sooty mold, further reducing photosynthetic processes and potentially making fruit unmarketable (Dara et al. 2015).

Previously, it has been shown that SLF nymphs and adults are quite susceptible to a wide variety of insecticidal modes of action (Leach et al. 2019). In vineyards, SLF adults are the target life stage for pest management tactics because the adults tend to aggregate in vineyards around the time of grape harvest. This has led growers to increase the frequency of pesticide applications (Urban 2019). Unfortunately, limited organic and biological control methods are currently available for SLF management. Naturally occurring entomopathogenic fungi have been observed to cause localized population collapse in the USA (Clifton et al. 2019). One strain of organic commercially available entomopathogenic fungi, *Beauveria bassiana* GHA, has demonstrated moderate efficacy against SLF nymphs and adult populations in field trials (Clifton et al. 2020). Although much research has focused on nymph and adult SLF management, little has focused on overwintering SLF, representing the longest immobile individual life stage.

However, what is unknown is if *B. bassiana* GHA applied to overwintering SLF egg masses can survive until the predicted hatch and subsequently infect the hatching nymphs. Here we examined the efficacy of different formulations of *B. bassiana* GHA at multiple seasonal timings during the SLF overwintering period. To investigate these objectives, SLF egg masses were collected and treated with *B. bassiana* GHA formulations during the winter, early spring, and late spring. The infected SLF egg masses were then held in laboratory conditions and stimulated to hatch, where they were then reared on tree-of-heaven. Suppose the SLF neonates encounter enough viable B. bassiana GHA spores. In that case, the fungus should be capable of germinating and killing the exposed nymph within a few days and sporulating through the cadaver's integument. Lastly, we examined the capability of *B. bassiana* GHA to survive on SLF egg masses when exposed to natural freeze-thaw cycles of winter.

Materials and Methods

The SLF egg masses were collected at various field sites within Frederick County, Virginia, during their overwintering stage or allowed to overwinter naturally. All egg masses were collected during the respective season of treatment application, from winter to spring. Egg masses were conveniently sampled from the landscape, mainly from tree-of-heaven, but not exclusively. The egg masses were carefully removed from the substrate by chiseling around the egg mass and then gently peeling the bark off the plant material. Only egg masses with the protective waxy covering intact were selected. Once removed from the substrate, the egg masses were stored in Petri dishes of various sizes. The egg masses were finally brought back to the Invasive Species Quarantine Facility in Blacksburg, VA, and kept in a climate-controlled incubator. To emulate overwintering conditions of egg masses collected during winter, incubators were held at 10°C, 65 % relative humidity, 16:8 light to dark ratio, and stored for a minimum of 100 days (Keena and Nielsen 2021). To induce hatching of winter and spring collected egg masses, they were transferred to another climate-controlled incubator set to 25°C, 65 % relative humidity, and 16:8 light to dark ratio (Keena and Nielsen 2021) until emergence occurred.

Tree-of-heaven were propagated in the Virginia Tech greenhouses. To maximize space, all tree-of-heaven were planted into 3.75 L pots. Seedlings within 20–60 cm were brought to the Invasive Species Quarantine Facility when required for SLF nymphs to feed upon. Greenhouse pests were managed with insecticidal soap and biological control agents when needed. Pest management was withheld for a minimum of one month before introduction to SLF to reduce confounding mortality.

The SLF egg masses were randomly divided into treatment groups and treated in-field, after collecting, and before leaving the quarantine zone in Virginia. We investigated two formulations of *B. bassiana* GHA, a wettable powder (WP) and an emulsifiable solution (ES). All treatments were at the highest label concentration (see Table 1) and used 378.5 L per acre (100 US gal/acre) spray rate. A 0.03% organosilicon surfactant (Silwet L77 surfactant) was added to the WP treatment to help suspend the spores in the solution. Applications were made with 100 ml plastic spray misters. Each egg mass was sprayed approximately 10–15 cm away from the egg mass surface. Egg masses were sprayed until run-off from the surface of the egg mass. Egg masses were then allowed to dry before returning to storage. We compared the two *B. bassiana* GHA formulations with untreated control (UTC) and water control (H2O) treatments.

The SLF were collected and treated in the field during the target treatment season, then put into cold storage to overwinter following protocols outlined prior. Once hatch occurred, egg masses were transferred to potted and caged tree-of-heaven. Egg hatch was assessed daily until hatch of the UTC commenced. The cages were 45x30 cm nylon fruit protection bags (Bitray). The SLF nymphs were monitored daily for any mortality. Any dead nymphs were removed from the cage and surface sterilized. First, to surface sterilize cadavers, they were immersed and agitated in diluted 0.5 % sodium hypochlorite solution for one minute. Then the cadavers were transferred to another solution of deionized water, where they were immersed and agitated for 15–20 sec. The cadavers were transferred to a third solution with deionized water for 5–10 sec. Finally, surface sterilized cadavers were transferred to a clean KimWipe to wick off excess liquid, and then cadavers were placed on a prepared Petri dish. Surface sterilized cadavers were placed on oatmeal dodine agar (Chase et al. 1986) with 150 mg/L chloramphenicol, crystal violet, or similar antibiotic to prevent cross-contamination of spore samples. Cadavers were given a maximum of four days to sporulate; any more than four days and contaminants can begin to grow on the plate. We counted any sporulated cadavers per replicate to get the percent sporulation of SLF eggs hatched. SLF nymphs that made it to the second instar were considered not contaminated. Additionally, all egg masses were analyzed for their total number of eggs, hatched and unhatched eggs. We utilized one-way ANOVA to analyze mean percent hatch, nymphal mortality, and cadaver sporulation differences. Sporulation differences were determined by the mean percent of SLF that hatched, died, and had their cadavers sporulated with *B. bassiana*. A Tukey's HSD post hoc test was performed if significant differences were observed.

To investigate the suitability of different *B. bassiana* GHA formulations when exposed to winter conditions egg masses were collected, treated, and were stored outside in 25 cm^3 bug dorms (BioQuip). The field site was provided by LABServices located in Hamburg, Pennsylvania. The egg masses were held at a southern-facing location to maximize ultra-violet exposure. The bug dorms offered minimal protection from environmental stimuli like wind and temperature. Although, the bug dorms did prevent rain from directly contacting the treated egg masses. Typically, SLF egg masses have been documented as being laid on the underside of tree branches (Liu and Hartlieb 2019); therefore, they would also be protected from rain. The treated egg masses were allowed environmental exposure until close to the predicted first hatch date. The predicted SLF first hatch date was estimated at approximately 200 cumulative growing degree-days using a high degree threshold of 35°C and a low degree threshold of 10°C (Liu 2020). Egg masses were treated on February 12th and exposed to winter conditions until April 24th, 2021. Potential spores were then removed from the egg mass surface using 0.1% organosilicon surfactant (Silwet L77). A sterile cotton swab was wetted with the organosilicon surfactant solution and gently rolled against the egg mass. The cotton swab was then be dipped into a microcentrifuge tube of organosilicon surfactant and rolled against the walls of the centrifuge tube to help dislodge any spores. This process was repeated two times to collect as many spores as possible from each replicate. A few drops of the spore-laden organosilicone surfactant solution were put onto yeast benylate agar per replicate and allowed to germinate for 18–24 hours at room temperature (22–28°C) (Milner et al. 1991). After incubation, a slice of the germinated agar was cut out and placed onto a microscope slide. The agar was stained using a drop of lactophenol cotton blue to help to view spores and germlings. The stain was allowed to dry completely to prevent spores in the stain solution from moving to the perimeter of the coverslip when placed on top of the stained agar. The slide was then examined using 400–650X bright-field microscopy. *B. bassiana* spores were counted and analyzed for those that have and have not germinated; 200 total spores were counted per replicate to determine percent germination. One egg mass corresponds to one replicate. This process was repeated on SLF egg masses, designated as the control but not exposed to winter conditions that were treated, allowed to dry, then had spores immediately removed following the same methods. We utilized one-way ANOVA to analyze mean percent germination differences, and if significant differences were observed, Tukey's HSD post hoc test was performed.

Results

We saw no significant difference between the treatment's mean percent hatch and application timing, although we observed fluctuating hatch rates across all treatments and application timings (Table 2). The mean percent nymphal mortality was high for all treatments and application timings. We observed no significant difference between treatment and mean nymphal mortality across all application timings (Table 2). Conversely, *B. bassiana* fruit bodies were successfully reared from the surface sterilized SLF cadavers across all application timings but were not detected in the UTC or H2O control. We saw no significant difference between mean percent sporulation during the winter application, although sporulation did occur in both the WP and the ES treatments. Significant differences between mean percent sporulation was observed during the early spring application timing for the ES treatment (F (3(32) = 5.641, p = .003). Applications in late spring observed greater mean percent sporulation in both treatments, although the significant difference from the controls was only observed in the ES treatment (F (3)22) = 5.702, p = .005) (Table 2).

Finally, *B. bassiana* GHA spores were successfully recovered from SLF egg masses treated with either formulation. Egg masses that were treated with either formulation of *B. bassiana* GHA and not exposed to winter conditions germinated at higher rates than those exposed to winter conditions (F (5,12) = 219.41, p < .001). Between both formulations of *B. bassiana* GHA, we observed greater germination rates of the WP formulation in both the control application and winter exposure with 90.8 and 57.2 mean percent germination, respectively (Table 3). In the control application, significant differences were observed between all treatments (F (2,6) = 1465.44, p <.001) (Table 3). The winter exposure resulted in significantly greater mean percent germination of the WP compared to the ES and UTC control (F (2,6) = 64.181, p <.001) (Table 3). In both applications, control and winter exposure, no *B. bassiana* GHA spores were identified in the UTC treatment.

Discussion

We did not observe any impact of the treatments on hatching SLF; therefore, the *B. bassiana* GHA treatments did not appear to provide ovicidal effects in this study. Overall, low hatch rates were observed for all treatments, including the UTC and H20 treatments. Low hatch rates could have resulted from sampling methodology disrupting the eggs or storage conditions not providing the optimal environment for development. There is no established life table data available for SLF; therefore, we cannot determine if these lab-reared hatch rates differ from naturally reared SLF. Our methodology introduced unintentional variability of overwintering days between the different application timings. For example, those SLF egg masses treated during the late spring were not stored in the climate control incubator but instead overwintered naturally. In the future, to control for overwintering day variability, all SLF egg masses should be collected during the winter, stored in the climate-controlled incubators to overwinter, and treated during the corresponding application timing. The SLF egg masses should be induced to hatch simultaneously during the predicted hatch using cumulative degree days. Finally, SLF egg masses should be more carefully removed from the substrate to minimize sampling variability further.

We observed high mortality throughout all application timings and treatments of SLF that successfully hatched. We did not observe statistically significant differences between application timing and all treatments. We did observe decreased nymph mortality rates of the control treatments during the late spring application timing, although that is not statistically significant. While high mortality is typical among SLF reared in a laboratory setting, our high mortality may inexorably be linked to the inadequate food supply. Future replications should provide more robust TOH for immature SLF to feed on. Additionally, SLF's natural propensity to climb (Kim et al. 2011) results in many nymphs getting stuck in the cage netting and inflating natural mortality. Alternative cage design with limited creases in the material may help decrease nymph mortality.

Despite the high nymph mortality, sporulated SLF cadavers confirm that infectious exposure occurred. The absence of *B. bassiana* sporulation on SLF cadavers from UTC and H2O control groups demonstrates that wild *B. bassiana* was not present on the egg masses and surface sterilization techniques are effective. The capability of the *B. bassiana* GHA spores to withstand winter settings, combined with the presence of winter sporulation on SLF cadavers, emphasizes that winter applications are viable while not as practical as early or late spring applications. We saw the highest sporulation rates from cadavers of those egg masses treated with the ES treatment, though not statistically different from the WP treatment.

We successfully demonstrated the survivability of *B. bassiana* GHA spores applied to overwintering SLF egg masses. We found that winter freeze-thaw cycles negatively impacted *B. bassiana* GHA spores survivability on SLF egg masses of both treatments. It is possible that various other environmental variables influenced the survivability of *B. bassiana* GHA spores on overwintering SLF egg masses, such as ultra-violet radiation and relative humidity (Zimmermann 2007). We did not detect any *B. bassiana* GHA spores on the UTC control, suggesting any environmentally ambient *Beauveria* is not contaminating the treatments. We saw that the WP treatment had triple the mean germination than the ES treatment, suggesting that the WP treatment provided a more optimal environment for the spores to survive in.

Moving forward, we intend to repeat these experiments while also addressing some of our shortcomings. Specifically, we would like to enhance the standardization of our rearing methodology to minimize variability. In addition to repeating this experiment with *B. bassiana* GHA, we will investigate different *B. bassiana* strains. Finally, we will explore the relationship between treatment efficacy and treatment dose rate when applied to overwintering SLF egg masses at various seasonal timings.

Acknowledgments

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Figures and Tables

Table 1: Treatments and active ingredients. All applications rates followed the maximum label rate and were applied until runoff using a hand spray mister. The quantity of spores in the solution was held relatively constant between treatments.

Treatment	Active ingredient	Rate (g or ml) per 378.5 L	Spores per ml solution
UTC	NA	NA	NA
H2O	NA	NA	NA
Wettable powder	*Beauveria bassiana* GHA	907	1.06E+08
Emulsifiable solution	*Beauveria bassiana* GHA	1893	1.10E+08

Table 2: Mean percent hatch, nymphal morality, and cadaver sporulation of SLF egg masses sprayed with various formulations of *B. bassiana* GHA during different seasonal application timings. Egg hatch was assessed daily until hatch of the UTC commenced. The SLF nymphs were monitored daily for any mortality. Cadavers were surface sterilized and plated on selective agar to induce sporulation of infected SLF nymphs. Values in a group followed by the same letter are not significantly different. (Tukey's HSD, α = 0.05).

		Mean		
Application timing	Treatment	Hatch (%)	Nymphal mortality (%)	Cadaver sporulation (%)
Winter	UTC	36.7a	83.1a	0.0a
	H2O	35.9a	90.8a	0.0a
	WP	48.4a	90.6a	3.9a
	ES	26.6a	77.0a	2.1a
Early spring	UTC	52.7a	57.8a	0.0a
	H2O	40.4a	73.7a	0.0a
	WP	70.5a	71.9a	10.8ab
	ES	66.8a	76.1a	15.6b
Late spring	UTC	50.9a	50.0a	0.0a
	H2O	77.1a	56.5a	0.0a
	WP	66.1a	71.0a	22.4ab
	ES	36.9a	81.5a	24.5b

Table 3: Mean percent germination of *B. bassiana* GHA spores applied to overwintering SLF egg masses and exposed to natural winter conditions. Control Application timing corresponds to

those SLF egg masses treated but not exposed to prolonged periods of winter freeze-thaw cycles. Values in a group followed by the same letter are not significantly different. (Tukey's HSD, α = 0.05).

Application timing	Treatment	Mean Germination (%)
Control	UTC	0.0a
	WP	90.8c
	ES	81.5b
Winter	UTC	0.0a
	WP	57.2b
	ES	15.8a

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SPOTTED LANTERNFLY, *Lycorma delicatula,* ENTERS VIRGINIA VINEYARDS

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Spotted lanternfly invaded Pennsylvania in 2014, the first infestation outside of Asia. In each subsequent year, SLF expanded its range in that state, finally reaching the Ohio state line following the corridor surrounding Interstate 40. SLF became an important pest in Pennsylvania, causing death of grapevines, a marked reduction in yield, and a tripling of insecticide use (Harper et al. 2019). SLF had earlier proven to be a serious pest of grape in South Korea, where it had been introduced from China multiple times (Lee et al. 2019, Kim et al. 2021).

SLF was first found in Virginia in January 2018, at a commercial site on the north side of Winchester. Dead adults were found, as well an egg masses on various trees. The site was bounded by US 11 and rail lines, indicating the potential for human-assisted transport. In June 2016, the infested area was estimated to be 259 ha. By the end of that season, Oct 2018, it included 4662 ha, in November 2019 10,360 ha, and in November 2021, 51,541 ha (1 sq mi, 18 sq mi, 40 sq mi, and 199 sq mi, respectively).

The present range now includes 15 counties and the City of Lynchburg. While the infestation is still most intensive in Frederick County, SLF has spread into other counties in the Shenandoah Valley and northern Piedmont. The phenology in northern Virginia was studied by Dechaine et al. (2021). Eggs begin to hatch the last week of April or first week of May. Nymphal development continues through spring and summer, with adults first appearing in mid-July, present until mid-November. Egg masses first appear in late September.

While SLF was found developing on a table grape arbor in 2018 and 2019 near the original detection, the first detection of SLF in a commercial winegrape vineyard was made while surveying Frederick County vineyards in October 2020. Several other vineyards were close to or in the infestation zone, so further finds were expected. In 2021, SLF was found in 6 commercial vineyards by Virginia Tech and USDA-ARS personnel, with 5 in Frederick County and one in Clarke County. Several counties with detections of SLF are important grape-growing counties, so continued monitoring is crucial. Late summer will be the time of greatest risk of invasion into vineyards by adults; nymphs may occur in spring, but survival in the vineyard is not high (Leach and Leach 2020).

Grape growers in whose vineyards detections have been made have responded actively. Insecticide applications have been made, even with low numbers of insects found. Pyrethroids have been the most common insecticide class reported; this class has been shown to be effective at killing SLF, with longest residual life (Leach 2021). However, pyrethroids are notoriously disruptive of beneficial arthropod populations, and care must be taken to avoid induction of secondary pest outbreaks as far as possible.



Fig. 1. Spotted lanternfly second instar on table grapes, 2018. Fort Collier, Winchester
Fig. 2. Spotted lanternfly fourth instars on table grapes, 2019. Fort Collier Winchester.
Fig. 3. Spotted lanternfly adult at commercial vineyard, Frederick County.

Another response has been to cut down tree of heaven adjacent to vineyard blocks. The intent here is to remove a host plant that is very attractive and important to the development of SLF. Management of TOH can be an important tactic in SLF management (Pfeiffer et al. 2019). However, current management calls for cutting to be supplemented with herbicide treatment. If no chemical control follows, TOH will re-sprout from roots and cut stumps. The result in the cases of affected vineyards was the production of thick, succulent stands of TOH, infested with SLH, a likely source of further immigration in vineyard blocks.

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HORTICULTURE

A RECIPE FOR PREDICTING FRUIT SET USING THE FRUITLET GROWTH RATE MODEL: TESTED IN 2021

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These are the basic INGREDIENTS and DIRECTIONS for predicting apple fruit set using the fruitlet growth rate model as outlined in a new UMass Fruit Team Fact Sheet: HRT-RECIPE - Predicting fruit set using the fruitlet growth rate model (https://ag.umass.edu/fruit/fact-sheets/hrt-recipe-predicting-fruit-set-using-fruitlet-growth-rate-model). Based on work by Greene et al "A fruit is predicted to persist if the growth rate over the measurement period was at least 50% or greater of the fastest growing fruit; and a fruit is predicted to persist if the growth rate slowed to 50% or less of the growth rate of the fastest growing fruit." [1]

Here are the RECIPE INGREDIENTS and DIRECTIONS for predicting fruit set using the fruitlet growth rate model:

INGREDIENTS

- 5 tall-spindle trees of same variety
- Flagging tape and permanent marker
- Flower cluster labels (Avery 5201)
- 14 flower clusters per tree, times 5 trees = 70 flower clusters total
- Digital caliper (Figure 2.)
- Malusim app (Google Play or Apple Store)
- or Ferri spreadsheet (Ferri spreadsheet 2021 Master v 2.1 for predicting fruit set w/ macros, Ferri spreadsheet directions) and Perennia Orchard Tools app (iPhone only)

DIRECTIONS

- Tag trees 1-5, count total number of blossom clusters per each tree, and determine desired crop load per tree
- Tag clusters (1-14)
- Begin measuring fruitlets at app. 6-7 mm
- Measure fruitlets at 4 to 7 day intervals, entering measurements into Malusim app or Orchard Tools. Measurement interval will depend on temperature and/or chemical thinner application(s), both of which affect fruitlet growth rate
- Run fruitlet growth rate model in Malusim app
- Or export data from Orchard Tools and copy into Ferri spreadsheet and run fruitlet growth rate model. (A reminder, if using the Ferri spreadsheet, on each measurement date, the number of remaining clusters with fruitlets on each tree must be counted for the model run to be most accurate.)
- Use predicted fruit set to determine need for further chemical thinning sprays

A 2021 field verification was done using the RECIPE. Five tall-spindle Honeycrisp trees on G.41 rootstock were selected, the number of flower clusters counted to assess potential fruit set, and fourteen flower/fruit clusters per tree tagged for measurements. Fruitlet measurements began on 19-May 2021 and were re-measured at three-day intervals five more times with the final measurement on 3-June, 2021 when the average fruitlet size was 22.5 mm and the chemical thinning window had closed. Both petal fall and 10 mm chemical thinners were applied, however, exact application details are not availabel. But most likely they were NAA at petal fall and NAA/carbaryl combination at 10 mm, as would be common grower practice when fruit thinning is desired.

Fruitlet measurements were entered in the field using Orchard Tools on an iPhone, exported and then imported into the Ferri spreadsheet to predict fruit set per tree (Table 1.).

Date	Average Overall Fruitlet Diameter (mm)	Predicted % Fruit Set per Tree	Predicted Average Number of Apples per Tree
May 19			561
May 22	9.7	76%	423
May 25	12.6	44%	245
May 28	17.2	16%	93
May 31	18.4	14%	75
June 3	22.5	12%	70

Table 1. Portion of Ferri spreadsheet output predicting fruit set

In September, at final harvest, the actual number of Honeycrisp apples on each tree were counted and averaged 61 apples per tree. This is close to the 70 apples predicted by the predicting fruit set RECIPE. Growers are advised to use the RECIPE for predicting fruit set using the fruitlet growth rate model to better advise chemical thinning applications and achieve close to the desired crop load of apples in their orchard and improve their profitability.

Figure 1. Avery 5201 flower cluster label

Figure 2. Digital caliper measuring fruitlets

For more information and to download Ferri spreadsheet…

Thanks to Phil Schwallier/MSU, Tom and Joe Ferri, Duane Greene/UMass, Terence Robinson et al./Cornell, and Michelle Cortens/Perennia for all their work on predicting apple fruit set using the fruitlet growth rate model…

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PLANT PATHOLOGY

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CONTROL OF SHOOT BLIGHT AND CANKERS ON PEAR WITH REGALIA AND THE EFFECT OF GATTEN® AND PARADE® ON APPLE POWDERY MILDEW

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Cankers are infected dead zones of bark on branches, trunk or rootstock that develop after *Erwinia amylovora* invades wood from diseased flowers and shoots. Cankers form quickly and are more destructive on pear in comparison to apple trees, often leading to tree death. One of the missing links in management of fire blight are spray programs that prevent development of cankers after shoot blight infections. We evaluated efficacy of sprayed and trunk-injected giant knot-weed extract (Regalia) for pear shoot blight and canker control and compared it to oxytetracycline and streptomycin. The trial was conducted on 3-yr-old trees of cultivar 'Bartlett' and the five treatments were applied with a hand trunk injector (2) and sprayed dilute to drip at 100 gal/A (3) using a handgun sprayer (250 PSI).

Apple powdery mildew is a rising issue for the Mid-Atlantic fruit growers as DMI fungicides like myclobutanil (Rally) are apparently weakening in their efficacy, indicating on a potential rise of resistance in *Podosphaera leucotricha* to triazoles. New fungicide classes with different modes of action are needed to reduce the selection pressure from DMI-s. We evaluated efficacy of Gatten fungicide (flutianil FRAC U13) and compared it to Parade 20SC (pyraziflumid, FRAC 7), Rally, and sulfur, in control of apple powdery mildew (Table 1). The trial was conducted on cultivar 'Idared' on MM.111 rootstock. Treatments were applied using an air blast sprayer at 3 to 14 days spray intervals, delivering 100 gal/A.

In June 2019, we found that untreated control trees developed 80.9% shoot blight severity and 46.7% canker incidence. Five preventive spray applications of Regalia (30.7 fl oz/A) in spring prevented shoot blight severity development after inoculation with *E. amylovora*. The same spray treatment prevented the development of fire blight cankers from the infected shoots on pear wood. The five Regalia spray applications were made at bud burst, green cluster, white bud, petal fall, fruit set, respectively. The next best treatment was oxytetracycline (16 oz/A + Regulaid 32 fl oz) applied at bloom and fruit set which also completely prevented shoot blight severity and canker incidence. A single trunk injection of oxytetracycline at 0.31 g per each inch of trunk diameter gave 94.8% control of shoot blight severity and 91% control of canker incidence in comparison to the untreated control. The two preventive spray applications of streptomycin (16 oz/A + Regulaid 32 fl oz) applied at bloom and fruit set gave 86.3% shoot blight severity control and 84.2% control of canker incidence. Trunk injection of Regalia in fall of 2018 did not control the disease with 75% shoot blight severity and 38.5% canker incidence.

With a high infection pressure in 2021, there was a weak but significant effect of Parade, sulfur and three out of four Gatten spray programs, on reducing primary mildew on terminal shoots (Table 1). The disease severity in treatments ranged from 47.5% to 76% in comparison to 85% in the untreated control (Table 1). Gatten EC, Parade, Rally and sulfur, provided a better reduction of secondary mildew on shoots with a disease incidence in these treatments ranging from 18.3 to 29.2%. The possible reasons for weak effect could be that Gatten and Parade have poor eradicative i.e. post-infection effect on the primary mildew and the lack of fungicides applied during bloom (21 days gap). Similar reasons could explain the weak effect on secondary infections on shoots. An added factor is the lack of continued fungicide applications at second and third cover. Rally, had the best effect, controlling both primary and secondary powdery mildew (Table 1). However, due to lack of coverage during bloom, even Rally allowed 48% primary infection severity and 18.3% secondary infection incidence. The second-best treatments in control of secondary powdery mildew infections were both Gatten 5EC rates and Parade, allowing only 27%, 29% and 25% of secondary infection incidence on shoots.

Table 1. Control of powdery mildew with new fungicides Gatten and Parade.

	Treatment program (amount per Acre)	Spray Timing [y]	Primary mildew severity on shoots 1 July (%) [z]	Incidence of secondary mildew on shoots, 1 July (%) [z]
1	Untreated Control	-	85.0 ± 2.4 a	39.6 ± 3.1 a
2	Microthiol Disperss 20 lbs + Manzate Pro-Stick 75 DG 3 lb	TC	76.0 ± 4.5 ab	29.2 ± 6.0 b
	Gatten 5EC 3.2 fl oz + LI 700 0.125% + Manzate[x] 3 lb	PK		
	-	EB, BL		
	Gatten 5EC 3.2 fl oz + LI-700 [x] 0.125% + Manzate 3 lb	PF		
	Gatten 5EC 3.2 fl oz + LI-700 0.125% + Manzate 3 lb	FC		
3	Microthiol Disperss 20 lbs + Manzate 3 lb	TC	65 ± 1.3 b	27.0 ± 6.1 bc
	Gatten 5EC 6.4 fl oz + LI-700 0.125% + Manzate 3 lb	PK		
	-	EB, BL		
	Gatten 5EC 6.4 fl oz + LI-700 0.125% + Manzate 3 lb	PF		
	Gatten 5EC 6.4 fl oz + LI-700 0.125% + Manzate 3 lb	FC		
4	Microthiol Disperss 20 lbs + Manzate 3 lb	TC	66.5 ± 3.3 b	39.2 ± 2.6 a
	Gatten 2SC 8.0 fl oz + LI-700 0.125% + Manzate 3 lb	PK		
	-	EB, BL		
	Gatten 2SC 8.0 fl oz + LI-700 0.125% + Manzate 3 lb	PF		
	Gatten 2SC 8.0 fl oz + LI-700 0.125% + Manzate 3 lb	FC		
5	Microthiol Disperss 20 lbs + Manzate 3 lb	TC	72.0 ± 3.7 b	32.6 ± 0.6 ab
	Gatten 2SC 16.0 fl oz + Silwet 0.125% + Manzate 3 lb	PK		
	-	EB, BL		
	Gatten 2SC 16.0 fl oz + LI-700 0.125% + Manzate 3 lb	PF		
	Gatten 2SC 16.0 fl oz + LI-700 0.125% + Manzate 3 lb	FC		
6	Parade 20SC 3.2 fl oz + Manzate 3 lb	TC, PK, PF, FC	70.0 ± 2.2 b	24.5 ± 2.0 bc
7	Rally 40WSP 6 oz + Manzate 3 lb	TC, PK	47.5 ± 9.8 c	24.2 ± 9.3 c
	Merivon 4 fl oz + Manzate 3 lb	PF, FC		
8	Microthiol Disperss 20 lbs + Manzate 3 lb	HIG, TC, PK, BL, PF, FC	69.0 ± 6.0 abc	29.3 ± 1.8 b

[x] Manzate Pro-Stick 75 DG and LI-700 (80%) were used in all treatments where these are abbreviated.
[y] 30 Mar – HIG, ½ inch green; 5 Apr – TC, tight cluster; 8 Apr – PK, pink bud; 12 Apr – EB, early bloom; 20 Apr – BL, full bloom; 29 Apr – PF, petal fall; 13 May – FC, first cover.
[z] Means with standard error of the mean (SEM) followed by the same letter within column, i.e. rated disease parameter, are not significantly different from one another (LSD test, $P \leq 0.05$). Each mean consisted of 4 replicate trees.

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EXPLORING THE EFFECTS OF SPRAY TACTICS ON SELECTION FOR FENHEXAMID RESISTANCE IN *BOTRYTIS CINEREA*

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Introduction

Selection for resistance in fungal pathogen populations is a direct outcome of fungicide applications and the rate of resistance emergence is determined by factors such as spray strategies, fungal genotype, and fungal reproductive cycle. General resistance management strategies such as rotation and mixtures of fungicides have been widely implemented. However, detailed guidelines for single-site fungicide doses and multi-site mixing partners have yet to be documented, both of which are important factors affecting resistance selection.[1] Further, no studies have been able to successfully quantify the extent to which efficacy of fungicides are compromised under resistance scenarios. The main objectives of this research are to determine the efficacy of selected fungicides for controlling *Botrytis cinerea* with varying frequencies of resistance, the impact of dosage of high-risk fungicides, and the involvement of multi-site fungicides on resistance selection.

Methods

A series of detached fruit assays were conducted to test the objectives outlined above. Two unique detached fruit assays were completed and subsequently repeated. The first assay tested the disease control efficacy and resistance selection of the fenhexamid doses on the fungicide label. In contrast, the second assay tested the high fungicide rate from the label as well as a few, lower, exploratory doses on disease control efficacy and resistance selection.

Isolate Selection and Media Preparation

Botrytis cinerea isolates were selected based on their level of resistance to the active ingredient fenhexamid (tradename: Elevate). To confirm the phenotype of each isolate, cultures were grown on potato dextrose agar (PDA) and incubated at 22^0C in light conditions until sporulation. Spores were harvested from the cultures and plated on both malt extract agar (MEA) and malt extract agar amended with the discriminatory dose of 50 ppm fenhexamid. The plates were incubated at 22^0C in dark conditions to induce germination. After 18 hours the lengths of the germination tubes were measured on both MEA and MEA amended with 50 ppm Fenhexamid. Isolates whose germination tubes were at least 50% the lengths on the amended media compared to the unamended media were classified as resistant. Isolates whose germination tubes were distorted or less than 10% the lengths on the amended media compared to unamended media were classified as sensitive.

Inoculum Preparation

Spore suspensions were prepared from a combination of eight *Botrytis cinerea* isolates. Autoclaved tap water was used to flood the plates of sporulating cultures. Tween 20 was added to the water to facilitate the collection of spores. The resulting spore suspensions from each of the sensitive isolates were mixed and diluted to a spore concentration of $1x10^5$ spores/mL. This was repeated for the four resistant isolates. Then the spore suspensions composed entirely of sensitive and resistant isolates of equal spore concentrations were mixed to produce spore suspensions of 0%, 3%, 10%, and 30% resistant spores, which served as the starting inoculum for the detached fruit assays.

Grape Sterilization and Fungicide Application

Organic grapes were surface sterilized using a 10% sodium hypochlorite solution for two minutes. Then they were rinsed in autoclaved deionized water for two minutes to remove residue. The grapes were dried for two hours in an open biosafety cabinet. Then the grapes were sprayed with their corresponding fungicide treatments and kept in the biosafety cabinet until dry. Fungicide treatments varied in concentration and the presence of a multi-site mixing partner. Concentrations of the single-site fungicide included 1198ppm, 839ppm, 210ppm, 25ppm, and a 0ppm control. The doses of 1198ppm and 839ppm were determined from the recommended high and low doses on the fungicide label. The additional lower doses of 210ppm and 25ppm were included to test whether doses less than those on the fungicide label were more effective at limiting resistance selection. The have been named quarter low and true low, respectively. The 4798ppm concentration of the multi-site fungicide was determined by the medium rate recommended on the fungicide label.

Fungicide Treatment	Fenhexamid Concentration	Captan Concentration
1	1198 ppm	0 ppm
2	839 ppm	0 ppm
3	210 ppm	0 ppm
4	25 ppm	0 ppm
5	0 ppm	0 ppm
6	1198 ppm	4798 ppm
7	839 ppm	4798 ppm
8	210 ppm	4798 ppm
9	25 ppm	4798 ppm
10	0 ppm	4798 ppm

Table 1. The table outlines the formulation of the ten fungicide treatments in the experiment. Included are the rates of active ingredient of both fenhexamid and captan, which have the tradenames of Elevate 50 WDG and Captan 80 WDG respectively.

Inoculation and Harvest

After the fungicide applications, each grape was wounded with an autoclaved toothpick and inoculated with 15 μL of spore suspension. The grapes were incubated in a sterilized box with moistened paper towels to increase humidity and induce fungal infection. After 48 hours the lids were removed from the boxes to allow for a decrease in humidity to promote sporulation on the infected grapes. After another four days, the diameter of the lesions was measured for each berry. The lesion measurements included both a vertical diameter measurement as well as a horizontal diameter measurement. Spores were then harvested from all berries using a moistened inoculation loop. A spore suspension was obtained from each replicate, which was subsequently plated on both MEA and MEA amended with 50ppm fenhexamid. Finally, the spore suspensions were used to inoculate another set of grapes with the same fungicide treatment to produce further generations. Detached fruit assays were continued for three successive generations.

<u>Spore Counting and Phenotyping</u>

The MEA plates spread with spore suspensions were incubated at 22^{0}C under dark conditions to promote spore germination. After 18 hours, the relative frequency of resistance was measured for each replicate. The phenotype of thirty spores was observed by analyzing three groups of ten spores on each plate, following the same protocol as described above.

Results

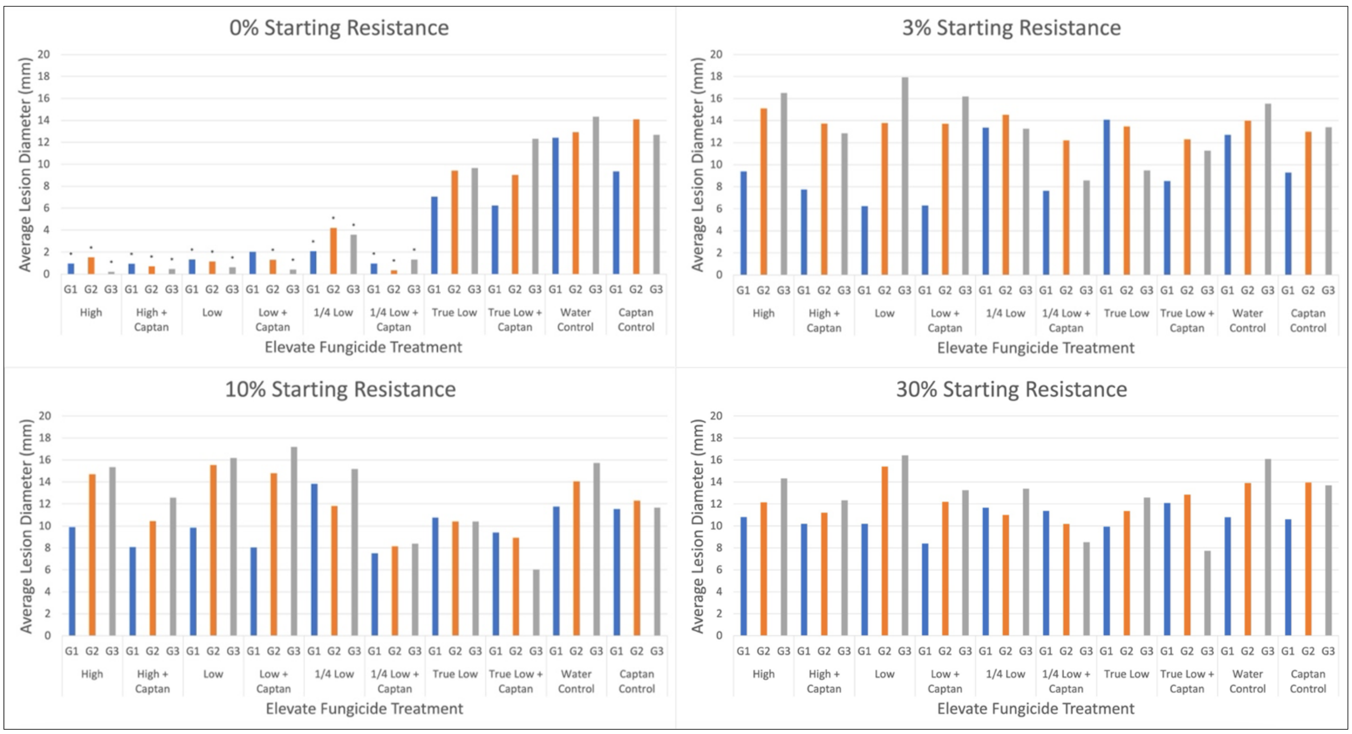

Figure 1. The figure shows the average lesion diameter resulting from each fungicide treatment under varied resistance scenarios. Additionally, the graphs display the values for each of the three generations. Treatments marked with an asterisk are significantly different to their respective control.

The disease control efficacy of elevate was high under scenarios of complete sensitivity. The labeled doses as well as the quarter low exploratory dose resulted in lesions significantly lower than their controls through all generations. However, disease control was lost with the introduction of resistance into the starting inoculum. At 3%, 10%, and 30% starting resistance, no fungicide treatments were statistically different from their respective controls (Figure 1). Generally, lesions diameters increased over each generation, but no significant disease control was achieved under these scenarios.

Across all resistance scenarios, there was no significant difference between the labeled high and labeled low fungicide dose on disease control. In addition, there is no significant difference between treatments of the single-site fungicide and those of a mixture of single-site and multi-site (Figure 1). The captan only treatment resulted in similar disease control to the water only control across resistance scenarios and generations.

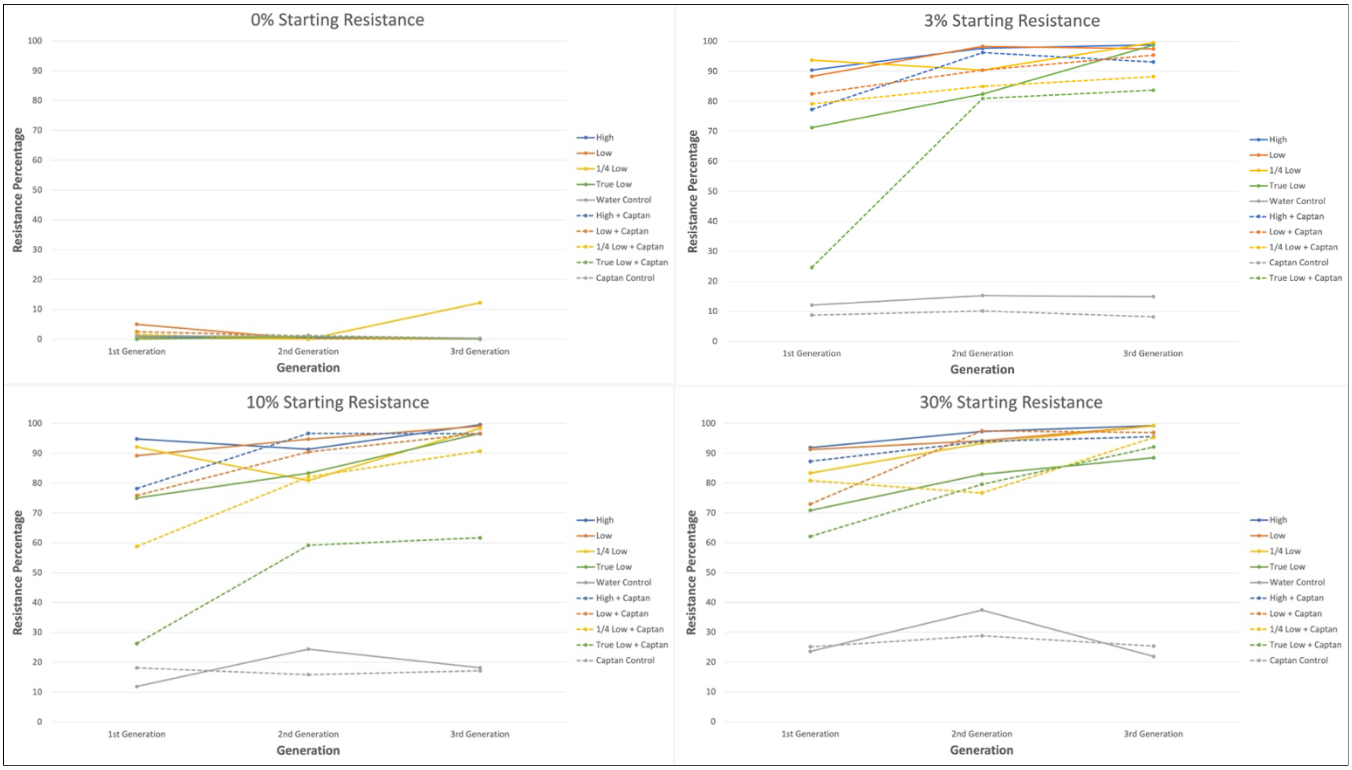

Figure 2. The figure shows the frequency of resistance of the spores resulting from each fungicide treatment across three generations and subsequent fungicide applications.

Under entirely sensitive scenarios, resistance management was maintained for all fungicide treatments. This was observed in the graph of 0% starting resistance where all fungicide treatments held constant around 0% resistance throughout the three generations. However, once tested under scenarios with resistance present, the labeled high and low doses were unable to manage resistance selection and resulted in resistance percentages above 70% after one generation (Figure 2). Additionally, there was no significant difference between the labeled high and low fungicide doses on resistance selection. Both exploratory doses, quarter low and true low, performed similarly to the labeled doses and resulted in resistance percentages above 70% in the absence captan.

The addition of the multi-site fungicide, captan, had a positive effect on limiting selection for resistance. The fungicide treatments mixed with captan consistently resulted in lower resistance percentages than their corresponding single-site only treatment. In addition, the two lower exploratory doses of quarter low and true low limited resistance selection better than their labeled high and low counterparts when mixed with captan. These effects were highlighted in the "True Low + Captan" fungicide treatment that successfully managed resistance after the first generation at 3% and 10% starting resistance (Figure 2).

Discussion

Our lab assays do not seem to indicate a distinct difference between a high and low dose on the fungicide label, in terms of both disease management and resistance selection. Although unable to provide significant disease control, the true low dose mixed with captan seemed to largely limit resistance selection at low starting resistance levels. Regardless, fungicide dose should be as low as possible when they are applied to the environment.

Another important factor impacting resistance selection is the application timing of the fungicide. In this experiment, the fungicide was applied prior to infection with the artificial inoculum. However, in the field, fungicides may also be sprayed well after infection has occurred. Thus, detached fruit assays are currently being conducted with the same protocols in scenarios where application occurs post-infection. Additionally, to test the validity of all the detached fruit assays, greenhouse trials were conducted during the summer of 2021 on whole grape clusters and field trials will be conducted in the summer of 2022.

References

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USING LEAF WETNESS AND TEMPERATURE TO PREDICT *COLLETOTRICHUM* INFECTION OF GRAPES

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Ripe rot of wine grapes is considered a major threat to many Mid-Atlantic vineyards and other regions with wet and warm conditions during fruit ripening. Recent investigations into ripe rot in Maryland found multiple species of *Colletotrichum* to be associated with the disease, and *C. fioriniae* was the most prevalent. Epidemiological understanding of ripe rot was lacking, and prior research has found certain wetness and temperature conditions to be critical to *C. acutatum* infection of strawberries. Therefore, investigations into optimum wetness and temperature conditions for *C. fioriniae* infection of grape berries were conducted for the eventual improvement of ripe rot management tactics.

C. fioriniae isolates collected from ripe rot symptomatic grapes were utilized for inoculum for three similar trials. The first trial consisted of a 60 second drenching of detached, pre-harvest Cabernet Sauvignon berries with a 1 x 10^6 conidia per milliliter spore suspension followed by covering with plastic film to maintain surface moisture. The inoculated berries were then placed in incubators set at temperatures between 10 to 30 °C. At 4-hour intervals between 0 and 24 hours, the plastic covering was removed from 30 berries in each incubator, allowing the berries to dry. After the 24-hour period, the berries were incubated until ripe rot symptoms developed. The percentage of berries per wetness and temperature treatment with ripe rot symptoms was recorded as the ripe rot incidence. This experiment was conducted twice. Similar trials were conducted on potted, greenhouse grown Cabernet Sauvignon grapevines. The second trial involved inoculating grapevine clusters at full bloom by misting with the spore suspension and covering with a plastic bag to maintain surface moisture. The potted vines were placed in plant growth chambers set between 12 to 32 °C and plastic bags were removed from about 5 clusters per temperature/wetness duration treatment at 6-hour intervals between 0 and 24 hours. The vines were then returned to the greenhouse to mature, and ripe rot symptoms were evaluated as the disease developed. The severity of ripe rot on each cluster was calculated by dividing the number of berries with ripe rot symptoms by the total number of berries per cluster. The third experiment also involved inoculating potted grapevine clusters at the same temperatures and wetness durations, but at the pre-harvest cluster developmental stage rather than the bloom stage. The pre-harvest potted trial was conducted twice. Preliminary logistic regression models were created from the ripe rot incidence data of the detached fruit trials and linear regression models were created from the ripe rot severity data from the pre-harvest potted grapevine trials.

On the detached grape trials, ripe rot incidence ranged from 0 to 90 percent, with incidence tending to be lowest at the lowest temperatures and wetness durations and highest at the higher temperatures and wetness durations. A similar trend occurred in the pre-harvest-inoculated potted trials. In the bloom-inoculated potted trials, low ripe rot severities were observed at all temperatures and wetness durations. Due to this, a predictive model was not created with the bloom inoculation trial data. The low amount of disease observed in the bloom inoculation trial may suggest that the bloom developmental stage is more resistant to infection than the pre-harvest stage. A logistic regression model created from the combined data from the two detached fruit trials appeared to best fit the data with an R^2 of 0.59 as opposed to separate models for the two experiments individually. This model regards wetness duration as *w*, temperature as *t*, and infection risk (ranging from 0 to 1) as *inf*:

$$\ln\left(\frac{inf}{1-inf}\right) = -1.57 + 0.07w + 0.017t - 0.0032w^2 + 0.0042\,wt$$

A linear regression model created from the data of the first pre-harvest potted trial appeared to fit the data better than the data of the repeated trial or the combination of the two trials with an R^2 of 0.39:

$$inf = -0.22 + 0.0098t + 0.019w + 0.00073wt$$

Both models given above can utilize given wetness duration and temperature data to predict infection risk, although the coefficients of determination suggest that more refined prediction models could be produced. Despite this, both models do describe a similar temperature and wetness duration-to-infection risk relationship that match models previously described for the prediction of *Colletotrichum* infection of other crops. This demonstrates that a dependable and accurate model for predicting the risk for *Colletotrichum* infection of wine grapes with weather conditions would be valuable for increased ripe rot control and for the reduction of unnecessary fungicide applications. Furthermore, the developmental stage appeared to play a significant role in the susceptibility of grape berries to disease, and this should be an important consideration in ripe rot management.

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APPLE BLOTCH CAUSED BY *DIPLOCARPON CORONARIAE*: A RISING THREAT TO APPLE PRODUCTION IN THE MID-ATLANTIC UNITED STATES

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Apple blotch caused by *Diplocarpon coronariae*, a detrimental disease affecting apple production in Europe and Asia in the past two decades, is now emerging in the United States. We first observed clear signs and symptoms of the disease in 2017 on almost all cultivars, including Mutsu, Honeycrisp, Gala, Red Delicious, Golden Delicious, Pristine, Grimes Golden, and others. Small circular brown to black spots appear on the upper surface of mature leaves with embedded acervuli at their centers. The infected leaves will rapidly turn yellow, leading to severe crown defoliation affecting fruit quality and reducing tree vigor. In addition to leaves, we observed symptoms on apple fruit as small, depressed circular black lesions with acervuli at the center.

We investigated spore dispersal patterns and fungicide efficacy in Mid-Atlantic to inform application timing, fungicide selection, and assist fungicide resistance management. We also evaluated the relative transcription levels of defense-related genes in apple cultivars during infection with *D. coronariae* to shed light on plant immunity responses that could assist the development of tolerant apple cultivars through breeding.

From symptomatic apple leaves and fruit collected in the Mid-Atlantic region, we isolated 53 slow-growing dark grey colonies for which ITS DNA sequences matched with *D. coronariae*. Fungicides thiophanate methyl, difenoconazole, and fluxapyroxad significantly suppressed the mycelial growth of *D. coronariae in vitro*, and fluxapyroxad + pyraclostrobin, captan, and fluazinam showed good apple blotch control in the orchard. Fontelis, Aprovia, and Regalia did not significantly reduce disease incidence, but they did significantly reduce defoliation severity. Spore traps were placed in tree canopies of four cultivars, Honeycrisp, Rome, Gala, and Delicious, in three successive years from 2018 to 2020. After q-PCR assays for spore detection and quantification, non-fungicide treated orchards consistently showed higher conidia counts than samples from fungicide treated trees and forested woodlots. Spore dispersal in non-fungicide treated orchards was low in early spring and dropped to undetectable levels in late May and early June before rising exponentially to peaks in July and August, which coincided with symptom development. After inoculation with *D. coronariae,* ‘Honeycrisp’ showed delayed onset of disease symptoms and lower disease severity in comparison to Fuji. The transcription profile of seven host defense-related genes showed that PR-2, PR-8, LYK4, and CERK1 were highly induced only in Honeycrisp at 2- and 5-days post inoculation.

We report the emergence and rising importance of apple blotch disease on leaves and apple fruit in the Mid-Atlantic U.S. High spore dispersal in late July and early August in non-fungicide treated orchards coincided with symptom development. Low numbers of spores detected in orchards receiving fungicide treatments indicated the effectiveness of currently applied fungicides in the Mid-Atlantic. We found that in ‘Honeycrisp,’ defense genes are upregulated more strongly, and disease progression is slower than ‘Fuji’. Overall, this work lays a foundation for further investigation of the disease and will assist in developing best management practices.

MANAGEMENT OF PEACH DISEASES WITH BIORATIONAL FUNGICIDES

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The overall goal of this field study was to evaluate the efficacy of two biorational materials for management of fungal diseases of peach. The first material, Howler 50DF, contains the active ingredient *Pseudomonas chlororaphis strain AFS009*. The second biorational material, Theia 100DF, contains the active ingredient *Bacillus subtilis* strain AFS032321. These biorational materials provide multiple modes of action that prevent pathogens from colonizing and infecting a wide variety of crops.

A third material, Esendo, was also examined for efficacy. Esendo is a pre-mix of the active ingredient in Howler, *Pseudomonas chlororaphis strain AFS009* at 44.25%, and the active ingredient in Abound, azoxystrobin, at 5.75%.

The first objective of the study was to determine and compare the efficacy of the biorational fungicides. To accomplish this goal, the materials were applied full season so control of all diseases could be examined. The second objective was to evaluate the efficacy of integrated programs consisting of biorational and conventional materials. The final objective was to compare the biorational programs to conventional programs.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2021 growing season at the Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. The test block consisted of 25-year-old ‘Autumnglo’ peach trees grafted on ‘Lovell’ rootstock. Trees were 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 were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing are shown in Table 1.

Assessment. Blossom blight canker (*Monilinia fructicola*) was evaluated on 15 June by examining 20 shoots per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 17-18 June by examining 40 fruit per tree. Scab (*Fusicladium carpophilum*) was evaluated on 17 Aug by examining 25 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 4 Sept by examining all fruit on arbitrarily selected branches (~ 50 fruit / tree). For postharvest evaluations, 25 asymptomatic uninjured fruit were harvested from each replicate tree and placed on benches in a shaded greenhouse (Ave: 78°F; Min: 75°F; Max: 83°F). Brown rot and other rots were evaluated at 3- and 6-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 monthly temperatures were above normal for four of the five months during which the study was conducted (Table 2). Monthly temperature averages for April, May, June, July, and August were 2, 0, 2, 1, and 1°F above the 30-year mean, respectively. These conditions were favorable for early season development of blossom blight cankers and peach rusty spot lesions on fruit, mid-season development of scab, and brown rot during the preharvest fruit ripening period.

Except for July, monthly rainfall totals in 2021 were below normal for each of the remaining four months (Table 2). Although remnants of hurricane Elsa on 8-9 July contributed 2.60 in to July's very high rainfall accumulation, heavy rain during 1-3 July added 4.20 in to the 8.50 in total (Table 1). Although a dry period occurred from 26 Apr through 26 May, rainfalls were fairly frequent throughout most of the remaining periods, especially in July and August which each received 9 rain periods ≥ 0.10 inches (Table 1, Table 2). In particular, six rain periods occurred during the 21 day preharvest period, which was quite favorable for brown rot development.

Blossom Blight. Blossom blight disease pressure in the test block was at a very high level in 2021. Fifty-five percent of non-treated shoots had at least one canker, with an average of 0.86 cankers per shoot (Table 3). This quantity of cankers would provide a considerable amount of inoculum for infection of fruit later in the season.

All treatments significantly reduced canker incidence and severity (Table 3). The most effective treatments (based on disease incidence), which were not significantly different from each other, were Howler, Theia, Esendo, and the Theia / Conventional program (trt 4). This last program integrated Vangard, Theia, and Rovral for blight control during bloom. Disease control for these treatments ranged from 93% for Howler to 78% for the Theia / Conv integrated program.

The least effective programs were the Howler / Conventional program (trt 2) and the standard program (trt 6), both of which provided 73% control. However, note that standard programs often have Rovral applied at petal fall as well as full bloom, which would have been stronger for blossom blight control. The Flint Extra was substituted since it also provides anti-sporulant activity against scab, which was deemed to be at a high level in the block.

Rusty Spot. The dry period from 26Apr through 25May produced conditions highly favorable for rusty spot, a powdery mildew disease (Table 1). These environmental conditions, combined with the high susceptibility of 'Autumnglo', resulted in a major epidemic. Non-treated control trees had 83% of fruit infected with an average 1.29 lesions per fruit (Table 4).

Under these high disease pressure conditions, Howler failed to significantly reduce rusty spot development (Table 4). All other treatments produced significant reductions in disease, but the levels of control were quite low. Disease control ranged from 34% for the Theia / Conventional program (trt 4) to 63% for the standard (trt 6).

Given the disease-favorable conditions, a more typical standard consisting of Rally at 6 oz/A applied at all four spray timings (PF, SS, 1C, 2C) would have given a higher level of control. However, rusty spot does not initially become visible until 2C, which is then too late for implementing a stronger program.

Scab. Conditions were highly favorable for scab development in 2021. Non-treated trees had 98% infected fruit with 81% of these fruit having 10 or more lesions (Table 5). The frequent rain periods from late May through July plus a high amount of overwintering inoculum were most likely the cause for the major epidemic (Table 1).

All treatment programs significantly reduced scab development on fruit (Table 5). The most effective programs were Ensendo and the full captan standard program (trt 6), which provided 94% and 71% control, respectively. Howler (trt 1), which provided 48% control and was equivalent to the standard (trt 6), was more effective than Theia (trt 3), which provided only 19% control.

When Howler was incorporated into the standard program (trt 2), the level of control was equivalent to the standard program (Table 5). However, when Theia was incorporated into the standard program (trt 4), the level of control was significantly lower than that of the standard; the integrated program had 57% infected fruit while the standard had 28% infected fruit. This difference in efficacy of the two integrated programs, relative to the standard, makes sense since the full season Howler program was significantly more effective than the full season Theia program (see above).

Brown Rot. Brown rot disease pressure was quite high. At harvest on 4Sep, 66.5% of non-treated control fruit were observed with brown rot (Table 6). This outcome was partly due to the occurrence of six potential infection periods (rain periods with ≥ 0.10 in) during the final 21 days prior to harvest, when fruit are most susceptible (Table 1). The high incidence of blossom blight canker, no doubt, provided adequate inoculum for these periods (Table 3).

All treatments significantly reduced the amount of brown rot at harvest (Table 6). The levels of control, from most to least effective, were Ensendo (94%); standard (90%); Howler / Conv

(85%); Theia / Conv (77%); Howler (68%); and Theia (61%). The two integrated programs, Howler / Conv (trt 2) and Theia / Conv (trt 4), provided control equivalent to the standard. Thus, the two Indar applications in the standard preharvest program could be replaced by either Howler or Theia without any loss in control.

By 7-DPH, disease incidence on the NTC fruit had reached 78% fruit infection (Table 6). At this time, the Theia / Conv, Standard, Howler / Conv, and Esendo had equivalent levels of disease incidence. The percent controls for these treatments were 81%, 77%, 72%, and 67%, respectively. Both full season Howler and Theia programs had significantly more rot at this time than all other treatments, providing only 38% to 40% control.

Other Rots. No *Rhizopus*, anthracnose, or *Phomopsis* fruit rots were observed during the harvest assessment. Only 2% *Phomopsis* rot was observed at 7-DPH.

Table 1. Weather and spray timings for 2021 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	45.3	0.07		1-May	54.0	0		1-Jun	64.3	0	**3rd Cover**
2-Apr	34.9	0		2-May	68.8	0		2-Jun	67.4	0	
3-Apr	38.8	0		3-May	66.4	0.1		3-Jun	70.3	0.28	
4-Apr	53.0	0		4-May	72.2	0.01	**1st Cover**	4-Jun	73.1	0	
5-Apr	56.1	0		5-May	65.9	0.27		5-Jun	77.8	0	
6-Apr	58.6	0		6-May	56.4	0		6-Jun	79.3	0	
7-Apr	57.3	0	**Pink**	7-May	54.9	0		7-Jun	80.7	0	
8-Apr	54.2	0		8-May	50.4	0.02		8-Jun	78.7	0	
9-Apr	50.9	0.07		9-May	50.8	0		9-Jun	75.9	0.01	
10-Apr	59.6	0.13		10-May	55.8	0		10-Jun	74.9	0	
11-Apr	60.7	0.53		11-May	56.2	0		11-Jun	64.8	0.11	
12-Apr	47.5	0.1		12-May	55.1	0		12-Jun	67.9	0	
13-Apr	51.1	0	**Bloom**	13-May	57.4	0		13-Jun	68.9	0	
14-Apr	53.6	0.05		14-May	59.6	0		14-Jun	72.8	0.72	
15-Apr	55.2	0		15-May	58.9	0.04		15-Jun	71.0	0.58	
16-Apr	48.5	0		16-May	58.3	0		16-Jun	68.9	0	**4th Cover**
17-Apr	50.5	0		17-May	60.6	0	**2nd Cover**	17-Jun	66.1	0	
18-Apr	52.5	0		18-May	63.9	0		18-Jun	70.6	0	
19-Apr	51.9	0		19-May	70.7	0		19-Jun	76.4	0.11	
20-Apr	58.3	0	**Petal Fall**	20-May	66.6	0		20-Jun	77.0	0.01	
21-Apr	54.7	0.15		21-May	64.6	0		21-Jun	77.7	0.21	
22-Apr	41.3	0		22-May	75.4	0		22-Jun	68.1	0.88	
23-Apr	49.0	0		23-May	80.8	0		23-Jun	63.9	0	
24-Apr	54.3	0.02		24-May	64.6	0		24-Jun	65.2	0	
25-Apr	54.3	0.55		25-May	64.0	0		25-Jun	66.8	0	
26-Apr	51.0	0		26-May	75.2	0.84		26-Jun	75.9	0	
27-Apr	60.5	0		27-May	72.7	0.01		27-Jun	79.6	0	
28-Apr	72.2	0	**Shuck Split**	28-May	61.2	0.53		28-Jun	81.4	0	
29-Apr	71.3	0		29-May	49.6	1.07		29-Jun	83.0	0	**5th Cover**
30-Apr	63.2	0		30-May	49.0	0.33		30-Jun	84.8	0	
				31-May	58.9	0					

Table 1 – continued –

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Jul	77.2	3.05		1-Aug	69.0	0.04		1-Sep	75.2	1.26	
2-Jul	70.8	0.71		2-Aug	68.6	0.01		2-Sep	68.1	0	
3-Jul	66.6	0.44		3-Aug	67.5	0		3-Sep	64.1	0	**1 dph**
4-Jul	70.3	0		4-Aug	67.2	0		4-Sep	65.1	0	**Harvest**
5-Jul	75.8	0		5-Aug	72.0	0					
6-Jul	81.4	0		6-Aug	76.4	0	**8th Cover**				
7-Jul	83.4	0		7-Aug	73.1	0.18					
8-Jul	79.7	0.57		8-Aug	70.5	1.05					
9-Jul	76.5	2.03		9-Aug	74.8	0					
10-Jul	75.0	0		10-Aug	79.2	0.15					
11-Jul	76.6	0.02		11-Aug	80.6	0.13					
12-Jul	81.1	0.73		12-Aug	81.9	0					
13-Jul	81.8	0.01	**6th Cover**	13-Aug	83.6	0					
14-Jul	82.4	0		14-Aug	80.2	0.01					
15-Jul	80.6	0		15-Aug	76.0	0.01					
16-Jul	82.9	0		16-Aug	74.6	0					
17-Jul	82.6	0.49		17-Aug	76.8	0.04					
18-Jul	74.8	0.05		18-Aug	80.4	0					
19-Jul	75.9	0		19-Aug	81.3	0					
20-Jul	77.3	0		20-Aug	75.1	0.7	**15 dph**				
21-Jul	75.8	0		21-Aug	74.1	0.06					
22-Jul	70.7	0		22-Aug	74.7	0.24					
23-Jul	71.2	0	**7th Cover**	23-Aug	77.4	0.16					
24-Jul	73.7	0		24-Aug	78.8	0.01					
25-Jul	77.1	0.11		25-Aug	79.0	0					
26-Jul	78.8	0.03		26-Aug	80.4	0					
27-Jul	78.4	0		27-Aug	80.4	0.59	**8 dph**				
28-Jul	75.1	0		28-Aug	73.7	0					
29-Jul	74.0	0.26		29-Aug	72.5	0.08					
30-Jul	77.7	0		30-Aug	76.3	0.49					
31-Jul	68.7	0		31-Aug	76.0	0.01					
								dph = days pre-harvest			

Table 2. Comparison of 2018-2021 Monthly Temperature and Rainfall Data, Bridgeton NJ *			
Month & Year	**Average Temp (°F)**	**Total Rainfall (in)**	**# Rains ≥ 0.10 in**
April 2021	54	1.67	5
April 2019	57	3.74	6
April 2018	50	3.77	6
April (30-year mean)	52	3.58	---
May 2021	62	3.22	6
May 2019	65	3.94	7
May 2018	67	6.12	11
May (30-year mean)	62	4.07	---
June 2021	73	2.91	7
June 2019	73	4.66	10
June 2018	72	2.88	6
June (30-year mean)	71	3.37	---
July 2021	77	8.50	9
July 2019	79	4.70	7
July 2018	77	4.76	5
July (30-year mean)	76	4.30	---
August 2021	76	3.96	9
August 2019	75	2.16	3
August 2018	77	3.75	11
August (30-year mean)	75	4.18	---

* No data in 2020 due to research stoppage as result of Covid-19 pandemic

Table 3. Blossom Blight Canker Incidence and Severity [1]					
Treatment [2]		Rate / A	Timing	% Shoots w. Canker [3]	# Cankers per Shoot [3]
0	Non-treated control	--------	--------	55.0 a	0.86 a
1	**Howler 50DF + Dyne-Amic**	**5.0 lb**	**All sprays**	3.8 c	0.04 c
2	**Vangard 75WG** **Howler 50DF + Dyne-Amic** **Rovral 4F + Howler 50DF + Dyne-Amic** Captan 80WDG + Rally 40WSP Howler 50DF + Dyne-Amic Captan 80WDG + Rally 40WSP Howler 50DF + Dyne-Amic Captan 80WDG Howler 50DF + Dyne-Amic Merivon 4.18SC	**5.0 oz** **5.0 lb** **1.5 pt + 5.0 lb** 3.0 lb + 5.0 oz 5.0 lb 3.0 lb + 5.0 oz 5.0 lb 2.5 lb 5.0 lb 5.5 fl oz	**P** **B** **PF** SS 1C 2C 3C, 5C, 7C 4C, 6C, 8C 15, 1 dph 8 dph	15.0 b	0.16 b
3	**Theia 100DF + Dyne-Amic**	**3.0 lb**	**All sprays**	10.0 bc	0.10 bc
4	**Vangard 75WG** **Theia 100DF + Dyne-Amic** **Rovral 4F + Theia 100DF + Dyne-Amic** Captan 80WDG + Rally 40WSP Theia 100DF + Dyne-Amic Captan 80WDG + Rally 40WSP Theia 100DF + Dyne-Amic Captan 80WDG Theia 100DF + Dyne-Amic Merivon 4.18SC	**5.0 oz** **3.0 lb** **1.5 pt + 3.0 lb** 3.0 lb + 5.0 oz 3.0 lb 3.0 lb + 5.0 oz 3.0 lb 2.5 lb 3.0 lb 5.5 fl oz	**P** **B** **PF** SS 1C 2C 3C, 5C, 7C 4C, 6C, 8C 15, 1 dph 8 dph	12.1 bc	0.13 bc
5	**Esendo 50DF + Dyne-Amic**	**2.8 lb**	**All sprays**	7.5 bc	0.10 bc
6	**Vangard 75WG** **Rovral 4F** **Flint Extra 4.05SC** Captan 80WDG + Rally 40WSP Captan 80WDG Indar 2F Merivon 4.18SC	**5.0 oz** **1.5 pt** **3.8 fl oz** 3.0 lb + 5.0 oz 2.5 lb 9.0 fl oz 5.5 fl oz	**P** **B** **PF** SS, 1C, 2C 3C-8C 15, 1 dph 8 dph	15.0 b	0.19 b

[1] Blossom blight treatments, rates, and application timings in **boldface;** dph = days pre-harvest
[2] Dyne-Amic added at 48 fl oz/100 gal (0.375% v/v) to all Howler, Theia, and Esendo sprays
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 4. Rusty Spot Incidence and Severity[1]					
Treatment [2]		**Rate / A**	**Timing**	**% Infected Fruit** [3]	**# Lesions per Fruit** [3]
0	Non-treated control	--------	--------	83.1 a	1.29 a
1	**Howler 50DF + Dyne-Amic**	**5.0 lb**	**All sprays**	81.9 a	1.29 a
2	Vangard 75WG Howler 50DF + Dyne-Amic **Rovral 4F + Howler 50DF + Dyne-Amic** **Captan 80WDG + Rally 40WSP** **Howler 50DF + Dyne-Amic** **Captan 80WDG + Rally 40WSP** Howler 50DF + Dyne-Amic Captan 80WDG Howler 50DF + Dyne-Amic Merivon 4.18SC	5.0 oz 5.0 lb **1.5 pt + 5.0 lb** **3.0 lb + 5.0 oz** **5.0 lb** **3.0 lb + 5.0 oz** 5.0 lb 2.5 lb 5.0 lb 5.5 fl oz	P B **PF** **SS** **1C** **2C** 3C, 5C, 7C 4C, 6C, 8C 15, 1 dph 8 dph	49.4 bc	0.68 c
3	**Theia 100DF + Dyne-Amic**	**3.0 lb**	**All sprays**	54.4 b	0.88 b
4	Vangard 75WG Theia 100DF + Dyne-Amic **Rovral 4F + Theia 100DF + Dyne-Amic** **Captan 80WDG + Rally 40WSP** **Theia 100DF + Dyne-Amic** **Captan 80WDG + Rally 40WSP** Theia 100DF + Dyne-Amic Captan 80WDG Theia 100DF + Dyne-Amic Merivon 4.18SC	5.0 oz 3.0 lb **1.5 pt + 3.0 lb** **3.0 lb + 5.0 oz** **3.0 lb** **3.0 lb + 5.0 oz** 3.0 lb 2.5 lb 3.0 lb 5.5 fl oz	P B **PF** **SS** **1C** **2C** 3C, 5C, 7C 4C, 6C, 8C 15, 1 dph 8 dph	55.0 b	0.75 bc
5	**Esendo 50DF + Dyne-Amic**	**2.8 lb**	**All sprays**	40.0 cd	0.46 d
6	Vangard 75WG Rovral 4F **Flint Extra 4.05SC** **Captan 80WDG + Rally 40WSP** Captan 80WDG Indar 2F Merivon 4.18SC	5.0 oz 1.5 pt **3.8 fl oz** **3.0 lb + 5.0 oz** 2.5 lb 9.0 fl oz 5.5 fl oz	P B **PF** **SS, 1C, 2C** 3C-8C 15, 1 dph 8 dph	30.6 d	0.35 d

[1] Rusty spot treatments, rates, and application timings in **boldface;** dph = days pre-harvest
[2] Dyne-Amic added at 48 fl oz/100 gal (0.375% v/v) to all Howler, Theia, and Esendo sprays
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 5. Scab Incidence and Severity[1]						
Treatment[2]		Rate / A	Timing	% Inf Fruit[3]	% Fruit 1-10 Les[3]	% Fruit >10 Les[3]
0	Non-treated control	--------	--------	98.0 a	17.0 b	81.0 a
1	**Howler 50DF + Dyne-Amic**	**5.0 lb**	**All sprays**	51.0 cd	27.0 ab	24.0 c
2	Vangard 75WG Howler 50DF + Dyne-Amic Rovral 4F + Howler 50DF + Dyne-Amic **Captan 80WDG + Rally 40WSP** **Howler 50DF + Dyne-Amic** **Captan 80WDG + Rally 40WSP** **Howler 50DF + Dyne-Amic** **Captan 80WDG** Howler 50DF + Dyne-Amic Merivon 4.18SC	5.0 oz 5.0 lb 1.5 pt + 5.0 lb **3.0 lb + 5.0 oz** **5.0 lb** **3.0 lb + 5.0 oz** **5.0 lb** **2.5 lb** 5.0 lb 5.5 fl oz	P B PF **SS** **1C** **2C** **3C, 5C, 7C** **4C, 6C, 8C** 15, 1 dph 8 dph	37.0 cd	22.0 b	15.0 cd
3	**Theia 100DF + Dyne-Amic**	**3.0 lb**	**All sprays**	79.0 b	15.0 b	64.0 b
4	Vangard 75WG Theia 100DF + Dyne-Amic Rovral 4F + Theia 100DF + Dyne-Amic **Captan 80WDG + Rally 40WSP** **Theia 100DF + Dyne-Amic** **Captan 80WDG + Rally 40WSP** **Theia 100DF + Dyne-Amic** **Captan 80WDG** Theia 100DF + Dyne-Amic Merivon 4.18SC	5.0 oz 3.0 lb 1.5 pt + 3.0 lb **3.0 lb + 5.0 oz** **3.0 lb** **3.0 lb + 5.0 oz** **3.0 lb** **2.5 lb** 3.0 lb 5.5 fl oz	P B PF **SS** **1C** **2C** **3C, 5C, 7C** **4C, 6C, 8C** 15, 1 dph 8 dph	57.3 c	38.7 a	18.7 c
5	**Esendo 50DF + Dyne-Amic**	**2.8 lb**	**All sprays**	6.0 e	4.0 c	2.0 d
6	Vangard 75WG Rovral 4F Flint Extra 4.05SC **Captan 80WDG + Rally 40WSP** **Captan 80WDG** Indar 2F Merivon 4.18SC	5.0 oz 1.5 pt 3.8 fl oz **3.0 lb + 5.0 oz** **2.5 lb** 9.0 fl oz 5.5 fl oz	P B PF **SS, 1C, 2C** **3C-8C** 15, 1 dph 8 dph	28.0 d	16.0 b	12.0 cd

[1] Scab treatments, rates, and application timings in **boldface;** dph = days pre-harvest
[2] Dyne-Amic added at 48 fl oz/100 gal (0.375% v/v) to all Howler, Theia, and Esendo sprays
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

<table>
<tr><th colspan="7">Table 6. Brown Rot Harvest and Post-Harvest Incidence [1]</th></tr>
<tr><th colspan="2"></th><th></th><th></th><th colspan="3">% Infected Fruit</th></tr>
<tr><th colspan="2">Treatment [2]</th><th>Rate / A</th><th>Timing</th><th>Harvest [3]</th><th>3-DPH [3]</th><th>7-DPH [3]</th></tr>
<tr><td>0</td><td>Non-treated control</td><td>--------</td><td>--------</td><td>66.5 a</td><td>26.0 a</td><td>78.0 a</td></tr>
<tr><td>1</td><td>Howler 50DF + Dyne-Amic</td><td>5.0 lb</td><td>All sprays</td><td>21.2 bc</td><td>7.0 bc</td><td>47.0 b</td></tr>
<tr><td>2</td><td>Vangard 75WG
Howler 50DF + Dyne-Amic
Rovral 4F + Howler 50DF + Dyne-Amic
Captan 80WDG + Rally 40WSP
Howler 50DF + Dyne-Amic
Captan 80WDG + Rally 40WSP
Howler 50DF + Dyne-Amic
Captan 80WDG
Howler 50DF + Dyne-Amic
Merivon 4.18SC</td><td>5.0 oz
5.0 lb
1.5 pt + 5.0 lb
3.0 lb + 5.0 oz
5.0 lb
3.0 lb + 5.0 oz
5.0 lb
2.5 lb
5.0 lb
5.5 fl oz</td><td>P
B
PF
SS
1C
2C
3C, 5C, 7C
4C, 6C, 8C
15, 1 dph
8 dph</td><td>9.9 cd</td><td>7.0 bc</td><td>22.0 c</td></tr>
<tr><td>3</td><td>Theia 100DF + Dyne-Amic</td><td>3.0 lb</td><td>All sprays</td><td>25.9 b</td><td>12.0 b</td><td>48.0 b</td></tr>
<tr><td>4</td><td>Vangard 75WG
Theia 100DF + Dyne-Amic
Rovral 4F + Theia 100DF + Dyne-Amic
Captan 80WDG + Rally 40WSP
Theia 100DF + Dyne-Amic
Captan 80WDG + Rally 40WSP
Theia 100DF + Dyne-Amic
Captan 80WDG
Theia 100DF + Dyne-Amic
Merivon 4.18SC</td><td>5.0 oz
3.0 lb
1.5 pt + 3.0 lb
3.0 lb + 5.0 oz
3.0 lb
3.0 lb + 5.0 oz
3.0 lb
2.5 lb
3.0 lb
5.5 fl oz</td><td>P
B
PF
SS
1C
2C
3C, 5C, 7C
4C, 6C, 8C
15, 1 dph
8 dph</td><td>15.5 bcd</td><td>4.0 bc</td><td>14.7 c</td></tr>
<tr><td>5</td><td>Esendo 50DF + Dyne-Amic</td><td>2.8 lb</td><td>All sprays</td><td>4.3 d</td><td>2.0 c</td><td>26.0 c</td></tr>
<tr><td>6</td><td>Vangard 75WG
Rovral 4F
Flint Extra 4.05SC
Captan 80WDG + Rally 40WSP
Captan 80WDG
Indar 2F
Merivon 4.18SC</td><td>5.0 oz
1.5 pt
3.8 fl oz
3.0 lb + 5.0 oz
2.5 lb
9.0 fl oz
5.5 fl oz</td><td>P
B
PF
SS, 1C, 2C
3C-8C
15, 1 dph
8 dph</td><td>6.4 d</td><td>3.0 c</td><td>18.0 c</td></tr>
<tr><td colspan="7">[1] Brown treatments, rates, and application timings in boldface; dph = days pre-harvest; DPH = days post-harvest
[2] Dyne-Amic added at 48 fl oz/100 gal (0.375% v/v) to all Howler, Theia, and Esendo sprays
[3] Means in same column with same letter do not differ significantly according to Waller-Duncan K-ratio t-test (α=0.05, K=100).</td></tr>
</table>

MANAGEMENT OF PEACH DISEASES WITH
BIORATIONAL AND CONVENTIONAL FUNGICIDES

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The main objectives of this field study were twofold. The first objective was to determine and compare the efficacy of several biorational fungicides for management of peach diseases. These materials were applied full season so control of all diseases could be examined. The second objective was to compare the efficacy of the new DMI fungicide, Cevya, with the current standard DMI, Indar, for management of brown rot fruit rot. In addition, a standard program was included for comparison, which alternated Cevya with Merivon during the preharvest period.

The biorational materials examined in this study were: Stargus (*Bacillus amyloliquefaciens* strain 727 cells and spent fermentation media); Regalia (extract of *Reynoutria sachalinensis,* giant knotweed); and Oso (Polyoxin D zinc salt). In addition to a full season program, Oso was also examined as a component of a conventional program and an organic program. In each of these two latter programs, the Oso timings were focused on brown rot management.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2021 growing season at the Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. The test block consisted of 5-year-old 'Glowingstar' peach trees grafted on 'Lovell' rootstock. Trees were 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 were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing are shown in Table 1.

Assessment. Blossom blight canker (*Monilinia fructicola*) was evaluated on 17-18 May by examining 20 shoots per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 21 June by examining 40 fruit per tree. Scab (*Fusicladium carpophilum*) was evaluated on 2 Aug by examining 25 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 16 Aug by examining all fruit on arbitrarily selected branches (~ 50 fruit / tree). For postharvest evaluations, 25 asymptomatic uninjured fruit were harvested from each replicate tree and placed on benches in a shaded greenhouse (Ave: 79°F; Min: 75°F; Max: 86°F). Brown rot and other rots were evaluated at 3- 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 monthly temperatures were above normal for four of the five months during which the study was conducted (Table 2). Monthly temperature averages for April, May, June, July, and August were 2, 0, 2, 1, and 1°F above the 30-year mean, respectively. These conditions were favorable for early season development of blossom blight cankers and peach rusty spot lesions on fruit, mid-season development of scab, and brown rot during the preharvest fruit ripening period.

Except for July, monthly rainfall totals in 2021 were below normal for each of the remaining four months (Table 2). Although remnants of hurricane Elsa on 8-9 July contributed 2.60 in to July's very high rainfall accumulation, heavy rain during 1-3 July added 4.20 in to the 8.50 in total (Table 1). Although a drought occurred from 26 Apr through 26 May, rainfalls were fairly frequent throughout most of the remaining periods, especially in July and August which each received 9 rain periods ≥ 0.10 inches (Table 1, Table 2). In particular, five rain periods occurred during the 21 day preharvest period, which was quite favorable for brown rot development.

Blossom Blight. Blossom blight disease pressure in the test block was at a very high level in 2021. Fifty percent of non-treated shoots had at least one canker, with an average of 0.93 cankers per shoot (Table 3). This quantity of cankers would provide a considerable amount of inoculum for infection of fruit later in the season.

All treatments significantly reduced canker incidence and severity (Table 3). The most effective treatments (based on disease incidence), which were not significantly different from each other, were Regalia, Stargus, Oso, Oso/Rovral, and the standard Vangard/Rovral. Disease control for these treatments ranged from 90% (Stargus, Oso organic) to 95% (Vangard/Rovral, Oso full season, Oso/Rovral).

No fungicides were applied during bloom for the Cevya and Indar conventional programs (treatments 2 and 3); emphasis was on brown rot fruit rot management. Nevertheless, these two treatments had significantly less canker development than the non-treated control. This outcome was most likely due to control during shuck-split by Bravo Ultrex. At early shuck split, some late flowers are still in petal fall stage and therefore are susceptible to infection.

Rusty Spot. The susceptibility of 'Glowingstar' to rusty spot was not known at the start of the study. On non-treated control trees, 35% of fruit had rusty spot with an average severity of

0.42 lesions per fruit (Table 4). Based on disease development observed on highly susceptible cultivars, such as ‘Autumnglo’, the 2021 season was highly favorable to rusty spot development. ‘Augutmnglo’ had over 90% fruit infection. Thus, ‘Glowingstar’ can be labeled as having moderate susceptibility.

The critical spray timings for rusty spot control are petal fall, shuck split, first cover, and second cover. All treatments significantly reduced rusty spot incidence and severity. The most effective treatments were Regalia, Oso/Microthiol Disperss, and Oso full season. These materials provided 63%, 70%, and 77% disease control, respectively.

The standards for rusty spot control are myclobutanil (Rally) and flutriafol (Rhyme), which were not included in the study. The Bravo/Captan sprays in treatments 1, 2, 3, and 7 are primarily for scab control, yielding only partial control of rusty spot.

Scab. Conditions were highly favorable for scab development in 2021. Non-treated trees had 98% infected fruit with 79% of these fruit having 10 or more lesions (Table 5). The frequent rain periods from late May through June, plus a high amount of overwintering inoculum, were most likely the cause for the major epidemic.

All treatment programs significantly reduced scab development on fruit (Table 5). The most effective programs were those which included Bravo at SS followed by Captan cover sprays (the standard). These programs provided 95% (trt 1, 2) to 98% (trt 7) control. The Oso organic program (trt 8), which utilized the sulfur product Microthiol Disperss for scab management, was equally effective, providing 97% control.

Although all three biorational programs significantly reduced scab incidence, as well as % fruit with 10 or more lesions, the level of control was nevertheless low (Table 5). Stargus and Regalia provided only 10% and 21% control, respectively. Oso performed somewhat better, providing 71% control, but still had significantly more disease than the Bravo/Captan standards.

Brown Rot. Brown rot disease pressure was quite high. At harvest on 16Aug, 58% of non-treated control fruit were observed with brown rot (Table 6). This outcome was partly due to the occurrence of five potential infection periods (rain periods with ≥ 0.10 in) during the final 21 days prior to harvest, when fruit are most susceptible (Table 1). The high incidence of blossom blight canker, no doubt, provided adequate inoculum for these periods (Table 3).

The most effective treatments at harvest were the standard Merivon/Cevya/Merivon (trt 1) and the Oso conventional program, Oso/Miravis/Oso (trt 7), which provided 97% and 96% control, respectively (Table 6). These two programs continued to deliver very good control at 3-days postharvest, providing 94% and 84% control, respectively, at this assessment.

The Cevya and Indar DMI programs (trts 2, 3) provided equivalent control of brown rot “across the board” (Table 6). No statistical differences between these two treatments were observed at harvest and during both postharvest assessments. However, their level of control at harvest was not as good as the standard (trt 1) or Oso conventional (trt 7). Cevya provided 87% control while Indar provided 83% control.

The three biorational materials (trts 4, 5, 6) delivered partial control of brown rot at best (Table 6). At harvest, Regalia, Stargus, and Oso provided 59%, 56%, and 47% control, respectively. While disease incidences at harvest were significantly lower than the non-treated control, these disease control levels were much too low to be commercially acceptable.

Given the partial control afforded by Oso, the high degree of efficacy of the Oso/Miravis/Oso program (trt 7) necessitates explanation. During the 21-day preharvest period from 27 July through 16 August, four of the five infection periods (7, 8, 10, & 11 Aug) occurred immediately after the 10-dph Miravis spray timing (Table 1). Thus, the arguably more effective material, Miravis, was applied at the ideal time for maximum control. When the Miravis is replaced by Oso, as in treatments 6 and 8, the level of brown rot control is considerably lower.

Other Rots. Little to no *Rhizopus*, anthracnose, or *Phomopsis* fruit rots were observed during the harvest and postharvest assessments. The percent incidence of these three diseases were 0%, 1%, and 0.5%, respectively.

Table 1. Weather and spray timings for 2021 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	45.3	0.07		1-May	54.0	0		1-Jun	64.3	0	**3rd Cover**
2-Apr	34.9	0		2-May	68.8	0		2-Jun	67.4	0	
3-Apr	38.8	0		3-May	66.4	0.1		3-Jun	70.3	0.28	
4-Apr	53.0	0		4-May	72.2	0.01		4-Jun	73.1	0	
5-Apr	56.1	0		5-May	65.9	0.27		5-Jun	77.8	0	
6-Apr	58.6	0	**Pink**	6-May	56.4	0		6-Jun	79.3	0	
7-Apr	57.3	0		7-May	54.9	0	**1st Cover**	7-Jun	80.7	0	
8-Apr	54.2	0		8-May	50.4	0.02		8-Jun	78.7	0	
9-Apr	50.9	0.07		9-May	50.8	0		9-Jun	75.9	0.01	
10-Apr	59.6	0.13		10-May	55.8	0		10-Jun	74.9	0	
11-Apr	60.7	0.53		11-May	56.2	0		11-Jun	64.8	0.11	
12-Apr	47.5	0.1		12-May	55.1	0		12-Jun	67.9	0	
13-Apr	51.1	0		13-May	57.4	0		13-Jun	68.9	0	
14-Apr	53.6	0.05	**Bloom**	14-May	59.6	0		14-Jun	72.8	0.72	
15-Apr	55.2	0		15-May	58.9	0.04		15-Jun	71.0	0.58	
16-Apr	48.5	0		16-May	58.3	0		16-Jun	68.9	0	**4th Cover**
17-Apr	50.5	0		17-May	60.6	0		17-Jun	66.1	0	
18-Apr	52.5	0		18-May	63.9	0		18-Jun	70.6	0	
19-Apr	51.9	0		19-May	70.7	0		19-Jun	76.4	0.11	
20-Apr	58.3	0	**Petal Fall**	20-May	66.6	0		20-Jun	77.0	0.01	
21-Apr	54.7	0.15		21-May	64.6	0	**2nd Cover**	21-Jun	77.7	0.21	
22-Apr	41.3	0		22-May	75.4	0		22-Jun	68.1	0.88	
23-Apr	49.0	0		23-May	80.8	0		23-Jun	63.9	0	
24-Apr	54.3	0.02		24-May	64.6	0		24-Jun	65.2	0	
25-Apr	54.3	0.55		25-May	64.0	0		25-Jun	66.8	0	
26-Apr	51.0	0		26-May	75.2	0.84		26-Jun	75.9	0	
27-Apr	60.5	0		27-May	72.7	0.01		27-Jun	79.6	0	
28-Apr	72.2	0		28-May	61.2	0.53		28-Jun	81.4	0	
29-Apr	71.3	0	**Shuck Split**	29-May	49.6	1.07		29-Jun	83.0	0	**5th Cover**
30-Apr	63.2	0		30-May	49.0	0.33		30-Jun	84.8	0	
				31-May	58.9	0					

Table 1 – continued –

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Jul	77.2	3.05		1-Aug	69.0	0.04					
2-Jul	70.8	0.71		2-Aug	68.6	0.01					
3-Jul	66.6	0.44		3-Aug	67.5	0					
4-Jul	70.3	0		4-Aug	67.2	0					
5-Jul	75.8	0		5-Aug	72.0	0					
6-Jul	81.4	0		6-Aug	76.4	0	**10-dph**				
7-Jul	83.4	0		7-Aug	73.1	0.18					
8-Jul	79.7	0.57		8-Aug	70.5	1.05					
9-Jul	76.5	2.03		9-Aug	74.8	0					
10-Jul	75.0	0		10-Aug	79.2	0.15					
11-Jul	76.6	0.02		11-Aug	80.6	0.13					
12-Jul	81.1	0.73		12-Aug	81.9	0					
13-Jul	81.8	0.01	**6th Cover**	13-Aug	83.6	0	**3-dph**				
14-Jul	82.4	0		14-Aug	80.2	0.01					
15-Jul	80.6	0		15-Aug	76.0	0.01					
16-Jul	82.9	0		16-Aug	74.6	0	**Harvest**				
17-Jul	82.6	0.49		17-Aug	76.8	0.04					
18-Jul	74.8	0.05		18-Aug	80.4	0					
19-Jul	75.9	0		19-Aug	81.3	0					
20-Jul	77.3	0		20-Aug	75.1	0.7					
21-Jul	75.8	0		21-Aug	74.1	0.06					
22-Jul	70.7	0		22-Aug	74.7	0.24					
23-Jul	71.2	0		23-Aug	77.4	0.16					
24-Jul	73.7	0		24-Aug	78.8	0.01					
25-Jul	77.1	0.11		25-Aug	79.0	0					
26-Jul	78.8	0.03		26-Aug	80.4	0					
27-Jul	78.4	0		27-Aug	80.4	0.59					
28-Jul	75.1	0		28-Aug	73.7	0					
29-Jul	74.0	0.26	**18-dph**	29-Aug	72.5	0.08					
30-Jul	77.7	0		30-Aug	76.3	0.49					
31-Jul	68.7	0		31-Aug	76.0	0.01					
								dph = days pre-harvest			

Table 2. Comparison of 2018-21 Monthly Temperature and Rainfall Data, Bridgeton NJ *			
Month & Year	**Average Temp (°F)**	**Total Rainfall (in)**	**# Rains ≥ 0.10 in**
April 2021	54	1.67	5
April 2019	57	3.74	6
April 2018	50	3.77	6
April (30-year mean)	52	3.58	---
May 2021	62	3.22	6
May 2019	65	3.94	7
May 2018	67	6.12	11
May (30-year mean)	62	4.07	---
June 2021	73	2.91	7
June 2019	73	4.66	10
June 2018	72	2.88	6
June (30-year mean)	71	3.37	---
July 2021	77	8.50	9
July 2019	79	4.70	7
July 2018	77	4.76	5
July (30-year mean)	76	4.30	---
August 2021	76	3.96	9
August 2019	75	2.16	3
August 2018	77	3.75	11
August (30-year mean)	75	4.18	---

* No data in 2020 due to research stoppage as result of Covid-19 pandemic

Table 3. Blossom Blight Canker Incidence and Severity [1]					
Treatment		Rate / A	Timing	% Shoots w. Canker [2]	# Cankers per Shoot [2]
0	Non-treated control	--------	--------	50.0 a	0.93 a
1	**Vangard 75WG** **Rovral 4F** Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG Merivon 4.18SC + Latron B-1956 Cevya 3.34SC + Latron B-1956	**5.0 oz** **1.5 pt** 3.3 lb 3.0 lb 2.5 lb 5.0 fl oz + 8 fl oz 5.0 fl oz + 8 fl oz	**P** **B, PF** SS 1C-5C 6C 18, 3 dph 10 dph	2.5 c	0.03 d
2	Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG Cevya 3.34SC + Latron B-1956	3.3 lb 3.0 lb 2.5 lb 5.0 fl oz + 8 fl oz	SS 1C-5C 6C 18, 10, 3 dph	27.5 b	0.34 c
3	Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG Indar 2F + Latron B-1956	3.3 lb 3.0 lb 2.5 lb 9.0 fl oz + 8 fl oz	SS 1C-5C 6C 18, 10, 3 dph	32.5 b	0.48 b
4	**Regalia 5% + Nu-Film-P**	**64 fl oz + 32 fl oz**	**All timings**	3.8 c	0.05 d
5	**Stargus + Nu-Film-P**	**96 fl oz + 32 fl oz**	**All timings**	5.0 c	0.06 d
6	**Oso 5%SC + Latron B-1956**	**6.5 fl oz + 8 fl oz**	**All timings**	2.5 c	0.03 d
7	**Oso 5%SC + Latron B-1956** **Rovral 4F** Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG Oso 5%SC + Latron B-1956 Miravis 1.67SC + Latron B-1956	**6.5 fl oz + 8 fl oz** **1.5 pt** 3.3 lb 3.0 lb 2.5 lb 6.5 fl oz + 8 fl oz 5.1 fl oz + 8 fl oz	**P, PF** **B** SS 1C-5C 6C 18, 3 dph 10 dph	2.5 c	0.03 d
8	**Oso 5%SC + Latron B-1956** Microthiol Disperss 80DF Oso 5%SC + Latron B-1956	**6.5 fl oz + 8 fl oz** 15.0 lb 6.5 fl oz + 8 fl oz	**P, B, PF** SS, 1C-6C 18, 10, 3 dph	5.0 c	0.06 d

[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]**
0	Non-treated Control	--------	--------	35.0 a	0.42 a
1	Vangard 75WG **Rovral 4F** **Bravo Ultrex 82.5WDG** **Captan 80WDG** Captan 80WDG Merivon 4.18SC + Latron B-1956 Cevya 3.34SC + Latron B-1956	5.0 oz **1.5 pt** **3.3 lb** **3.0 lb** 2.5 lb 5.0 fl oz + 8 fl oz 5.0 fl oz + 8 fl oz	P B, **PF** **SS** **1C, 2C,** 3C-5C 6C 18, 3 dph 10 dph	15.0 bcd	0.18 bc
2	**Bravo Ultrex 82.5WDG** **Captan 80WDG** Captan 80WDG Cevya 3.34SC + Latron B-1956	**3.3 lb** **3.0 lb** 2.5 lb 5.0 fl oz + 8 fl oz	**SS** **1C, 2C,** 3C-5C 6C 18, 10, 3 dph	20.0 bc	0.24 b
3	**Bravo Ultrex 82.5WDG** **Captan 80WDG** Captan 80WDG Indar 2F + Latron B-1956	**3.3 lb** **3.0 lb** 2.5 lb 9.0 fl oz + 8 fl oz	**SS** **1C, 2C,** 3C-5C 6C 18, 10, 3 dph	21.9 b	0.26 b
4	**Regalia 5% + Nu-Film-P**	**64 fl oz + 32 fl oz**	**All timings**	13.1 cd	0.14 cd
5	**Stargus + Nu-Film-P**	**96 fl oz + 32 fl oz**	**All timings**	20.0 bc	0.21 bc
6	**Oso 5%SC + Latron B-1956**	**6.5 fl oz + 8 fl oz**	**All timings**	8.1 d	0.09 d
7	**Oso 5%SC + Latron B-1956** Rovral 4F **Bravo Ultrex 82.5WDG** **Captan 80WDG** Captan 80WDG Oso 5%SC + Latron B-1956 Miravis 1.67SC + Latron B-1956	**6.5 fl oz + 8 fl oz** 1.5 pt **3.3 lb** **3.0 lb** 2.5 lb 6.5 fl oz + 8 fl oz 5.1 fl oz + 8 fl oz	P, **PF** B **SS** **1C, 2C,** 3C-5C 6C 18, 3 dph 10 dph	21.3 b	0.23 b
8	**Oso 5%SC + Latron B-1956** **Microthiol Disperss 80DF** Oso 5%SC + Latron B-1956	**6.5 fl oz + 8 fl oz** **15.0 lb** 6.5 fl oz + 8 fl oz	P, B, **PF** **SS, 1C, 2C,** 3C-6C 18, 10, 3 dph	10.6 d	0.13 cd

[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]**
0	Non-treated Control	--------	--------	98.0 a	19.0 a	79.0 a
1	Vangard 75WG Rovral 4F **Bravo Ultrex 82.5WDG** **Captan 80WDG** **Captan 80WDG** Merivon 4.18SC + Latron B-1956 Cevya 3.34SC + Latron B-1956	5.0 oz 1.5 pt **3.3 lb** **3.0 lb** **2.5 lb** 5.0 fl oz + 8 fl oz 5.0 fl oz + 8 fl oz	P B, PF **SS** **1C-5C** **6C** 18, 3 dph 10 dph	5.0 d	4.0 b	1.0 d
2	**Bravo Ultrex 82.5WDG** **Captan 80WDG** **Captan 80WDG** Cevya 3.34SC + Latron B-1956	**3.3 lb** **3.0 lb** **2.5 lb** 5.0 fl oz + 8 fl oz	**SS** **1C-5C** **6C** 18, 10, 3 dph	5.0 d	5.0 b	0.0 d
3	**Bravo Ultrex 82.5WDG** **Captan 80WDG** **Captan 80WDG** Indar 2F + Latron B-1956	**3.3 lb** **3.0 lb** **2.5 lb** 9.0 fl oz + 8 fl oz	**SS** **1C-5C** **6C** 18, 10, 3 dph	3.0 d	2.0 b	1.0 d
4	**Regalia 5% + Nu-Film-P**	**64 fl oz + 32 fl oz**	**All timings**	77.0 b	24.0 a	53.0 b
5	**Stargus + Nu-Film-P**	**96 fl oz + 32 fl oz**	**All timings**	88.0 b	26.0 a	62.0 b
6	**Oso 5%SC + Latron B-1956**	**6.5 fl oz + 8 fl oz**	**All timings**	28.0 c	17.0 a	11.0 c
7	Oso 5%SC + Latron B-1956 Rovral 4F **Bravo Ultrex 82.5WDG** **Captan 80WDG** **Captan 80WDG** Oso 5%SC + Latron B-1956 Miravis 1.67SC + Latron B-1956	6.5 fl oz + 8 fl oz 1.5 pt **3.3 lb** **3.0 lb** **2.5 lb** 6.5 fl oz + 8 fl oz 5.1 fl oz + 8 fl oz	P, PF B **SS** **1C-5C** **6C** 18, 3 dph 10 dph	2.0 d	2.0 b	0.0 d
8	Oso 5%SC + Latron B-1956 **Microthiol Disperss 80DF** Oso 5%SC + Latron B-1956	6.5 fl oz + 8 fl oz **15.0 lb** 6.5 fl oz + 8 fl oz	P, B, PF **SS, 1C-6C** 18, 10, 3 dph	3.0 d	3.0 b	0.0 d

[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]	3-DPH [2]	7-DPH [2]
0	Non-treated Control	--------	--------	58.0 a	50.0 a	94.0 a
1	Vangard 75WG Rovral 4F Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG **Merivon 4.18SC + Latron B-1956** **Cevya 3.34SC + Latron B-1956**	5.0 oz 1.5 pt 3.3 lb 3.0 lb 2.5 lb **5.0 fl oz + 8 fl oz** **5.0 fl oz + 8 fl oz**	P B, PF SS 1C-5C 6C **18, 3 dph** **10 dph**	1.5 d	3.0 d	25.0 e
2	Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG **Cevya 3.34SC + Latron B-1956**	3.3 lb 3.0 lb 2.5 lb **5.0 fl oz + 8 fl oz**	SS 1C-5C 6C **18, 10, 3 dph**	7.8 c	10.0 cd	51.0 d
3	Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG **Indar 2F + Latron B-1956**	3.3 lb 3.0 lb 2.5 lb **9.0 fl oz + 8 fl oz**	SS 1C-5C 6C **18, 10, 3 dph**	9.7 c	11.0 cd	59.0 d
4	**Regalia 5% + Nu-Film-P**	**64 fl oz + 32 fl oz**	**All timings**	23.6 b	19.0 bc	75.0 c
5	**Stargus + Nu-Film-P**	**96 fl oz + 32 fl oz**	**All timings**	25.5 b	28.0 b	84.0 bc
6	**Oso 5%SC + Latron B-1956**	**6.5 fl oz + 8 fl oz**	**All timings**	30.5 b	28.0 b	92.0 ab
7	Oso 5%SC + Latron B-1956 Rovral 4F Bravo Ultrex 82.5WDG Captan 80WDG Captan 80WDG **Oso 5%SC + Latron B-1956** **Miravis 1.67SC + Latron B-1956**	6.5 fl oz + 8 fl oz 1.5 pt 3.3 lb 3.0 lb 2.5 lb **6.5 fl oz + 8 fl oz** **5.1 fl oz + 8 fl oz**	P, PF B SS 1C-5C 6C **18, 3 dph** **10 dph**	2.5 d	8.0 d	51.0 d
8	Oso 5%SC + Latron B-1956 Microthiol Disperss 80DF **Oso 5%SC + Latron B-1956**	6.5 fl oz + 8 fl oz 15.0 lb **6.5 fl oz + 8 fl oz**	P, B, PF SS, 1C-6C **18, 10, 3 dph**	25.6 b	26.0 b	80.0 c

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

MANAGEMENT OF PEACH BACTERIAL SPOT:
EFFICACY OF BIORATIONAL MATERIALS

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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 overall objective of this study was to determine the efficacy of two biorational materials, CX-6700 and FungOut, for management of peach bacterial spot. The active ingredient in CX-6700 consists of bacteriophage (a virus) that specifically attacks the *X. arboricola* pv *pruni* pathogen. After each bacterial cell is infected, the phage replicate and are released when the cell disintegrates (lysis). These newly produced phage can infect additional bacteria, repeating the process many times, resulting in a reduction in the pathogen population.

The active ingredient in FungOut is citric acid, an organic acid commonly found in fruits, such as lemons and limes. Citric acid has both antifungal and direct bactericidal activity. Consequently, citric acid is commonly used as a disinfectant against bacteria and also viruses. In plant disease control, citric acid is used as both a fungicide and bactericide. In this study, FungOut is also being tested in alternation with a copper bactericide, Kocide 3000.

The standards for comparison in this study were the antibiotic FireLine 45WP (oxytetracycline) and the copper material Kocide 3000 30DF (copper hydroxide). A treatment that alternates these two products was also included. Finally, all sprays were timed according to a simple rule based on rain events; see below for details.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2021 growing season at the Rutgers Agricultural Research and Extension Center, Bridgeton NJ. Peach trees in the test orchard consisted of the highly susceptible cultivar ‘Sunhigh’ (SH) grafted on ‘Halford’ rootstock. Trees were 5-years old and planted at 25 ft x 25 ft spacing.

Treatments. Bactericide treatments were replicated four times in a randomized complete block design. Treatment plots consisted of single trees 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 treatment applications.

The first spray was applied at early (< 5%) shuck-split. Subsequent sprays followed the rule shown below, beginning at 3-days after the first spray.

> **<u>Spray Application Timing Rule</u>.** *If the forecasted amount of rainfall on the day before the rain event is >= 0.25", then a spray will be applied that day. The subsequent residual control period will begin on the day of the rainfall and extend two days afterward for a total of three days. Sprays will not be applied during this 3-day residual period. The next spray will be applied when the 0.25" rainfall requirement is once again achieved.*

Treatment application dates and phenological timing are shown in Table 1.

Insecticides were applied as needed using a commercial airblast sprayer. The fungicide Flint Extra at 3.8 fl oz/A was applied once at shuck-split to reduce peach scab development, thereby allowing easier assessment of bacterial spot later in the season. No other fungicides were applied.

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 and CX-6700. This pH correction was not necessary for FireLine or FungOut.

Assessment. Two types of fruit assessments were performed near the end of the epidemic on 21 July. First, a bacterial spot fruit disease assessment, which consisted of incidence (% infected fruit) and severity (# lesions per fruit) evaluations, was performed. Second, a marketable fruit evaluation was conducted. In this latter 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 5 footnotes. A total of 25 arbitrarily selected fruit were examined per plot for each assessment.

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 26 July. 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.

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. Overall, average temperatures for the months of April, May, June, and July were slightly above (0 – 2°F) the 30-year normal (Table 2). More importantly, total rainfall for the critical April, May, and June months was below the 30-year averages. Only 18 potential infection periods (rainfall periods ≥ 0.10 in) occurred during these three months in 2021, versus 23 periods in 2018 and 2019. The total number of rainfall periods ≥ 0.25 in, the threshold used by the application timing rule, was only seven during April and May, but increased to 11 in June and July.

Application Timing Forecasts. Following the initial spray at early shuck-split on 29 Apr, a total of 11 sprays were forecasted using the "Spray Application Timing Rule" (Table 3). Three of the forecasts (7 May, 9 June, and 22 July) were false positives. Rainfall events ≥ 0.25" were forecasted for the next day, thereby triggering a spray application, but less than this amount of rainfall actually occurred.

Only one false negative forecast occurred throughout the entire season (Table 3). An evening "surprise" thunderstorm on 26 May, which resulted in 0.84 in rainfall, was missed by the weather report. Although no spray was applied for this rain event, a spray was applied the very next day for some correctly forecasted rains.

Overall, the Spray Application Timing Rule tracked potential infection periods quite well. Also, the short 3-day residual period used by the rule did not appear to result in an abundance of closely timed applications. The average time between sprays was 8 days, which is nearly identical to the 7-day interval used for a calendar-based program. Of course, the 0.25" rainfall threshold may need to be lowered to avoid missing infections resulting from lesser rainfalls, but this could lead to too short a spray interval and an excessive number of applications.

Disease Incidence and Severity. Near the end of the epidemic on 21 July, 47% of non-treated fruit had at least one lesion present (Table 4). Although all of the treated fruit had *numerically* lower percentages of infected fruit than the control, all treatments except one did not have *significantly* lower levels of disease incidence than the non-treated control. For this group of treatments, disease control levels were 6% for FungOut, 17% for CX-6700, 32% for Kocide/FireLine, and 34% for both Kocide and Kocide/FungOut. Only FireLine applied alone was observed to significantly reduce disease incidence, providing 60% control.

In contrast to disease incidence, all of the treatments, except for one, had significantly lower levels of disease severity than the non-treated control. Reductions in lesion density were 57% for CX-6700, 65% for Kocide/FungOut, 72% for Kocide, 87% for Kocide/FireLine, and 97% for FireLine. Only FungOut alone failed to significantly reduce disease severity, providing only a 9% decrease in lesion density. No differences in severity were observed among those treatments that were effective.

Marketable Fruit. All treatments, except for one, significantly increased the percentage of total saleable fruit, which consists of fruit in grades 1+2 (Table 5). The percent of total saleable fruit ranged from 91% for CX-6700 to 98% for FireLine. Only FungOut, when applied alone, failed to significantly increase total saleable fruit to a level greater than the control.

All treatment programs significantly increased the percentage of grade 1 fruit, which ranged from 77% for FungOut to 95% for FireLine (Table 5). Most treatments were not significantly different from each other in their level of grade 1 fruit. The only difference was FungOut versus FireLine; the latter provided 18% more grade 1 fruit.

Unlike grade 1 fruit, there is no desire to maximize grade 2 fruit levels. Nevertheless, this category is better than cull since it does contribute to total sales.

Foliar Infection. None of the treatments had significantly lower percentages of infected leaves than the non-treated control (Table 7). The only significant difference observed was between Kocide/FireLine and Kocide/FungOut. The latter treatment had 17.2% fewer infected leaves than the former.

Only two treatments, FireLine alone and Kocide alternating with FireLine, were found to significantly reduce defoliation (Table 7). Relative to the control, FireLine reduced leaf abscission by 73% while Kocide/FireLine reduced abscission by 40%.

SUMMARY & CONCLUSIONS

Maximizing the percentage of grade 1 fruit is a major goal of most disease control programs since these fruit have the highest economic value. All of the treatments in this study accomplished this objective, as indicated by the market grade 1 results. The significant reductions in disease severity further support the findings in marketable fruit. Lower lesion densities translate into smaller total lesion areas, a parameter for the grading process.

Based on results for marketable fruit (grade 1) and fruit disease severity, the CX-6700 and Kocide/FungOut biorationial treatments were as effective as the three standards. No significant differences were observed among these treatments for these two dependent variables. Defoliation was significantly greater for the biorational materials versus FireLine or Kocide/FireLine, but the amount observed, approximately 30%, is tolerable for orchards having moderate or greater vigor.

Although FungOut significantly increased the percentage of grade 1 fruit over the non-sprayed control, its total saleable fruit (grades 1+2) was not significantly higher than the control. Furthermore, FungOut was not as effective as the FireLine standard for grade 1 fruit. Thus, FungOut may be best deployed in alternation with other bactericides, such as Kocide 3000 used in this study.

Additional data are needed from another season to confirm the findings observed for the biorational treatments.

Table 1. Weather, spray timings, and assessments for the 2021 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	45.3	0.07		1-May	54.0	0		1-Jun	64.3	0	
2-Apr	34.9	0		2-May	68.8	0		2-Jun	67.4	0	**4th Cover**
3-Apr	38.8	0		3-May	66.4	0.1	**1st Cover**	3-Jun	70.3	0.28	
4-Apr	53.0	0		4-May	72.2	0.01		4-Jun	73.1	0	
5-Apr	56.1	0		5-May	65.9	0.27		5-Jun	77.8	0	
6-Apr	58.6	0		6-May	56.4	0		6-Jun	79.3	0	
7-Apr	57.3	0		7-May	54.9	0	**2nd Cover**	7-Jun	80.7	0	
8-Apr	54.2	0		8-May	50.4	0.02		8-Jun	78.7	0	
9-Apr	50.9	0.07		9-May	50.8	0		9-Jun	75.9	0.01	**5th Cover**
10-Apr	59.6	0.13		10-May	55.8	0		10-Jun	74.9	0	
11-Apr	60.7	0.53		11-May	56.2	0		11-Jun	64.8	0.11	
12-Apr	47.5	0.1		12-May	55.1	0		12-Jun	67.9	0	
13-Apr	51.1	0		13-May	57.4	0		13-Jun	68.9	0	
14-Apr	53.6	0.05		14-May	59.6	0		14-Jun	72.8	0.72	**6th Cover**
15-Apr	55.2	0		15-May	58.9	0.04		15-Jun	71.0	0.58	
16-Apr	48.5	0		16-May	58.3	0		16-Jun	68.9	0	
17-Apr	50.5	0		17-May	60.6	0		17-Jun	66.1	0	
18-Apr	52.5	0		18-May	63.9	0		18-Jun	70.6	0	
19-Apr	51.9	0		19-May	70.7	0		19-Jun	76.4	0.11	
20-Apr	58.3	0		20-May	66.6	0		20-Jun	77.0	0.01	
21-Apr	54.7	0.15		21-May	64.6	0		21-Jun	77.7	0.21	
22-Apr	41.3	0		22-May	75.4	0		22-Jun	68.1	0.88	**7th Cover**
23-Apr	49.0	0		23-May	80.8	0		23-Jun	63.9	0	
24-Apr	54.3	0.02		24-May	64.6	0		24-Jun	65.2	0	
25-Apr	54.3	0.55		25-May	64.0	0		25-Jun	66.8	0	
26-Apr	51.0	0		26-May	75.2	0.84		26-Jun	75.9	0	
27-Apr	60.5	0		27-May	72.7	0.01	**3rd Cover**	27-Jun	79.6	0	
28-Apr	72.2	0		28-May	61.2	0.53		28-Jun	81.4	0	
29-Apr	71.3	0	**Shuck Split**	29-May	49.6	1.07		29-Jun	83.0	0	
30-Apr	63.2	0		30-May	49.0	0.33		30-Jun	84.8	0	
				31-May	58.9	0					

Table 1 – continued –

Date	Temp	Rain	Spray	Date	Temp	Rain	Spray	Date	Temp	Rain	Spray
1-Jul	77.2	3.05	**8th Cover**	12-Jul	81.1	0.73		22-Jul	70.7	0	**11th Cover**
2-Jul	70.8	0.71		13-Jul	81.8	0.01		23-Jul	71.2	0	
3-Jul	66.6	0.44		14-Jul	82.4	0		24-Jul	73.7	0	
4-Jul	70.3	0		15-Jul	80.6	0		25-Jul	77.1	0.11	
5-Jul	75.8	0		16-Jul	82.9	0	**10th Cover**	26-Jul	78.8	0.03	**Foliar Assess**
6-Jul	81.4	0		17-Jul	82.6	0.49		27-Jul	78.4	0	
7-Jul	83.4	0		18-Jul	74.8	0.05		28-Jul	75.1	0	
8-Jul	79.7	0.57	**9th Cover**	19-Jul	75.9	0		29-Jul	74.0	0.26	
9-Jul	76.5	2.03		20-Jul	77.3	0		30-Jul	77.7	0	
10-Jul	75.0	0		21-Jul	75.8	0	**Fruit Assessment**	31-Jul	68.7	0	
11-Jul	76.6	0.02									

Table 2. Comparison of 2018-21 Monthly Temperature and Rainfall Data, Bridgeton NJ *				
Month & Year	**Average Temp (°F)**	**Total Rainfall (in)**	**# Rains ≥ 0.10 in**	**# Rains ≥ 0.25 in**
April 2021	54	1.67	5	2
April 2019	57	3.74	6	---
April 2018	50	3.77	6	---
April (30-year mean)	52	3.58	---	---
May 2021	62	3.22	6	5
May 2019	65	3.94	7	---
May 2018	67	6.12	11	---
May (30-year mean)	62	4.07	---	---
June 2021	73	2.91	7	4
June 2019	73	4.66	10	---
June 2018	72	2.88	6	---
June (30-year mean)	71	3.37	---	---
July 2021	77	8.50	9	7
July 2019	79	4.70	7	---
July 2018	77	4.76	5	---
July (30-year mean)	76	4.30	---	---

* No data in 2020 due to research stoppage as result of Covid-19 pandemic

Table 3. Application Timing Forecasts based on 0.25" Rainfall Threshold Rule [1]					
Application		**Rain Period Event [2]**		**False**	
Date	**Timing**	**Rainfall (in)**	**Ave Temp (°F)**	**Positive**	**Negative**
29 April	Shuck Split	0.00	71.3	Initial Spray	
3 May	1st Cover	0.38	68.2	---	---
7 May	2nd Cover	0.02	50.4	✓	---
26 May	---	0.84	75.2	---	✓
27 May	3rd Cover	1.94	58.1	---	---
2 June	4th Cover	0.28	70.3	---	---
9 June	5th Cover	0.12	70.4	✓	---
14 June	6th Cover	1.30	71.9	---	---
22 June	7th Cover	0.88	68.1	---	---
1 July	8th Cover	4.20	71.5	---	---
8 July	9th Cover	2.60	78.1	---	---
16 July	10th Cover	0.54	78.7	---	---
22 July	11th Cover	0.00	70.7	✓	---

[1] See Materials and Methods section for details on Forecasting Rule
[2] Rainfall & temperature data are sums & averages of actual levels recorded (not forecasted amounts)

Table 4. Bacterial Spot Incidence and Severity on Sunhigh Fruit (21 July)				
Treatment	**Rate / A**	**Application Timing**	**% Infected Fruit [1, 2]**	**# Lesions / Fruit [1, 2]**
		CONTROL		
Non-treated control	--------	------	47.0 a	13.4 a
		COPPER AND ANTIBIOTIC STANDARDS		
Kocide 3000 30DF [3]	1.7 oz	SS, 1C-11C	31.0 ab	3.8 b
FireLine 45WP	6.75 oz	SS, 1C-11C	19.0 b	0.4 b
Kocide 3000 30DF [3] FireLine 45WP	1.7 oz 6.75 oz	SS 2C 4C 6C 8C 10C 1C 3C 5C 7C 9C 11C	32.0 ab	1.7 b
		BIORATIONAL TREATMENTS		
CX – 6700 [3]	64 fl oz / 100 gal	SS, 1C-11C	39.0 ab	5.8 b
FungOut	1.4% v/v	SS, 1C-11C	44.0 a	12.2 a
Kocide 3000 30DF [3] FungOut	1.7 oz 1.4% v/v	SS 2C 4C 6C 8C 10C 1C 3C 5C 7C 9C 11C	31.0 ab	4.7 b

[1] Means calculated from 100 fruit (25 fruit/rep x 4 reps).

[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 5. Marketable Sunhigh Fruit (21 July)					
			% Fruit in Category [1, 2]		
Treatment	Rate/A	Application Timing	Market Grade 1	Market Grade 2	Grades 1 + 2
CONTROL					
Non-treated control	--------	------	59.0 c	18.0 a	77.0 b
COPPER AND ANTIBIOTIC STANDARDS					
Kocide 3000 30DF [3]	1.7 oz	SS, 1C-11C	88.0 ab	4.0 b	92.0 a
FireLine 45WP	6.75 oz	SS, 1C-11C	95.0 a	3.0 b	98.0 a
Kocide 3000 30DF [3] FireLine 45WP	1.7 oz 6.75 oz	SS 2C 4C 6C 8C 10C 1C 3C 5C 7C 9C 11C	88.0 ab	8.0 b	96.0 a
BIORATIONAL TREATMENTS					
CX – 6700 [3]	64 fl oz / 100 gal	SS, 1C-11C	83.0 ab	8.0 b	91.0 a
FungOut	1.4% v/v	SS, 1C-11C	77.0 b	11.0 ab	88.0 ab
Kocide 3000 30DF [3] FungOut	1.7 oz 1.4% v/v	SS 2C 4C 6C 8C 10C 1C 3C 5C 7C 9C 11C	84.0 ab	9.0 ab	93.0 a

[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” (not listed).

[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 6. Bacterial Spot Incidence and Defoliation on Sunhigh Foliage (26 July)					
Treatment	**Rate / A**	**Timing**	**% Infected Leaves [1, 2]**	**% Abscised Leaves [1, 2]**	**% Infected & Abscised Leaves [1, 2]**
		CONTROL			
Non-treated control	--------	------	80.6 ab	29.9 a	86.7 a
		COPPER AND ANTIBIOTIC STANDARDS			
Kocide 3000 30DF [3]	1.7 oz	SS, 1C-11C	73.8 ab	33.5 a	82.8 a
FireLine 45WP	6.75 oz	SS, 1C-11C	79.9 ab	8.2 c	81.7 a
Kocide 3000 30DF [3] FireLine 45WP	1.7 oz 6.75 oz	SS 2C 4C 6C 8C 10C 1C 3C 5C 7C 9C 11C	83.7 a	17.8 b	86.4 a
		BIORATIONAL TREATMENTS			
CX – 6700 [3]	64 fl oz / 100 gal	SS, 1C-11C	73.9 ab	27.0 a	80.6 a
FungOut	1.4% v/v	SS, 1C-11C	73.4 ab	31.2 a	81.2 a
Kocide 3000 30DF [3] FungOut	1.7 oz 1.4% v/v	SS 2C 4C 6C 8C 10C 1C 3C 5C 7C 9C 11C	66.5 b	34.3 a	78.2 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.

APPLE CHLOROTIC LEAF SPOT VIRUS ON cv. PRISTINE IN NEW ENGLAND

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Several growers in New England states have reported fruit quality issues with Pristine apples, similar to that caused by plant bugs and rosy apple aphids on fruit, consisting of multiple small to medium sized surface dents and deformities. However, the accompanying leaf chlorosis does not resemble either plant bug or aphid injury, and the injury occurs consistently on the same trees year after year without spreading to other nearby trees, either Pristine or other varieties. This suggested that a virus might be to blame, and analysis at Agdia Laboratories (Elkhart, IN) in August 2021 positively identified infection by Apple Chlorotic Leaf Spot Virus (ACLSV) as the culprit.

Pristine is a scab-resistant cultivar developed under the Purdue/Rutgers/University of Illinois breeding program. It is an early variety and is described as good eating quality, but it is very fragile to handle, and it is grown in small quantities by only a handful of growers in this region. It does have a niche for pick your own and direct retail markets, however, because it is a good-tasting apple that ripens very early.

Apple Chlorotic Leaf Spot Virus is a Trichovirus and is described as “a filamentous, flexuous particle virus, 680–780 nm long and 12 nm in width. It shows high molecular variability and a number of virus isolates differing in pathogenicity have been described. In apple trees, ACLSV frequently is detected in co-infection with Apple stem grooving virus and/or Apple stem pitting virus. ACLSV is mainly transmitted by grafting. No natural virus vectors are currently known (Yoshikawa, 2001) and ACLSV is not known to be seed or pollen transmitted. (From Barba et al., Control of Plant Virus Diseases)

Several recent surveys have identified a number of viruses, most of which appear to be latent, in apple trees in commercial orchards in the Northeast. This is a matter of increasing concern for growers and, presumably, for nursery growers as well. It appears in this case that some of the original Pristine stock may have been infected with the virus, and grafts from that infected stock have been propagated over the years. There does not appear to have been any transmission other than from grafting.

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TACKLING THE ROLE OF ENVIRONMENTAL AND HOST FACTORS IN *ERWINIA AMYLOVORA* SURVIVAL AND LONG-TERM PERSISTENCE IN FIRE BLIGHT CANKERS

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Fire blight, caused by *Erwinia amylovora*, affects around 180 species of the Rosaceae family, including economically important fruit crops like apple, pear and Asian pear, but also ornamental and wild plant species. The disease spreads systemically, and every host organ is susceptible to being infected by *E. amylovora*, especially flowers and actively growing shoots and fruitlets. The main fire blight symptoms are progressive necrosis affecting green tissues and secretion of ooze droplets linked to the disease transmission. During the middle and towards the end of the host's growing season, fire blight cankers develop on perennial tissues of branches, the trunk and/or the rootstock, which may lead to the death of branches and the entire tree. Fire blight cankers enable the pathogen to survive over the winter and serve as a source of infection for the disease renewal in the following growing season. However, there is barely any information on how the host resistance to fire blight affects *E. amylovora* populations in cankers, how these populations fluctuate over time, or how environmental conditions affect *E. amylovora* in cankers.

To study the effect of different environmental and host-related parameters in *E. amylovora* populations in cankers, we developed cankers in apple cultivars 'Cortland', 'Cameo' and 'Honeycrisp', pear cultivars 'Bartlett' and 'Bosc', and Asian pear cultivars 'Hosui', 'Shinko' and 'Yoinashi' by shoot inoculations. The pathogen live cell populations in these cankers were monitored over time using viability digital PCR (v-dPCR) we previously developed. The resulting data were used to assess the effect of irrigation, host species and/or cultivar, as well as the canker harvesting period, on *E. amylovora* populations in cankers. Experiments we conducted over two independent years - in 2016, characterized by an extreme drought affecting New York State, and in 2018, a year with the expected average rainfall amounts.

Our results revealed concurrent effects of the season in which cankers were collected (summer, fall, winter, spring), the year the experiment was performed in, the host cultivar/species and the irrigation treatments, on the probability to detect *E. amylovora* in cankers. The highest and lowest concentrations of the pathogen in cankers were detected in Summer and Winter, respectively, regardless of the assayed host species. In general, *E. amylovora* populations in apple were significantly lower than in pear and Asian pear, which coincided with less severe symptoms. The lack of irrigation and weather conditions dominated by drought led to more severe fire blight symptoms and a lower success of the pathogen in overwintering. The pathogen survival of winter conditions was also positively correlated to the host's resistance to fire blight (higher in apple and lower in pear and Asian pear). Our work reveals novel information on *E.*

amylovora survival that may be useful for designing new management options for fire blight and may be critical for improving the prediction of new fire blight outbreaks.