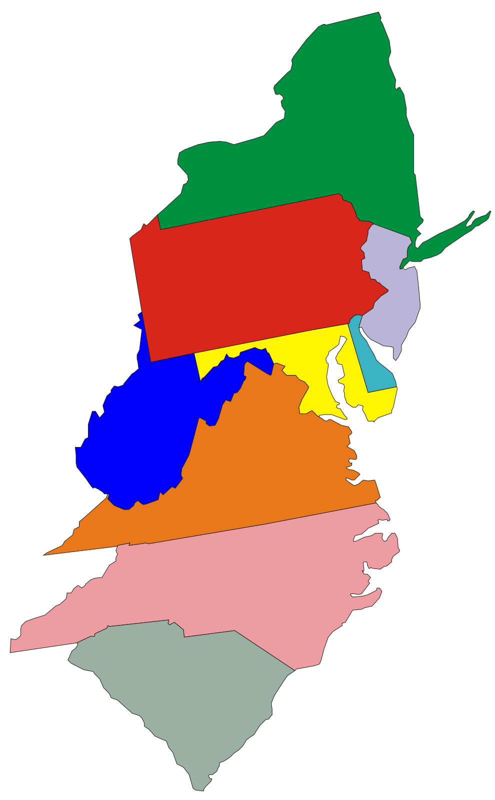
PROCEEDINGS

90th

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE



December 4 & 5, 2014

WINCHESTER, VIRGINIA

(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the

Cumberland-Shenandoah

Fruit Workers Conference

90th Annual Meeting

December 4th and 5th, 2014

Hampton Inn and Conference Center

Winchester, VA

Arthur Agnello, Peter Jentsch, and Sara Villani

New York State Agricultural Experiment Station

Cornell University

Geneva, NY

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Plant Pathology

Horticulture

2014 Cumberland Shenandoah Fruit Workers Conference Participants

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90th Annual Cumberland – Shenandoah Fruit Workers Conference
December 4–5, 2014
Hampton Inn and Conference Center, Winchester, VA

CONFERENCE AGENDA

Thursday, December 4

8:30 - 9:00 a.m.	**Registration** – Pre-registration Room
9:00 – 9:05 a.m.	**Call to order** – 90th Cumberland – Shenandoah Fruit Workers Conference Washington Room
9:05 - 10:00 a.m.	**Call of the States**
10:00 - 10:30 a.m.	**General Session** **Black Stem Borer – A New Pest in Apples** Deborah Breth, Cornell Coopertive Extension, Lake Ontario Fruit Team, Albion, NY
10:30 - 10:45 a.m.	Break
10:45 – 11:15 a.m.	**Non-Native Ambrosia Beetles as Indicators of Tree Health** Dr. Chris Ranger, USDA-Agricultural Research Service, Wooster, OH
11:15 – 11:45 a.m.	**Integrating Novel Strategies into Managing Ambrosia Beetles in Nurseries** Dr. Pete Schultz, Hampton Roads AREC, Virginia Beach, VA
11:45 – 12:00 Noon	**Discussion**
12:00 - 1:00 p.m.	Lunch – Washington Room
1:00 - 3:00 p.m.	**Concurrent Sessions** Entomology – Washington Room Plant Pathology – Jefferson Room Horticulture – Madison Room
3:00 - 3:15 p.m.	Break
3:15 - 5:00 p.m.	**Resume Concurrent Sessions**
5:30 - 7:30 p.m.	**Industry Sponsored Mixer**

Friday, December 5

8:00 - 9:00 a.m.	**Business Meeting** – Washington Room Meeting overview and financial report - Art Agnello, Tracy Leskey CSFWC Reorganization Committee Report - Jim Walgenbach
9:00 – 9:30	**Concurrent Sessions Continued** (Plant Pathology)
9:30	**Adjourn**

CONCURRENT SESSIONS AGENDA
Entomology – Washington Room

Thursday, December 4

1:00-1:15	**2014 experience with codling moth and oriental fruit moth monitoring and mating disruption** Greg Krawczyk, Travis Enyeart
1:15-1:30	**Codling moth mating disruption using aerosol emitters** Larry Gut, Peter McGhee
1:30-1:45	**Monitoring oriental fruit moth in mating disruption orchards** Jim Walgenbach, Steve Schoof
1:45-2:00	**The latest improvements in reliability and accuracy of an electronic pest monitoring system in apples** Brian Lehman, Greg Krawczyk, Johnny Park
2:00-2:15	**Choice experiments examining host preference of *Halyomorpha halys* (Hemiptera: Pentatomidae) nymphs** Angelita Acebes-Doria, Tracy C. Leskey, J. Christopher Bergh
2:15-2:30	**BMSB captures in traps and injury to apples: Effects of orchard border habitat** Chris Bergh, Tracy Leskey
2:30-2:45	**Development of an attract-and-kill strategy for the brown marmorated stink bug** Rob Morrison, Tracy Leskey
2:45-3:00	**Interspecific competition between *Drosophila suzukii* and *Zaprionus indianus* larvae in rearing medium and grapes** Meredith Shrader, Douglas Pfeiffer
3:00-3:15	Break
3:15-3:30	**Monitoring for parasitoids of Spotted-Wing Drosophila (*Drosophila suzukii*) in Virginia fruit crops** James C. E. Wahls, Douglas G. Pfeiffer
3:30-3:45	**Developing an attract-and-kill management strategy for spotted wing drosophila** Tracy Leskey and The Leskey Lab
3:45-4:00	**Employing trap and kill in organic raspberry production of the Spotted Wing Drosophila, *Drosophila suzukii*** Peter Jentsch, Tim Lamposona
4:00-4:15	**A fixed-spray system for spotted wing Drosophila management in high tunnel raspberries** Art Agnello, Andrew Landers, Greg Loeb
4:15-4:30	**Update on the Cornell Apple Insecticide Selection Tool** Jay Harper, Art Agnello, Harvey Reissig
4:30-4:45	**Apple insect control for homeowners and organic growers: Re-examining fruit bags** Daniel Frank

Plant Pathology – Jefferson Room

Thursday, December 4

1:00-1:15	**An update on grapevine viruses in Virginia and vector management strategies** Taylor J. Jones, Mizuho Nita
1:15-1:30	**Occurrence and distribution of grape-pathogenic Botryosphaeriaceae fungi in grapevine nursery stocks** Gregory Klinger, Mizuho Nita
1:30-1:45	**Characterizing the timing of infection of ripe rot of grape, caused by *Colletotrichum acutatum* and *C. gloeosporioides*** Charlotte Oliver, Mizuho Nita
1:45-2:00	**Fungicide performance trials for powdery midlew and downy mildew, Winchester, VA 2014** Mizuho Nita
2:00-2:15	**Aprovia - A new fungicide for control of key apple diseases** Erin Hitchner, Allison Tally
2:15-2:30	**Fungicide resistance on tree- and small fruit crops in Japan** Hideo Ishii
2:30-2:45	**An *in-vivo* bioassay for estimating fungicide residues on peach fruit** N. Lalancette, J. Gager, K. McFarland
2:45-3:00	**Contribution of mid-season cover sprays to management of peach brown rot at harvest** N. Lalancette, J. Gager, K. McFarland
3:00-3:15	Break
3:15-3:30	**Phytotoxicity to apples following the application of captan, single-site fungicide, and adjuvant tank mixtures** Sara Villani, Kerik Cox, Deborah Breth
3:30-3:45	**A quick fungicide efficacy screening for ripe rot pathogens, *Colletotrichum acutatum* and *C. gloeosporioides*, using Alamar blue dye** Charlotte Oliver, Mizuho Nita
3:45-4:00	**What I learned at the 10th International IOBC/WPRS Workshop on Pome Fruit Diseases in Stellenbosch, South Africa** Kari Peter
4:00-4:15	**Introducing the University of Maryland Grape and Small Fruit Pathology Program, serving Maryland and Southern Pennsylvania** Cassandra Swett
4:15-4:30	**Recognize these symptoms? Blueberry Mosaic Virus, a long established but newly described putative fungal-vectored virus on highbush blueberries** Cassandra Swett, Dimitre Mollov
4:30-4:45	**Fungicide performance trials for Botrytis and other late season rots, Winchester, VA 2014** Mizuho Nita

Plant Pathology – Jefferson Room (continued)

4:45-5:00 **Evaluation of bactericide programs for the management of fire blight on 'Gala' apples and bacterial spot on peach in Pennsylvania, 2014**
Kari Peter and Brian Lehman

Friday, December 5

9:00-9:15 **Highlights of Apple Fungicide Testing, 2014**
K. S. Yoder
9:15-9:30 **Fire Blight Management Tests in 2014**
K. S. Yoder

Horticulture – Madison Room

Thursday, December 4

1:00-1:15 **Developing research and extension programs for hard cider producers**
Greg Peck
1:15-1:30 **Field performance of Asian pear cultivars in the hot, humid conditions of the Mid-Atlantic region**
Chris Walsh, Julia Harshman, Anna Wallis Amy Barton Williams, Mike Newell, G.R. Welsh
1:30-1:45 **Performance of northern highbush, southern highbush, and rabbiteye blueberry varieties in the Southern Maryland region**
Ben Beale
1:45-2:00 **Yield results from the first two fruiting years of blueberry variety trials established in southern Delaware**
Emmalea Ernest, Gordon Johnson, Hail Bennet
2:00-2:15 **Evaluating the pollen tube growth characteristics of different crabapple cultivars**
Candace DeLong, Keith Yoder, Leon Combs, Greg Peck
2:15-2:30 **Two season fruiting of primocane blackberries, Vinifera grape winter injury**
Gordon C. Johnson
2:30-2:45 **Productivity of 'Triple Crown' blackberry on the rotating cross-arm trellis system**
Ann K. Rose, Fumiomi Takeda
2:45-3:00 **Field-testing advanced selections from the Geneva apple rootstock breeding program**
Anna Wallis, Bryan Butler, Doug Price, Chris Walsh, Julia Harshman, Gennaro Fazio

3:00-3:15 Break

3:15-3:30 **Creating models of dormant trees using computer vision**
Amy Tabb

Business and Financial

90th Annual Cumberland-Shenandoah Fruit Workers Conference

Program Highlights and Business Meeting Minutes, December 5, 2014
Host State – New York/Cornell NYSAES, Geneva

Cornell University (New York State Agricultural Experiment Station – Geneva) hosted the 90th Annual Cumberland-Shenandoah Fruit Workers Conference at the Hampton Inn and Conference Center in Winchester, Virginia on December 4-5, 2014. There were 99 registered participants and 40 papers presented. Registration was $67 and was intended to cover the cost of the meeting rooms, Thursday lunch, breaks, website service and credit card fees associated with an online registration process instituted for this meeting. Art Agnello served as general chair and secretary, assisted by Peter Jentsch and Sara Villani, while Tracy Leskey continued her role as treasurer. Art Agnello served as moderator for the Entomology sessions, Sara Villani moderated the Plant Pathology session; and Greg Peck (VA Tech) served as moderator for the Horticulture Session. Peter Jentsch provided technical support.

The meeting began at 9:00AM on Thursday with a "Call of the States" that included a brief report on the crop, weather, and pest conditions for each state during the 2014 season. This was followed by the General Session, which focused on the recently noted and increasingly challenging problem of infestations of ambrosia beetles in several apple growing regions. The first presentation, "Black stem borer – A new pest in apples", was given by Deborah Breth, who initially detected and helped identify the pest problem in 2013, and described her trapping and monitoring trials this year in western NY. The next presentation was "Non-native ambrosia beetles as indicators of tree health", given by Chris Ranger, USDA-ARS, Wooster, OH, describing his studies on the behavior of this group of beetles and the relationship between their infestations and tree physiology. Finally, Pete Schultz, Hampton Roads AREC, Va Tech, gave a presentation on "Integrating novel strategies into managing ambrosia beetles in nurseries", which described his work on current approaches to control this pest complex in the ornamentals nursery sector. After lunch, concurrent sessions in Entomology, Plant Pathology and Horticulture started, and continued through Friday morning. A Social Mixer was held on Thursday evening, which was sponsored by Arysta, Bayer, CBC, Dow, Gowan, Nichino, Suterra, Syngenta, UPI, and Valent.

The business meeting was called to order by Art Agnello on Friday at 8:00AM. There was a brief overview of the meeting attendance and participation details, followed by a comment and discussion session featuring some considerations that next year's organizers might take into account to improve certain aspects of the meeting, including the apparent trend of fewer submitted talks, as was seen this year. One suggested change was the possibility of incorporating an Industry Update into the General Session, with constraints in place on either the number of slides or amount of time permintted per presenter. Another suggestion was to adopt a format change allowing presentations of 20 minutes in duration rather than the current 15, although it was recognized that session moderators can already exercise some discretion in determining the length of time a presenter can speak. There was a comment expressing the value of requesting that someone present an executive summary of the BMSB Working Group meeting for the benefit of those who do not normally attend them, as these have been held immediately before the CSFW Conference. Finally, a suggestion was made that representatives of the states contributing to The Mid-Atlantic Regional Fruit Loop might take advantage of this meeting by getting together either before or after the CSFWC to discuss Pest Management Guidelines updates.

Next was the organization's Financial Report, which was presented by Tracy Leskey. With the current balance and 99 paid attendees, along with generous contributions from chemical suppliers, the organization is in good standing and will be able to meet all the anticipated bills for 20014. Registration payment from one attendee had not been received at the time (but was forthcoming within the following week).

Jim Walgenbach next presided over a report from the CSFWC Reorganization Committee, which featured proposals for a more efficient structure for managing the organizational and hosting responsibilities of administering this meeting on an annual basis, in consideration of the diminishing and unequal numbers of state-based researchers available to take on the various tasks using the current rotation system. From discussion on reorganization of the administration of the CSFWC, the following was agreed:

1. There was agreement that a more structured organization would benefit the conference.
2. A Transition Committee was established that would serve as a temporary executive committee to do the following during the next year:
    a. Determine the organizational structure (i.e., executive director, officers, executive committee membership, etc.) of the conference, including an Executive Director position with defined responsibilities.
    b. Determine legal requirements to create a paid executive director position (may need to create at 501C and have Articles of Incorporation and Bylaws).
    c. Set the agenda for the 2015 CSFWC in cooperation with Virginia Tech – next year's host.
3. The following people volunteered to serve on the Transition Committee
    a. Jim Walgenbach, NC State University
    b. b. Tracy Leskey, USDA-ARS
    c. Kathleen Leahy, Polaris Orchard Management
    d. Doug Pfeiffer, Virginia Tech
    e. Dan Donahue, Cornell University
    f. Paul Umlor, Wilbur-Ellis Company, MI

The 2015 CSFWC will be held on December 3–4, again at the Hampton Inn. Virginia will host the meeting.

Respectfully submitted,

Art Agnello
General Chair & Secretary

Tracy Leskey
Treasurer

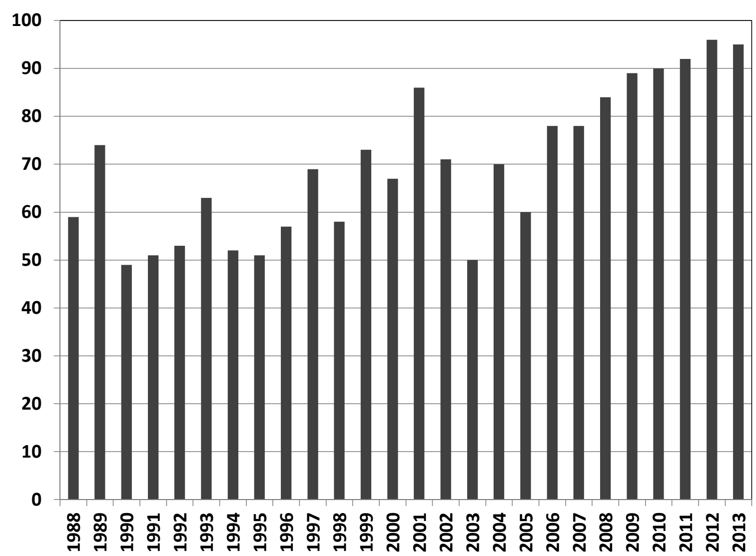
Committee on Reorganization of Administration of the Cumberland-Shenandoah Fruit Workers Conference

Committee Members: Bryan Butler, David Combs, Greg Peck, Tracy Leskey, Brian Olson, Jim Walgenbach (chair).

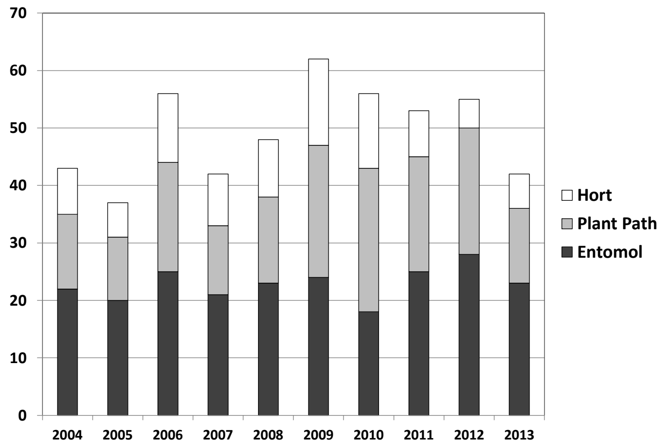
Committee Charge: To propose a new organizational structure for administration of the Cumberland-Shenandoah Fruit Workers Conference.

Background: The Cumberland-Shenandoah Fruit Workers Conference (CSFWC) has been meeting annually in the mid-Atlantic region since 1925. This multidiscipline conference is devoted to discussing recent trends and research activities on fruits in the eastern US. While both small and tree fruits are included, the majority of the conference has been devoted to apples, peaches and, to a lesser extent, grapes. The conference is traditionally held on the Thursday and Friday before Thanksgiving. In the event that a scientific society meeting conflicts with traditional dates, the CSFWC is usually moved to the Thursday and Friday after Thanksgiving.

Attendance at the CSFWC is available from the Proceedings and is illustrated below for the past 25 years (2013 is estimated by JFW). Prior to 1996, the conference was open only to university and government-affiliated research, teaching and extension personnel. In response to concerns about declining attendance in the early 1990s, two surveys were conducted to assess the membership's opinion of 1) opening the meeting to industry personnel and consultants and 2) the program structure. At the 1992 Business Meeting, membership voted to continue to limit attendance to university and government affiliated individuals, and to maintain the same program schedule. In 1996 the invitation list was expanded to include the crop production/protection industry, but only one representative per company was allowed. In 2009, the invitation list was expanded to include "any interested agriculture professional involved with fruit regardless of their affiliation or role in the industry." Since this decision, attendance has consistently been in the high 80's to low 90's.



The CSFWC is a multidiscipline meeting that includes participation by the sciences of horticulture, entomology and plant pathology. The program consists of a three-hour general session on the first morning of the meeting, which includes a brief update from each state (Call of the States) followed by several presentations that are usually of interest across disciplines. The remainder of the meeting consists of concurrent sessions for each discipline. The adjacent figure shows the number of presentations by each discipline over the last 10 years, and serves as an estimate of participation by the various disciplines. The average numbers of presentations in the entomology, plant pathology and horticulture sessions during this time are 22.9, 17.3 and 9.2, respectively.



Finances: Income and expenses for the 2013 CSFWC is shown below (provided by T. Leskey). The two sources of income are registration fees and industry donations. Registration fees are $60 for pre-registration (submitting payment several weeks before the meeting) and $75 at the meeting. Industry donations are used to support a mixer, which was first held in 2007. Note that industry support for the mixer declined from $2950 in 2010 to $1,350 in 2013. With a net profit of $834.08, the CSFWC bank balance is approximately $11,940. An additional occasional expense that did not occur in 2013 is support for a guest speaker. In 2012, average income (including industry support) and expense (including guest speaker) per attendee was $80.26 and $78.98, respectively.

Category	Item	Amount($)
Income	Registration	6,250.00
	Industry support for mixer	1,350.00
	Total Income	**7,600.00**
Expenses	Rooms (1250) + tax/surcharge (128.75)	1,378.75
	Luncheon (1025) + tax/surcharge (406.41)	1,431.41
	Breaks (210) + tax/surcharge (65.86)	275.86
	Mixer – food (2336.30) + tax/surcharge (785.31)	3,121.61
	Mixer – alcohol (425) + tax/surcharge (133.29)	558.29
	Total Expenses	**6,765.92**
2010 Balance		**834.08**
Overall Balance (estimated)		**11,940.00**

Current Organizational Structure: Administrative responsibilities for the CSFWC rotates on an annual basis among Land Grant Universities in the mid-Atlantic region and the USDA-ARS Laboratory in Kearneysville, WV. The treasurer, a voluntary position, is the only permanent officer. Tracy Leskey of the USDA-ARS is the current treasurer. The schedule for institutions organizing upcoming meetings is listed below:

2014 New York (Cornell University)
2015 Virginia (Virginia Tech)
2016 North Carolina (NC State University)
2017 Pennsylvania (Penn State)
2018 New Jersey (Rutgers) / SC (Clemson)
2019 USDA / WV / MD (USDA-ARS, WV University, University of Maryland)

A volunteer from the organizing institution serves as General Chair of the conference and is responsible for all activities associated with planning the conference. The degree to which these responsibilities are shared varies widely among institutions, depending on the number of participants from the organizing institution. In Appendix A is a list of General Chair responsibilities that was created by J. Walgenbach following the 2010 meeting hosted by NC.

Limitations to Current Organizational Structure:

The current administrative structure of the CSFWC poses several limitations to maintaining continuity and future growth of the conference.

- There is great diversity in the level of participation by various organizing institutions that can lead to an overwhelming workload for a General Chair from a low-participatory institution.
- The trend in recent years, and which is anticipated to continue in the future, is for Land Grant institutions to employ fewer applied scientists with specific commodity (including fruit) responsibilities. This will have multiple effects, including reduced meeting attendance, fewer scientific presentations, and increased workload for organizing institutions.
- Expansion of the invitation list in 2009 has led to higher and more consistent attendance compared with any other time in the last 25 years. This has largely been the result of greater participation by industry representatives. To remain a viable conference that is relevant to its whole membership, conference leadership should be expanded to include industry representatives.

The absence of continuity in leadership with the current organizational structure has impeded implementation of more efficient operational procedures, such as on-line registration, ability to pay registration fees with credit cards, and a dedicated, user-friendly website that would allow for access to proceeding articles by the general public.

Model for New Organizational Structure:

The Orchard Pest and Disease Management Conference (OPDMC), held annually in Portland, OR, is similar to the CSFWC in terms of meeting objectives, diversity of participants, and content. Compared to CSFWC, the OPDMC has a slightly higher attendance (120-150), longer history of participation by industry, greater focus on entomology, and a more formalized organizational structure, which includes:

- Articles of Incorporation and Bylaws
- Executive Director (paid)
- Treasurer
- Secretary
- President
- Executive Committee
- Audit Committee
- Nominations Committee
- Resolutions Committee
- Meeting registration and payment (including credit cards) via Acteva website.

The OPDMC structure serves as a good starting point for discussion of a new organizational structure of the CSFWC. CSFWC currently has a balance of approximately $11,000, with the conference making several hundred dollars each year. Hence, funds are currently available to pay an executive director if such a position if deemed desirable.

APPENDIX A
Check List for Cumberland-Shenandoah Fruit Workers Conference Chair Person
(Prepared by J. Walgenbach following 2010 Meeting)

Time	Task
December	Sign contract with hotel that details dates of conference, price of room rentals, and reserves block of rooms for attendees. Jennifer Seo is the contact at the Hampton Inn.
Early September	Contact Doug Pfeiffer and become an administrator for the CSFWC website at Virginia Tech's Scholar website. This will be used to update email list and send out notices.*
	Line up the general session program theme and guest speakers.
Mid September	Send out 1st notice of meeting, including instructions on how and when to make hotel room reservation, register for meeting (form for 2010 meeting attached), and request presentation.**
Early October	Contact sponsors for mixer. List of sponsors and amount donated is attached. Also attached is a power point file of sponsor logos that are setup at the meeting luncheon and mixer acknowledging sponsors. Chris Bergh has plastic holders (four 8 x12 and four 5 x 7 frames) for displaying logos.***
Mid October	Send out 2nd notice of meeting.
Late October	Contact Jennifer Seo (Hampton Inn) to finalize plans for meeting, including selecting menu for lunch and mixer (contract for lunch and mixer attached – they sub this out to a caterer).
Early November	After registration deadline, contact Jennifer Seo with a final number for lunch and the mixer.****
	Once all presentation requests are submitted, set the program and send out to all members on the mailing list.
At the Meeting	Have list of pre-registrants and give each a receipt at the registration desk. Also have separate receipts for on-site registrants. Don't forget name tags and sharpies, and a sheet for those not on the mailing list to get emails for updating the master mailing list.

*The mailing list should be updated after the meeting to include new attendees at the current year's meeting.

**Preregistration is $60, and late registration (on-site) is $75. All checks should be made out to "CSFWC." Hold all checks until the meeting and then give to Tracy Leskey (CSFWC treasurer).

***Each plastic holder requires 2 PPT slides. Hence, you'll need 8 copies each of the 8 x 10 and 5 x 7 printouts to fill out the plastic holders. I laminated the pictures, which made them fit the holders more snug.

****In addition to those that registered in advance, there were 6 on-site registrations (i.e., did not pre-register), so you may want to increase the number by 4 or 5 people.

Treasurer's Report

Cumberland-Shenandoah Fruit Workers Conference
2013-2014
Financial Report

Income 2013-2014

Receipts From 2013 Registrations (94)	6250.00
Support For Mixer	1350.00
Interest (2013)	4.06
Total Income	**7604.06**

Expenses 2013***

Hampton Inn – room rental, luncheon, breaks, mixer	6765.92
Additional Meeting Expenses (guest speaker travel, etc.)	*NONE*
Total Expenses	**6765.92**

******$2,500 deposit for 2014 meeting***

Total Account Balance -- November 20, 2014 $9,928.29 (-$4460.40)

Cumberland-Shenandoah Fruit Workers Conference
2013 Meeting Cost Breakdown
Total Meeting Costs = $6765.92

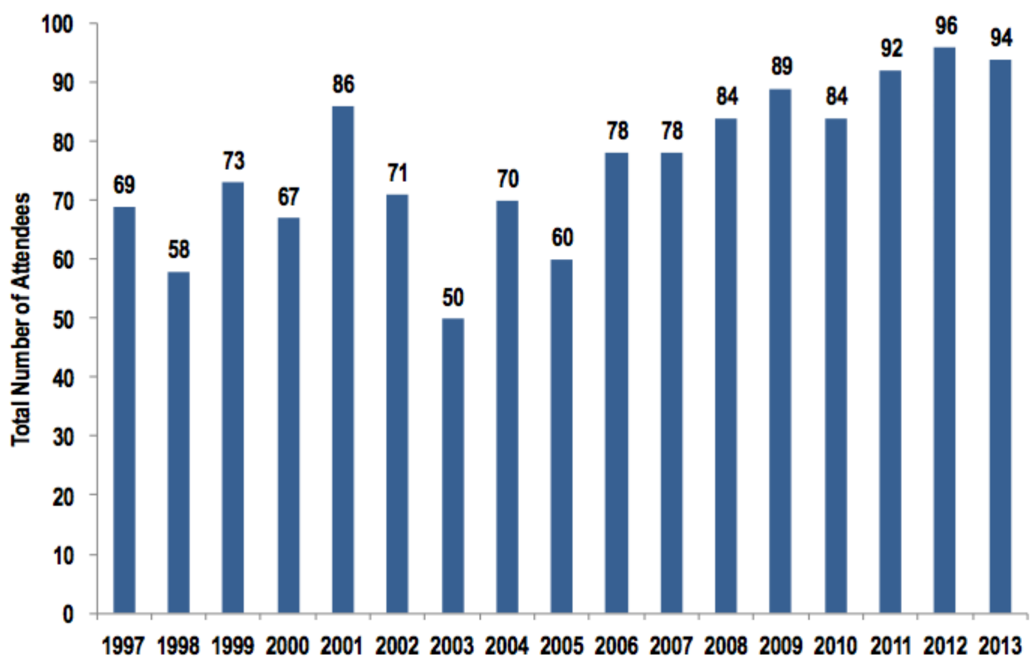
Facility	**$1378.75 ($14.67 per attendee)**
All Food + Non-Adult Beverages	**$4,828.88 ($51.37 per attendee)**
Adult Beverages	**$558.29 ($5.94 per attendee)**

Total Cost Per Attendee = $71.98 ($71.97 last year)
Income Per Attendee = $80.89 ($80.26 last year)

CSFWC Total Costs Per Meeting

Year	Total	Cost Per Attendee
1997	1671.15	23.43
1998	1624.40	28.00
1999	1916.78	26.25
2000	2134.64	31.86
2001	2453.93	28.53
2002	2055.61	28.95
2003	1876.73	36.80
2004	2297.78	32.83
2005	2356.91	39.28
2006	3636.68	46.62
2007	5063.82	64.92
2008	6093.40	72.54
2009	6052.39	67.25
2010	6573.02	78.25
2011	6769.27	73.57
2012	7581.78	71.97
2013	6765.92	71.98

Cumberland-Shenandoah Fruit Workers Conference *Attendance*



Cumberland-Shenandoah Fruit Workers Conference
Future Host States

- •2015 Virginia
- •2016 North Carolina
- •2017 Pennsylvania
- •2018 New Jersey / SC
- •2019 WV / MD / USDA-ARS
- •2020 New York

Call of the States

CALL OF THE STATES – MARYLAND

Chris Walsh
University of Maryland, College Park

The 2014 growing season began with a long, cold, test winter. Winter temperatures affected cold-tender crops throughout the state. Mike Newell reported that annual-culture strawberry yields at Queenstown were lower than expected despite floating row covers. On January 4, the air temperature dropped to 0°F at Wye REC. This same temperature was recorded under the 1.2 oz floating row cover as wind speeds were more than 20 mph. Examination of cut Chandler strawberry crowns five days afterwards revealed damage in 93% of the crowns. Fruit yields measured in Chandler were 19% lower (0.96 lb/plant) than the long-term average of 1.2 lb/plant at Wye.

On March 4th, the early-morning low temperature at National Airport was 14°F while at Dulles Airport it was -1°F. The unusually cold weather in January plus the second cold wave in March also affected peach trees, grapevines and fig trees. While most peach trees produced a good crop, many grape varieties were affected. Dr. Joe Fiola reported that vines in low, wet spots experienced much more damage than those planted in the same vineyard on higher ground. Vine damage appeared to decrease linearly moving up the slope. Across the state, there was variety-specific damage, with reds showing more vine damage and crop loss than whites. Joe reported that Malbec, Merlot and Syrah fared the worst, Pinot Noir, Sauvignon Blanc and Chardonnay were intermediate, while Cabernet Sauvignon, Cabernet Franc, Chambourcin and other French hybrids showed little winter injury.

Dr. Cassandra Swett noted that the winter injury continued to affect grapevines through the fall, especially susceptible varieties such as Merlot. In some vineyards the winter injury appears to be leading to crown gall. More damage will likely be seen in 2015, even in the absence of another harsh winter.

In the Chesapeake Bay Area, many growers and homeowners reported damage to mature fig trees. Many of these established trees were severely damaged to the soil line. On some, new shoots emerged later in the season from the trunks or from the crown region.

Cold winter temperatures were followed by a cool, wet spring. This delayed planting and diminished pollination and fertilization in stone fruits. There was a very light cherry crop. Peach set was not very good, however growers reported that the lack of fruit-to-fruit competition coupled with favorable summer rainfall led to a surprisingly good peach size and yield.

During the summer, Dr. Swett also found that Blueberry mosaic-associated virus, a newly described disease on blueberry, was present in Maryland. This disease was previously described as an unknown mosaic disorder. Identification of the virus has facilitated several new research projects in the region.

While winter and spring were problematic, this was a near-perfect summer for most fruit growers. Consistent rainfall coupled with low humidity and cooler-than-average summer temperatures and very attractive fruit. Dr. Joe Fiola reported that grapes ripened over a longer period than usual. While early cultivars appeared to ripen just a bit later than normal, many mid- and late-season cultivars were delayed by 2 to 4 weeks. Acid levels were above average, but the juice acidity appeared manageable for winemakers.

Dr. Chris Walsh noted some similar effects on apples. While Gala ripened as expected at the end of August, the ripening of later cultivars was delayed. Fruit had good size, excellent red color development and above-average sugar levels. In early-November, SSC levels of 18°Brix were measured in Cripps Pink fruit from a tall-spindle planting at Keedysville. This was the highest level of soluble solids ever measured in apple fruit grown at that site.

In this same tall-spindle planting, Bryan Butler noted additional tree losses of Cripps Pink budded onto G.41 and G.935 rootstocks following a summer storm. Tree losses began when a windstorm damaged recently-planted trees. Trunk breakage continued in 2014 even though these trees had fully filled their allotted trellis space and were in full production.

While most pome fruits produced quality crops in 2014, late-ripening Asian pears had postharvest problems. Olympic and Ya Li pears had unacceptable levels of internal flesh browning. Some breakdown was noted at harvest in early-October, but these browning symptoms became more pronounced during storage.

At the end of the season, Dr. Swett reported that Topsin M was no longer effective for grey mold (Botrytis) control in strawberries. Thiram is recommended as an addition to the fungicide rotation program. Hopefully the two Thiram products registered for use in MD will be renewed in 2015.

ADDITIONAL MARYLAND OBSERVATIONS

Bob Rouse
Agriculturalist LLC, Denton, MD
(Emeritus Faculty, Univ. MD)

Winter 2013-14 was very hard on vinifera variety wine grapes, with severe winter injury especially on poor sites. Many vines just died. The French Hybrids did much better and American varieties showed little if any winter injury. Good site locations made out much better than sites with cold pockets or lower field elevations. Five feet higher made a difference.

Plasticulture strawberries did well. The long cool spring led to a longer harvest season. The Great Lakes being froze over did have a plus for us. The major disease issue is botrytis fungicide resistance, which has led to changes in spray programs.

Peaches at good sites did well and required less thinning this past season.

The outlook for this coming winter may be a challenge, as snow cover in Siberia is greater than any season except 1967 and 1976. In 1967, we had a good amount of snow in our area. 1976-77 was the winter the Chesapeake Bay froze over and we had no snow cover and lots of winter injury on fall seeded small grain. It's colder this fall and is setting up to be a colder winter.

CALL OF THE STATES - NEW YORK

Art Agnello and Dave Kain
Cornell University, NYS Agricultural Experiment Station, Geneva, NY

Entomology

This year was another of those seasons that seemed to have a bipolar personality, as it demonstrated an inability to settle into a single trend for very long. We started out waiting an extended time for spring weather to actually arrive, as recurring cold temperatures following a 'respectable' NY winter created much uncertainty about when the season was really on track to start, and late freezes took their toll on many peach and other stone fruit plantings, as well as selected apple varieties. Some warm spells in late June and late July never seemed to take hold for long, and the precipitation pattern was a patchwork of severe downpours and soakers offset by dry, sun-baked stretches. On the plus side, the cooler night temperatures helped fruit color, and of course the abundant rain contributed to good size, so overall, we ended up with a good apple crop from this harvest.

Once again this year, insect pests were not too rampant, although a number of them needed some extra attention, as is common. The rainy early season help to keep down mite numbers until about midsummer, when some blocks ran into population blow-ups. For another year, San Jose scale infestations were a common concern, along with woolly apple aphid, both of which are notable for being old nemeses with impressive staying power; these ended up being particularly problematic late in the season as harvest progressed. Codling moth and oriental fruit moth continued to be important drivers of many insect management programs, particularly in Western NY, and apple maggot kept rolling along for weeks with some very high trap numbers into September. Contrary to our expectations, Brown marmorated stink bug had a delayed year in the Hudson Valley, and was nearly absent altogether in the rest of the state. Spotted wing drosophila continued as a more universal, and urgent, concern, still mostly for berry growers; our cherry and peach plantings benefitted from this species' late arrival this year. More worrisome was black stem borer, the ambrosia beetle that has been found as the cause of tree decline and death in numerous plantings around the state, and for which we have precious little information so far about appropriate control measures. Doubtless this will be the topic of much discussion during the winter months.

EASTERN NEW YORK OBSERVATIONS

Dave Rosenberger
Cornell University, Hudson Valley Research Lab, Highland, NY

Plant Pathology

In 2014, fire blight was more severe throughout the Hudson Valley than in any year over the past several decades. Extended warm humid weather during apple bloom generated at least three or four days of blossom blight infection periods (as determined with MaryBlyt), and most apple growers needed at least two perfectly timed streptomycin sprays to protect trees. Many growers applied three sprays. Streptomycin worked very well in orchards where it was applied, but too many growers sprayed only those trees that they considered susceptible based on cultivar and tree age and left older trees of less susceptible cultivars unsprayed. Because of the long duration of the blight infection periods, inoculum was apparently transferred to old trees that had been left unprotected (perhaps prior to the first strep spray), and therefore blight showed up in unprotected blocks that had been considered at low risk for infection even though younger blocks that had been sprayed with strep had very little blight. In some cases, the older trees then provided inoculum that spread back into younger trees during summer.

The events this year suggest that we should perhaps modify our extension recommendations by suggesting that growers spray susceptible blocks as soon as the epiphytic infection potential (EIP) as determined by MaryBlyt approaches 100 rather than waiting for an EIP of 100 <u>PLUS</u> predicted rainfall as is currently the practice in eastern New York. Delaying the first strep application for a day or two after EIP reaches 100 provides many hours during which pollinating insects can spread inoculum to additional trees. Apply streptomycin a bit sooner (as EIP approaches 100, even if no wetting is expected) should suppress bacterial populations and therefore eliminate extended periods when high bacterial populations are available for dissemination during bloom.

CALL OF THE STATES - NORTH CAROLINA

Jim Walgenbach
Mountain Horticultural Crops Research & Extension Center
Mills River, NC

Weather conditions in North Carolina during the 2014 growing season were relatively cool with normal rainfall. The peach crop, most of which is located in the Sand Hills region near Pinehurst along with scattered plantings throughout the piedmont and foothills, was short due to a spring freeze. The majority of the 4,000-acre peach crop is sold locally at roadside stands and farmers markets, and prices held up well throughout the season. In those orchards where peaches and apples are adjacent to one another and the peach crop was lost, several growers reported high oriental fruit moth pressure in apples. The peach crop was not sprayed due to the lack of a crop, and first generation OFM on peach shoots served as a source of infestations in apples. In those areas that did have a crop, insect and disease pressure was considered normal, except for a San Jose scale problem in the Sand Hills region. Severe SJS populations were likely due to several years of relying exclusively on pyrethroids for insect control.

The apple crop was about 75% of a full crop. With a good crop throughout the country, prices were low in 2014. Two insects were of note in 2014. Early season OFM populations were unusually high in non-mating disruption orchards and resulted in about 0.5 to 1% damage in early June in several orchards. As a result of these problems, many growers applied sprayable OFM pheromone to manage mid- and late-season populations. Damage levels were low at harvest. Brown marmorated stink bug populations continue to expand throughout apple production areas in the mountains and piedmont. Currently, populations are most intense and require chemical control in the Wilkes County area. Detections are common in the main production region in Henderson County, but only a couple of orchards have experienced damage at this time. Glomerella leaf spot continues to cause severe problems throughout NC and is the leading cause of crop loss on Gala, Golden Delicious, Pink Lady and similar cultivars. The disease was most intense beginning in early September, and resulted in considerable losses in fruit rots.

Personnel-wise, Steve McArtney, pomologist at NC State University with area-wide responsibilities in Georgia and Tennessee, resigned from his position after 10 years and joined Valent Biosciences. Nearly three years after Turner Sutton's retirement, the apple pathology position is scheduled to be filled in 2015 as an Assistant Extension Professor, stationed at the Mountain Horticultural Crops Research & Extension Center in Mills River. The position will be responsible for apples and ornamentals.

CALL OF THE STATES - PENNSYLVANIA

Krawczyk, G., R. M Crasweller*, and K. Peter.
The Pennsylvania State University
Fruit Research and Extension Center, Biglerville, PA
*Department of Horticulture, State College, PA

Horticulture

Weather was the big story for 2014. There were several periods of extremely cold temperatures in January and February across the state with all parts of the state having some day(s) with negative temperatures. Wine grapes and some peaches suffered flower bud death from these events. *Vinifera* grapes were the most damaged with some vine death even in Adams County. There was also some peach tree death. The season was slow to develop with bud break later than previous years. Bud break for most of the state occurred in the second week of April, with the exception of Centre and Erie counties. A statewide period of warm temperatures from May 8 through May 13, however, pushed all trees to eliminate the normal geographical differences from north to south. The result was that bloom was compressed across the entire state. Many orchards from the central portion of the state went from open cluster to bloom to petal fall in a matter of a few days. For example, last year at Rock Springs there was a period of about 10 days from our first bloom on McIntosh to full bloom of all varieties. That did not occur as we went from a few flowers open on Friday May 9 to beginning of petal fall for McIntosh on May 12. Fortunately, full bloom was later than it has been for the past several seasons.

Post-bloom weather was ideal for fruit cell division and growth. Rainfall in May through August was in excess of 17 inches. The result was a crop that picked out longer than what was estimated due to large fruit size. Fortunately, precipitation in the fall was back to normal to a little on the dry side which allowed for a trouble free harvest. Unfortunately, the cool August temperatures delayed harvest. A warm up in temperatures the first week of September overcame the harvest delay.

Plant Pathology

In general, PA had a wet April, May, June, and August (July saw only 2.14 inches of rain). Consequently, we saw 12 scab infection periods during the primary season, and the entire bloom period was an infection period for fire blight, with disease conditions persisting through June. This year was considered an epidemic year for fire blight in PA – at Penn State's farm, we had approximately 20% of our trees infected with some degree of fire blight. This was also a good year for conditions for cedar apple rust and infection periods coincided with apple scab infection periods. Powdery mildew wasn't as much an issue since it was so wet; however, incidence did increase somewhat during July due to drier conditions. Incidence of *Fabraea* leaf spot on pear was also reported this year. As far as summer diseases, sooty blotch and flyspeck conditions started around June 15. For apple rots, a high incidence of bitter rot was observed and starting in July and is subsequently becoming an issue for folks who have been pulling fruit out of cold storage in December.

For stone fruit, there were excellent conditions early in the season (late May) for bacterial spot and we observed fruit lesions as early as June 8. This was also an excellent year for cherry leaf spot – over 40 infection periods were recorded and symptoms were reported as early as the week of June 8. We also had a severe mid-April freeze, which knocked back a lot of the cherry crop. Consequently, growers cut back their fungicide applications on cherries and cherry leaf spot became very problematic for a lot of growers this year. Bacterial canker on cherry also was problematic as a result of the mild spring.

Entomology

Due to colder than usual temperatures in the spring, the biofixes for our most common fruit pests occurred relatively late during the 2014 season: for OFM on April 23rd, STLM on April 17th, CM on May 09th, TABM May 12th and OBLR on May 29th.

Brown marmorated stink bug populations were not very abundant during the spring; however, the numbers increased significantly during late summer and early fall. Overall for the entire season, the cumulative numbers of BMSB collected in traps utilizing the same pheromones and placed at the same locations as during the 2013 season were only about 5-10 percent lower than during the previous season. Insecticides used against BMSB created increasing management challenges with scale insects, woolly apple aphid and European red mites. The other pests causing some control problem were pear psylla, plum curculio, and borers but in most cases the challenge was localized and limited to only few, individual orchards.

Despite increased overall insecticide usage for the control of BMSB, the internal fruit feeders such as codling moth and Oriental fruit moth and leafroller complex continued to generate some control challenges in isolated orchards resulting again in rejections of fruit by Pennsylvania fruit processors (i.e., over 250 rejections with 80-20 CM: OFM split).

A new invasive insect pest, potentially affecting fruit and grapes, was discovered in one of PA counties. Spotted lanternfly, *Lycorna delicatula* (Hemiptera: Fulgoridae), was observed in five townships of Berks County (southeast PA). The area where this new species was observed is currently quarantined by the Pennsylvania Department of Agriculture, as monitoring and detection surveys are planned for the 2015 season.

CALL OF THE STATES - VIRGINIA

Greg Peck, Keith Yoder, and Chris Bergh
Alson H. Smith, Jr. Agricultural Research and Extension Center
Winchester, VA

Horticulture: Winter 2013-14 was quite cold with above average snowfall, resulting in considerable southwest injury to fruit trees, especially 2- to 3-year old apples. Frost on 16 and 17 April, when earlier blooming apples approached full bloom of king flowers in Winchester, made thinning decisions more difficult. However, frost damage was not extensive and many growers reported average yields. Peach trees in low-lying sites were most heavily damaged. Central Virginia growers did not have much frost damage. Overall, the growing season was relatively mild, with only a few days above 95ºF and no extended periods of drought.

Tree Fruit Pathology: Most apple diseases had opportunity for infection in 2014, from early season (scab, cedar-apple and quince rusts, powdery mildew and fire blight) to summer diseases (Brooks spot, sooty blotch, flyspeck and rots). For stone fruits, there was ample opportunity for scab infection in May, bacterial spot of susceptible cultivars, pre-harvest brown rot infection on peaches and leaf spot and brown rot on cherries. Throughout the late spring and summer, wetting periods and rain volume were quite localized, but most areas had evening and night wetting that resulted in extended wetting at temperatures >70ºF that were favorable for rot development.

Apple scab and rusts: Scab ascospores were trapped 29 Mar, before green tip. Primary scab infection periods occurred 11 and 14 Apr, and lesions appeared just before a heavy secondary infection period (28 Apr -1 May), which promoted secondary scab infections through May. Extended wetting also brought the heaviest quince rust infection in >10 years. Additional secondary scab and cedar-apple rust occurred 10 May; 13-14 May; 15-16 May (16 hr at 67-54° with 2.9 in. rain). The heavy rainfall likely reduced the residual efficacy of protective fungicides, putting selection pressure on apple scab for resistance to "at risk" fungicides. Early-season spray weather wasn't good for coverage, possibly contributing to some scab and rust problems. Somewhat unusually, cedar-apple rust occurred during most apple scab infection periods; rust galls persisted at least to mid-June, resulting in lesions on unprotected terminal shoots. From 1 Jun- 1 Sep, 18 of the 23 extended wetting periods had temperatures >70ºF, and were expected to favor rot development.

Powdery mildew spores were present under favorable conditions 9 Apr and we had 42 dry weather "mildew infection days" from 9 Apr through 18 Jun. Infection was common on susceptible varieties and actively growing shoots were susceptible into July or later.

Fire Blight was common in many areas, with most infection in Virginia occurring on late bloom where there was wetting between 8-16 May. There were concerns about fire blight on new nursery stock and, considering the origin of the stock, the possibility that streptomycin-resistant fire blight may have come with it.

Summer diseases: The sooty blotch/flyspeck threshold, starting wetting hour accumulation 18 May, reached the 250 wetting hour threshold on 3 Jul, a couple of days later than 2013. By 14 Jul, 328 wetting hours had accumulated and sooty blotch/flyspeck symptoms were apparent on non-protected trees in fungicide test blocks. As of 2 Sep, 702 wetting hours had accumulated (near average since 1994).

September was relatively dry and harvest mostly uninterrupted; few serious storage rot problems have been reported. Generally there was less Glomerella leaf spot than 2013; it developed later in southern VA and NC than 2013 but was an issue on late varieties in NC.

Grape Pathology: Due to cold temperatures during the winter and temperature fluctuations during the spring, there were many cases of crown gall in Virginia and we expect more effects from it in coming seasons. Bud break of Chardonnay started around 1 May in Winchester, about 2 weeks later than average. A series of rain events after bloom in early June caused downy mildew outbreaks in some vineyards. There were several outbreaks of ripe rot in southern Virginia; some vineyards showed more than 50% disease incidence on clusters. It appears that ripe rot is becoming a perennial issue in the south. Weather conditions at the end of the season were cool and dry. Some growers experienced hail events, but most growers reported a good harvest.

Entomology: There were indications that low winter temperatures may have affected the survivorship of overwintering adult BMSB. BMSB captures in pheromone traps were relatively low through July then increased in August and September. Relatively cool conditions through the summer may have affected BMSB development and rate of population increase and the general consensus was of lower populations overall than in some previous years. There were numerous reports of fewer adult BMSB invading homes in fall 2014 than in some previous years, although also instances of invasions considered equivalent to previous years. Weather was likely associated with prolonged and heavy PC pressure in experimental blocks at Winchester in 2014 and new injury was recorded well into the summer. To some extent, growers appear to have reduced their post-bloom applications of broad-spectrum insecticides, likely due in part to woolly apple aphid outbreaks in 2012 and 2013 and concerns about outbreaks of other secondary pests. There were fewer reports of woolly apple aphid outbreaks in 2014 than in 2013; some blocks with heavy pressure from this pest in 2013 were virtually free of it in 2014. Emergency Exemptions for bifenthrin and dinotefuran against BMSB were issued for NC, VA, WV, MD, PA, NJ and DE. Biofix dates for oriental fruit moth and codling moth at Winchester occurred within the expected range, based on records since 2000. Generally light codling moth and oriental fruit moth pressure, with isolated instances of codling moth pressure. Relatively large populations of soybean thrips that often co-occurred with eastern flower thrips were identified in some apple blocks in central and northern Virginia for the second year. Injury and stunting of growth on young apple terminals was fairly common where this occurred, but the relationship between this injury and feeding by one or both species remains unclear. There were some concerns about whether this injury increased terminal susceptibility to shoot blight. Environmental conditions favored sustained terminal growth well into the season, and the same effects were reported in some locations in mid-August.

Spotted wing drosophila and African fig fly populations in vineyards increased late in the season, presumably after being set back by the cold winter. They eventually developed into damaging populations in wine grapes and other berry crops. In an insecticide trial in a commercial vineyard, approximately 18% of berries in the control plots were injured by spotted wing drosophila. Japanese beetle was also a problem in some vineyards.

Not for Citation or Publication
Without Consent of the Author

Black Stem Borer – A New Pest in Apples

Deborah Breth – CCE-LOF
Art Agnello – Cornell, NYSAES
Kerik Cox – Cornell, NYSAES
Elizabeth Tee – CCE-LOF
Hannah Rae Warren – Cornell Intern

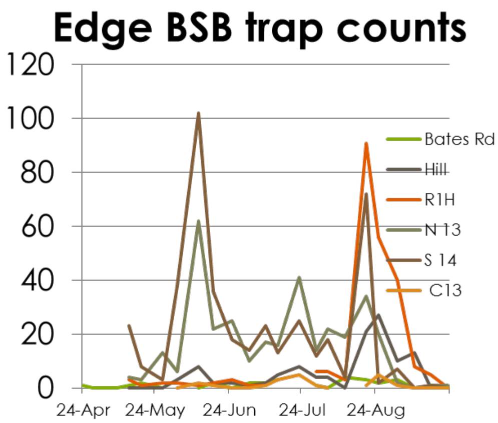
History:
BSB was introduced from eastern Asia and first found in Long Island, NY in 1932. It is a general wood boring insect in a group called Ambrosia beetles. It has a very wide host range including American beech, maple, dogwood, black walnut, oak, magnolia, and many other ornamental/forest species. It was first reported in apple and sweet cherry in 1982. Black stem borer was first detected in 2013 in 6 apple sites in the Lake Ontario Fruit Region of NY all in association with fire blight. Growers complained of trees dying or oozing from holes or fire blight from oozing rootstocks where there was no history of fire blight. Since then, we have identified 25 sites with trees dying ranging from first-leaf plantings to 15 year old plantings. Most are in younger trees. Nursery trees have also been attacked.

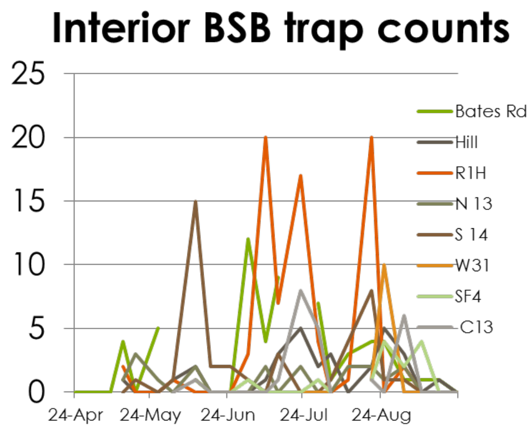
Biology:
Adult beetles overwinter in galleries at the base of infested trees. After 2-3 days with max temperatures ≥ 68^{o}F in the spring, the females emerge from overwintering sites to infest new sites. It coincides with "4 days after first bloom on Norway maple, and full bloom on border Forsythia." The adult female drills a hole ~1mm in diameter, and hollows out a channel into the heartwood of small trees (2-50 cm diameter). The female starts to culture a fungal food source, *Ambrosiella hartigii*, but can also carry *Fusarium*. The foundress, the adult female, lines the chambers with the "Ambrosia" fungus for the larvae, and lays her eggs (tiny, ~1mm white, football shaped) in the chamber. It takes about 30 days for development from egg to larvae (3 instars) to adult producing 2 generations per year. Late summer the beetles migrate to a hole lower in the trunk to overwinter - as many as 100 in one chamber. The beetles go into diapause - not active again until the next spring. The ratio of females to males is about 10:1. It is still unclear if BSB is overwintering in the bases of apple trees.

Monitoring and Trapping:
Symptoms of infestation include blistering of bark and sometimes just oozing sap or fire blight ooze from a tiny hole in the trunk. The holes can be in the rootstock as low as the soil line and higher than 6 feet. After calm, rain-free days, look for "toothpick frass" which is not actually excrement, but compacted sawdust sticking out of the holes, if left undisturbed can get quite long.

Art Agnello worked with Dr. Peter Schultz, entomologist from Virginia Tech's Hampton Roads Agricultural Research and Extension Center to identify traps to monitor for this pest. Dr. Shultz uses inverted "Simply" traps with rectangular openings cut in side panels, and baited with ethanol lures in semipermeable membrane from Agbio (agbio@agbio-inc.com). We put a drop of low toxicity anti-freeze in the lid to catch and kill the beetles in the trap. These traps are hung 2-3 feet off the ground the first warm day in the spring. The traps were hung on the edge of woods next to orchards and in the interior of orchard. We checked traps weekly. Figure 1 shows that the first activity in adult flight started late April since the temperatures cooled below 68 F until May 8. Note the Y axis on the trap data for the edge of the plantings has a range of 0 to 120 compared to 0 to 20 in the traps set in the interior of the planting. There were 3 peaks of activity for adult beetles in traps reflecting the reported 2 generations of eggs produced in the season about a month apart.

Figure 1. Weekly trap data using Simply Traps:





A second method of trapping was suggested by John D. Vandenberg, USDA, using beech loglets (bolts), 12 inch lengths of beech trees, approximately 1 inch in diameter soaked in 10 to 15% EtOH for 3 days. They use ethanol diluted or cheap Vodka. They were hung about 1 foot off the ground using an electrical tie tied to perimeter fencing or trellis systems. This system needs to be monitored and replaced every 3 days and is very intensive. These bolts did not catch as many BSB as the "simply" traps.

Attempt at control:
Ornamental Nurseries rely on permethrin on a 2-week schedule. Dr. Chris Ranger has tested other insecticides such as neonicotinoids, anthranilic diamides (cyazypyr, acelepryn), and tolfenpyrad, and found them not effective. In apples, we looked for insecticides that were labeled for "trunk boring species" including Warrior II or Grizzly, lambda-cyhalothrin, or Declare (gamma-cyhalothrin) or
chlorpyrifos trunk sprays.

On May 5, pre-bloom, we applied the following treatments to drip with mist blower sprayer and monitored a couple times in the season for fresh activity in the treatment plots replicated 4 times. There was no untreated check since the grower was nervous about too many lost trees. Lorsban Advanced @ 1.5 qt./100 had 1% activity in trees. Danitol @16 oz./100 had 6% activity in trees.

Cobalt Advanced @1.3 qt./100 had 3% activity in trees. The Grower standard (Lorsban with airblast) had 5% activity.

Conclusions:

- Ethanol-baited traps worked best to detect and monitor the presence of *X. germanus.*
- The first activity of adults caught in traps was noted in WNY on April 24 after a few warm days over 68F.
- Activity stopped until May 13 while temperatures did not exceed 65F between 4/22-5/8.
- There were much higher counts in traps along edges than interiors.
- Adult capture for beetles emerging from overwintering sites peaked on Jun 11.
- The 1st generation adults emerged July 9-23.
- The 2nd generation adults emerged Aug 20 and continued to be active through September 16.

Control strategy is still under question:

- It appears spray coverage can be an issue – top to bottom of tree. Spray coverage cannot be blocked by tree guards or weeds. Since holes are found at the soil line, do we need to spray to the soil line?
- We need to test biological controls to kill beetles or symbiotic fungus, fungicides and insecticides.
- Is it necessary to destroy infested trees? Some have lost 30%. But when we cut cross-sections of infested trunk, we could see that new cambium had grown around it and closed the hole on the surface of the trunk. So if the tree does not collapse, it may not die. Not all trees die.
- We need to identify what factors determine tree mortality. Is it dependent on the species of fungal symbiont? Or is there a stress attracting BSB which would kill the tree anyway in the absence of BSB?
- Work will continue in 2015 to identify and evaluate control for BSB.

NON-NATIVE AMBROSIA BEETLES AS INDICATORS OF TREE HEALTH

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Non-native ambrosia beetles (Coleoptera: Curculionidae, Scolytinae) are increasingly being recognized as challenging pests of ornamental, horticultural, and forestry products. Two species are especially problematic in ornamental tree nurseries and orchards in the Midwestern, Northeastern, Northwestern, and Southern United States, namely the black stem borer, *Xylosandrus germanus*, and the granulate ambrosia beetle, *Xylosandrus crassiusculus.*

Adult female *X. germanus* and *X. crassiusculus* bore into the stems or trunks of trees and tunnels are then created within the sapwood and heartwood leading to a series of chambers for rearing the brood. Beetles transmit a symbiotic fungus into the tunnels and brood chambers that provides nourishment for the larvae and adults. *Ambrosiella* species are associated with *X. germanus* and *X. crassiusculus* as their symbiotic fungi, but other secondary pathogens have been isolated from beetles and galleries (Weber and McPherson 1984; Hulcr et al. 2012; Kostovcik et al. 2014).

Eggs, larvae, and adults are found together in the tunnels and galleries (Weber and McPherson 1983a). Females result from fertilized eggs, while males arise from unfertilized eggs. *Xylosandrus germanus* and *X. crassiusculus* have two to three generations per year depending on their geographic location. Adults overwinter primarily as females in clusters within the tunnels and brood chambers.

Adults begin leaving their overwintering sites within trees in woodlots as early as March in North Carolina and Tennessee, and mid-April to May in Ohio and Illinois. Adult females then search for new hosts to colonize. Both *X. germanus* and *X. crassiusculus* have broad host ranges of >200 and >120 species, respectively (Weber and McPherson 1983b; Schedl 1962). Common hosts for *X. germanus* and *X. crassiusculus* include magnolia, redbud, dogwood, Japanese snowbell, oak, and maple, but reports have also included apple, ash, beech, black walnut, buckeye, cherry, elm, goldenraintree, hickory, honeylocust, linden, peach, pear, pecan, poplar, rhododendron, sassafras, sumac, sweetgum, tupelo, willow, and yellowwood. Deciduous hosts are preferred over coniferous tree species for both *X. germanus* and *X. crassiusculus*.

Symptoms of ambrosia beetle attacks include sawdust “toothpicks” sticking out from the tunnel entrances, along with sap oozing, wilting foliage, branch dieback, and profuse basal sprouts. Colonization by *X. germanus* and *X. crassiusculus* does not always result in tree death, but growth and aesthetic value can be negatively affected.

Physiologically-stressed trees are preferentially attacked by *X. germanus* and *X. crassiusculus*, and an efficient mechanism aids the adult females in locating vulnerable hosts (Ranger et al. 2010, 2013, 2014). For instance, Weber and McPherson (1984) concluded *X. germanus* could differentiate among even slight differences in host quality after documenting black walnut *Juglans nigra* L. trees with impaired growth rates were attacked over unimpaired trees. Characterization of the spatial distribution of attacked trees within diverse landscapes also demonstrated that *X. germanus* only targeted certain species and individuals within a given location (Ranger et al. 2014). Attacks have been reported on apparently-healthy trees, yet, such trees may actually have been inapparently-stressed at the time of attack (Ranger et al. 2010, 2013, 2014). Notably, the physiological status of trees at the time of attack is often unknown. While appearing “apparently healthy,” asymptomatic trees that are in a recently weakened state can still emit volatile attractants that signify their vulnerability.

Like other Scolytinae that target weakened trees, ethanol is an important host-derived attractant for *X. germanus* and *X. crassiusculus*. Trees baited, irrigated, or injected with ethanol are preferentially attacked by *X. germanus* and *X. crassiusculus*, but not neighboring untreated trees (Ranger et al. 2012). Beetles also efficiently locate and attack trees emitting ethanol, but rarely landed on adjacent trees not emitting ethanol (Ranger et al. 2014). Comparatively low amounts of ethanol can be detected in the vascular tissue of healthy trees, but considerably higher concentrations are induced in response to a variety of physiological stressors, including flood and drought stress, girdling, freezing, pathogens, root and crown disturbance, and pollutants (Kimmerer and Kozlowski 1982; Kelsey 2001; Ranger et al. 2013).

Field observations at an ornamental nursery documented extensive ambrosia beetle attacks on *Cornus florida* L., subjected to standing water for 14 days following a July 2006 flooding event in northeastern Ohio (Ebner *et al*., 2007; Ranger, pers. obs). Similarly, extensive attacks were recorded on *C. florida* trees subjected to flood-stress and poor drainage at two ornamental nurseries in Ohio following extensive precipitation events associated with 2011 being the wettest year on record for the state (NOAA 2012a; Ranger et al. 2013). Subsequent experiments demonstrated that flood-stress induces the emission of ethanol from the bark of *C. florida* trees (Ranger et al. 2013). *Xylosandrus germanus* and *X. crassiusculus* also preferentially landed on and attacked flooded dogwoods, but did not attack neighboring non-flooded trees (Ranger et al. 2013). Additional studies have determined that beetles preferentially attack tree species intolerant of flooding, but not those tolerant of flooding (Ranger, unpub. data).

Field observations from ornamental nurseries have also indicated that frost injury can lead to the emission of ethanol and thereby predispose trees to attack by ambrosia beetles (Ranger et al. 2014). In particular, the mild winter experienced in Ohio in 2012 resulted in some trees having early and vulnerable growth, which was then subjected to at least three significant frost events in April 2012. These frost events resulted in visible frost injury to a variety of deciduous trees, including some that were subsequently attacked by ambrosia beetles, specifically, Kentucky yellowwood (*Cladrastis kentukia*), Japanese maple (*Acer palmatum*), Japanese snowbell (*Styrax japonicus*), Japanese Zelkova (*Zelkova serrata*), and redbud (*Cercis canadensis*). Ambrosia beetle attacks have also previously been observed on tulip poplar (*Liriodendron tulipifera*) following an early spring freeze in Ohio and Tennessee. Recent experiments conducted in Ohio and Virginia demonstrated that frost injured *S. japonicus* were preferentially attacked by *X. germanus* and *X. crassiusculus* (Ranger, unpub. data). La Spina et al. (2013) also demonstrated that bark tissue on beech, *Fagus sylvatica* L., trees experimentally injured by freezing was more attractive to X. germanus and other ambrosia beetles than non-injured tissue. Winter injury associated with low temperature stress occurring in Ohio and neighboring states during the winter of 2013-2014 also appeared to have predisposed trees in ornamental nurseries, tree fruit orchards, and landscapes to attack by ambrosia beetles (Ranger, pers. obs.).

Thus, despite a broad host range, *X. germanus* and *X. crassiusculus* exhibit a preference for trees in a weakened physiological condition (Ranger et al. 2010, 2013, 2014). An increase in the frequency of extreme climatic events (Easterling et al. 2000; Kharin and Zwiers 2005) may therefore result in more frequent attacks on living, but weakened trees in ornamental nurseries and orchards (Ranger et al. 2014). Hosts weakened by physiological stressors may also not have the energy reserves available to defend themselves against infection by symbiotic fungi or secondary pathogens associated with *X. germanus* and *X. crassiusculus.* Considering that ethanol is emitted from trees responding to the early on-set of physiological stress, and *X. germanus* and *X. crassiusculus* exhibit a preference and efficient capability for locating such trees, certain non-native ambrosia beetles can serve as an indicator of declining tree health (Ranger et al. 2013, 2014). Since conventional insecticides do not always protect physiologically-stressed trees from ambrosia beetle attack, minimizing potential stressors and maintaining host vigor should be the primary foundation of a sustainable management plan for *X. germanus* and *X. crassiusculus.*

Acknowledgments
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INTEGRATING NOVEL STRATEGIES INTO MANAGING AMBROSIA BEETLES IN NURSERIES (AND PERHAPS ORCHARDS)

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Ambrosia beetles (Coleoptera: Curculionidae, Scolytinae) are serious pests of ornamental nurseries in the US. The non-native *Xylosandrus crassiusculus* and *Xylosandrus germanus* are problematic in Virginia. Adult females excavate a series of galleries and brood chambers in the heartwood, and subsequently inoculate hosts with symbiotic fungi. Symptoms include frass “toothpicks”, oozing sap, wilting foliage, branch dieback and profuse basal sprouts (Ranger et al. 2013). Flight activity begins in early spring and is closely related to periods with maximum temperatures exceeding 20°C (68°F) (Reding et al. 2013). The emission of ethanol from stressed or dying trees is an important olfactory cue for adults to locate a vulnerable host (Ranger et al. 2012).

Current management options for lessoning tree losses to nursery growers include: monitoring maximum daily temperatures, deploying and checking ethanol baited-traps catches as an indicator of beetle activity, and field scouting for evidence of frass “toothpicks”. There are several commercial and homemade trap styles available that can be baited with a slow release ethanol pouch lure. Traps should be placed along the perimeter of the nursery and hung so the bottom of the trap is close to the ground, but not obscured by vegetation. Historical data indicate that the adults enter the nursery or orchard from the surrounding woods, most typically where there is a water source or poor drainage. Sprays directed at the trunks with permethrin or bifenthrin are recommended when three consecutive days over 68°F are forecast, which often coincides with breaking of tree dormancy. If trees become attacked, growers are encouraged to leave attacked trees standing in nursery for 30 days. These attacked trees will continue to accumulate new attacks and can offer protection as a trap crop to surrounding undamaged trees. After 30 days, trees should be removed from the property or destroyed to ensure that the next generation of beetles does not emerge. Freshly cut bolts have been used to intercept beetles entering the nursery in early spring. Bolts may be infused with ethanol or frozen to serve as a trap that beetles will attack. Trap trees may be utilized as part of a push/pull strategy. Trees may be injected with ethanol using an Arborjet Tree IV if the trees are in ground. In a pot-in-pot production system, trees may be artificially flooded or cold stressed to elicit the release of ethanol. Ethanol production depends on the intolerance of a tree to a particular type of stress, and ethanol is a key volatile cue for attracting ambrosia beetles. Beetle attraction is to the ethanol, regardless if the source is a living tree, bolt, or trap.

Following years of above average precipitation, field observations indicated that some species of in-ground nursery trees were susceptible to ambrosia beetle attacks. In three separate studies, the objective was to determine if artificial flooding increased the number of beetle attacks on otherwise healthy trees in PNP nurseries. Tree species prone to certain physiological stressors, such as flood intolerant dogwood, are susceptible to attack by ambrosia beetles. In all three studies, dogwood, cherry and eastern redbud trees were all vigorously attacked when the root ball was subjected to standing water in the growing container. Across these studies, non-flooded control trees were not attacked while in proximity of the artificially flood-stressed trees. Studies in Virginia nurseries found that artificial flooding created trap trees that are very efficacious in attracting and trapping *X. crassiusculus* and other ambrosia beetles, particularly when located near woodlots.

Cold injury and frost cracks play a role in infestation of *Xylosandrus* on some species of trees. Virginia experienced below average temperatures from December 2013 through March 2014. Spring field observations revealed tree bark damage in both the nursery and landscape settings and an increase in the number of trees and tree genera attacked by ambrosia beetles. To assess the influence of cold stress on tree attractiveness and susceptibility to ambrosia beetles, trees that had broken dormancy were placed in a commercial temperature-controlled warehouse for a 3 day period to simulate overnight temperatures below freezing. Cold-stressed trees were paired with controls and deployed along a woodlot experiencing ambrosia beetle attacks in previous years. Cold exposure resulted in wilted, dead leaves and bark splitting to the trees and were preferentially attacked by ambrosia beetles. No attacks occurred on neighboring non-cold-stressed control trees. Studies in Virginia found that natural or artificially induced cold stress creates trees and bolts that are very efficacious in attracting and/or trapping *X. crassiusculus* and other ambrosia beetles.

In earlier studies, freshly cut bolts were also effective in attracting ambrosia beetles if they had been treated to emit ethanol. Studies have shown that freshly cut bolts filled with ethanol are highly attractive to beetle attack. Bolts can be drilled to create a reservoir and then filled with 70% ethanol or 70% pharmacy grade ethyl alcohol (denatured ethanol) and sealed to prevent evaporation. Alternately, bolts may also be soaked in water and frozen for three days to serve as a trap for beetles. A grower interception system could utilize bolts around the perimeter to protect ornamental and orchard stock when flooding container grown trees is not an option. Beetles bore into the bolts and create frass “toothpicks” that are highly visible. Bolts should be removed from the orchard or destroyed after 30 days in order to prevent the next generation of beetles from emerging.

These studies identify pest management tools to effectively reduce tree losses from ambrosia beetles. The attract-and-kill strategy with flooded trees, ethanol treated bolts, or ethanol baited traps are effective strategies. A broader question is if ambrosia beetles are serving as IPM scouts to identify stressed trees ahead of outward symptoms.

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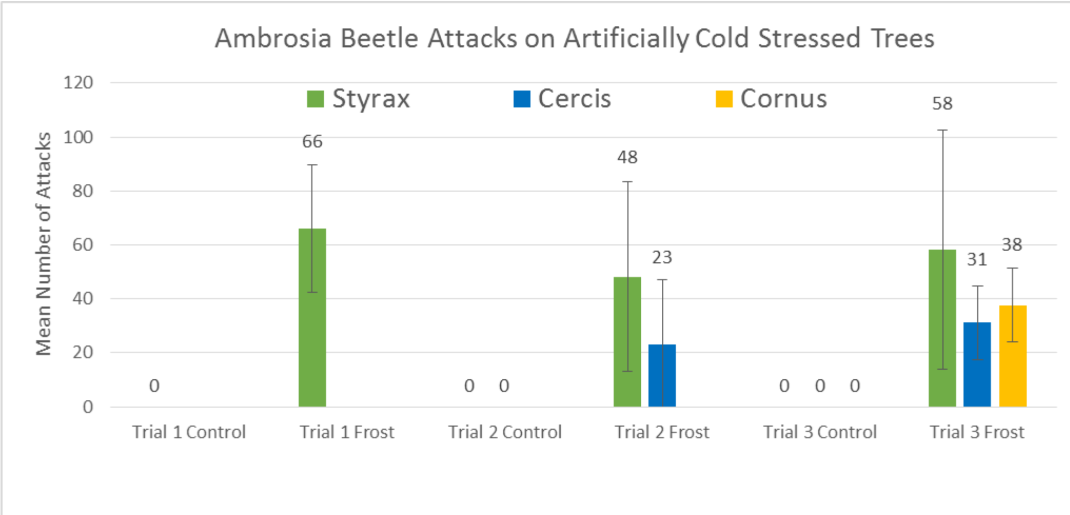

Figure 1.- Effect of ambrosia beetle attacks to trees exposed to 3 days of cold stress and an equal number of unexposed control trees.

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Evaluation of Mating Disruption Products and Lures for Monitoring Codling Moth and Oriental Fruit Moth in Apples

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Codling moth (CM) and oriental fruit moth (OFM) are the two major lepidopteran pests of apples in North Carolina orchards. Management is achieved either through insecticide applications timed to coincide with egg-hatch of specific generations, or with the use of various mating disruption products.

The standard product for mating disruption in NC orchards has been Isomate CM/OFM TT dispensers applied at 200 per acre. Product and application cost is a limitation to the more widespread use of mating disruption, despite the benefits apparent to most long-time users of mating disruption. Several alternative products are available to reduce material cost or application cost, including the use of puffers or misters, and more recently CideTrak Meso dispensers from Trece. Meso dispensers are applied at reduced rates – 30 dispensers per acre – and contain less pheromone. The inclusion of a pear ester kairomone (referred to as DA) compensates for the lower per-acre rate of pheromone release by increasing the activity of the CM pheromone. One objective of this work was to compare the performance of standard CideTrak dispensers to Meso dispensers.

In addition to different types of dispensers, there are also a variety of new pheromone lures for monitoring moth captures in mating disruption orchards. The addition of the pear ester kairomone (DA) to codling moth pheromone has been available for several years and is designed to increase to attractiveness of codling moth to its pheromone. Also, the addition of codling moth pheromone to OFM pheromone has been observed to increase OFM capture compared to its own pheromone. Finally, the addition of acetic acid has been observed to enhance the attractiveness of lures to codling moth. A second objective of this study was to compare different combinations of pheromones and kairomones for attractiveness of codling moth and OFM in both mating disruption and non-disrupted orchards.

Materials and Methods

At each of three locations (replicates), three blocks (4 to 7 acres each) of mature mixed-variety apple trees were assigned to one of three treatments: 1) CideTrak CM/OFM at 200 dispensers/acre, which resulted in a total per-acre deployment of 46 grams of CM pheromone (codlemone) and 20 grams of OFM pheromone (3-component blend); 2) CideTrak Meso dispensers applied at 30 dispensers/acre, equivalent to 22.5 grams of CM pheromone,15 grams of OFM pheromone, and 15 gms of pear ester kairomone (DA) per acre; and 3) non-disrupted control. At each location all three blocks were roughly adjacent to one another. Two of the replications (Fruitland 1 and 2) were in different areas of the same farm, while the third (Sugarloaf) was managed by a different grower several miles away. Dispensers were hung on 24 and 25 April (Fruitland 1 and 2) and 23 April (Sugarloaf). Although insecticide use varied between the two farms, the same insecticide program was followed across all three treatment blocks in each replication. The trees in Fruitland 1 and 2 were minimally sprayed, while the Sugarloaf location received a full-season spray program consisting of two applications each of Delegate and Assail, and one application each of Intrepid, Provado and Altacor.

Effectiveness of mating disruption treatments was assessed with moth captures in pheromone traps and fruit damage assessments at harvest in September. Traps consisted of Pherocon VI Delta-style traps hung in the upper third of the canopy and baited with one of four lures: 1) CMDA combo lure containing approximately 3 mg each of CM pheromone and the pear ester kairomone, 2) CMDA combo lure plus a separate acetic acid lure (AA), 3) CMDA/OFM combo lure plus AA, and 4) a standard OFM L2 lure. Therefore, each treatment block contained four traps, two with lures exclusively for CM (CMDA and CMDA+AA), one exclusively for OFM (OFM L2), and one for both CM and OFM (CMDA/OFM+AA). All traps were checked weekly and liners were replaced as necessary to maintain a clean surface. All lures, including AA, were replaced at 8-week intervals. Damage assessments were obtained by examining 50 fruit from each of 4 trees per block on 24 September (Fruitland) or 5 trees per block on 11 September (Sugarloaf). Fruit harvested in September were all cut to detect internal damage. Trap data were subjected to ANOVA and means were separated by LSD ($P=0.05$). Some data sets were transformed using $\sqrt{x}$ before ANOVA, but means are presented as back transformations.

Results

The Fruitland orchard used in this study had very high CM and OFM populations, with season total trap captures of coding moth (CMDA baited traps) and OFM (OFM-L2 baited traps) averaging 107 and 711 moths per trap, respectively. OFM populations were also high at the Sugarloaf site, with a season total of 657 moths/trap in the OFM-L2 trap, but codling moth populations were low, with a season total of only 12 moths/trap in the CMDA trap.

For codling moth pheromone trap captures, there was no significant effect of either mating disruption or pheromone lure effects (Table 1). Season total trap captures in the various pheromone dispenser treatments and in traps baited with different lures is shown in Fig. 1. The lack of differences in pheromone dispenser effects may have been due to high codling moth captures not only within treatment blocks, but also in non-treated orchard surrounding treatments. Although lure effects were not significant, trap captures followed the same trend as in 2013 when lures containing both codling moth and OFM pheromone captured fewer moths than either the same lure with acetic acid or the standard L2 lure. Codling moths were active from May through late August (Fig. 2), during which time two generations were completed.

Results with OFM were more clear, with both the mating disruption dispenser and pheromone lure effects being significant, while the interaction was not significant (Table 1). Significantly fewer moths were captured in the CideTrak treatment compared with the Meso or control, and the Meso treatment capture was significantly lower than the control (Fig. 3). In addition, the CMDA/OFM+AA lure was significantly more attractive to OFM moths than the standard OFM L2 lure. OFM were active throughout the trapping period from late April through early October (Fig. 4). The reduced OFM captures in Meso and CideTrak treatments were consistent throughout the year, suggesting that pheromone was emitted from dispensers throughout the study period. While the CM/OFM+AA lures captured more moths than the OFM L2 lures, seasonal trap captures followed the same trend throughout the season (Fig. 5).

Conclusions

This was the first year that mating disruption was used in either orchard, and, with the exception of codling moth populations at the Sugarloaf site, both OFM and codling moth densities were high. Contrasting results with codling moth and OFM, in which mating disruption treatment did not significantly affect pheromone trap captures for codling moth but did for OFM, is indicative of the relative ease of disrupting in-flight communication of OFM compared with codling moth. Despite the high densities of OFM, seasonal trap captures in the CideTrak and Meso treatments were reduced by 98.3 and 81.8% below the control, respectively. The CideTrak treatment only suppressed codling moth trap capture by about 40% of control capture.

Lure effect results were similar to those in 2013, where the addition of acetic acid did not enhance the attractiveness of CMDA lures, and the addition of OFM pheromone to codlemone slightly depressed captures of codling moth. In contrast, the addition of CMDA and acetic acid to OFM lures significantly enhanced captures of OFM. While this enhanced lure did not change the seasonal pattern of trap captures, it may prove to be a useful tool for monitoring OFM in mating disruption orchards where OFM L2 lures typically do not capture any moths.

Table 1. ANOVA statistics for mating disruption effects and pheromone trap lure effects for codling moth and oriental fruit moth. Henderson County, NC. 2014

Insect	Factor	df (trt, error)	F	P
Codling moth	Mating disruption	2, 18	0.27	0.76
	Lure	2, 18	1.43	0.26
	Interaction	4, 18	0.54	0.71
Oriental fruit moth	Mating disruption	2, 12	39.72	<0.001
	Lure	1, 12	4.70	0.05
	Interaction	2, 12	0.77	0.484

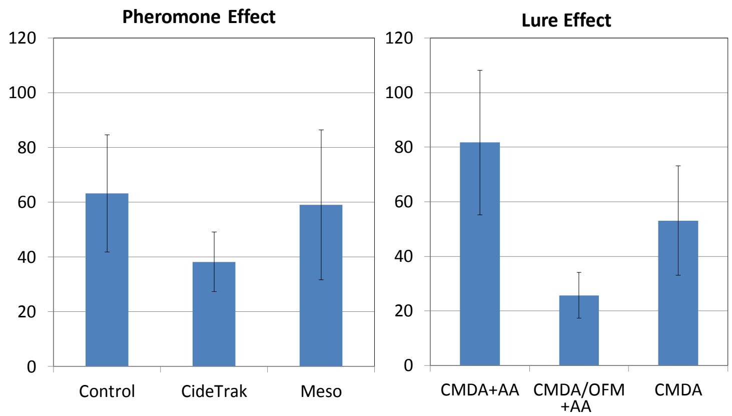

Fig. 1. Mean (±SEM) season total codling moth pheromone trap captures in apples treated with different mating disruption dispensers (pheromone effect) and in traps baited with different lures (lure effect). Henderson County, NC. 2014.

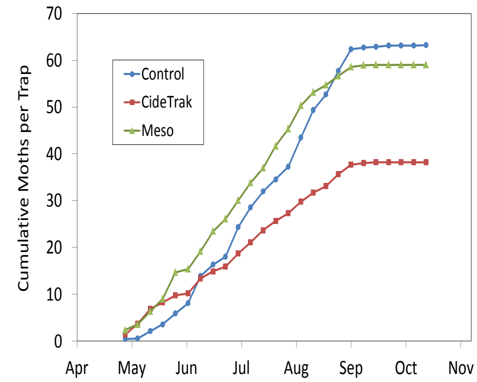

Fig. 2. Mean codling moth pheromone trap captures in blocks of apples treated with different phermone dispesers for mating disruption. Henderson County, NC. 2014.

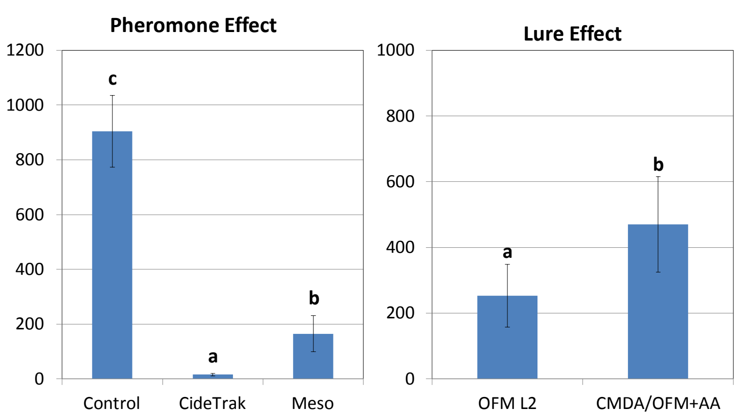

Fig. 3. Mean (±SEM) season total OFM pheromone trap captures in apples treated with different mating disruption dispensers (pheromone effect) and in traps baited with different lures (lure effect). Henderson County, NC. 2014.

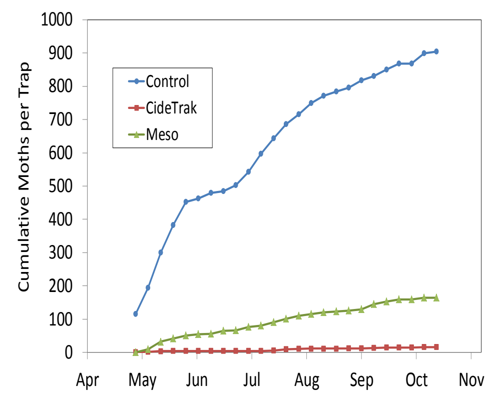

Fig. 4. Mean OFM pheromone trap captures in blocks of apples treated with different pheromones for mating disruption . Henderson County, NC. 2014.

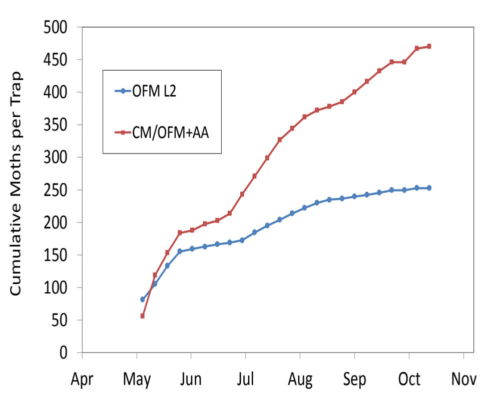

Fig. 5. Mean oriental fruit moth captures in traps baited with different lures across all mating disruption treatments. Henderson County, NC. 2014.

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THE LATEST IMPROVEMENTS IN RELIABILITY AND ACCURACY OF AN ELECTRONIC PEST MONITORING SYSTEM IN APPLES

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Monitoring insect pests in the orchard can provide growers with valuable information about the density of specific pest populations and aid in the decision-making process on whether to actively manage insect pests. The complete automation of insect trapping and monitoring has the potential to reduce labor costs by reducing the labor required for insect trap counts and trap maintenance. Testing was conducted on an automated pest detection system using bio-impedance based electronic sex pheromone prototype traps (Z-Trap) in 2014 at the Penn State Fruit Research and Extension Center to monitor adult codling moth (CM), *Cydia pomonella* (L.) and oriental fruit moth (OFM), *Grapholita molesta* (Busck), two major insect pests in tree fruit orchards throughout the U.S. The testing was aimed at determining the accuracy and reliability of the automated traps, as well as the wireless communication system and the web-based user interface program.

The testing during the 2014 season was aimed at validating the reliability and accuracy of moth captures in the electronic traps and to compare to the performance of large plastic delta traps (grower standard). The system consisted of the traps, a wireless communication system to relay capture data to a base station where it was uploaded to the internet, and a user interface where trap location and data could be viewed and monitored. Each trap was equipped with a microcontroller, a wireless communication module, and a 3.2v rechargeable battery pack to power the traps. Electrically charged three millimeter diameter steel pins surrounded a sex pheromone lure. An electrical signal was generated when a moth contacted adjacent pins. An algorithm was then applied to the signal to determine whether it was caused by a target insect (i.e., CM/OFM) and rule out non-target insect captures and electrical noise that would normally cause the signal to be counted as detection. Moths that contacted the pins fell through a funnel and into a collector where weekly counts were made. The daily insect capture data was sent to a base station, which automatically uploaded the data to a web interface specifically designed to organize and display insect trap capture data.

Eight Z-Traps were deployed throughout an apple orchard at the Pennsylvania State University, Fruit Research and Extension Center in Biglerville, PA. Four traps were deployed to monitor OFM and four to monitor CM populations. The 2014 trap versions were virtually identical to traps tested in 2013 but were equipped with new firmware updates and software modifications to improve detection accuracy and extend battery life. For each Z-Trap deployed there was also a large plastic delta (LPD) trap deployed as an industry standard to compare with the performance of the Z-Traps. All traps were equipped with a three-meter long antenna extension cable to project the antenna above the tree canopy. Counts were made weekly and batteries were charged only as needed. Traps were programmed to operate between 1500 hrs and 2300 hrs.

Performance varied among the traps, but most traps had few electrical or mechanical problems. The battery charge lasted considerably longer than the previous season with six of the eight traps operating the entire season without charging the batteries. The two traps that failed were traps that had electrical malfunctions which drained the batteries prematurely. Traps detections vs. capture rates varied between the traps, as well as throughout the season. In some instances, traps caught more moths than they reported to the base station. In other instances there were more reported moth captures than actual captures. In most of the CM traps, the moth capture was typically over-reported (Figure 1). Cumulative CM capture from all traps was less than half of what was detected in the traps. This is likely due to increased moisture in the air causing electrical noise, a problem that was first realized in 2013. The electrical noise created signals that are similar to the signal created by the moths contacting the pins, thus counting them as a detection. The firmware in the trap was updated at the beginning of the 2014 season to correct this problem. Significant improvements were made over the 2013 season, but adjustments to the detection algorithm and firmware modifications still need to be made. Figure 2 shows a trap that under-reported captures, particularly at the beginning and end of the season during periods when there was increased moth flight. The trap software is designed to eliminate multiple detections if another moth contacted the rods within a minute of the previous detection due to the chances of counting the same moth more than once. With those settings in place, it is possible that more than one moth was captured and detected but not reported to the base station during that time period. This would be likely to happen during increased moth flight, but unlikely during periods when fewer moths are flying. This pattern was typical of OFM traps that caught larger numbers of moths and may explain why it didn't happen with CM, since fewer moths were caught overall. However, the actual capture rates for all OFM traps were much closer to the detection rates than they were for CM traps. Overall weekly moth capture from all CM (Figure 3) and OFM (Figure 4) traps combined was very similar to moth captures in the large plastic delta traps.

In the future, efforts to improve capture vs. detection accuracy will focus on these areas of interest: 1) Modifying the firmware to address the problem of moths being captured but not detected and 2) making adjustments to the algorithm and firmware as needed to address the false detections caused by environmental conditions. Energy consumption has decreased substantially from last year, so battery efficiency is a lower priority and more effort can be directed toward the other priorities. Communication was very reliable this season, but efforts are also underway to increase communication distances. Overall, the 2014 season showed significant improvements in the reliability and accuracy of the system, but testing and research are ongoing to further improve the system.

Acknowledgments:
The authors wish to acknowledge the funding for portions of this study from the State Horticultural Association of Pennsylvania.

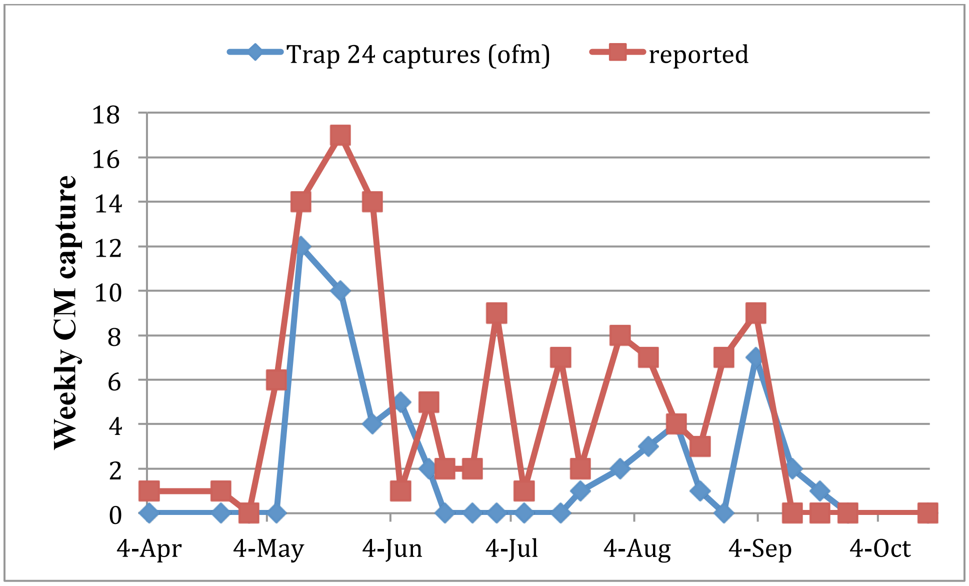

Figure 1: Weekly capture of CM adults by one Z-Trap at FREC during the 2014 season. The blue line represents the actual number of CM adults captured by the Z-trap, and the red line represents the number of moths the trap reported to the base station. This particular trap over-reported the actual number of moth captures most weeks but both lines had a similar trend.

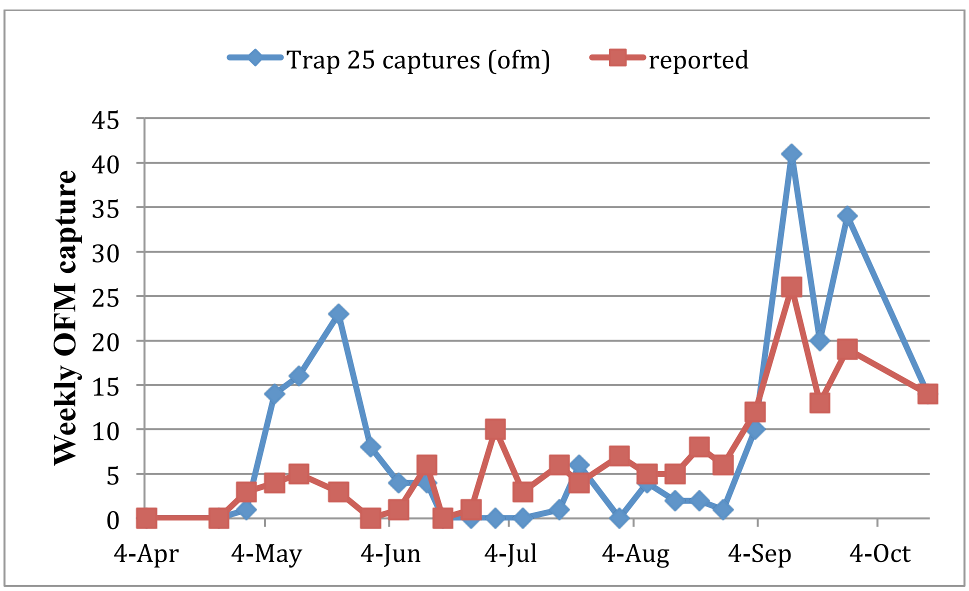

Figure 2: Weekly capture of OFM adults by one Z-Trap at FREC during the 2014 season. The blue line represents the actual number of OFM adults captured by the Z-trap, and the red line represents the number of moths the trap reported to the base station. This particular trap under-reported the actual number of moth captures most weeks but both lines had a similar trend.

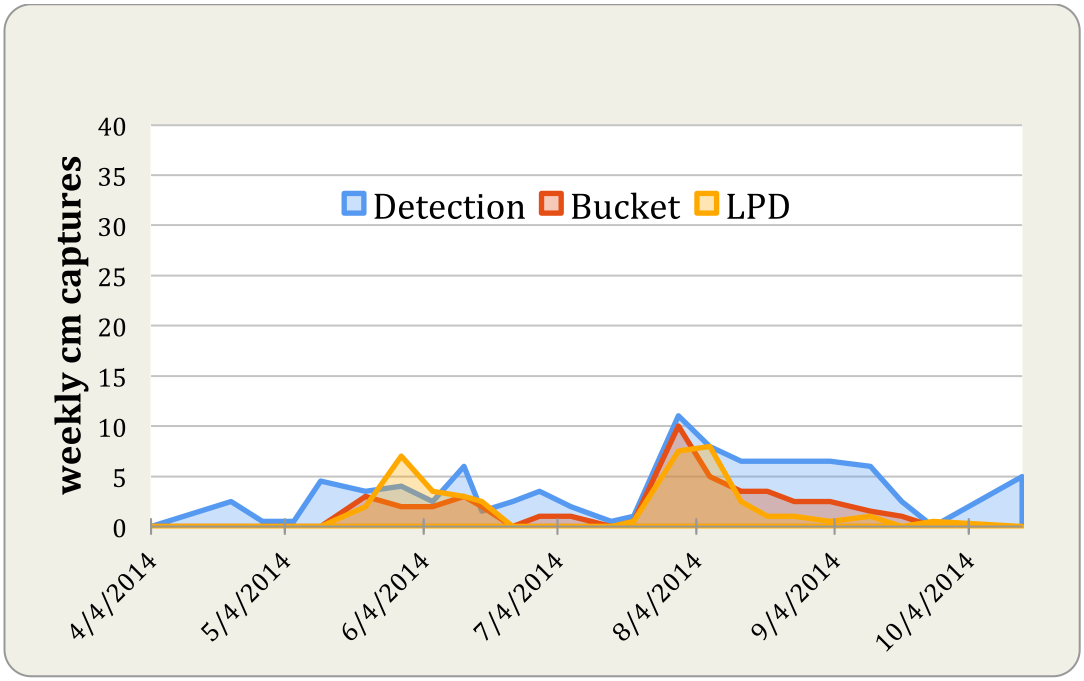

Figure 3. Average weekly CM detections in all Z-Traps (blue line) compared to the actual moth captures in the Z-traps (red line) and the conventional large plastic delta traps (orange line) at PSU in 2014.

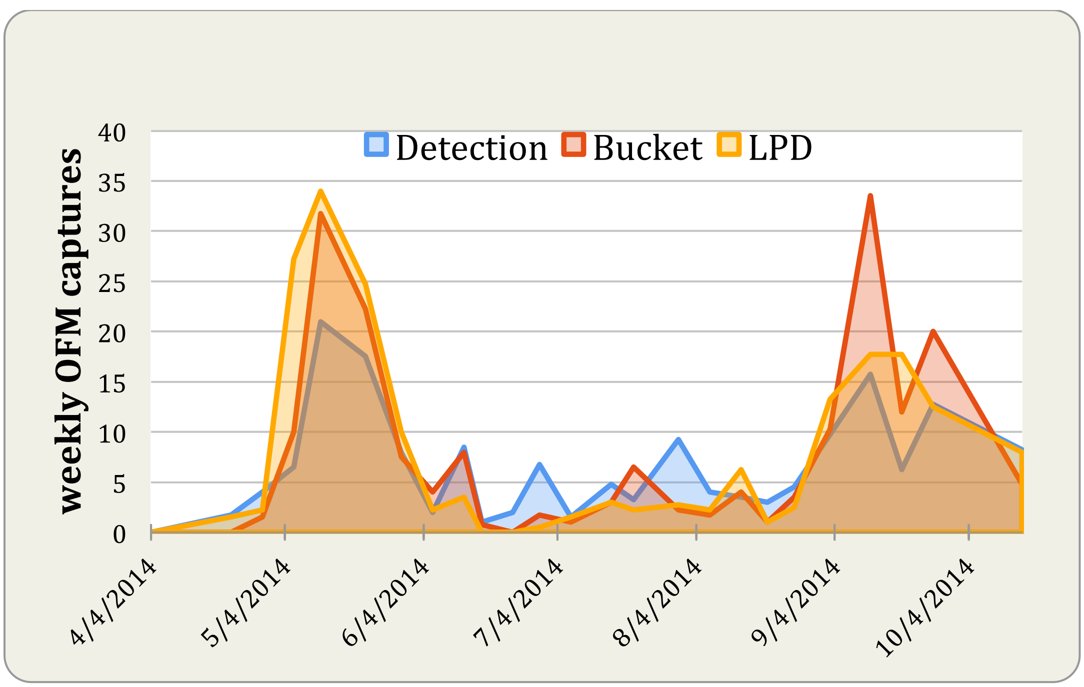

Figure 4. Average weekly OFM detections in all Z-Traps (blue line) compared to the actual moth captures in the Z-traps (red line) and the conventional large plastic delta traps (orange line) at PSU in 2014.

DEVELOPING THE BEHAVIORAL BASIS OF ATTRACT-AND-KILL FOR THE BROWN MARMORATED STINK BUG IN APPLE

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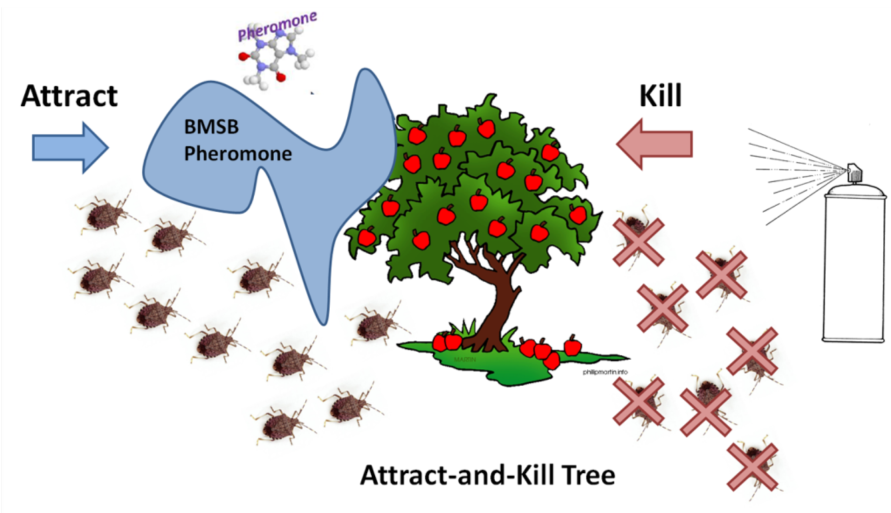

Figure 1. The concept behind attract-and-kill.

Since the introduction of the brown marmorated stink bug (*Halyomorpha halys*) from Asia (Hoebeke and Carter, 2003), growers have been forced to increase their insecticide usage by up to 4-fold (Leskey et al., 2012). This has resulted in the disruption of many IPM programs for tree fruit crops, including apple. This is not sustainable in the long-term, so alternative strategies need to be developed to manage *H. halys* that concurrently reduce the reliance on insecticides. One alternative approach is the use of attract-and-kill, whereby adults and nymphs are attracted to a specific site with semiochemicals that is regularly treated with insecticide to remove them from the population (Figure 1). Because *H. halys* is a perimeter driven threat, with higher abundances often along the edges of the fields (Venugopal et al., 2014; Rice et al., 2014), attract-and-kill sites may need to be deployed along the perimeters of orchards. However, before this can be implemented in grower's orchards, some baseline questions about the behavior of *H. halys* and efficacy of attract-and-kill needs to be evaluated.

Prior to 2012, only the aggregation pheromone for *Plautia stali* (methyl decatrienoate – MDT) had been identified to show cross-activity for *H. halys* (Khrimian et al., 2007). More recently, the *H. halys* aggregation has been identified as (3S,6S,7R,10S)-10,11-epoxy-bisabolen-3-ol (major component) and (3R,6S,7R,10S)-10,11-epoxy-1-bisabolen-3-ol (minor component) (Khrimian et al., 2014). For the following attract-and-kill experiments, we used either high (1000 mg) or low (100 mg) doses of *H. halys* aggregation pheromone in combination with 66 mg of MDT. When these semiochemicals are used in combination, they have a synergistic effect on attraction of *H. halys* to bait sources (Weber et al., 2014).

The presentation at CSFW attempted to answer three primary baseline questions dealing with attract-and-kill for managing *H. halys* in apple: 1) the area of arrestment (or "spillover") around a pheromone source, 2) the retention time that adults can be sequestered at attract-and-kill trees, and 3) whether high season-long kill of *H. halys* can be obtained using attract-and-kill sites. It is important to know the amount of spillover so that if this strategy is deployed in commercial orchards, we know whether to expect large swaths of damage created by the attract-and-kill sites. The second question is important, because adults need to stay at attract-and-kill sites long enough to take up a lethal dose of insecticide. Finally, the third question is important, because we need to know whether these sites are effect at killing *H. halys* throughout the season in order to provide sufficient control.

Overall, we found that the area of arrestment around a pheromone source was small, that the retention time at a host with food could be increased by the addition of baits, and that we could obtain a large kill of *H. halys* throughout the season. The results are definitely encouraging, and more in-depth information about the behavioral basis of attract-and-kill will be forthcoming in a refereed journal article, so stay tuned.

Acknowledgements

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Not for Citation or Publication
Without Consent of the Author

INTERSPECIFIC COMPETITION BETWEEN *DROSOPHILA SUZUKII* AND *ZAPRIONUS INDIANUS* LARVAE IN REARING MEDIUM AND GRAPES

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The insect pest ecology within Virginia vineyards has changed dramatically over the past decade with the introduction of several new invasive species. The latest introductions have been the spotted-wing drosophila, *Drosophila suzukii* (SWD), and the African fig fly, *Zaprionus indianus* (AFF). While SWD is a direct pest of wine grapes impacting production by ovipositing into individual grapes, AFF is a secondary pest which uses SWD oviposition wounds as well as cracked grapes as oviposition sites. Both fly species are capable of introducing pathogenic infections such as yeasts into the grape clusters. Depending on the larval infestation of the grapes, and the resulting sour rot, the whole cluster may be unsuitable for use in wine production. An observation by a Piedmont wine grower in 2012 estimated they lost 80% of a grape variety due to fly infestation and sour rot. The grower had an infestation of SWD, however the majority of flies in the field and adult flies reared in the lab from infested grape clusters were identified as AFF. The objective of this study was to try and understand the interactions of AFF larvae on SWD larvae within the vineyard.

The relationship of fly larvae within a food source has been reported to be competitive, thus leading to the increased mortality, decreased growth and reduced fecundity of the competing individuals based upon density (Bakker 1961). The degree of interspecific competition was measured by larval and pupal mortality, pupal volume, developmental time and the number of eggs laid by emerging SWD females.

Materials and Methods

<u>Commercial Media Study</u>. Larval densities tested (SWD:AFF); 2:2 and 4:4. Controls for each species were also tested with four and eight eggs per media cube. A total of 15 reps for both the interspecific competition study and controls was conducted. Eggs less than 24 hrs old of SWD and AFF were collected and placed on a 0.38g molasses media cube. Cubes were then placed into a 20 ml glass tube and capped with a cotton ball. Tubes were held in a growth chamber at 12:12 L/D at 23° C until pupation.

<u>Wine Grape Study.</u> Larval densities on a wine grape (SWD:AFF); 4:4 and 8:8 on a single wine grape. Each grape weighed approximately 1.5g with an average degrees brix of 22. Controls for each were 8 and 16 larva per grape. Ten reps for both the interspecific competition and controls were conducted. L1 larva instead of eggs and were placed onto a single Petit Verdot grape. Grapes were then placed into a 20 ml glass tube and capped with a cotton ball. Tubes were held in a growth chamber at 12:12 L/D at 23° C until pupation.

<u>Competition Evaluation.</u> Larval and pupal mortality were observed and recorded during both studies. Pupae were removed from the media blocks and grapes and measured (length and width) to determine pupal volume* (Takahashi and Kimura 2005). Each pupa was placed into a 15 ml glass specimen tube and plugged with a cotton ball until emergence. Developmental time

from egg to adult was recorded. The sex of each fly was determined and fitness was evaluated based on the lifetime egg production of any females that emerged.

$$*V = \frac{4}{3}\pi\left(\frac{w}{2}\right)^2\left(\frac{l}{2}\right)$$

Results

Commercial Media Study. There was no significant interspecific interaction between SWD and AFF for pupal volume at the 2:2 and 4:4 densities when compared to the corresponding controls (Table 1). The mean number of number of eggs laid by females was also not effected. However, there was a significantly different developmental time as well as an increase in larval mortality at the 4:4 density when compared to the control (df = 3, F = 14.5, P < 0.0001 (Table 1).

Wine Grape Study. Both larval and pupal mortality of SWD was too high to determine any statistically significant interspecific interactions (Table 2). Mortality of AFF was significant; however emergence from grapes was higher numerically than that of SWD. No female SWD survived long enough to collect any oviposition data. AFF pupal volume did not decrease due to density.

Discussion

While the interactions of AFF larvae at the 4:4 density on the commercial media showed an increase in developmental days as well as an increase in larval mortality the resulting female SWD did not show a decrease in pupal volume. They also did not show a decrease in fecundity at the densities tested. Since pupal volume is directly correlated to the reproductive potential of female flies the interspecific competition study on media needs to be repeated until the egg/larval density effects pupal volume. The increase in developmental days may impact the number of generations a year in vineyards. This may be more important around harvest when populations explode. Delaying emergence by a couple days may give growers a larger window to harvest grapes. The mortality for SWD on grapes was significant with only 2-5% emerging as adults for the interspecific competition as well as for the controls. Pupal volume for both species decreased overall when compared to the flies reared on media. AFF survivorship rate around 20%, which correlates with field and laboratory findings in grapes from 2012 and 2013. This experiment needs to be repeated at lower densities to give a more accurate assessment of AFF larval competition with SWD. The high mortality of both fly species maybe due in part to the lack of nutrition available from the grapes. Even though grapes (~1.5g) weighed significantly more than the media cube (0.38g) the seed of the grape instead of flesh comprised most of the mass, which is not utilized as nutrition for fly development. Further testing involving an uneven density of egg/larvae for AFF and SWD interactions might also shine some insight into the interspecific competition of AFF and SWD. An increase of SWD mortality by AFF in the grapes maybe beneficial to growers by limiting the SWD populations in the field. If AFF follows every SWD oviposition wound and 80% of what emerges is AFF, which cannot oviposit into intact grapes, then the SWD populations should decrease. Therefore the amount of damaged clusters should also decrease or remain the same based upon the number of SWD females that emerge. Further studies need to be conducted to fully understand the changing ecology in Virginia vineyards.

Table 1. Table 1. Summary of interspecific density competition study between D. suzukii and Z. indianus on 0.38g commercial media at two different densities. Data only representative of SWD.

Substrate	Egg Density on Substrate	Mean Pupal Volume (mm^3)	Mean Developmental Time (days)	Mean Eggs Laid in Lifetime	Larval Mortality (%)	Pupal Mortality (%)
Media	2:2(SWD: AFF)	3.8 ± 0.12 f 3.3 ± 0.08 m	11.1 ± 0.08 f 11.0 ± 0.11 m	156 ± 26.1	23.3	17
	4 SWD Control	4.0 ± 0.11 f 3.5 ± 0.09 m	11.0 ± 0.0 f 10.7 ± 0.11 m	199.4 ± 30.7	31	0
	4:4(SWD: AFF)	4.1± 0.13 f 3.6± 0.1 m	11.2 ± 0.1 f* 11.1 ± 0.13 m*	206.8 ± 31.2	35*	25.6
	8 SWD Control	3.9± 0.1 f 3.6± 0.1 m	10.5 ± 0.13 f 10.2 ± 0.17 m	181.0 ± 34.0	15	24.5

Table 2. Summary of interspecific density competition study between *D. suzukii* and *Z. indianus* on a single Petit Verdot grape.

Substrate	Larval Density on Substrate	Fly Species	Mean Pupal Volume(mm^3)	Mean Developmental Time (days)	Mean Eggs Laid in Lifetime	Larval Mortality (%)	Pupal Mortality (%)	Total Mortality (%)
Petit Verdot Grape	4:4(SWD: AFF)	SWD	2.9 Sexes combined	N/A	N/A	97.5	100	100
		AFF	2.9 ± 0.1	16 ± 1.5	N/A	80.0	12.5	82.5
	8 SWD Control	SWD	2.9 Sexes combined	11 (2 female, 1 male)	N/A	87.5	60	95
	8:8(SWD: AFF)	SWD	2.6 Sexes combined	11 (1 female)	N/A	95	75	98.8
		AFF	3.01 ± 0.19	14.4 ± 0.6	N/A	70	37.7	81.3
	16 SWD Control	SWD	2.9 Sexes combined	14 (1 male)	N/A	97	80	99.4

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SENTINEL TRAPPING FOR PARASITOIDS OF SPOTTED WING DROSOPHILA (*DROSOPHILA SUZUKII*) IN VIRGINIA FRUIT CROPS

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Since its introduction to North America in 2008, spotted wing drosophila (SWD) has become a widespread economic pest of small fruits including caneberries, cherries, blueberries, and grapes [Pfeiffer 2012, Walsh et al. 2011]. Biological control research will be important in developing an effective pest management program for SWD. Hymenopteran parasitoids hold potential value for biological control, including classical biological control. Before classical biological control can be implemented, it is essential to study the community of natural enemies that is already present in the invaded system. This research aims to determine which parasitoids of drosophilids are present in Virginia fruit crops, and if any can successfully attack SWD in the field.

In order to sample for local parasitoids, sentinel traps were developed using modified deli containers. Each trap held two Petri dishes, one baited with *Drosophila* rearing media and one baited with seasonal fruit. In the laboratory, the baits were pre-infested with several hundred *Drosophila* larvae, either SWD (*D. suzukii*) or *D. melanogaster*, or were left uninfested as a control. Each field site had 6 traps: two pre-infested with *D. suzukii*, two pre-infested with *D. melanogaster*, and two controls. Table 1 shows date ranges and number of trapping days per trap in each crop type. Bait dishes were left in the field for 3-7 days, and then brought back to the laboratory where larvae were reared to adulthood. Emerged adult flies and parasitoids were collected and preserved in 70% ethyl alcohol.

TABLE 1. Date range and trapping days of *Drosophila* parasitoid sentinel traps in Virginia fruit crops.

Crop Type	**Date Range (2014)**	**Trapping Days (per trap)**
Cherry	6/10 - 6/24	14
Caneberry		
Site 1	7/8 - 9/9	25
Site 2	7/10 - 10/3	31
Blueberry	8/14 - 9/26	21
Grape		
Site 1	9/12 - 9/24	10
Site 2	9/26 - 10/14	14
Total	6/10 - 10/14	115

By the end of the 2014 field season, three parasitoid species representing families Figitidae, Braconidae, and Pteromalidae were reared from sentinel traps. Of the figitids, 61 were reared from cherry bait in the cherry orchard, and 154 were reared from caneberry bait in a caneberry field. A total of four braconids were also reared from caneberry bait in the same caneberry field. In addition, 37 pteromalids were reared from banana bait in the blueberry farm. All parasitoids were reared from *D. melanogaster* or, possibly, from native parasitoids that had infested baits while in the field. No parasitoids were reared from dishes with rearing media, blueberry bait, or grape bait.

Parasitoids were not reared from SWD, possibly due to SWD's higher hemocyte load (up to five times more than that of *D. melanogaster*), which is associated with an advanced resistance to parasitization [Kacsoh & Schlenke 2012]. The grape baits were largely eaten by yellow jackets, which likely explains why no parasitoids were reared from grape baits, but it remains unknown why no parasitoids were reared from blueberry baits.

Parasitoids collected from this study will soon have species identification. In addition to another field season of sentinel trapping, future research will evaluate the ability of these parasitoids to attack SWD and *D. melanogaster* in controlled laboratory conditions. Furthermore, future research will determine how parasitoids of drosophilids respond to different fruit volatiles – do parasitoids find particular fruit volatiles more attractive than others?

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DEVELOPING ATTRACT AND KILL STRATEGIES OF THE SPOTTED WING DROSOPHILA FOR ORGANIC RASPBERRY PRODUCTION, *DROSOPHILA SUZUKII* MATSUMARA (*DIPTERA*: *DROSOPHILIDAE*).

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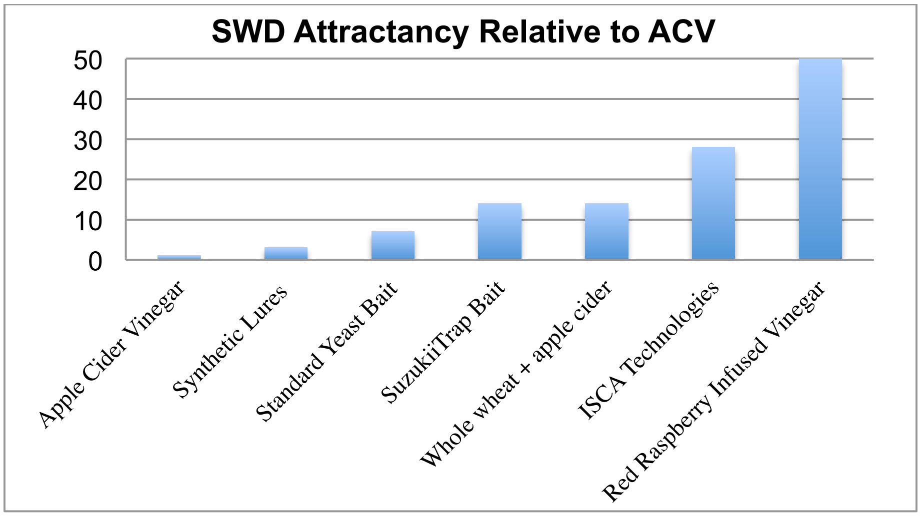
The Spotted Wing Drosophila, *Drosophila suzukii* Matsumara (SWD) has become a key pest of NY small fruit since first detected in 2011. Estimated losses in 2012 exceeded 1.3 million in blueberry alone. Yearly infestation levels of 40-100% fruit injury had been observed in un-sprayed berry by mid-August in commercial raspberry and blackberry plantings. Due to escalating SWD populations and the rapid severity of damage they cause as the season progresses, mid-late season management of summer and fall berries now requires intensive insecticide programs. Small fruit growers must employ a 3-4 day application interval for commercial market acceptability of fruit, initiated upon first trap capture of the adult. This level of committed management has forced many farmers, especially those using organic production systems, to reduce or eliminate late season berry production.

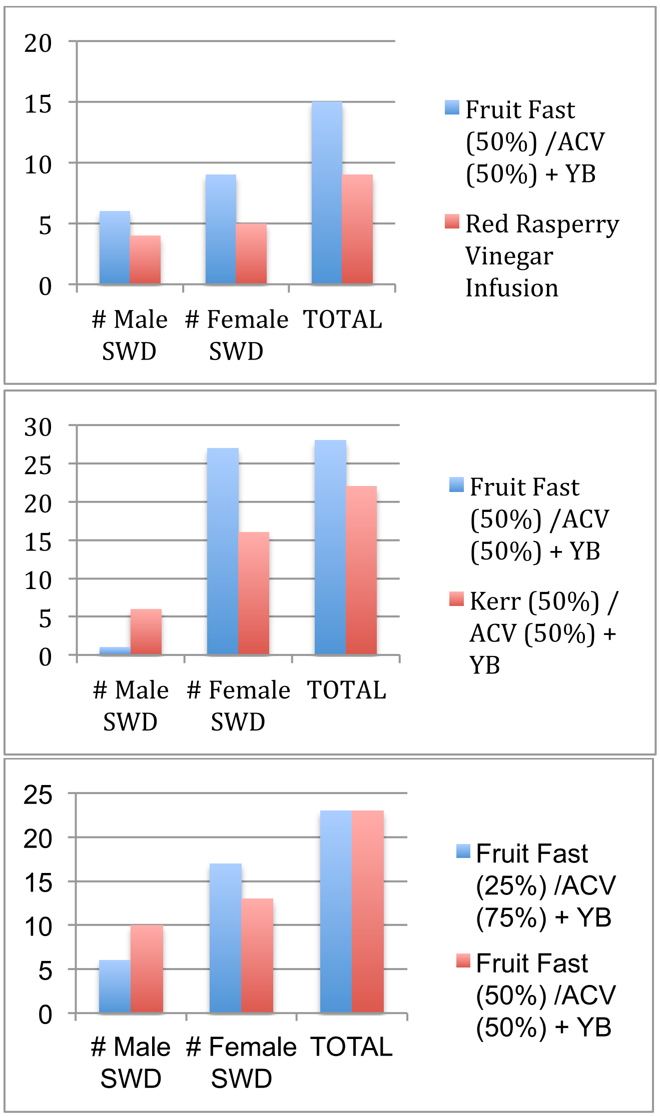
Alternative approaches to managing the SWD are being studied to reduce the need for intensified pesticide use in conventional and organic small fruit production systems. One approach we are evaluating aims to reduce SWD adult populations through the use of Attract and Kill (ATK) bait station. In studies to determine the attractiveness of volatiles used as lures for monitoring SWD in the field using a scale of 0 to 50, the highest level of attractiveness was found to be the red raspberry infusion [1] (Graph 1). Initial laboratory studies of different baits to determine the level of attraction between bait using 20 to 30 mature SWD adult flies introduced to 'Bug Dorm Rearing Cages' (BioQuip) in binary choice tests over a 24-hour period. Comparisons were made of ATK solution using two brands of red raspberry concentrate (RRC) (Fruitfast® & Kerr®) with apple cider vinegar (ACV) and brewers yeast (YB) absorbed by super absorbent polymer crystals (SAP) (SoilMoist®) placed in a 50 x 9 mm petri dish (Corning; brand Falcon®) to red raspberry infusion (RRI) alone. The RRI demonstrated comparable attractiveness to SWD adults as the RRI in both 50:50 and 25:75 dilutions of RRC : ACV (Graph 2). In a second trial, 1000 mL of ATK solution was added to 0.51uL of the insecticide Entrust EC (spinosad), SAP and Gelatin crystals layered over a 4" circumference netted disk (PAK Unlimited 'Blockade' Insect Netting 36 x 25 mils) in a 4" petri dish, allowed to dry (SAP Station). In this study SAP Stations were assayed for residual efficacy, comparing the attraction of wicked supplied sugar water to SAP gel stations that had been freshly made and or sealed and opened, rehydrated, dried for 5, 7, 12, 19 and 26 days, All of which show comparable degree of mortality after 4 hour feeding intervals (Graph 3).

Attract and kill field applications were made in one site in Accord, NY using inverted clear 4 oz. plastic cups covered with red and black electrical tape allowing 1" opening to suspended lid attached to the top wire of 7 rows, 290' in length with 10' row spacing of red raspberry var. 'Prelude'. On 9 August, 2014, 3 oz. dose of SAP per station was placed at 20' intervals replenished weekly throughout the season totaling 100 per 0.4 A. An 8' x 14' net (PAK

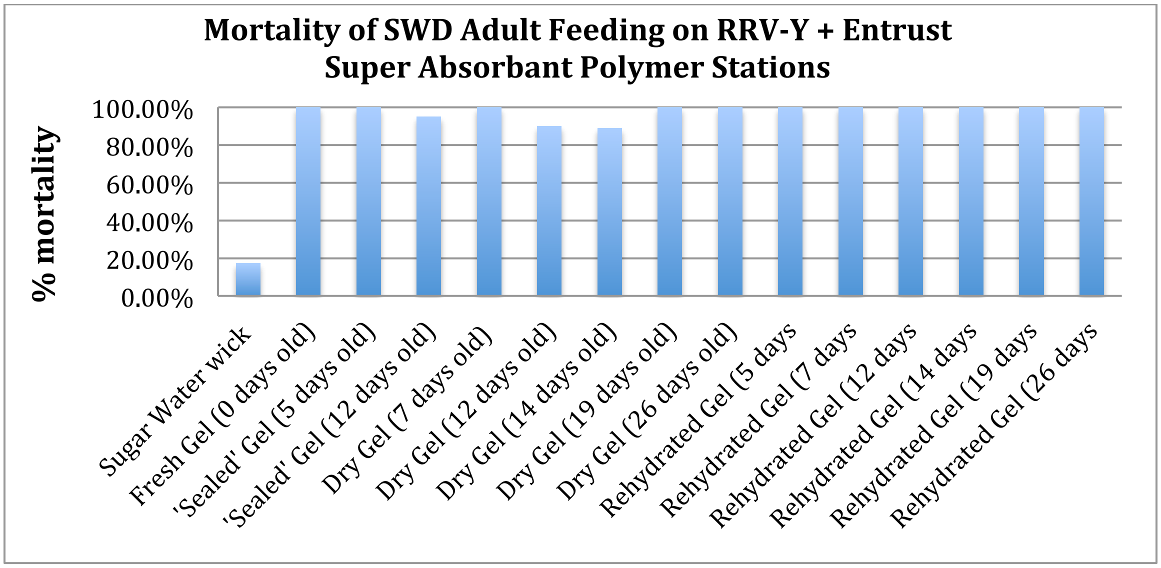
Unlimited ‘Blockade’ Insect Netting 36 x 25 mils) was placed along the south end of the berry patch, 40’ from the crop, positioned on existing deer fencing along the wooded edge, sprayed weekly with ATK solution and the high dilute labeled field rate of Bifenthrin to intercept migrating adult SWD. Assessments of traps placed along the wooded edge, crop edge and crop interior combined with fruit assessments for percent infestation and SWD eggs or larva per gram fruit weight were monitored (Graph 4). Infestation levels did not exceed 30% where in previous years suffered 100% injury during the 2012-13 seasons. As late emergence of SWD provided lower levels of fruit injury, further testing with higher density and tighter spacing of SAP stations should be employed to test this approach in years of high SWD infestation before recommendations for use is made.



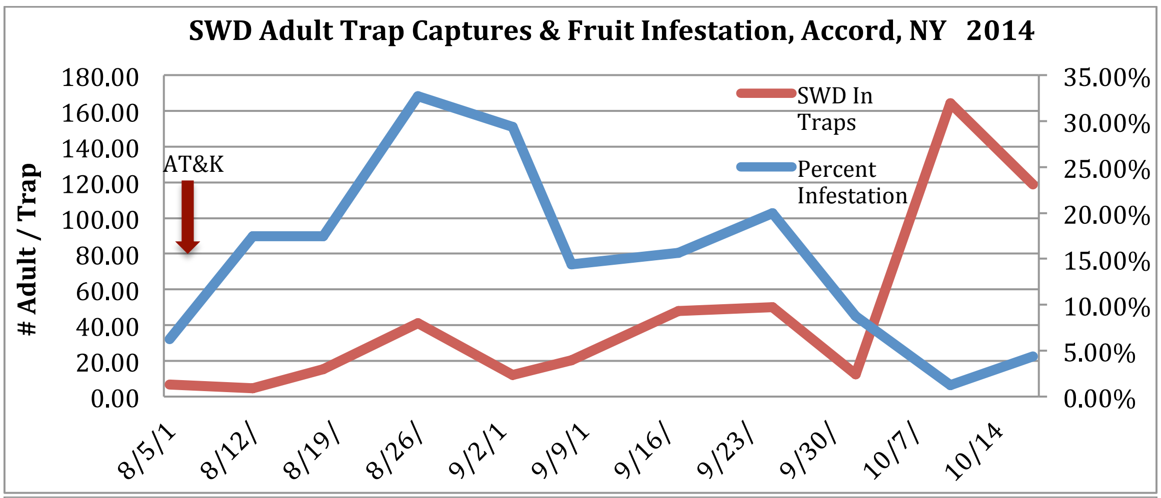
Graph 1 Attractiveness of SWD to lure types.

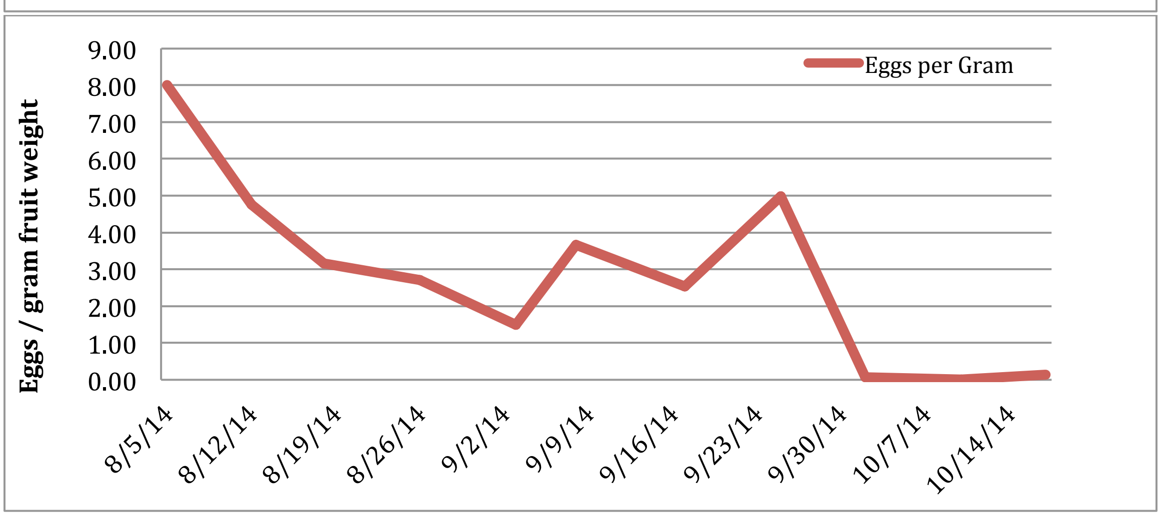


Graph 2. Baits assessment to determine SWD attraction.



Graph 3. Baits assessment to determine SWD attraction.





Graph 4. Field monitoring for SWD Adults and assessment for fruit injury.

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A fixed-spray system for Spotted Wing Drosophila management in high tunnel raspberries

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Spotted wing drosophila (SWD) represents a serious challenge for fruit growers in the Northeast and elsewhere. Later maturing berries, such as blueberries, fall raspberries and day-neutral strawberries, appear to be especially vulnerable. Raspberries grown in high tunnels are particularly vulnerable to SWD. The invasion of SWD has forced raspberry growers to dramatically increase insecticide applications to produce marketable fruit, an especially significant logistical challenge for high tunnel production. Pesticides are the only practical management tools currently available to growers. To achieve a reasonable level of control, they need to be applied frequently (5–7-day spray intervals) over a long harvest period. These repeated insecticide applications are expensive (fuel and operator expenses plus the pesticides), time-consuming and sometimes not fully effective. Moreover, operating application equipment in the high tunnel environment can be very challenging. Previous work has been done in tree fruits using irrigation-type tubing fitted with greenhouse microsprinklers to deliver pesticide sprays directly to the crop canopy from a centralized pump. The supply lines are fixed on support wires within or above the canopy to optimize spray delivery and coverage.

A fixed system to apply insecticides may help mitigate a number of pest management problems in high tunnel production. Fixed sprayer systems may be particularly cost-effective in high tunnels, as the framework to support the fixed lines is already present. A fixed sprayer system would save time in the application of insecticides compared with using conventional application equipment (e.g., a backpack sprayer). Coverage, and therefore effectiveness, may also be improved with a fixed system.

In mid-July 2013, an arrangement of fixed tubing and nozzles for pesticide application was installed in each of three high tunnel (HT) systems currently under bramble production in NY: a high tunnel raspberry research planting at the NYS Agricultural Experiment Station in Geneva, a blackberry research planting at the Cornell Horticulture high tunnels in Ithaca, and a high tunnel raspberry operation at Stonewall Hill Farm (Dale Ila Riggs), in Stephentown, NY. The main supply lines consisted of 3/4" polyethylene irrigation tubing strung above the planted rows, and affixed to the cross-struts of the HT structure using cable ties, with 1/4" micro-tubing drop lines suspended down to the plant canopy every 5' along each side of the row. Each drop line was fitted with a Netafim DAN 7000 series microsprinkler with an 8-mm orifice and a flat circular pattern spreader; each unit contained a 20-psi check valve. All supply lines were connected to a PVC manifold (mounted on a board near the HT entrance) fitted with an individual pressure gauge and ball valve for each line; the manifold in turn was connected to a portable wheeled greenhouse sprayer (Rear's Nifty Nursery-Cart model) with a 25-gal tank and a 3 HP gasoline motor powering a diaphragm pump. Each tunnel consisted of three planted rows, ranging from 100–120 ft in length; only a single line was operated at a time in order to optimize spray pressure along the extent of the line.

During the last week of July, SWD adult traps were deployed adjacent to the HT systems at each site to get an indication of local population pressure near each planting. Traps were plastic deli cups containing a fermented yeast+flour mixture, with apple cider vinegar as a drowning medium. Numbers of SWD adults captured were very low initially and began to increase starting in mid-August; however, to protect the fruit from attack by undetected SWD females, preventive insecticide treatments were also started at the end of July. The two principal products used were Delegate [spinetoram] (3–6 oz/A) and Assail [thiamethoxam] (5 oz/A), to each of which was added 2 lb sugar/100 gal as a feeding stimulant. Sprays were applied weekly from 29 July through 23 September. All applications were made at dusk to minimize exposure to foraging bees.

To assess efficacy of the insecticide treatments in preventing SWD fruit infestation, samples of maturing fruit were taken weekly beginning the first week of August, and held at room temperature in the lab to rear out any larvae in the fruit to the adult stage. Numbers of samples taken ranged from 8-13 per site, each consisting of 10–20 berries (~50–100 g total), taken from both the fixed spray planting and a check planting at each site. At Stephentown, a commercial site where ripe fruit was picked nearly daily, there were generally low numbers of flies reared from the fruit, with no major difference between the fixed spray and backpack sprayer treatments. At the Geneva HT system, twice as many flies were obtained from backpack-treated fruits as at the commercial site, and 5 times as many from the fixed spray treatment. The Ithaca HT blackberries had the highest SWD adult emergence: 8 times more in the fixed spray treatment than the commercial site, and numbers comparable to Geneva in the backpack treatment (e.g., twice as many as the commercial planting).

On 25 Sept, to measure spray deposition from the system in the fully developed canopy, water-sensitive cards were stapled onto the leaves on the outside portion of the row as well as in the inside center of the canopy, both on the leaf tops and undersides, and on the left and right side of candidate rows. The system was run for 30 seconds with water only, and video imaging software was used to assess average card coverage. Results showed that spray coverage was highly variable, but predictably best on the outside of the canopy, and markedly better on the tops of the leaves (40-100% coverage, above the average seen in field trials) than on the undersides (1-26%). Cards in the inside center of the canopy were less well covered (16-67% on leaf tops, still acceptable levels; 1-8% on undersides).

In 2014, these trials were repeated at the Stephenstown commercial farm, following the installation of a center overhead line to improve coverage to the insides of the rows. Another modification made at this site was the incorporation of an air compressor to blow residual spray solution out of the system following an application. The numbers of emerged SWD adults from the fruit samples were at the same general levels as in 2013, varying from 0.05-0.28 insects per berry, with higher levels often (but not uniformly) observed in the fixed spray treatment; statistical analyses have not yet been conducted on these data.

We believe that the availability of a fixed sprayer system could make growing high tunnel raspberries more feasible in the age of SWD. Fixed sprayer systems may also prove practical for smaller field plantings of high-value blueberries and raspberries. Importantly, the adoption of fixed sprayer systems for berry crops will reduce grower exposure to insecticides, as there will not be a need to travel through the planting to apply them.

Acknowledgments
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Update on the Cornell Apple Insecticide Selection Tool

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Apple growers face difficult decisions when trying to balance their need for effective insect control with cost and marketing constraints. This is not a straightforward process because the choice of an insecticide is complicated by various use restrictions, the presence of beneficial insects, production parameters, and marketing issues. To assist growers in choosing between their various management options, an insecticide selection tool that incorporates IPM guidelines would also be very helpful. Such a tool would generate least cost options that are subject to constraints such as rotation of pesticides for resistance management and pre-harvest intervals as well as other types of user imposed constraints. This type of tool would be useful both for in-season decision making and pre-season planning that would allow growers to better benefit from bulk discounts.

Similar efforts in the past to develop least-cost tools for pesticide use have involved the use of complex mathematical programming models. An example of this type of work was done by Olsen, Harper, and Curran (1996) using an integer programming model that selected least cost herbicide programs for corn (and soybean; unpublished). By selecting the weed species to be controlled and the level of control desired, customized herbicide programs were generated. The models also accounted for crop rotation and tillage practices and for changes in the minimum level of control desired for an individual weed species or set of weeds. The major problem with this type of approach is that it requires the use of expensive proprietary mathematical programming software to generate solutions, so it was never intended as tool to be used directly by farmers.

Current spray recommendations for New York State found in the *Cornell Pest Management Guidelines for Commercial Tree Fruit Production* provide fruit growers with a wealth of information including labelled rates, pre-harvest intervals, re-entry restrictions, and a judgment of the efficacy of each alternative. The challenge is to develop a planning tool that will help New York apple growers select insecticides that take into account these types of constraints while also being readily accessible and user-friendly. Because the idea is to develop a tool that will be available without the need for complex, proprietary software, Microsoft Excel is chosen as the basis for the apple insecticide selection tool. Users have the option to change the default price list and select attributes that reflect their production environment. Macros written in Visual Basic for Applications (VBA) then perform the necessary calculations, execute various sorting algorithms, and implement certain heuristic decision rules to come up with a least-cost solution. The efficacy data used in the apple insecticide selection tool was obtained from the 2014 Cornell Pest Management Guidelines for Commercial Tree Fruit Production (Table 7.1.1 Activity spectrum of pome fruit insecticides and acaricides, p. 63-64). The efficacy data is based on a 4-point scale, where 0 = not effective, 1 =poor, 2 = fair, and 3 = good. The list of insecticides and acaricides labelled for use in New York and their range of rates was also obtained from 2014 Cornell Pest Management Guidelines for Commercial Tree Fruit Production (Table 11.1.1 Pesticide Spray Table–Apples, p. 113-142).

Specifically, the apple insecticide decision tool:

1) allows the user to specify whether they:
   a) can use restricted use pesticides,
   b) are located on Long Island (where certain insecticides are not labeled),
   c) wish to only consider materials that are OMRI approved,
   d) want to only use materials that are considered "low risk" (reduced risk, mating disruption, oil, bT etc.),
   e) want to exclude organophosphates from consideration,

2) allows the user to select the minimum level of control desired based on selection of:
   a) insecticides with at least fair (moderate) efficacy or
   b) insecticides with the highest level of efficacy available,

3) allows user to select the insecticide application level (lowest, mid-point, or highest based on the range of labeled rates), and

4) has a default price list of insecticide costs that can be adjusted by user.

The format of the user input section of the tool can be seen in Figure 1 (the actual pesticide list is 75 lines long). Clicking on the "Calculate results" box transfers data, calculates costs, and initiates the various sorting algorithms and decision heuristics (programmed in VBA) to select the least cost option given the user's inputs in 1-4. The insecticide selection tool also uses IRAC codes (listed in Table 7.1.1 of the *Cornell Pest Management Guidelines for Commercial Tree Fruit Production*) to evaluate consecutive sprays to minimize potential resistance and constrains summer sprays based on a user selected pre-harvest interval.

An example of the output from the insecticide selection tool can be found in Figure 2 (the actual output is 19 columns wide and 156 rows long). Least-cost options are generated each management scenario by pest and stage of development/time of season based on the user specified rate and efficacy level. The next cheapest alternative with a different IRAC code is also generated for each pest for each management scenario for subsequent summer sprays to encourage the user to rotate pesticides to minimize potential resistance. Choice of the insecticides for later summer sprays are constrained based on pre-harvest intervals specified by the user.

This decision making tool could be used to develop a similar selection tool for apple fungicides. Efficacy data is available is also available for fungicides in New York based on a 5-point scale, where 0 = none, 1 = slight, 2 = fair, 3 = good, and 4 = excellent (*2014 Cornell Pest Management Guidelines for Commercial Tree Fruit Production*, Table 6.1.1. Activity spectrum of apple fungicides, p. 55-56). It could also be used to develop similar pesticide selection tools for other states (for example, Pennsylvania has efficacy data for both insecticides/miticides and fungicides; *Pennsylvania 2014-2015 Tree Fruit Production Guide*, Table 4-6. Apples: Insecticide and miticide efficacy and Table 4-8. Apples: Fungicide efficacy). This approach could also be used for other fruit crops (for example, peaches and pears) or any other crops with efficacy data (vegetables).

The planned date for making the apple insecticide selection tool available to the growers depends on several issues including what the final format will be (for example, as web pages or as a downloadable Excel file). If anyone is interested, the current version of the tool can be obtained from the author (contact Jayson Harper at jkh4@psu.edu); any comments for further improvements or adaptations would be appreciated. It is anticipated that additional improvements will be made to the basic structure of the selection tool to streamline the sorting procedures and potentially make it more adaptable for other crops and other states.

References:

2014 Cornell Pest Management Guidelines for Commercial Tree Fruit Production. Pesticide Management Education Program, Cornell University, 2013.

Olsen, J.R., J.K. Harper, and W.S. Curran. "Selecting Cost-Minimizing Herbicide Programs for Corn (Zea mays)." *Weed Technology* 10(1996): 327-336.

Pennsylvania 2014-2015 Tree Fruit Production Guide. Penn State Cooperative Extension, 2013.

Figure 1. Example of the user input section of the Cornell Apple Insecticide Section Tool.

Click boxes:

- Instructions
- CALCULATE RESULTS

Management scenarios evaluated:

1) Any insecticide (including restricted use materials)
2) No restricted-use pesticides
3) Pesticides approved for use on Long Island only
4) OMRI approved pesticides only
5) Reduced risk/low impact insecticides only
6) Non-OP insecticides only

Application Rate:

- ◉ Low
- ○ Mid
- ○ High

Efficacy desired:

- ◉ Moderate minimum
- ○ Highest available

Pre-harvest interval: 14

Trade Name	Active ingredient	unit	Default Price per unit	Your price per unit	Price to use for analysis	Reduced Risk/Low Impact?	OP?
Acramite 50WS	bifenazate	lb	$65.98	$0.00	$65.98	N	N
Actara 25WDG	thiamethoxam	oz	$3.42	$0.00	$3.42	Y	N
Admire Pro 4.6SC	imidacloprid	oz	$2.68	$0.00	$2.68	N	N
Agree 3.8WS	*Bacillus thuringiensis*	lb	$13.00	$0.00	$13.00	Y	N
Agri-Flex SC	abamectin/thiamethoxam	oz	$3.84	$0.00	$3.84	N	N
Agri-Mek 8SC	abamectin	oz	$4.55	$0.00	$4.55	N	N
Altacor 35WDG	chlorantraniliprole	pt	$12.50	$0.00	$12.50	Y	N
Ambush 25WP	permethrin	oz	$0.45	$0.00	$0.45	N	N
Apollo 4SC	clofentezine	oz	$5.40	$0.00	$5.40	Y	N
Asana XL 0.66EC	esfenvalerate	oz	$0.56	$0.00	$0.56	N	N
Assail 30SG	acetamiprid	oz	$4.61	$0.00	$4.61	Y	N
Avaunt 30WDG	indoxacarb	oz	$6.35	$0.00	$6.35	Y	N
Aza-Direct 1.2L	azadirachtin	oz	$1.65	$0.00	$1.65	Y	N
Azatin XL 0.27EC	azadirachtin	oz	$3.00	$0.00	$3.00	Y	N
Baythroid XL 1EC	cyfluthrin	oz	$1.37	$0.00	$1.37	N	N
Beleaf 50SG	flonicamid	oz	$10.05	$0.00	$10.05	Y	N
Belt 4SC	flubendiamide	oz	$6.73	$0.00	$6.73	Y	N
Biobit XL 2.1FC	*Bacillus thuringiensis*	lb	$12.75	$0.00	$12.75	Y	N
Calypso 4F	thiacloprid	oz	$5.26	$0.00	$5.26	Y	N
Carpovirusine 0.99SC	granulosis virus	qt	$277.00	$0.00	$277.00	Y	N
Centaur 0.7WDG	buprofezin	oz	$2.43	$0.00	$2.43	Y	N

Figure 2. Example of the results reported by the Cornell Apple Insecticide Section Tool.

Moderate efficacy minimum, lowest labeled rate	Any insecticide (including restricted use materials)	cost/A	Efficacy	No restricted use insecticides	cost/A	Efficacy	Insecticides approved for use on Long Island	cost/A	Efficacy
Additional Summer sprays									
American plum borer	*Lorsban 4EC	$25.48	High	Assail 30SG	$36.88	Moderate	*Lorsban 4EC	$25.48	High
Apple aphid, Spirea aphid	*Asana XL 0.66EC	$2.69	High	Assail 30SG	$11.53	High	*Asana XL 0.66EC	$2.69	High
Apple maggot	*Baythroid XL 1EC	$3.29	High	§Surround 95WP	$23.75	Moderate	*Baythroid XL 1EC	$3.29	High
Apple rust mite	†Nexter 75WS	$11.44	Moderate	†Nexter 75WS	$11.44	Moderate	Portal 0.4EC	$13.96	High
Climbing cutworms: Darksided, Dingy, Mottled, Spotted, Variegated	§Dipel 10.3DF	$6.38	Moderate	§Dipel 10.3DF	$6.38	Moderate	§Dipel 10.3DF	$6.38	Moderate
Codling moth	*Baythroid XL 1EC	$2.74	Moderate	§Dipel 10.3DF	$6.38	Moderate	*Baythroid XL 1EC	$2.74	Moderate
Comstock mealybug	Portal 0.4EC	$13.96	High	Portal 0.4EC	$13.96	High	Portal 0.4EC	$13.96	High
Dogwood borer	*Lorsban 4EC	$25.48	High	Assail 30SG	$36.88	Moderate	*Lorsban 4EC	$25.48	High
European corn borer	§Dipel 10.3DF	$6.38	Moderate	§Dipel 10.3DF	$6.38	Moderate	§Dipel 10.3DF	$6.38	Moderate
European red mite	*Vendex 50WP	$1.56	Moderate	†Nexter 75WS	$9.68	High	*Vendex 50WP	$1.56	Moderate
Japanese beetle	†*Endigo ZC	$9.85	High	Sevin 4F	$20.63	High	Sevin 4F	$20.63	High
Lesser appleworm	*Asana XL 0.66EC	$2.69	High	§Entrust 80WP	$8.48	Moderate	*Asana XL 0.66EC	$2.69	High
Obliquebanded leafroller	*Asana XL 0.66EC	$2.69	Moderate	§Javelin 7.5WDG	$6.00	Moderate	*Asana XL 0.66EC	$2.69	Moderate
Oriental fruit moth	*Asana XL 0.66EC	$2.69	High	§Entrust 80WP	$8.48	Moderate	*Asana XL 0.66EC	$2.69	High
Oystershell scale	Sevin 4F	$20.63	High	Sevin 4F	$20.63	High	Sevin 4F	$20.63	High
Plum curculio	*Warrior II 2.08EC	$3.02	Moderate	Sevin 4F	$20.63	Moderate	*Warrior II 2.08EC	$3.02	Moderate
Redbanded leafroller	*Baythroid XL 1EC	$3.29	High	§Javelin 7.5WDG	$6.00	High	*Baythroid XL 1EC	$3.29	High
San Jose scale	*Leverage 360	$4.85	Moderate	Esteem 35WP	$35.92	High	*Leverage 360	$4.85	Moderate

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AN UPDATE ON GRAPEVINE VIRUSES IN VIRGINIA AND VECTOR MANAGEMENT STRATEGIES

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Among perennial crop worldwide, the most number of viruses (> 60) have been detected from grapevines (Martelli & Boudon-Padieu, 2006; Rayapati, 2012). A majority of these viruses are considered as minor threats to production, in that they either display less economic significance or have limited geographical distribution; however, there are several viruses that are considered a major threat due to high economic importance (Martelli & Boudon-Padieu, 2006; Rayapati, 2012). Examples being the grapevine leafroll complex, rugose wood complex, degeneration/decline disease complex, and fleck disease complex (Martelli & Boudon-Padieu, 2006). Insect vectors transmit many of these diseases, and mealybugs (Pseudococcidae) and scale insects (Coccidae) are known to transmit grapevine leafroll disease (Tsai, Rowhani, Golino, Daane, & Almeida, 2010). mealybugs have been found in many sites in Virginia. Recognizing the impacts of virus diseases, many grapevine-growing regions of the United States have implemented virus surveys and vector research to document the presence and spread of viruses in vineyards. Until recently, very limited information has been available about grapevine viruses and associated vectors in Virginia vineyards.

A statewide survey of commercial vineyards in Virginia (VA), USA and surrounding states was recently conducted during 2009 through 2014 seasons for the presence of fourteen grapevine viruses: Grapevine leafroll-associated virus (GLRaV)-1, -2, -3, -4, -4 strain 5, -4 strain 9, Grapevine rupestris stem pitting associated virus (GRSPaV), Grapevine virus A (GVA), Grapevine virus B (GVB), Grapevine fleck virus (GFkV), Tomato ringspot virus (ToRSV), Grapevine Pinot gris virus (GpgV), Grapevine vein clearing virus (GVCV), and Grapevine red blotch associated virus (GRBaV). Random petiole samples were collected from different locations on a vine (e.g. petioles from random shoots on the vine all over the canopy, including the top, middle, bottom and edges) and pooled for testing from vineyards in Virginia and surrounding states. The petiole samples were sealed in a plastic bag and stored in a cooler containing ice. In the lab, 0.25 g of each sample was placed into grinding bags (BIOREBA, Switzerland) containing 5 ml of a filter-sterilized grapevine extraction buffer (1.59 g/liter Na_2CO_3, 2.93 g/liter $NaHCO_3$, 2% Polyvinylpyrrolidone-40, 0.2% Bovine Serum Albumin, and 0.05% Tween 20) (Sigma-Aldrich Co. LLC, St. Louis, MO), and ground using a mechanical grinder (BIOREBA, Switzerland, Homex 6 [115V]). Crude extracts were then transferred into 1.5-ml microcentrifuge tubes and stored at -80°C until used in a one-tube one step RT-PCR and PCR methods using primers and conditions specific for each virus (Al Rwahnih et al., 2013; Naidu & Mekuria, 2010; Osman, Leutenegger, Golino, & Rowhani, 2007; Zhang, Singh, Kaur, & Qiu, 2011). Out of 722 grapevine samples, GLRaV-1, GLRaV-2, GLRaV-3, GLRaV-4, GLRaV-4 strain 5, GLRaV-4 strain 9, GRSPaV, GVA, GVB, and GFkV were detected in 2, 9, 23, 0.8, 0.4, 0.4, 51, 4, 2, and 0.8%, respectively. Out of 574 grapevine samples tested so far, ToRSV was detected in 1.5% and GRBaV in 22%. No samples tested positive for GPgV or GVCV.

To complement the survey, multiple field trials testing efficacy of foliar-application of insecticidal treatments to either prevent the spread of mealybugs and associated viruses within a field and/or knock back the population were implemented. One commercial vineyard site in Orange, VA consisted of a single row of Chardonnay and examined the effects of Acetamiprid (Assail 2 oz/A) and M-Pede (insecticidal soap) to control existing mealybug population during the 2013 and 2014 seasons. In 2013, there were no significant differences ($P<0.05$) found between the treatments or the control. Another site, a research vineyard at the AHS Jr. AREC in Winchester, VA, containing healthy young vines interplanted with old, GLRaV-3 positive vines. Dinotefuran (Movento 6 oz/A) and ß-cyfluthrin (Baythroid 3 oz/A) were examined; however, it resulted spreads of GLRaV-3 to the healthy vines during the 2012, 2013, and 2014 seasons. In all three seasons, control and Baythroid treated vines resulted in significantly higher populations of mealybugs ($P<0.05$) than the Movento treated vines. Mealybugs were first found moving to new, healthy vines in 2013 and by the end of 2014, all vines were positive for GLRaV-3. No evidence of mealybug movement to healthy, young vines with Movento treatment was witnessed; however, GLRaV-3 was transmitted to these vines, indicating that mealybugs in the field were very efficient on transmission of GLRaV-3.

To summarize, twelve of the fourteen viruses tested for are present in Virginia with GLRaV-3, GRBaV, and GRSPaV being the three most common viruses in mid-Atlantic states. With the high prevalence of virus infected vines, integrated pest management is critical to prevent the further spread of these viruses. Current results show promising control using new, systemic products like Movento; however, despite its effectiveness at controlling the vector, grapevine leafroll disease can be transmitted within a few years.

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THE OCCURRENCE AND DISTRIBUTION OF GRAPE-PATHOGENIC BOTRYOSPHAERIACEAE FUNGI IN NURSERY STOCKS

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Grapevine trunk disease caused by fungi in the Botryosphaeriaceae family is a growing concern in the wine industry and major cause of grapevine decline. As of 2013, there are at least 21 species in the Botryosphaeriaceae known to infect the xylem tissues of grapevines, causing a syndrome referred to as Botryosphaeria dieback or Botryosphaeria canker. Typical symptoms of this disease on perennial wood include brown streaking of grapevine wood underneath the bark and wedge-shaped areas of discolored, necrotic tissue visible in trunk cross-sections. Symptoms occurring on green tissues during the growing season include interveinal necrosis on leaves, leaf drop, shriveling of fruit, and shoot dieback. Botryosphaeria dieback often leads to early death of the vine.

Because it often takes several years after inoculation for Botryosphaeria dieback to show symptoms in grapevines, it can be hard to determine exactly from where the inoculum originated and how it was introduced to the vineyards. Due to the exposure of vascular tissues to the environment, pruning is considered a major route of exposure for this disease. In addition to annual pruning wounds, nursery vines are often of concern to growers, because widespread infection of vines might not be manifested for 5 or more years after planting. The nursery propagation process contains an inherent risk of trunk diseases due to the storage of large numbers of vine cuttings in close proximity to one another and the pruning wounds inflicted on the vines.

This report is an attempt to survey how widespread Botryosphaeria disease organisms are in grapevine nursery stocks commonly purchased by wine grape growers. Samples of nursery vine scion trunk wood, graft union wood, rootstock trunk wood, and rootstock root wood were obtained from 4 commercial nurseries in California and New York. DNA was extracted from each sample and a nested PCR protocol was used to selectively amplify DNA from Botryosphaeriaceae fungi.

Of 511 samples, 37 (7.24%) tested positive for grape-pathogenic Botryosphaeriaceae. There was no significant variation found in infection rate based on nursery, grape variety, rootstock, and sample location (scion wood, graft union, etc.). No significant differences in infection rates were observed between samples that had certified pathogen-free rootstock wood and those that did not. However, there were weakly significant differences between vines whose scion wood was certified pathogen-free and those whose scion wood was not certified pathogen free (p=0.07), with disease incidences of 7.24% and 13.58%, respectively, of 385 samples that had certification information. Based on this data, we do not have any strong indications of what factors are driving Botryosphaeria disease incidence in nursery grapevines. The relationship between certified pathogen-free grapevines and disease incidence is worthy of further examination, as it may be that pathogen-free propagation procedures are lowering Botryosphaeria disease incidence in nursery vines.

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CHARACTERIZING THE TIMING OF INFECTION OF RIPE ROT OF GRAPE, CAUSED BY *COLLETOTRICHUM ACUTATUM* AND *C. GLOEOSPORIOIDES*

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Ripe rot is a grape cluster rot that is endemic to Virginia and has been reported to cause up to 30% crop loss at harvest, with the potential to reduce the wine quality by producing off flavors. The causal fungal complexes, *Colletotrichum acutatum* and *C. gloeosporioides*, are part of a genus that commonly form latent infections on hosts. *C. acutatum* has been found to infect grape inflorescences and vegetative tissues on other host plants without initially causing symptoms. Before this disease can be controlled, the growth stages that are most vulnerable must be determined along with grape variety susceptibility.

The objectives of this study were to determine which cluster growth stages and varieties were the most susceptible to both *C. acutatum* and *C. gloeosporioides*. Experiments were conducted in the field and on potted plants in growth chambers at six different growth stages; bloom, bb-sized berries, pea-sized, berry touch, veriason, and two weeks before harvest. Four different varieties were tested in the field and as potted plants.

These experiments have been repeated over the 2012, 2013 and 2014 growing seasons. Cultures of *C. acutatum* and *C. gloeosporioides* were grown on an antibiotic-amended ¼-strength PDA for a week. Spores were harvested by flooding the surface of the media with sterile water, filtered through sterilized miracloth, and then concentration was adjusted to 1×10^5 by hemocytometer. In the field, the suspension of *C. acutatum* or *C. gloeosporioides* was applied by hand atomizer to 6-8 clusters of Cabernet Sauvignon, Cabernet Franc, Chardonnay, and Merlot at each of the growth stages. With Merlot and Chardonnay, this process was replicated five times down a row. Clusters were bagged with a wet paper towel for 24hrs. With the potted plants, the suspension of *C. acutatum* or *C. gloeosporioides* was applied by hand atomizer to 2-3 clusters (total of two plants) of Cabernet Sauvignon, Chardonnay, Merlot and Petit Verdot at each of the growth stages. Clusters were bagged with a wet paper towel and whole plants were placed in an environmental growth chamber at 25°C for 24hrs. Afterwards, plants were placed in a hoophouse to ripen fruit. At the end of the season, clusters were harvested and visually assessed for presence of ripe rot.

Preliminary results did show that grape clusters are susceptible from bloom until harvest and similar trends were found in the studies from 2012 and 2013 with no significant differences found between *C. acutatum* and *C. gloeosporioides* in the 2013 growing season. However there was a significant difference between the cluster maturities and grape varieties. Merlot and Petit Verdot were overall less susceptible to ripe rot while Chardonnay was overall the most susceptible out of the varieties tested. Significantly lower disease incidence was observed at berry touch in the field while in the potted vine study had lower incidence at bloom.

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A QUICK FUNGICIDE EFFICACY SCREENING FOR RIPE ROT PATHOGENS, *COLLETOTRICHUM ACUTATUM* AND *C. GLOEOSPORIOIDES,* USING ALAMARBLUE® DYE

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Ripe rot is a grape cluster rot that is endemic to Virginia and was generally regarded as a minor, late season disease. However, in recent years, ripe rot has been reported to cause up to 30% crop loss at harvest in certain Virginia vineyards. Since this was considered to be a minor pathogen, fungicides that are listed for control are limited for the causal fungal complexes, *Colletotrichum acutatum* and *C. gloeosporioides*. With the plethora of chemistries available for purchase, a quick, cost-effective method of screening potential fungicide controls is a very desirable research tool.

The objective of this study was to adapt an existing alamarBlue® (AB) dye assay for use with *C. acutatum* and *C. gloeosporioides* and nine different fungicide chemistries. Mycelia and spores were tested using a serial dilution (1000, 100, 10, 1, 0.1, 0.01 ppm) and an intermediate series (500, 300, 200, 150, 50, and 30 ppm) to provide a preliminary EC50 of each of the nine tested commercial formulation fungicides (Fig. 1).

Fungicide stocks of commercial formulations were made to 2000 ppm in 40% ethanol with the addition of salicylhydroxamic acid (SHAM) to Abound and sodium bicarbonate to Captan and Mettle to adjust the pH to 7. Immediately before use, stocks were diluted to double the final concentration using 2% potato dextrose (PD) broth. Plates were assembled using 100 µL fungicide and 100 µL 10^5 spore suspension for spore wells and 100 µL fungicide and 100 µL broth with aerial mycelia for mycelial wells. Broth negative controls and fungal positive controls were included for each fungicide. A separate fungicide-negative control plate was prepared to observe false positive reaction due to fungicide formulation. AB dye was added to each test well at 10% of the final solution. Plates were incubated in a moist chamber at 25°C in darkness for 48hrs. Visual assessments of plates were taken at 24 and 48 hrs to observe color change.

Preliminary results show that Endura (SDHI) and IKF-309 are not effective for controlling ripe rot. Although it showed efficacy with detached berry assay, Mettle (DMI) resulted in relatively high EC50 value. We speculate that this is potentially due to having to adjustment of the pH since Mettle has a low pH. This problem could be avoided using a different DMI fungicide. Overall, this AB assay is a cost effective and time efficient method of screening fungicide sensitivities to most conventional fungicides but can be prone to contamination.

Figure 1. Preliminary LD50 calculations

Trt #	Fungicide	Chemical name	FRAC code	PPM in field**	*C. acutatum* Mycelia	*C. acutatum* Spores	*C. gloeosporioides* Mycelia	*C. gloeosporioides* Spores
1	Abound	azoxystrobin	11 (QoI)	215.3	34.4	187.0	46.9	205.3
2	Captan 80	captan	M4	1922.2	103.8	40.7	59.4	30.2
3	Dithane	mancozeb	M3	1333.5	36.0	10.0	20.9	363.8
4	Topsin M	thiophanate-methyl	1 (Beta-tublin inhibitor)	841.0	215.2	143.6	257.8	210.1
5	Mettle	tetraconazole	3 (DMI)	36.0	24.3	**37.8**	**69.3**	**67.6**
6	Endura	boscalid	7 (SDHI)	420.5	**701.8**	**445.6**	**434.3**	**494.0**
7	Prophyt	phosphorous acid	33	3382.9	129.2	85.1	139.8	63.8
8	Champ	fixed copper	M1	2775.2	147.5	76.1	187.5	131.9
8*	Cueva	fixed copper	M1	2000.0	75.0	50.0	75.0	125.0
9	IKF-309	unknown	U8 (Actin Disruptor)	70.3	**316.4**	**377.9**	**301.9**	**494.0**

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Fungicide performance trials for control of powdery and downy mildew of grape in Winchester Virginia, 2014

Powdery mildew trial was conducted with 'Chardonnay' grapes planted in 2009, trained to a vertical shoot positioning (VSP) system with bilateral cordons, with a spacing of 5-ft between vines and 10-ft between rows. Plots consisted of three consecutive vines, and were arranged in a completely randomized block design among four blocks. Treatments were applied with a 4 gal backpack air sprayer, regulated to 21 psi by a CFValve system (GATE LLC) through a single boom with a flat fan nozzle (TeeJet 8003VS). The interval between applications was approximately 12-14 days (varying based on vine growth). Treatments were tank-mixed with Revus (7 floz/A) in order to suppress downy mildew infection. Prior to the experimental treatment, all vines were treated with Dithane 75DF (3 lb/A), Microthiol Disperss (3 lb/A), Rally (myclobutanil, 3.4 oz/A) to control various diseases. All treatments were applied four times according to the following interval: at-bloom (6 Jun), fruit set (19 Jun), pea-size (1 Jul), and final spray (17 Jul). In addition, an application of Vangard (8 oz/A) was applied at bloom (6 Jun) to all vines to control Botrytis blossom blight. Due to the rain events, there was a 16-day gap between the pea-size and final spray. Diseases were visually assessed five times during the season, and results from 14 Jul are shown. Of the three vines used for each treatment replication, outer cordons adjacent to the next treatment were not assessed in order to avoid recording effects from fungicide drift. Sixty leaves and thirty clusters were assessed per plot. These leaves and clusters were randomly selected, and the estimated percentage of infected area (disease severity) per leaf or per cluster and diseased tissue (disease incidence) were recorded. With four blocks, there were a total of 240 leaves and 120 clusters assessed per treatment. The linear mixed model was used to conduct the analysis of variance (SAS 9.3, SAS institute, Cary NC). Treatment was considered as a fixed effect, and block was considered as a random effect.

Bud break at Winchester was 1 May, and 50% bloom was 2 Jun. Relatively speaking, we received less amount of rain in 2014. The total amount of precipitation at Winchester was about 4.0 inches from bud break to bloom, followed by 2.3 and 2.9 inches of rain during June and July, respectively. Mean leaf disease incidence of powdery mildew varied from 1.7% to 47% and disease severity varied from 0.0% to 0.5%. Cluster disease incidence and severity varied from 41% to 100% and 0.5% to 59%, respectively. Treatment differences were highly significant ($P < 0.001$) on all disease measurements, and a good separation of treatment means was found. In general, disease intensity of all treatments were significantly lower than that of check (Revus only treatment), with an exception of cluster incidence where only Luna Tranquility resulted in significantly lower disease incidence than other treatments. As with the previous year, Luna Tranquility showed a very good control of powdery mildew in this trial. Other notable result was that SP2700 was not significantly different from Quintec with an exception on leaf disease incidence where SP2700 resulted in a significantly higher number.

		Leaf				Cluster			
Treatment[z]	Days after first application[y]	Incidence[x]		Severity[w]		Incidence[x]		Severity[w]	
Revus 8 fl oz only (Check)….	32, 45, 57	47.1	A	0.5	A	98.8	A	58.6	A
Sulfur 3 lb (Standard) ……….	32, 45, 57	19.2	C	0.2	BC	100.0	A	45.1	B
Quintec 4 fl oz ………….……	32, 45, 57	15.8	C	0.2	BC	100.0	A	11.2	C
SP2700 2.66 lb……………...	32, 45, 57	29.2	B	0.3	B	100.0	A	20.3	C
Luna Tranquility 16 fl oz …...	32, 45, 57	1.7	D	0.0	C	41.3	B	0.5	D

z All rates are calculated based on per acre bases using 100 gal of water. Unless it is noted, all treatment was tank mixed with mancozeb and Prophyt in order to prevent other diseases.

y First fungicide application was 12 May 2014. At day 28, all treatment received mancozeb + sulfur + myclobutanil as pre-treatment powdery mildew and black rot control. At day 31, all treatments received Vangard (8 oz/A) as Botrytis control

x Disease incidence = percentage of diseased leaves: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

w Disease severity = percentage of area of leaves or bunches diseased: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

Downy mildew trial was conducted with 'Merlot' grapes planted in 2009, trained to a vertical shoot positioning (VSP) system with bilateral cordons, with a spacing of 5-ft between vines and 10-ft between rows. Plots consisted of three consecutive vines, and were arranged in a completely randomized block design among four blocks. Treatments were applied with a 4 gal backpack air sprayer, regulated to 21 psi by a CFValve system (GATE LLC) through a single boom with a flat fan nozzle (TeeJet 8003VS). The interval between applications was approximately 12-14 days (varying based on vine growth). Treatments were tank-mixed with sulfur (3 lb/A) in order to suppress powdery mildew infection. Prior to the experimental treatment, all vines were treated with Dithane 75DF (3 lb/A), Microthiol Disperss (3 lb/A), Rally (myclobutanil, 3.4 oz/A) to control various diseases. All treatments were applied four times according to the following interval: at-bloom (10 Jun), fruit set (24 Jun), and pea-size (9 Jul). In addition, an application of Vangard (8 oz/A) was applied at bloom (10 Jun) to all vines to control Botrytis blossom blight. Diseases were visually assessed five times during the season, and results from 22 Jul are shown. Of the three vines used for each treatment replication, outer cordons adjacent to the next treatment were not assessed in order to avoid recording effects from fungicide drift. Sixty leaves and thirty clusters were assessed per plot. These leaves and clusters were randomly selected, and the estimated percentage of infected area (disease severity) per leaf or per cluster and diseased tissue (disease incidence) were recorded. With four blocks, there were a total of 240 leaves and 120 clusters assessed per treatment. The linear mixed model was used to conduct the analysis of variance (SAS 9.3, SAS institute, Cary NC). Treatment was considered as a fixed effect, and block was considered as a random effect.

Bud break at Winchester was 5 May, and 50% bloom was 10 Jun. Relatively speaking, we received less amount of rain in 2014 than a typical year. The total amount of precipitation at Winchester was about 4.0 inches from bud break to bloom, followed by 2.3 and 2.9 inches of rain during June and July, respectively. Probably because of a 10-day period from bloom where we did not receive any precipitations, we did not observe any downy mildew on cluster. Thus, we are reporting only leaf data. Leaf disease incidence ranged from 5% to 85% and leaf disease severity varied from 0% to 9%. Quintec alternated with Torino (check treatment) resulted in the highest disease incidence and severity as expected. Three numbered treatments SP2700, CX10470, and CX10250 by themselves were not significantly different from the check treatment in both leaf disease incidence and severity. Interestingly, although it was only one application in between two CX10470 applications, having a mancozeb application resulted in significant reduction in both leaf disease incidence and severity. CX10250 alternated with Double Nickel also resulted in significant reductions in both incidence and severity; however, the degree of the reductions was not as big as that of CX10470 alternated with mancozeb. Mildicut in high (40 fl oz) and low (35 fl oz) concentrations, Ranman with Silwet, and mancozeb in high (3 lb) and low (1.5 lb) concentrations all resulted in the same level of control of downy mildew.

		Leaf			
Treatment[z]	Days after first application[y]	Incidence[x]		Severity[w]	
Quintec 4 fl oz alt. with ………………	36, 64				
Torino 3.2 fl oz (Check) ………………	50	77.50	AB	8.81	AB
Mancozeb 3 lb (Standard) …….........	36, 50, 64	2.50	E	0.06	E
SP2700 2.66 lb ………………………..	36, 50, 64	72.50	BC	9.41	A
Ranman 2.75 fl oz with Silwet 2.0 fl oz	36, 50, 64	0.83	E	0.01	E
Mildicut 40 fl oz ……………….………	36, 50, 64	0.00	E	0.00	E
Mildicut 35 of oz ………………………	36, 50, 64	0.83	E	0.04	E
CX10470 1.75 pt ……………………….	36, 50, 64	64.17	CD	2.99	D
CX10470 1.75 pt alt. with ……….…..	36, 64				
Mancozeb 3 lb ……………….….……..	50	7.92	E	0.10	E
CX10250 4.5 oz …………………...……	36, 50, 64	85.42	A	7.02	BC
CX10250 4.5 oz alt. with ………………	36, 64				
Double Nickel 2qt ……………………….	50	55.00	D	5.52	C
Mancozeb 1.5 lb (1/2 rate standard) ..	36, 50, 64	5.42	E	0.12	E

[z] All rates are calculated based on per acre bases using 100 gal of water. Unless it is noted, all treatment was tank mixed with sulfur in order to prevent powdery mildew.

[y] First fungicide application was 12 May 2014. At day 28, all treatment received mancozeb + sulfur + myclobutanil as pre-treatment powdery mildew and black rot control. At day 31, all treatments received Vangard (8 oz/A) as Botrytis control

[x] Disease incidence = percentage of diseased leaves: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

[w] Disease severity = percentage of area of leaves or bunches diseased: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

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FUNGICIDE RESISTANCE ON FRUIT TREES AND STRAWBERRY IN JAPAN

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1. DMI fungicide resistance on pear

In Japan, DMI fungicides were registered for apple and pear scab control in 1986. However, DMI resistance had been reported on apple scab and other diseases overseas. Due to this, we recommended apple and pear growers to apply DMIs less than 3 times a year in alternation or a mixture with other fungicides carrying different modes of action. This recommendation has been widely accepted on apple and resistance management has been successful. Isolates of apple scab fungus less sensitive to DMIs have been detected sometimes but no resistance problems have occurred in the field yet.

In contrast, DMIs were sprayed more frequently in some pear growing regions and field performance of DMIs decreased eventually (Ishii, 2012). Resistance development has been confirmed in 2005. On potted pear trees inoculated with *Venturia nashicola*, the scab fungus, control efficacy of fenarimol and hexaconazole was low suggesting that resistant populations were distributed widely in the area. Occasionally, the efficacy of difenoconazole was also slightly low. It might indicate further sift of DMI sensitivity toward high resistance.

Mycelial growth tests on fungicide-amended PDA medium were routinely employed for testing DMI sensitivity. However, it has been shown that these tests were not reliable as fenarimol sensitivity of fungal isolates was equivalent to the level of baseline despite that these isolates were obtained from plants where the control efficacy of this fungicide was lost in inoculation tests. Where incomplete cross-resistance exists among DMIs, the use of difenoconazole is recommended in a mixture with iminoctadine albesilate or cyprodinil. The former fungicide has a broad control spectrum with low to medium risk for resistance development.

2. QoI fungicide resistance on fruit trees and strawberry

On fruit trees and strawberry, field resistance to QoI fungicides has been reported in various diseases although their impact on fungicide performance differ in the field (Table 1). In *Colletotrichum gloeosporioides*, resistant isolates have been detected from strawberry (Inada et al., 2008), grapevine, pear, and apple. Cross-resistance was clearly observed among four QoI fungicides azoxystrobin, trifloxystrobin, pyraclostrobin and picoxystrobin.

A unique QoI fungicide pyribencarb was developed by Kumiai Chemical Industry Co., Ltd. Pyribencarb exhibited higher inhibitory activity and/or control efficacy against QoI-resistant isolates of apple scab (Table 2), grey mould and other fungi than preexisted QoI fungicides and was registered for many diseases including apple scab and strawberry anthracnose. Based on the relationship of biological activities and amino-acid sequence of binding sites on cytochrome *b* protein, it was suggested that pyribencarb may slightly differ in the binding sites from other QoI fungicides (Kataoka et al., 2007).

Table 1. Occurrence of QoI resistance on fruit trees and strawberry in Japan (as of Nov. 2014)

Disease	Pathogen
Strawberry anthracnose	*Colletotrichum gloeosporioides*
Strawberry powdery mildew	*Sphaerotheca aphanis* var. *aphanis*
Grapevine leaf blight	*Pseudocercospora vitis*
Grapevine downy mildew	*Plasmopara viticola*
Grapevine ripe rot	*Colletotrichum gloeosporioides*
Apple Alternaria blotch	*Alternaria alternata* apple pathotype
Apple bitter rot	*Colletotrichum gloeosporioides*
European pear black spot	*Alternaria alternata* apple pathotype
Japanese pear anthracnose	*Colletotrichum gloeosporioides*
Citrus and strawberry grey mould	*Botrytis cinerea*
Citrus scab	*Elsinoë fawcettii*

Table 2. Sensitivity of *Venturia inaequalis* isolates to QoI fungicides

Isolate	Inhibition of mycelial growth (%)	
	Azoxystrobin 100 ppm	Pyribencarb 100 ppm
Azoxystrobin-resistant:		
Poland 9	6.0	93.6
Poland 5	34.7	95.6
Poland 7	35.1	100.0
Poland 4	42.1	100.0
Azoxystrobin-sensitive:		
Ibaraki 1	90.6	100.0

3. SDHI fungicide resistance on strawberry

On this crop, SDHI resistance has been found only in grey mould and field performance of boscalid and penthiopyrad is still maintained in most cases. Boscalid-resistant isolates carry H272R/Y mutations in their *sdhB* gene encoding the fungicide-targeted enzyme succinate dehydrogenase. These boscalid-resistant isolates are sensitive to fluopyram (Ishii and Suzuki, 2013) and isofetamid (Kenja®) (Tsukuda, 2014).

Isolates of *C. gloeosporioides* and *C. acutatum* are naturally insensitive (resistant) to boscalid. Therefore, the use of a pyraclostrobin mixture with boscalid is very risky when QoI-resistant strains are distributed in the area.

Very recently, the newest SDHI fungicide pyraziflumid (NNF-0721) has been developed by Nihon Nohyaku Co., Ltd., Japan. This fungicide was tested on many crops including apple, pear, and strawberry and proved to be effective against scab, rust, Alternaria, grey mould etc.

4. Management of fungicide resistance and the Research Committee

The Research Committee on Fungicide Resistance, the Phytopathological Society of Japan was established in 1991. The Committee is independent of FRAC (Fungicide Resistance Action

Committee), the international group of agrochemical companies. Major activities of the Research Committee are to (1) organize a resistance symposium annually, (2) publish laboratory manuals for testing fungicide sensitivity in various pathogens on many crops, (3) list up literatures and reports on resistance published by Japanese researchers.

One of the other important activities is to design the guidelines how to save the use of at risk fungicides and distribute them to related authorities such as extension centers through the Ministry of Agriculture, Forestry and Fisheries. In apple, for example, the applications of QoIs and SDHIs are limited to less than 2 times for each per year. It is also advised to stop applications of these fungicides when resistant strains were detected in monitoring until their efficacy confirmed. These guidelines have already been adopted and used effectively to guide growers in many prefectures.

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Fungicide performance trials for control of Botrytis and other late season rots in Winchester, Virginia, 2014

Botrytis trial was conducted with 'Chardonnay' grapes planted in 2009, trained to a vertical shoot positioning (VSP) system with bilateral cordons, with a spacing of 5-ft between vines and 10-ft between rows. Plots consisted of three consecutive vines, and were arranged in a completely randomized block design among four blocks. Treatments were applied with a 4 gal backpack air sprayer, regulated to 21 psi by a CFValve system (GATE LLC) through a single boom with a flat fan nozzle (TeeJet 8003VS). The interval between applications was approximately 12-14 days (varying based on vine growth). Treatments were tank-mixed with Dithane 75DF (3 lb/A) and Microthiol Disperss (3 lb/A), in order to suppress other diseases. All treatments were applied four times according to the following interval: at-bloom (6 Jun), berry touch/bunch closure (16 Jul), veraison (14 Aug), and final spray (28 Aug – just in case if botrytis development happens close to harvest time). Botector treatments received one extra application on 2 Jun to cover the beginning of bloom period. Diseases were visually assessed five times during the season, and results from 26 Aug are shown. Of the three vines used for each treatment replication, outer cordons adjacent to the next treatment were not assessed in order to avoid recording effects from fungicide drift. Sixty leaves and thirty clusters were assessed per plot. These leaves and clusters were randomly selected, and the estimated percentage of infected area (disease severity) and diseased tissue (disease incidence) per cluster were recorded. With four blocks, there were a total of 120 clusters assessed per treatment. The linear mixed model was used to conduct the analysis of variance (SAS 9.3, SAS institute, Cary NC). Treatment was considered as a fixed effect, and block was considered as a random effect.

Bud break at Winchester was 1 May, and 50% bloom was 2 Jun. Relatively speaking, we received less amount of rain in 2014. The total amount of precipitation at Winchester was about 4.0 inches from bud break to bloom, followed by 2.3, 2.9, 2.8 inches of rain during Jun, Jul, and Aug, respectively. Mean cluster Botrytis incidence varied from 0 to 49%, and severity varied from 0 to 2.5%. Treatment differences were highly significant ($P < 0.001$) on all disease measurements, and a good separation of treatment means was found. In general, there were two groups: Botector (with or without Biolink), Tavano, and Isofetamid with IB18220 (at both rate) were not significantly different from the check treatment that did not receive any Botrytis specific materials. Rovral with Elevate, Isofetamid in high rate (20 fl oz), and Isofetamid with IB18121, and Luna Tranquility resulted in significantly lower disease intensity than the check. In addition, we did not see any Botrytis development with Luna Tranquility.

Treatmentz	Days after first application[y]	Cluster Incidence		% Control	Severity		% Control
Mancozeb 3lb+ Sulfur 3 lb (Check)	32, 72, 100	33.75	ABC	30.51	1.83	AB	26.29
Rovral 16 oz alt. with Elevate 16 oz	32,100 72	13.75	DEF	71.69	0.19	C	92.43
Isofetamid 20 fl oz	32, 72, 100	5.00	EF	89.70	0.10	C	95.96
Isofetamid 10.3 fl oz + IB18121 15.5 fl oz	32, 72, 100	13.75	DEF	71.69	0.30	BC	87.88
Isofetamid 10.3 fl oz + IB18220 3.97 fl oz	32, 72, 100	23.75	BCDE	51.10	0.39	BC	84.35
Isofetamid 6 fl oz +IB18220 3.97 fl oz	32, 72, 100	21.25	CDE	56.24	1.15	ABC	53.55
Luna Tranquility 16 fl oz	32, 72, 100	0.00	F	100.00	0.00	C	100.00
Botector 7 oz	28, 32, 72, 100	48.56	A	0.00	2.48	A	0.00
Botector 7 oz + Biolink Spreader Sticker 4 oz	28, 32, 72, 100	42.50	AB	12.49	1.33	ABC	46.48
Tavano 6.5 oz	32, 72, 100	32.50	ABCD	33.08	1.53	ABC	38.41

[z] All rates are calculated based on per acre bases using 100 gal of water. Unless it is noted, all treatment was tank mixed with mancozeb, sulfur and Prophyt in order to prevent other diseases.

[y] First fungicide application was 12 May 2014. At day 28, all treatment received mancozeb + sulfur + myclobutanil as pre-treatment powdery mildew and black rot control.

[x] Disease incidence = percentage of diseased leaves: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

[w] Disease severity = percentage of area of leaves or bunches diseased: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

In addition, two trials were conducted to evaluate the efficacy of Prophyt and Viathon against grape ripe rot. The first site at Winchester, VA consisted of a variety ‘Chardonnay’ planted in 2009, trained to a vertical shoot positioning (VSP) system with bilateral cordons, with a spacing of 5-ft between vines and 10-ft between rows. The second site at Eastern Shore (Machipongo, VA) consisted of two varieties ‘Chardonnay’ planted in 1999 and ‘Cabernet Sauvignion’ planted in 2006. Since this is more like a demonstration, there were three panels where each panel received the same treatment throughout the season. Each panel consisted of five vines. The locations of the treatment were assigned randomly. Treatments were applied with a 4 gal backpack air sprayer, regulated to 21 psi by a CFValve system (GATE LLC) through a single boom with a flat fan nozzle (TeeJet 8003VS). All treatments were applied four times according to the following interval: bloom, fruit set, berry touch, veraison, and late season (2 wks after veraison). Diseases were visually assessed five times during the season, and results from 4 Sept (for Eastern shore location) are shown. Of the five vines used for each treatment replication, ten clusters were assessed per treatment (= 50 clusters per treatment). These clusters were randomly selected, and the estimated percentage of infected area (disease severity) per cluster and diseased tissue (disease incidence) were recorded. The linear mixed model was used to conduct the analysis of variance (SAS 9.3, SAS institute, Cary NC). Treatment was considered as a fixed effect, and block was considered as a random effect. In addition, one random cluster per vine was sampled, and berries on these clusters were placed onto quail egg containers for 2 weeks of observation of symptom development.

Winchester location resulted in very low disease level (almost none with control), thus only Machipongo results are presented. Disease incidence on cluster varied from 37% to 66% and disease severity varied from 0.8% to 3.3%. Viathon alternated with Prophyt treatment resulted in significantly lower disease incidence and severity than the control. Please note that control received grower's spray program which included some measures against ripe rot.

	Machipongo						
Treatment	Timing	Incidence		% Control	Severity		%Control
Prophyt (only) …………	B, FS, BT, V, LS	65.31	A	0.01	1.65	AB	0.50
Viathon alt. with ………	B, V,						
Prophyt ……………………	FS, BT, LS	37.25	B	0.44	0.77	B	0.76
Control ……………………		66.00	A		3.26	A	

[z] All rates are calculated based on per acre bases using 100 gal of water. Unless it is noted, all treatment was tank mixed with mancozeb and Prophyt in order to prevent other diseases.

[y] Fungicide application varied at two sites.

[x] Disease incidence = percentage of diseased leaves: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

[w] Disease severity = percentage of area of leaves or bunches diseased: Numbers presented are the least square mean of percentage. The same letter indicates there was no significant difference between treatments (Tukey-Kramer adjustment method, the overall error rate = 0.05)

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EVALUATION OF BACTERICIDE PROGRAMS FOR THE MANAGEMENT OF FIRE BLIGHT ON 'GALA' APPLES AND BACTERIAL SPOT ON PEACH IN PENNSYLVANIA, 2014

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Bacterial diseases are difficult to control on pome and stone fruits, especially in the Mid-Atlantic where environmental conditions are favorable for these diseases every season. Few methods exist for fire blight disease control in apple and pear. The main available controls are removal of infected portions of trees, antibiotic sprays at bloom time, and use of less susceptible varieties and rootstocks. However, many of the newer, highly-popular apple varieties, including 'Gala,' 'Ginger Gold,' and 'Fuji', are very susceptible to fire blight. These susceptible varieties can have the effect of increasing fire blight disease problems when they are used extensively. Also, antibiotic use in agriculture is coming under increasing scrutiny out of concerns about the development of antibiotic-resistance among bacteria, and the use of streptomycin in organic apple production was phased out in October 2014. For stone fruit, production is severely limited by bacterial spot (caused by the bacterium *Xanthomonas arboricola* pv. *pruni*). Considered the most important bacterial disease of peach and nectarine in the eastern US, bacterial spot epidemics are especially severe in the southeastern US and the mid-Atlantic regions where the weather is warm, wet, and conducive to rapid disease development. Fire blight and bacterial spot are continuing problems faced by growers, so the development of novel control measures could be very useful.

The 2014 season was an excellent year for disease conditions for both fire blight and bacterial spot and this report presents the studies of evaluating products to control both diseases at the Penn State Fruit Research and Extension Center in Biglerville, PA. The following products to control the blossom blight phase of fire blight in apple were as follows: streptomycin (FireWall, AgroSource Inc., Mountainside, NJ); *Bacillus subtilus* QST 713 strain (Serenade Optimum, Bayer CropScience, Research Triangle Park, NC); *Streptomyces lydicus* WYEC 108 (Actinovate, Novozymes BioAg Inc., Brookfield, WI); and *Aureobasidium pullulans* strains DSM 14940 and 14941 (Blossom Protect, Westbridge Agricultural Products, Vista, CA). The following products to control bacterial spot on peach throughout the season were as follows: oxytetracycline (FireLine, AgroSource Inc., Mountainside, NJ), *Bacillus subtilus* QST 713 strain (Serenade Optimum, Bayer CropScience, Research Triangle Park, NC); copper sulfate pentahydrate (MasterCop, ADAMA, Raliegh, NC); copper hydroxide (Kocide 3000, DuPont, Wilmington, DE); and mono- and dipotassium salts of phosporous acid (Rampart, Loveland Products, Greeley, CO). Weather data was recorded with a Decagon weather monitoring system, and fire blight (MaryBlyt 7.1) infection periods were reported. Rainfall totals for April, May, June, July, and August were 5.93, 5.48, 5.0, 2.14, and 5.55 inches, respectively.

Fire Blight

Twelve year-old 'Gala' trees on M.7 rootstocks were used and single tree treatments were arranged in a randomized complete block with four replications. Before the first treatment was applied, three branches were selected per tree, marking 20 - 25 blossom clusters on the branch. Treatments were applied in the morning using a backpack mist blower until mist run-off: 2 May (20% Bloom); 5 May (80% Bloom); 7 May (100% Bloom). Late afternoon on the same day as the treatment application, blossoms on tagged branches were inoculated with a bacterial suspension of 10^7 *Erwinia amylovora* cells/ml using a spray bottle. Blossoms were inoculated on 2 May and 5 May; no bacteria was applied after the third treatment application on 7 May. Blossom clusters were evaluated on 28 May for infection. A cluster was rated infected if at least one blossom had fire blight symptoms. Total fire blight shoot strikes on the tree were also counted on 28 May, 25 June, and 11 July.

The entire bloom period (May 9 – 15) was an infection period, followed by four more infection periods by the end of May, which greatly affected rattail bloom and late blooming cultivars. Conditions continued to remain favorable for infection and disease progression throughout the month of June, with symptoms first manifesting during the first week of June, followed by statewide reports during the second and third weeks. Consequently, the fire blight control programs (Table 1) were tested under ideal conditions where there was high natural disease pressure. Streptomycin only (Treatment 2) applied on the three blossom treatment dates performed the best with 76.0% control. This was closely followed by Treatment 4 (69.2% control), with Serenade Optimum applied at 20% Bloom, followed by two applications of streptomycin, and Treatment 5 (56.3% control), with streptomycin applied at 20% and 100% Bloom and Serenade Optimum at 80% Bloom. Blossom Protect (Treatment 8) applied for all three treatment sprays had 39.5% control, which was significantly better than the Serenade Optimum treatment (Treatment 2, 19.2% control), the untreated check (0.0 %) and the two Actinovate treatments (Treatment 6, 6 oz, 2.5% control; Treatment 7, 12 oz, 6.5% control). The latter (Treatments 6 and 7) were statistically similar to the untreated check (Treatment 1). The total number of strikes on the trees was counted for each treatment, as well. As expected, trees where there was less blossom blight had fewer strikes throughout the season. However, since disease pressure was so high, it was difficult to keep the shoot strikes in check, despite blossom protection in the beginning.

Bacterial Spot

The spray programs were evaluated in 4 cultivar plots, which included 'Eastern Glo', 'Beekman', 'Snow King', and 'Sweet Dream', with 'Red Haven' as guard trees in between treatment plots. Treatments were arranged in a randomized complete block with 4 replications. Treatments were applied using a boom sprayer at 400 psi, delivering 100 gal/A. Application timings were as follows: 1 = 12 May (Petal fall/Shuck split); 2 = 22-23 May (1C); 3= 2 June (2C); 4 = 16 June (3C); 5 = 25 June (4C); 6 = 7 July (5C); 7 = 22 July (6C). Standard insecticide and fungicide maintenance programs were applied to the entire orchard with an airblast or boom sprayer delivering 100 gal/A at 400 psi. To evaluate disease and phytotoxicity severity on the leaves for both June and July, 5 shoots were randomly selected and 10 leaves were evaluated on the shoot starting at the base of the shoot; each leaf was evaluated for both % disease and % phytotoxicity (in July), 0 - 100% (50 leaves total evaluated per tree); the number of missing leaves per shoot was also recorded during the July evaluation for each of the 5 shoots evaluated. Disease incidence was determined based on the severity data. The leaf data presented in Table 2 is for July only. For fruit evaluations, 25 fruit per tree (100 fruit total/treatment) were assessed for bacterial spot disease by assessing the % area of the fruit covered with bacterial spot ('Eastern Glo' on 25 July; 'Beekman' on 4 August; 'Snow King' on 11 August; 'Sweet Dream' on 12 August) using the following rating scale: 1 = 0%; 2 = 1 - 3%; 3 = 4 - 8%; 4 = 9 - 15%; 5 = 15 - 25%; 6 = 25 - 45%; 7 = > 45%; scale was converted and mean % area covered shown.

We observed symptoms of pale green water soaked lesions on the leaves as early as late May. Typical control for bacterial spot is the use of the antibiotic oxytetracycline and copper from the appearance of the first green tissue. Oxytetracycline suppresses the bacteria and does not kill is, as well as only persists for approximately 48 hrs after application; copper is phytotoxic to peach/nectarine tree leaves, but the fruit are typically resistant to copper damage. When conditions are favorable, growers typically spray for disease control every 7-10 days. The cultivars used varied in their bacterial spot susceptibility; however, the management programs performed similarly between cultivars and the data reported is a compilation of the data evaluating all cultivars together (Table 2). The copper product, MasterCop (copper sulfate pentahydrate), was used for bacterial spot control in different concentrations (1.0 and 1.5 pints/A) throughout season. In addition, MasterCop at the 1 pt/A was mixed with hydrated lime plus vegetable oil, as well as mixed with vegetable oil alone. The rationale of using vegetable oil with and without hydrated lime was due to reports of the Bordeaux mixture (copper sulfate plus hydrated lime) plus vegetable oil being used to manage another bacterial stone fruit disease, bacterial canker of cherry. The use of vegetable oil is thought to act as a safener, thereby minimizing phytotoxcity of the copper. MasterCop at 1 pt/A was also rotated with1.0 qt/A Rampart (Mono- and dipotassium salts of Phosporous acid) or 14 oz Serenade Optimum (*Bacillus subtilus* QST 713 strain). These programs were compared to another copper formulation, Kocide 3000 at 0.5 lb/A, as well as the traditional bacterial spot control, oxytetracylcine (FireLine 1.5 lb/A).

<u>*Leaf disease evaluation:*</u> Among all cultivars, disease incidence and severity were significantly different between the untreated check and oxytetracycline treatment and the copper treatments, where the copper treatments had a lower incidence and severity of the disease (Table 2). The MasterCop

treatments performed similarly, regardless of rate (1.0 pt vs. 1.5 pt), and whether it was used by itself or rotated (1.0 pt only or plus vegetable oil vs. Serenade Optimum rotation or Rampart rotation). Kocide controlled disease better than the MasterCop or oxtytetratcycline treatments. In addition, when comparing the management programs for phytotoxicity when copper was used by itself (as well as when MasterCop was used with vegetable oil), Kocide at 0.5 lb/A was the least phytotoxic; however, when the number of missing leaves/shoot is compared, the copper only treatments are similar. When MasterCop was rotated with Rampart or Serenade Optimum or when MasterCop was combined with hydrated lime, phytotoxicity decreased compared to when copper was used alone. In addition, MasterCop rotated with Serenade Optimum and MasterCop mixed with hydrated lime and vegetable oil, also had fewer leaves missing. Although causing less phytotoxicity, oxytetratcycline (FireLine) did not control bacterial spot better than the untreated check. This was most likely due to the fact the residual control activity of oxytetracycline is around 48 hours, whereas copper lasts longer, thereby providing more disease control.

Fruit evaluation: Even though there was a high incidence of disease on the fruit for the different treatment programs (Table 2), the severity was low for all programs and significantly better than the untreated check. Although the oxytetracycline treatment was not significantly different in disease incidence compared the untreated check, the disease severity was significantly less. All copper treatments, with the exception of MasterCop rotated with Rampart, controlled disease on the fruit significantly better than the untreated and oxytetracycline treatments. MasterCop (1.0 pt and 1.5 pt), Kocide, MasterCop rotated with Serenade Optimum, and MasterCop mixed with hydrated lime and vegetable oil performed similarly for controlling bacterial spot on fruit and were statistically similar for disease incidence; however, Kocide and MasterCop/Serenade Optimum treatments had fruit with the least disease severity.

Table 1. 2014 Evaluation of fire blight blossom blight suppression and incidence of strikes during the season on 'Gala.'

	Treatment and Rate/A	B1[1]	B2	B3	% control	May strikes	June strikes	July strikes
1	Untreated				0.0 e[2]	84.3 a	90.0 ab	94.3 ab
2	Serenade Optimum 20 oz	X	X	X	19.2 d	73.0 a	81.8 ab	83.3 ab
3	FireWall 1.5 lb + Regulaid 1.0 pt/100 gal	X	X	X	76.0 a	28.0 bc	56.3 a-c	70.3 a-c
4	Serenade Optimum 20 oz	X			69.2 ab	24.5 bc	48.5 bc	53.8 bc
	FireWall 1.5 lb + Regulaid 1.0 pt/100 gal		X	X				
5	Serenade Optimum 20 oz		X		56.3 b	2.3 c	19.8 c	40.0 c
	FireWall 1.5 lb + Regulaid 1.0 pt/100 gal	X		X				
6	Actinovate 6 oz	X	X	X	2.6 e	46.3 ab	94.3 a	101.0 a
7	Actinovate 12 oz	X	X	X	6.5 de	49.0 ab	92.0 a	107.8 a
8	Blossom Protect 1.25 lb + Buffer Protect 8.75 lb	X	X	X	39.5 c	29.8 bc	64.3 ab	70.8 a-c

[1] Treatments were applied in the morning using a backpack mist blower until mist run-off : B1=2 May (20% Bloom); B2= 5 May (80% Bloom);B3= 7 May (100% Bloom)
[2] Values within columns followed by the same letter(s) are not significantly different P ≤ 0.05 according to Fisher's Protected LSD Test

Table 2. 2014 Evaluation of bacterial spot incidence and severity on peach.

Treatment & Rate/A	Timing[1]	Leaves - July evaluation				Fruit – at harvest	
		Incidence	Severity	Phyto-toxicity	# Missing	Incidence	Severity
1 Untreated	1-7	85.2 a[2]	4.1 a	0.2 g	3.9 b-d	89.6 a	10.6 a
2 FireLine 1.5 lb	1-7	89.3 a	3.4 b	0.2 g	3.8 b-d	84.8 ab	7.8 b
3 MasterCop 1.0 pt	1-7	58.4 bc	1.9 cd	6.3 b	4.6 a-c	75.5 de	6.0 cd
4 MasterCop 1.5 pt	1-7	55.6 c	1.8 cd	8.1 a	4.9 a	73.0 e	4.8 de
5 Kocide 0.5 lb	1-7	49.1 d	1.2 e	4.2 d	4.6 a-c	76.3 de	3.2 f
6 MasterCop 1.0 pt Rampart 1.0 qt	1, 3, 5, 7 2, 4, 6	62.7 b	2.1 c	3.7 e	4.1 a-c	86.4 ab	6.7 bc
7 MasterCop 1.0 pt Serenade Optimum 14 oz	1, 3, 5, 7 2, 4, 6	56.8 c	1.8 cd	3.1 f	3.0 d	74.7 de	4.2 ef
8 MasterCop 1.0 pt + hydrated lime 2.0 lb + vegetable oil 3.0 qt	1-7	56.5 c	1.5 de	2.7 f	3.0 d	80.0 cd	5.5 c-e
9 MasterCop 1.0 pt + vegetable oil 3.0 qt	1-7	58.0 c	1.6 d	5.6 c	4.7 ab	82.1 bc	6.4 c

[1]Application timings: 1=12 May (Petal fall/Shuck split); 2 = 22-23 May (1C); 3= 2 June (2C); 4= 16 June (3C); 5=25 June (4C); 6=7 July (5C); 7=22 July (6C).
[2] Values within columns followed by the same letter(s) are not significantly different P ≤ 0.05 according to Fisher's Protected LSD Test

APPLE (*Malus domestica* 'Fulford Gala')
Fireblight; *Erwinia amylovora*
Scab; *Venturia inaequalis*
Quince rust; *Gymnosporangium clavipes*
Cedar-apple rust; *G. juniperi-virginianae*
Powdery mildew; *Podosphaera leucotricha*

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Fire blight blossom blight, fruit russet effects, and fungal disease suppression on Gala apple, 2014.

Six copper formulations and three other treatments were compared to streptomycin (Firewall) for blossom blight, fruit finish effects and fungal disease control. The test was established on 13-yr-old trees in four randomized blocks using single-tree replications. Our goal was to select treatment/ inoculation days to be the day before a relatively warm day, as favorable for natural infection as possible. Treatments applied dilute to run-off in the morning of 18 Apr (Pk, Pink, #2-6 only); 24 Apr (bloom, Bl 1, all treatments); 28 Apr (Bl 2, full bloom, all treatments except #16) and again at 2 May (Bl 3, all trts except #16); 8 May (PF, petal fall, all treatments); and 19 May (first cover, 1C; #2-6 only). Two selected branches per tree were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ streptomycin-sensitive *E. amylovora* cells/ml in the evenings of 24 Apr, 28 Apr, and 2 May. There was no follow-up inoculation after the 8 May application. Infection data were based on counts of number of blossom clusters present on the inoculated branch at the time of the first inoculation. A cluster was rated as infected if it had at least one blossom with fire blight symptoms on 22 May. Captan 80WDG 15 oz/100 gal was applied to all treatments except "no treatment": 17 Jun, 2 Jul, and 17 Jul. (2nd-4th covers). Maintenance insecticides applied to the entire block with a commercial airblast sprayer included: Admire Pro, Altacor, Asana XL, Assail, BioCover MLT, Delegate, Imidan, Lannate LV, and Provado. Fruit scab was rated on the tree, counting 25 fruit per tree 1 Aug. Foliar fungal diseases rated on the first 12 leaves on each of 8 shoots / tree rated 4 Aug. Fruit finish and rusts were rated after harvest on 25-fruit samples picked 2 Sep.

Inoculation resulted in strong fire blight test conditions. The streptomycin standard (Firewall), performed as expected under these conditions, with excellent suppression of cluster and cluster leaf infection (Table 1). Nearly all treatments gave significant (p=0.05) suppression of fire blight infection of flower clusters and cluster leaves, including those not involving streptomycin. Fracture, applied alone in all applications (trt. #15), did not give significant control, and MasterCop (trt #13) did not significantly suppress infection of cluster leaves. Compared to non-treated fruit, increased russet was observed with treatments involving Blossom Protect (trts #2-4), NU-COP (trts #5-8), and Badge (trts #9-10). C-O-C-S alone (#11) significantly increased the russet rating, but C-O-C-S + Double Nickel (trt #12) did not. Treatments also impacted the incidence of other disease on leaves and fruit (Table 2). Blossom Protect schedules (trts #2-4), included fungicides at first cover timing that control scab, rusts and powdery mildew as expected, but the control of scab might have been somewhat reduced due to resistance to the SI fungicides. C-O-C-S alone (#11) gave significantly better fruit scab control than C-O-C-S + Double Nickel (trt #12). Under heavy rust pressures, most treatments gave significant reductions of cedar-apple rust on leaves and fruit and quince rust on fruit. Quince rust infection occurred during an infection period 28 Apr-1 May, and the bloom application schedule closely bracketed those dates on 28 Apr and 2 May. Under rather light mildew pressure on this cultivar, all treatments gave significant suppression with treatments that included Inspire Super or Rally at first cover providing superior mildew and rust control.

Table 1. Fire blight blossom blight incidence and fruit finish ratings on Gala apples, 2014. Virginia Tech AREC, Winchester.

	Treatment and rate/100 gal	Application timing: Pk	Bloom app. # 1	Bloom app. # 2	Bloom app. # 3	PF	1C	Fire blight infection*: % clusters Infected*	Fire blight infection*: % clusters with leaves infected*	Fruit finish ratings**: Russet Rating (0-5)	Fruit finish ratings**: USDA rating, % Xtra Fancy and Fancy
0	No treatment	--	--	--	--	--	--	71 e	53 f	0.8 a	96 a
1	FireWall 17 8 + Regulaid 1 pt	--	X	X	X	X		15 a	8 a	1.4 a-e	92 a-c
2	Rally 1.25 oz + Manzate 12 oz	X					X				
	Blossom Protect 5 oz + Buffer Protect 2.2 lb		X	X	X						
	Inspire Super 3 fl oz					X		24 ab	19 a-d	1.7 c-f	80 cd
3	Rally 1.25 oz + Manzate 12 oz	X				X					
	Inspire Super 3 fl oz + Blossom Protect 5 oz + Buffer Protect 2.2 lb		X								
	Blossom Protect 5 oz + Buffer Protect 2.2 lb			X	X			33 bc	24 b-d	1.5 b-e	92 a-c
	Inspire Super 3 fl oz						X				
4	Rally 1.25 oz + Manzate 12 oz	X									
	Blossom Protect 5 oz + Buffer Protect 2.2 lb			X	X		X	34 bc	25 b-e	1.7 c-f	83 b-d
	Inspire Super 3 fl oz		X			X					
5	NU-COP 50DF 4 oz	X	X	X	X	X	X	30 a-c	22 a-d	3.1 i	39 g
6	NU-COP HB 4 oz	X	X	X	X	X	X	31 a-c	20 a-d	2.7 hi	50 fg
7	NU-COP 50DF 4 oz	--	X	X	X	X	--	36 bc	20 a-d	2.5 g-i	55 e-g
8	NU-COP HB 4 oz	--	X	X	X	X	--	24 ab	16 a-c	2.0 e-g	73 de
9	Badge SC 7 fl oz	--	X	X	X	X	--	39 bc	21 a-d	1.8 d-f	68 de
10	Badge X2 7.1 oz	--	X	X	X	X	--	31 a-c	19 a-d	1.6 b-e	80 cd
11	C-O-C-S 50DF 4 oz	--	X	X	X	X	--	37 bc	26 c-e	2.2 f-h	65 d-f
12	C-O-C-S 50DF 4 oz + Double Nickel LC 8 fl oz	--	X	X	X	X	--	49 cd	28 c-e	1.3 a-d	91 a-c
13	MasterCop 5.4% 37 fl oz	--	X	X	X	X	--	50 cd	35 d-f	1.2 a-c	93 ab
14	FireWall 17 8 oz + Regulaid 1 pt	--	X	--	--	X	--	25 ab	15 a-c	1.2 a-c	95 a
	Fracture 2.12SL 7.6 fl oz		--	X	X	--					
15	Fracture 2.12SL 7.6 fl oz	--	X	X	X	X	--	60 de	43 ef	1.3 a-d	94 a
16	FireWall 17 8 oz + Regulaid 1 pt	--	X	--	--	X	--	24 ab	12 ab	1.1 ab	94 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications. Dilute application to the point of runoff.

* Infection data based on counts of number of clusters at inoculation and number of clusters with infection on inoculated branches 22 May.

** Fruit finish rated after harvest on a scale of 0-5 (0=perfect finish; 5=severe russet). USDA grades after downgrading by russet.

Table 2. Foliar and fruit fungal disease suppression on Gala apples, 2014. Virginia Tech AREC, Winchester.

	Bloom app. #						Scab infection			Cedar-apple rust			Quince	Mildew
Treatment and rate/100 gal	Pk	1	2	3	PF	1C	lvs inf.	les/leaf	% fruit	% lvs	les/lf	% fruit	rust, %	% lvs inf
0 No treatment	--	--	--	--	--	--	80 f	22.5 d-g	100 d	49 g	12.1 f	39 g	53 i	21 d
1 FireWall 17 8 + Regulaid 1 pt	--	X	X	X	X		77 d-f	19.6 b-f	97 cd	19 b-e	1.5 a-d	4 a-d	11 d-f	7 a-c
2 Rally 1.25 oz + Manzate 12 oz	X					X								
Blossom Protect 5 oz + Buffer Protect 2.2 lb		X	X	X										
Inspire Super 3 fl oz					X		66 b-d	10.8 a-c	39 a	<1 a	<0.1 a	0 a	0 a	4 a
3 Rally 1.25 oz + Manzate 12 oz	X				X									
Inspire Super 3 fl oz + Blossom Protect 5 oz + Buffer Protect 2.2 lb		X												
Blossom Protect 5 oz + Buffer Protect 2.2 lb			X	X										
Inspire Super 3 fl oz						X	51 ab	7.0 a	44 a	3 a	0.3 ab	0 a	0 a	3 ab
4 Rally 1.25 oz + Manzate 12 oz	X													
Blossom Protect 5 oz + Buffer Protect 2.2 lb			X	X		X								
Inspire Super 3 fl oz		X			X		52 ab	8.9 ab	49 a	2 a	0.5 ab	0 a	2 a-c	8 a-c
5 NU-COP 50DF 4 oz	X	X	X	X	X	X	54 a-c	13.3 a-e	48 a	10 b	0.9 a-c	0 a	1 ab	3 a
6 NU-COP HB 4 oz	X	X	X	X	X	X	52 ab	9.6 a-c	71 b	15 b-d	1.0 a-c	5 b-e	8 c-e	8 a-c
7 NU-COP 50DF 4 oz	--	X	X	X	X	--	51 ab	9.1 a-c	74 b	14 b-d	0.8 a-c	2 a-c	6 a-d	4 a
8 NU-COP HB 4 oz	--	X	X	X	X	--	44 a	10.5 a-c	77 b	33 ef	2.9 c-e	12 ef	18 e-g	7 a-c
9 Badge SC 7 fl oz	--	X	X	X	X	--	57 a-c	12.4 a-d	88 bc	26 c-e	3.3 de	1 ab	5 b-d	7 a-c
10 Badge X2 7.1 oz	--	X	X	X	X	--	65 b-d	a-e 14.0	b 84	8 b	0.6 ab	8 b-e	17 e-g	4 ab
11 C-O-C-S 50DF 4 oz	--	X	X	X	X	--	59 a-c	14.7 a-e	81 b	23 c-e	2.0 a-d	2 a-c	7 b-d	7 a-c
12 C-O-C-S 50DF 4 oz + Double Nickel LC 8 fl oz	--	X	X	X	X	--	67 c-e	23.0 d-g	99 d	32 ef	2.9 c-e	1 ab	12 d-f	8 bc
13 MasterCop 5.4% 37 fl oz	--	X	X	X	X	--	75 d-f	20.4 c-f	98 d	27 de	2.3 b-d	6 a-d	6 a-d	8 a-c
14 FireWall 17 8 oz + Regulaid 1 pt	--	X	--	--	X	--	80 ef	27.1 fg	100 d	24 c-e	3.2 de	8 c-f	35 h	9 c
Fracture 2.12SL 7.6 fl oz		--	X	X	--									
15 Fracture 2.12SL 7.6 fl oz	--	X	X	X	X	--	87 f	32.4 g	98 cd	14 bc	0.9 a-c	9 d-f	19 f-h	10 c
16 FireWall 17 8 oz + Regulaid 1 pt	--	X	--	--	X	--	76 d-f	23.9 e-g	99 d	45 fg	4.9 e	16 f	30 gh	9 c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications. Foliar diseases rated on the first 12 leaves on each of 8 shoots / tree 4 Aug; fruit scab data, on-tree scab counts of 25 fruit per rep 1 Aug. Rusts and fruit finish rated after harvest on a 25-fruit sample.

Treatments were applied dilute to the point of run-off in the morning of 18 Apr (Pink, #2-6 only); 24 Apr (bloom, Bl 1, all treatments); 28 Apr (Bl 2, full bloom, all treatments except #16); 2 May (Bl 3, all treatments except #16); 8 May (petal fall, PF, all trts); and 19 May (first cover, 1C; #2-6 only). Captan 80WDG 15 oz/100 gal applied to all treatments except “no treatment”: 17 Jun, 2 Jul, 17 Jul. Maintenance sprays applied to entire test block.

APPLE (*Malus domestica* 'Idared')
Fireblight; *Erwinia amylovora*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*

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Suppression of fire blight blossom blight on Idared apple, 2014.

Treatments involving eight different products were compared to streptomycin (Firev alone and in integrated schedules, for blossom blight control and fruit finish effects. The te: was established in four randomized blocks on 32-yr-old trees using single-tree replications border rows between treatment rows. The test strategy was generally to make applications the morning before inoculating in the evening in anticipation of a relatively warm day to foll All treatments were applied to both sides of the tree with a Swanson Model DA-400 airblas sprayer at 100 gallons per acre: 18 Apr (Pink, trt. #12 and 13 only); 22 Apr (early bloom, Bl treatments except #1); 25 Apr (Bl 2, mid-bloom, all treatments); 2 May (Bl 3, late bloom all treatments except #1); 9 May (PF, petal fall, all treatments). Four selected branches per tre each with about 25 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ streptomycin- sensitive *Erwinia amylovora* cells/ml. Inoculatic was done in the evening of 22 Apr, the morning of 26 Apr, and on the evening of 2 May. Tr were not inoculated after the petal fall application. Infection data were based on counts of number of blossom clusters present on the inoculated branch at the time of the first inocula A cluster was rated as infected if it had at least one blossom with any fire blight symptoms May or if infection had proceeded into the cluster leaves by 21 May. Fruit finish and diseas were rated on 25-fruit samples taken 15 Sep and evaluated 18 Sep. Maintenance insectici were applied to the entire block with a commercial airblast sprayer included: Admire Pro, Altacor, Asana XL, Assail, BioCover MLT, Calypso, Delegate, Diazinon Imidan, Provado, a Voliam Flexi.

Inoculation resulted in strong fire blight test conditions. The streptomycin standard (Firewall), performed as expected under these conditions, with suppression of cluster infec not only by the one with the full application schedule (#1), but also the treatment (#2) that received only the second bloom application (Table 3). However, the treatment that receive the second bloom application did not significantly suppress infection into the cluster leaves Several other treatments that involved materials applied in combination with streptomycin c alternated with streptomycin, also gave various degrees of control including: Serenade (Trt and 5), Actigard (Trt. #6 and 7) and Double Nickel (#11). Several treatments not involving streptomycin did not significantly suppress blossom infection, but did reduce cluster leaf infection, including Serenade (#3), Actinovate 6 oz (#8), Cueva (#14) and Blossom Protect (#16). Treatments which did not significantly suppress infection of blossoms or cluster leav included: Actinovate 12 oz (#9), Double Nickel (#10), CX-10250 (#12 and 13), and Cueva +Double Nickel (#15). The treatment schedule targeted control of fire blight blossom infecti but a cedar-apple rust infection period occurred during the test period, 28 Apr-1 May. Com to non-treated fruit, several of the treatments significantly suppressed cedar-apple rust frui infection including: Serenade Optimum + Regulaid (four applications, #3), CX-10250 (#12) 10250 + Double Nickel (#13) and Cueva + Double Nickel (#15). No treatment significantly affected fruit finish (Table 4), compared to non-treated fruit (p=0.05).

Table 3. Suppression of fire blight blossom blight and cedar-apple rust on Idared apple. 2014.

Treatment and rate/A	Application stage					Fire blight infection (%)		Cedar-apple rust, %
		Bloom #						
	Pk	1	2	3	PF	clusters infected*	clusters with leaf infection	fruit inf.
0 No treatment	--	--	--	--	--	80.2 e-g	43.5 d	15 c
1 FireWall 17 1.5 lb + Regulaid 1 pt/100gal	--	X	X	X	X	63.9 ab	14.8 a	7 a-c
2 FireWall 17 1.5 lb + Regulaid 1 pt/100gal	--	--	X	--	--	69.5 a-d	33.4 cd	14 c
3 Serenade Optimum 20 oz + Regulaid 1 pt	--	X	X	X	X	72.9 b-f	27.0 bc	1 a
4 Serenade Optimum 20 oz + Regulaid 1 pt FireWall 17 1.5 lb + Regulaid 1 pt	-- --	X --	-- X	-- X	-- X	64.5 ab	19.7 ab	6 a-c
5 Serenade Optimum 20 oz + Regulaid 1 pt FireWall 17 1.5 lb + Regulaid 1 pt	-- --	X --	X --	-- X	-- X	76.3 c-f	30.8 bc	12 bc
6 Actigard 50WG 2 oz + FireWall 17 1.5 lb + Regulaid 1 pt	--	X	X	X	X	60.7 a	12.3 a	7 a-c
7 Actigard 50WG 2 oz + Regulaid 1 pt FireWall 17 1.5 lb + Regulaid 1 pt	--	X --	-- X	X --	-- X	64.8 ab	19.8 ab	11 a-c
8 Actinovate 6 oz	--	X	X	X	X	73.5 b-f	27.1 bc	8 a-c
9 Actinovate 12 oz	--	X	X	X	X	85.5 g	35.1 cd	7 a-c
10 Double Nickel LC 1 qt	--	X	X	X	X	79.2 d-g	35.2 cd	8 a-c
11 Double Nickel LC 1 qt FireWall 17 1.5 lb + Regulaid 1 pt	--	X --	-- X	X --	-- X	67.6 a-c	26.1 bc	6 a-c
12 CX-10250 4.5 oz	X	X	X	X	X	80.2 e-g	35.0 cd	1 a
13 CX-10250 4.5 oz CX-10250 4.5 oz + Double Nickel 1 qt	X	-- X	-- X	-- X	X --	82.2 fg	38.0 cd	2 a
14 Cueva 1 gal	--	X	X	X	X	72.7 b-f	26.9 bc	7 a-c
15 Cueva 1 gal + Double Nickel 1 qt/A	--	X	X	X	X	80.2 fg	37.9 cd	2 ab
16 Blossom Protect 1.25 lb + Buffer Protect 8.75 lb	--	X	X	X	X	70.9 a-e	30.4 bc	9 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Four single-tree replications with border rows between treatment rows.

Applied airblast at 100 gal / acre as follows: 18 Apr (Pink, #12 & 13 only); 22 Apr (early bloom, Bl 1, all trts); 25 Apr (mid-bloom, Bl 2, all trts); 2 May (late bloom, Bl 3, all trts); 9 May (petal fall, PF, all trts).

Four selected branches per tree, each with about 25 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing 1×10^{6} *Erwinia amylovora* cells/ml in the evening of 22 Apr, the morning of 26 Apr, and in the evening of 3 May. Trees were not inoculated after the fourth (petal fall) application. Infection data were based on counts of number of blossom clusters present on the inoculated branch at the time of the first inoculation.

* A cluster was rated as infected if it had at least one blossom with any fire blight symptoms on 19 May or if infection had proceeded into the cluster leaves by 21 May.

Table 4. Fruit finish of Idared apples, 2014. Virginia Tech AREC

	Treatment and rate/A	Application stage					Fruit finish ratings *		
			Bloom #				Rating	% Xtra	% X-Fcy/
		Pk	1	2	3	PF	(0-5)	Fancy	Fancy
0	No treatment	--	--	--	--	--	1.2 a	63 ab	87 a
1	FireWall 17 1.5 lb + Regulaid 1 pt/100gal	--	X	X	X	X	1.2 a	61 ab	90 a
2	FireWall 17 1.5 lb + Regulaid 1 pt/100gal	--	--	X	--	--	0.9 a	79 ab	94 a
3	Serenade Optimum 20 oz + Regulaid 1 pt	--	X	X	X	X	1.4 a	60 ab	81 a
4	Serenade Optimum 20 oz + Regulaid 1 pt FireWall 17 1.5 lb + Regulaid 1 pt	-- --	X --	-- X	-- X	-- X	1.3 a	65 ab	90 a
5	Serenade Optimum 20 oz + Regulaid 1 pt FireWall 17 1.5 lb + Regulaid 1 pt	-- --	X --	X --	-- X	-- X	1.4 a	58 b	87 a
6	Actigard 50WG 2 oz + FireWall 17 1.5 lb + Regulaid 1 pt	--	X	X	X	X	1.1 a	70 ab	89 a
7	Actigard 50WG 2 oz + Regulaid 1 pt FireWall 17 1.5 lb + Regulaid 1 pt	--	X --	-- X	X --	-- X	1.0 a	80 ab	96 a
8	Actinovate 6 oz	--	X	X	X	X	1.0 a	69 ab	96 a
9	Actinovate 12 oz	--	X	X	X	X	0.9 a	74 ab	96 a
10	Double Nickel LC 1 qt	--	X	X	X	X	0.8 a	81 ab	92 a
11	Double Nickel LC 1 qt FireWall 17 1.5 lb + Regulaid 1 pt	--	X --	-- X	X --	-- X	1.2 a	69 ab	89 a
12	CX-10250 4.5 oz	X	X	X	X	X	1.3 a	67 ab	84 a
13	CX-10250 4.5 oz CX-10250 4.5 oz + Double Nickel 1 qt	X	-- X	-- X	-- X	X --	1.2 a	70 ab	86 a
14	Cueva 1 gal	--	X	X	X	X	0.6 a	88 a	95 a
15	Cueva 1 gal + Double Nickel 1 qt/A	--	X	X	X	X	0.8 a	86 ab	95 a
16	Blossom Protect 1.25 lb + Buffer Protect 8.75 lb	--	X	X	X	X	0.9 a	75 ab	92 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Four single-tree replications with border rows between treatment rows.

Applied airblast at 100 gal / acre as follows: 18 Apr (Pink, #12 & 13 only); 22 Apr (early bloom, Bl 1, all trts except #2); 25 Apr (mid-bloom, Bl 2, all trts); 2 May (late bloom, Bl 3, all trts except #2); 9 May (petal fall, PF, all trts).

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

APPLE (*Malus domestica* ‘Idared')
Fire blight; *Erwinia amylovora*
Scab; *Venturia inaequalis*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Fruit finish; russet

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Early season timing of MasterCop for fire blight control on Idared apple, 2014.

Six MasterCop rate and timing treatments were compared for secondary fire blight suppression and potential for fruit russetting. The test was conducted on 27-yr-old Idared/M.111 trees in a randomized block design with four single-tree replicates separated by border rows. The general test and inoculation strategy was to spray-inoculate blossom clusters at four locations in the tops of the test trees at early bloom and test the treatment effects against secondary infection. Treatments were applied dilute to runoff on each application date: 2 Apr (ST, silver tip; Trts 1, 4, & 5 only); 17 Apr (OC, open cluster; Trts 2, 4, & 5 only); 22 Apr (Bl, bloom: Trts 3-9); 22 Apr (inoculation); 5 May (PF, petal fall, Trts 3-9 only) and 12 May (1C, first cover, Trts 3-5 and 7-9). Blossom clusters were inoculated at four locations in the tops of the test trees at early bloom (22 Apr) by spraying to wet with a bacterial suspension containing $1X10^6$ E. amylovora cells/ml. Conditions were favorable for secondary spread throughout the tree in late bloom. Fruit finish and rusts were rated after harvest on 25-fruit samples picked 16 Sep and rated 24 Sep.

Inoculation of blossom clusters in the tops of the test trees favored secondary spread during late bloom, resulting in strikes throughout the trees. Several treatment schedules significantly reduced secondary fire blight strikes per tree. Treatments involving streptomycin (Harbour) applied alone during bloom (#6 and 7), and as part of an integrated schedule with MasterCop (#5) were the most effective fire blight treatments. Combining Double Nickel with MasterCop (#8) significantly reduced the number of strikes per tree compared to either Master Cop (#3) or Double Nickel alone (#9). The bloom and petal fall treatments bracketed a heavy quince rust infection period 28 Apr-1 May and several treatments significantly reduced quince rust infection, including MasterCop 6 fl oz (#3), Harbour (#7), and Double Nickel (#9). There were no significant differences in fruit finish by treatments in this test.

Table 5. Fire blight, rust suppression and fruit finish by early season copper applications.

	Treatment and rate/100 gal	Timing	Blight strikes /tree	Quince Rust (%)	Cedar-apple rust (%)	Fruit finish ratings *: Rating (0-5)	Fruit finish ratings *: % Xtra Fancy	Fruit finish ratings *: % X-Fcy/ Fancy
0	No treatment	---	272 e	23 c	13 a	1.3 a	53 a	85 a
1	MasterCop 10 fl oz	ST	158 c-e	18 bc	10 a	1.2 a	66 a	93 a
2	MasterCop 4 fl oz	OC	233 e	20 c	16 a	1.2 a	63 a	86 a
3	MasterCop 6 fl oz	BL, PF, 1C	225 de	6 ab	8 a	1.3 a	60 a	86 a
4	MasterCop 10 fl oz MasterCop 4 fl oz MasterCop 2 fl oz	ST OC BL, PF, 1C	98 b-d	16 bc	10 a	1.5 a	55 a	83 a
5	MasterCop 10 fl oz MasterCop 4 fl oz MasterCop 2 fl oz + Harbour 6 fl oz MasterCop 2 fl oz	ST OC BL, PF 1C	45 ab	7 ab	5 a	1.5 a	60 a	84 a
6	Harbour 6 fl oz	BL, PF	49 ab	15 a-c	6 a	1.3 a	62 a	90 a
7	Harbour 6 fl oz	BL, PF, 1C	14 a	6 ab	7 a	1.2 a	63 a	89 a
8	MasterCop 6 fl oz + Double Nickel LC 8 fl oz	BL, PF, 1C	109 bc	14 a-c	6 a	1.4 a	51 a	90 a
9	Double Nickel LC 8 fl oz	BL, PF, 1C	187 c-e	6 a	8 a	1.2 a	66 a	89 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replicates.
Fire blight strikes counted 9 Jun; fruit ratings at harvest 24 Sep.
* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet). USDA grades after downgrading by russet presumed not to be caused by mildew.

APPLE (*Malus domestica* 'Gala')
Scab; *Venturia inaequalis*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Rots (unspecified)
White rot; *Botryosphaeria dothidea*
Bitter rot; *Colletotrichum* spp.
Alternaria rot; *Alternaria* spp.
Phomopsis rot; *Phomopsis* spp.
Fruit russet

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Shoot blight suppression, summer disease control, and fruit finish, by post-bloom copper applications on Gala apple, 2014.

Five treatments were compared for shoot blight suppression, summer disease control and fruit finish effects on 13-yr-old Gala/M.26 trees. The test was conducted in a randomized block design with four single-tree replicates separated in the row by border trees. No fungicides were applied before the treatment series began at petal fall. Treatments were applied dilute to run-off: 12 May (PF, petal fall); 1st-8th covers, (1C-8C): 19 May, 28 May, 9 Jun, 23 Jun, 7 Jul, 21 Jul, 4 Aug, and 21 Aug. The inoculation approach in this shoot blight test was to inoculate three actively-growing shoot tips near the top of each test tree to favor secondary spread under the treatment series. Three shoot tips per tree were inoculated 9 May 2014 by dipping scissors in a suspension containing $1X10^6$ streptomycin-sensitive E. amylovora cells/ml, then cutting across the shoot tip. All other diseases developed from inoculum naturally present in the test area. Shoot blight strikes were counted 25 Jun. Fruit data are based on 25-fruit sample per rep harvested from each of four single-tree reps 4 Sep. Harvested fruit were stored at ambient warm temperatures through the evaluation process, with initial fruit evaluation 11 Sep, and final evaluation for storage rots after 18 days incubation at ambient temperatures 58-86°F. Maintenance materials applied to the entire test block with a commercial airblast sprayer during the test period included: Admire Pro, Altacor, Assail, Asana XL, BioCover MLT, Calypso, Delegate, Imidan, Lannate LV, and Provado.

Inoculation in the tops of trees resulted in subsequent shoot blight infection throughout the test trees, and all treatments significantly reduced the number of shoot blight strikes per tree (Table 6). No fungicides had been applied in this test block previously, and scab lesions from 11 Apr and 14 Apr infections were already present in the test block when the treatment series began 12 May. Fourteen secondary scab infection periods occurred 28 Apr-22 Jun. Under these delayed application conditions, all treatments significantly reduced fruit scab incidence, with the most effective being the standard Captan schedule (Trt #3) and Taegro + Cueva alternated with Captan (#4). Taegro + Cueva alternated with Captan was more effective than Double Nickel + Cueva alternated with Captan (#1). All treatments included Rally at first cover, which effectively reduced quince rust and cedar-apple rust of fruit. Captan was included in every application in treatment #3 and this provided the best sooty blotch/ flyspeck (SBFS) and rot control. Parallel treatments #1, 2, 4 & 5 compared Double Nickel + Cueva (#1), to Cueva alone (#2), Taegro + Cueva (#4), and Double Nickel + MasterCop (#5). Cueva alone gave better SBFS control than Taegro + Cueva (#4), but adding Taegro to Cueva significantly reduced rot incidence at harvest. Adding Double Nickel to Cueva significantly reduced bitter rot incidence that developed during post-storage incubation (Table 7). It is likely that rots were probably more prevalent due to the presence of inoculum on twigs killed by fire blight, so this could have confounded the assessment of direct effectiveness for rot control. There was no significant fruit finish effect by any treatment (Table 7).

Table 6. Shoot blight and summer disease suppression on Gala apples, 2014. Virginia Tech AREC, Winchester

	Treatment and rate/ 100 gal dilute	Timing	Shoot blight strikes/tree	Scab	Quince rust	Cedar-apple rust	Brooks spot	Any rot	Sooty blotch % fruit	Sooty blotch % area	Flyspeck % fruit	Flyspeck % area
				% fruit or fruit area infected at harvest								
0	Non-treated control	---	4.00 b	86 c	62 b	23 b	7 b	33 d	99 c	8.1 d	100 d	12.3 d
1	Double Nickel LC 1 qt + Cueva 2 qt Rally 1.25 oz + Captan 80WDG 7.5 oz Captan 80WDG 7.5 oz	PF,2,4,6 & 8C 1C, 3C, 5C,7C	0.25 a	36 b	12 a	0 a	0 a	15 bc	9 ab	0.5 a-c	39 bc	2.4 bc
2	Cueva 2 qt Rally 1.25 oz + Captan 80WDG 7.5 oz Captan 80WDG 7.5 oz	PF,2,4,6 & 8C, 1C, 3C, 5C,7C	0.75 a	39 b	12 a	0 a	0 a	22 cd	1 a	0.1 ab	22 ab	1.3 ab
3	Apogee 6 oz + Choice 1 qt + LI-700 1 pt + FireWall 4 oz + Captan 80WDG 7.5 oz Rally 1.25 oz + Captan 80WDG 7.5 oz Captan 80WDG 7.5 oz	PF 1C 2C-8C	0.25 a	12 a	9 a	0 a	0 a	3 a	0 a	0 a	11 a	0.5 a
4	Taegro 6 oz + Cueva 2 qt Rally 1.25 oz + Captan 80WDG 7.5 oz Captan 80WDG 7.5 oz	PF,2,4,6 & 8C, 1C, 3C, 5C,7C	0.25 a	12 a	5 a	0 a	0 a	7 ab	15 b	0.8 bc	49 c	3.7 c
5	Double Nickel LC 1 qt + MasterCop 6 fl oz Rally 1.25 oz + Captan 80WDG 7.5 oz Captan 80WDG 7.5 oz	PF,2,4,6 & 8C, 1C, 3C, 5C,7C	0.25 a	51 b	8 a	0 a	1 a	13 bc	21 b	1.6 c	39 bc	2.6 bc

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Dilute rates based on 400 gpa. Four single-tree reps.

Three shoot tips per tree inoculated by dipping scissors in *E. amylovora* in suspension containing $1X10^6$ strep-sensitive *E. amylovora* cells/ml, then cutting across the shoot tip, 9 May. Fire blight strikes per tree counted 25 June '14.

Counts of 25-fruit samples per tree picked 4 Sep.

Table 7. Summer disease and post-harvest rot suppression on Gala apple, 2014.

	Treatment and rate/ 100 gal dilute	Timing	Any rot at harvest	Post-harvest rots following 18 days' incubation at 56-86°F*: any rot	Bitter rot	White rot	Alter-naria	Russet rating (0-5)**
0	Non-treated control	---	33 d	59 c	35 d	27 c	11 b	1.3 a
1	Double Nickel LC 1 qt + Cueva 2 qt	PF,2,4,6&8C						1.1 a
	Rally 1.25 oz + Captan 80WDG 7.5 oz	1C,						
	Captan 80WDG 7.5 oz	3C, 5C,7C	15 bc	35 bc	11 a-c	20 bc	4 ab	
2	Cueva 2 qt	PF,2,4,6,8C						1.0 a
	Rally 1.25 oz + Captan 80WDG 7.5 oz	1C,						
	Captan 80WDG 7.5 oz	3C, 5C,7C	22 cd	36 bc	26 cd	14 a-c	2 ab	
3	Apogee 6 oz + Choice 1 qt + LI-700 1 pt + FireWall 4 oz + Captan 80WDG 7.5 oz	PF						1.6 a
	Rally 1.25 oz + Captan 80WDG 7.5 oz	1C						
	Captan 80WDG 7.5 oz	2C-8C	3 a	5 a	1 a	4 a	0 a	
4	Taegro 6 oz + Cueva 2 qt	PF,2,4,6,8C						1.2 a
	Rally 1.25 oz + Captan 80WDG 7.5 oz	1C,						
	Captan 80WDG 7.5 oz	3C, 5C,7C	7 ab	16 ab	12 bc	4 ab	1 a	
5	Double Nickel LC 1 qt + MasterCop 6 fl oz	PF,2,4,6,8C						1.0 a
	Rally 1.25 oz + Captan 80WDG 7.5 oz	1C						
	Captan 80WDG 7.5 oz	3C, 5C,7C	13 bc	17 ab	5 ab	8 a-c	6 ab	

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications.
Treatment dates: 12 May (PF, petal fall); First-8th covers (1C-8C): 19 May, 28 May, 9 Jun, 23 Jun, 7 Jul, 21 Ju 21 Aug.

* Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 4 Sep. After i evaluation 11 Sep, fruit were incubated and again rated after 18 days at ambient temperatures 56-86°F.

** Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet). USDA grades after downgrading by ru

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

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EUP test of Actigard for fire blight control on York Imperial apple. Strasburg, VA, 2013-14.

For the second consecutive year, Actigard was applied under an EUP permit in Valley View Orchard, Strasburg, VA. The test strategy was to select an orchard with evidence of some fire blight infection and inoculum carry-over, and to repeat application of the same treatments to the same trees in 2013 and 2014. The treatments were applied as separate applications over the regular schedule which included some copper products in this processing market orchard, applied to alternate row middles during the bloom period / fire blight season 21 Apr and 1 May (Cuprofix 5 lb/A) and 8 May (Badge SC 11 oz/A). The plot set-up involved two cultivars, York Imperial and Idared. Plots involved 4-6 tree replicates in a complete randomized block design in adjacent single tree rows for each cultivar. The treatments were applied airblast at 50 gal per acre from both sides of the tree row on each application date: 18 Apr (York, pink; Idared 80% bloom); 21 Apr (York, 20% bloom; Idared 80% bloom); 6 May (York 80% bloom-petal fall; Idared, late bloom to 5 mm fruit.

In 2013 conditions were not very favorable for natural infection, resulting in no significant differences between non-treated and treated trees. However, in 2014 conditions were more favorable for secondary spread through the tree in late bloom which was more prevalent in the York cultivar. Fire blight strikes were counted on Idared 18 June and on York Imperial 23 June. Compared to trees which received only the commercial schedule, all treatments gave significant control of fire blight strikes in York Imperial. Differences in Idared were again not significant (P=0.05).

Table 8. Fire blight strikes per tree, Actigard EUP Test on York Imperial and Idared apple.

		Blight strikes/tree									
		York Imperial replications					Idared replications				
Treatment and rate/acre	Timing	A	B	C	D	Mean	A	B	C	D	Mean
0 No treatment	---	14.8	5.5	3.4	10.8	8.62 b	0	0.8	0.2	0.5	0.36 a
1 FireWall 17 8 oz	Pink-PF	0.4	1.8	1.8	2.1	2.05 a	0.3	0	1.3	1.3	0.69 a
2 FireWall 17 8 oz + Actigard 50WG 2 oz	Pink-PF	2.5	0.4	0	1.7	1.73 a	0.3	0	0	0	0.06 a
3 Actigard 50WG 2 oz	Pink-PF	1.8	1.3	2.0	1.6	1.56 a	0.3	1.3	0.3	0.6	0.59 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four to six-tree replicates.
Fire blight strikes counted 18 Jun (Idared) or 23 Jun (York Imperial) 2014.

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

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Disease control by experimental and registered fungicides and mixtures on Golden Delicious, Idared, and York Imperial apples, 2014.

Fourteen experimental or registered combination treatment schedules were compared on three-tree sets of 14-yr-old trees. The test was conducted in a randomized block design with four replicates separated by non-treated border rows. Test rows had been non-treated border rows in 2013, which allowed mildew inoculum pressure to stabilize on 2014 test trees. Fungicide treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (all treatments, TC, tight cluster, Golden Delicious; York ½ "-green; Idared TC-open cluster); 24 Apr (Bl, early bloom, all except #7); 28 Apr (Trt 7 only); 4 May (all except #7; PF, petal fall); 9 May (Trt 7 only); 18 May (1C, 1st cover; all except #7); 23 May (Trt 7 only); 31 May (2C, 2nd cover; all except #7); 7 Jun (Trt 7 only); 14 Jun (3C, 3rd cover; all except #7); 20 Jun (Trt 7 only); 4C-8C, 4th-8th covers, all treatments: 28 Jun, 12 Jul, 25 Jul, 11 Aug, 29 Aug. Inoculum placed over each Golden Delicious test tree included cedar galls, wild blackberry canes with the sooty blotch and flyspeck fungi, and bitter rot mummies 20 May. Other diseases developed from inoculum naturally present in the test area, including cedar-apple rust inoculum from red cedars in the vicinity. Maintenance sprays, applied to the entire test block included Admire Pro, Altacor, Assail, Asana XL, BioCover MLT, Calypso, Delegate, Diazinon, Imidan, Lannate LV, and Provado. Ethephon 3 pt + Carbaryl 3 pt/A were applied to Golden Delicious trees as a thinning application 23 May. Foliar data are from counts of ten shoots per replicate tree: 18 Jun (York), 16 Jul (Idared), and 25 Jul (Golden Delicious). Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 17 Sep (Idared), 30 Sep (Golden Delicious) or 6 Oct (York). Idared fruit were held in cold storage 33 days, and Golden Delicious 17 days prior to start of warm temperature incubation; York fruit were incubated at warm temperatures immediately after harvest. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The early season was favorable for development of powdery mildew, scab, cedar-apple rust and quince rust. Mildew conidia were present 9 Apr, and there were 42 dry weather "mildew infection days" from 9 Apr-18 Jun, resulting in moderate infection of non-treated trees (Table 9). Merivon (Trts #13 and 14) and Luna Sensation alternated with Topguard (#12) had strong suppressive effects on primary mildew development, and this generally carried over to excellent control on leaves, leaf area affected, and fruit infection. Luna Tranquility + Silwet (#9) was significantly less effective than #11 (without Silwet) for mildew control. Trts #5-8 lost some benefit by not having an effective mildewcide at tight cluster stage. Combinations involving IKF-5411 (#2-4) gave significant mildew suppression but were noticeably weaker than treatments involving Merivon, Luna Sensation/Topguard, and Luna Tranquility/Topguard. Adding Manzate to IKF-5411 + Silwet reduced effectiveness against mildew. Rally (#1) performed as typical since the onset of SI fungicide resistance in 2005. The first scab infection period occurred 11 Apr and primary lesions were present during the heaviest secondary period 28 Apr-1 May, followed by 13 more secondary scab infection periods through June. Scab resistant to SI and QoI fungicides has been present in the test area for several years, and this probably impacted control by Rally (#1) and Luna Sensation/Topguard (#10 and 12). Treatments #5-8, which began the season with Manzate or Manzate + Captan and were followed by A15457 or A19334 alternated with Inspire Super, gave the best scab control overall (Table 10). The extended wetting period 28 Apr-1 May, also resulted in heavy quince rust and cedar-apple rust infection on fruit and there was prolonged cedar-apple rust infection pressure on foliage into mid-June. Treatments involving more frequent application of SI fungicides (Rally in #1 and A19334/Inspire Super in #8) were the most effective for cedar-apple rust control (Table 11) and those which had SI fungicides or Manzate in the bloom and petal fall sprays bracketing the wetting period 28 Apr-1 May (#1, 6-12, and 13) were generally more effective for quince rust control (Table 12) while those relying on SDHI fungicides (#2 and 3) or Captan (#13) were weaker for quince rust control. All treatments gave good control of Brooks spot (Table 12). Among treatments ending the season with Captan + Ziram, there was some evidence of comparative effects of mid-season cover spray fungicides or rate differences in the schedule on sooty blotch and flyspeck (Table 13) or post-harvest rots (Table 14). A reduction in the rate of A15457 to 3.5 fl oz (#7) resulted in more flyspeck on Golden Delicious compared to the 7 fl oz rate in #6, as did including Silwet with Luna Sensation + Captan (#9 vs. #11). IKF-5411 had weaknesses for all summer diseases (#2 and 3 vs. #4). A199334 (#8) gave better control of bitter rot than A15457 (#6 and 7). Compared to non-treated fruit, numerous treatments improved fruit finish of Golden Delicious and Idared fruit; only IKF-5411 showed any significant deleterious fruit finish effects (Table 15).

Table 9. Mildew control on Idared, and Golden Delicious apples, 2014.

	Treatment and rate/A	Timing	Idared primary effect*	Mildew, % leaves, leaf area or fruit inf. Idared lvs	Idared area	Idared fruit	Golden Del. lvs	Golden Del. area
0	Non-treated control	---	2.2 g	56 f	15 g	25 d	35 f	6 f
1	Rally 40WSP 5 oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	4.0 de	30 de	5 ef	0 a	13 b-e	2 b-e
2	IKF-5411 40SC 12.5 oz + Silwet L-77 114 ml/100 gal	TC-8C	3.7 ef	19 bc	3 b-d	10 c	8 ab	2 a-c
3	IKF-5411 400SC 12.5 oz	TC-8C	3.1 f	26 c-e	3 d-f	13 c	16 de	3 c-e
4	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Manzate 75DF 4 lb IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal +Captan 80WDG 3 lb	 TC-1C 2C-8C	3.7 ef	34 e	5 ef	2 ab	19 e	3 e
5	Manzate 75DF 6 lb Captan 80WDG 40 oz	TC-1C 2C-8C	4.2 de	33 de	6 f	2 a	20 e	3 de
6	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	3.6 ef	25 c-e	3 d-e	5 bc	12 b-e	2 b-e
7	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz (Delayed apps. Bl-3C) Inspire Super 2.82 EW 12 fl oz A15457 100EC 3.5 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C, PF, 2C 3C,4C 5C-8C	4.4 de	24 b-d	3 de	3 ab	18 e	3 c-e
8	Manzate 75DF 6 lb + Captan 80WDG 40 oz A19334 194.5EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	4.7 d	21 b-d	3 de	3 ab	15 c-e	3 b-e
9	Luna Tranquility 11.2 fl oz + Manzate 3 lb+ Silwet Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 30 oz + Silwet Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	6.1 c	16 b	3 cd	0 a	8 a-d	2 a-d
10	Luna Sensation 4 fl oz + Manzate 3 lb+ Silwet 114 ml Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4 oz + Captan 30 oz+ Silwet 114 ml Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	5.8 c	4 a	1 a	0 a	6 ab	2 ab
11	Luna Tranquility SC 11.2 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	5.6 c	6 a	1 ab	0 a	8 a-c	2 a-c
12	Luna Sensation 4 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	7.5 ab	4 a	1 a	1 a	6 ab	2 a-c
13	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	7.2 b	5 a	1 a-c	5 bc	4 a	1 a
14	Merivon 4 fl oz + Manzate 3 lb + Silwet 114 ml Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	8.1 a	3 a	1 a	1 a	4 a	1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree reps, 10 shoots/tree rated 18 Jun (York), 16 Jul (Idared), and 25 Jul (Golden Delicious) or postharvest counts of 25 fruit per replicate tree sampled: 17 Sep (Idared), 30 Sep (Golden Delicious), or 6 Oct (York). Test rows were non-treated border rows in 2013 to stabilize mildew inoculum pressure for 2014.

*Apparent suppressive effect rated on six primary mildew shoots / tree 5 Jun, scale: 1-10 (1= none; 10= excellent effect).

Treatments applied airblast at 100 gal/A applied as follows: 13 Apr (all treatments, TC, tight cluster, Golden Delicious; York ½ "-green; Idared TC-open cluster); 24 Apr (Bl, early bloom, all except #7); 28 Apr (Trt 7 only); 4 May (all except #7; PF, petal fall); 9 May (Trt 7 only); 18 May (1C, 1st cover; all except #7); 23 May (Trt 7 only); 31 May (2C, 2nd cover; all except #7); 7 Jun (Trt 7 only); 14 Jun (3C, 3rd cover; all except #7); 20 Jun (Trt 7 only); 4C-8C, 4th-8th covers, all treatments: 28 Jun, 12 Jul, 25 Jul, 11 Aug, 29 Aug.

Table 10. Scab control on Golden Delicious, Idared and York apples, 2014.

	Treatment and rate/A	Timing	Scab, % leaves or fruit infected					
			Golden Del.		Idared		York	
			lvs	fruit	leaves	fruit	leaves	fruit
0	Non-treated control	---	11 d-f	72 g	8 de	62 f	3 b-e	44 e
1	Rally 40WSP 5 oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	19 f	19 ef	13 e	21 e	6 de	12 d
2	IKF-5411 40SC 12.5 oz + Silwet L-77 114 ml/100 gal	TC-8C	8 c-e	7 b-e	5 cd	9 c-e	5 c-e	7 cd
3	IKF-5411 400SC 12.5 oz	TC-8C	9 de	21 f	4 b-d	8 c-e	2 a-c	11 cd
4	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Manzate 75DF 4 lb IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Captan 80WDG 3 lb	TC-1C 2C-8C	11 de	3 a-c	6 cd	12 de	7 e	1 ab
5	Manzate 75DF 6 lb Captan 80WDG 40 oz	TC-1C 2C-8C	10 de	10 c-f	3 a-d	6 a-d	4 c-e	3 a-c
6	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	1 a	2 a-c	1 a	0 a	<1 a	0 a
7	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz; (Delayed apps. Bl-3C) Inspire Super 2.82 EW 12 fl oz A15457 100EC 3.5 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C, PF, 2C 3C,4C 5C-8C	2 ab	2 ab	2 ab	3 a-c	1 ab	1 ab
8	Manzate 75DF 6 lb + Captan 80WDG 40 oz A19334 194.5EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	1 a	0 a	1 a	0 a	<1 a	0 a
9	Luna Tranquility 11.2 fl oz + Manzate 3 lb+ Silwet Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 30 oz + Silwet Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	3 bc	2 ab	3 a-d	7 b-e	1 a-c	1 ab
10	Luna Sensation 4 fl oz + Manzate 3 lb+ Silwet 114 ml Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4 oz + Captan 30 oz+ Silwet 114 ml Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	11 de	14 d-f	6 c-e	7 a-d	5 c-e	5 b-d
11	Luna Tranquility SC 11.2 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	8 c-e	5 a-c	4 b-d	10 c-e	2 a-d	7 cd
12	Luna Sensation 4 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	11 ef	13 ef	6 cd	9 b-e	4 c-e	9 cd
13	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	6 cd	1 a	4 a-d	1 ab	2 b-d	0 a
14	Merivon 4 fl oz + Manzate 3 lb + Silwet 114 ml/100 gal Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	6 c-e	4 a-d	3 a-c	4 a-c	1 ab	4 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree reps, 10 shoots/tree rated 18 Jun (York), 16 Jul (Idared), and 25 Jul (Golden Delicious) or postharvest counts of 25 fruit per replicate tree sampled: 17 Sep (Idared), 30 Sep (Golden Delicious), or 6 Oct (York).

Treatments applied airblast at 100 gal/A applied as follows: 13 Apr (all treatments, TC, tight cluster, Golden Delicious; York ½ "-green; Idared TC-open cluster); 24 Apr (Bl, early bloom, all except #7); 28 Apr (Trt 7 only); 4 May (all except #7; PF, petal fall); 9 May (Trt 7 only); 18 May (1C, 1st cover; all except #7); 23 May (Trt 7 only); 31 May (2C, 2nd cover; all except #7); 7 Jun (Trt 7 only); 14 Jun (3C, 3rd cover; all except #7); 20 Jun (Trt 7 only); 4C-8C, 4th-8th covers, all treatments: 28 Jun, 12 Jul, 25 Jul, 11 Aug, 29 Aug.

Table 11. Cedar-apple rust control on Golden Delicious, Idared and York apples, 2014.

			Cedar-apple rust,				
			% leaves infected			% fruit infected	
	Treatment and rate/A	Timing	G. Del.	Idared	York	Idared	York
0	Non-treated control	---	52 i	63 g	67 j	7 d	13 d
1	Rally 40WSP 5 oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	1 a	1 a	2 a	0 a	0 a
2	IKF-5411 40SC 12.5 oz + Silwet L-77 114 ml/100 gal	TC-8C	24 fg	24 de	34 gh	3 bc	8 c
3	IKF-5411 400SC 12.5 oz	TC-8C	36 h	33 ef	51 i	7 cd	11 d
4	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Manzate 75DF 4 lb IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + +Captan 80WDG 3 lb	 TC-1C 2C-8C	33 gh	26 de	38 h	1 ab	0 a
5	Manzate 75DF 6 lb Captan 80WDG 40 oz	TC-1C 2C-8C	42 hi	39 f	40 h	2 ab	0 a
6	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	10 c	11 bc	18 de	0 a	0 a
7	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz (Delayed apps. Bl-3C) Inspire Super 2.82 EW 12 fl oz A15457 100EC 3.5 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C, PF, 2C 3C,4C 5C-8C	8 bc	17 cd	19 de	0 a	0 a
8	Manzate 75DF 6 lb + Captan 80WDG 40 oz A19334 194.5EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	3 ab	3 a	6 b	0 a	0 a
9	Luna Tranquility 11.2 fl oz + Manzate 3 lb+ Silwet Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 30 oz + Silwet Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	10 cd	9 b	12 b-d	0 a	0 a
10	Luna Sensation 4 fl oz + Manzate 3 lb+ Silwet 114 ml Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4 oz + Captan 30 oz+ Silwet 114 ml Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	13 c-e	11 bc	14 c-e	0 a	0 a
11	Luna Tranquility SC 11.2 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	21 f	15 bc	21 ef	0 a	0 a
12	Luna Sensation 4 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	19 d-f	14 bc	10 bc	0 a	0 a
13	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	21 ef	20 cd	27 fg	2 ab	2 b
14	Merivon 4 fl oz + Manzate 3 lb + Silwet 114 ml/100 gal Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	34 h	33 ef	30 gh	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree reps, 10 shoots/tree rated 18 Jun (York), 16 Jul (Idared), and 25 Jul (Golden Delicious) or postharvest counts of 25 fruit per replicate tree sampled: 17 Sep (Idared), 30 Sep (Golden Delicious), or 6 Oct (York).

Treatments applied airblast at 100 gal/A applied as follows: 13 Apr (all treatments, TC, tight cluster, Golden Delicious; York ½ "-green; Idared TC-open cluster); 24 Apr (Bl, early bloom, all except #7); 28 Apr (Trt 7 only); 4 May (all except #7; PF, petal fall); 9 May (Trt 7 only); 18 May (1C, 1st cover; all except #7); 23 May (Trt 7 only); 31 May (2C, 2nd cover; all except #7); 7 Jun (Trt 7 only); 14 Jun (3C, 3rd cover; all except #7); 20 Jun (Trt 7 only); 4C-8C, 4th-8th covers, all treatments: 28 Jun, 12 Jul, 25 Jul, 11 Aug, 29 Aug.

Table 12. Quince rust and Brooks spot control on Golden Delicious, Idared and York apples, 2014.

			Quince rust, % fruit infected				Brooks spot, % fruit infected	
			G. Del.	Harvest counts				
	Treatment and rate/A	Timing	on tree	G. Del.	Idared	York	G. Del.	Idared
0	Non-treated control	---	40 e	26 c	49 f	37 d	18 b	42 c
1	Rally 40WSP 5 oz + Manzate 75DF 3 lb	TC-4C	0 a	0 a	0 a	0 a	1 a	2 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
2	IKF-5411 40SC 12.5 oz + Silwet L-77 114 ml/100 gal	TC-8C	27 d	25 c	35 e	3 b	0 a	1 ab
3	IKF-5411 400SC 12.5 oz	TC-8C	26 d	22 c	35 e	13 c	1 a	0 a
4	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal +							
	Manzate 75DF 4 lb	TC-1C	6 b	0 a	9 d	4 b	0 a	0 a
	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal +							
	Captan 80WDG 3 lb	2C-8C						
5	Manzate 75DF 6 lb	TC-1C	12 c	25 c	10 d	5 b		
	Captan 80WDG 40 oz	2C-8C					0 a	0 a
6	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC						
	A15457 100EC 7 fl oz	Bl,1C,3C,4C	0 a	0 a	0 a	0 a	0 a	0 a
	Inspire Super 2.82 EW 12 fl oz	PF, 2C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
7	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC						
	A15457 100EC 7 fl oz (Delayed apps. Bl-3C)	Bl,1C,	0 a	0 a	2 a-c	0 a	1 a	0 a
	Inspire Super 2.82 EW 12 fl oz	PF, 2C						
	A15457 100EC 3.5 fl oz	3C,4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
8	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC						
	A19334 194.5EC 7 fl oz	Bl,1C,3C,4C	0 a	0 a	0 a	0 a	0 a	0 a
	Inspire Super 2.82 EW 12 fl oz	PF, 2C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
9	Luna Tranquility 11.2 fl oz + Manzate 3 lb+ Silwet	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C	0 a	1 a	0 a	0 a	0 a	0 a
	Luna Sensation 4.0 oz + Captan 30 oz + Silwet	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C						
10	Luna Sensation 4 fl oz + Manzate 3 lb+ Silwet 114 ml	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C	0 a	0 a	0 a	0 a	0 a	0 a
	Luna Sensation 4 oz + Captan 30 oz+ Silwet 114 ml	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C						
11	Luna Tranquility SC 11.2 fl oz + Manzate 75DF 3 lb	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C	1 a	0 a	0 a	0 a	0 a	0 a
	Luna Sensation 4.0 oz + Captan 80WDG 30 oz	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C						
12	Luna Sensation 4 fl oz + Manzate 75DF 3 lb	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C	0 a	0 a	1 ab	0 a	0 a	0 a
	Luna Sensation 4.0 oz + Captan 80WDG 30 oz	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C						
13	Merivon 4 fl oz + Captan 80WDG 2 lb + Silwet 114 ml	TC-4C	23 d	4 b	4 cd	0 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						
14	Merivon 4 fl oz + Manzate 3 lb + Silwet 114 ml/100 gal	TC-4C	0 a	7 b	5 b-d	0 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C						

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree reps, On-tree counts of 50 fruit per Golden Delicious tree 2 Sep, or postharvest counts of 25 fruit per replicate tree sampled: 17 Sep (Idared), 30 Sep (Golden Delicious), or 6 Oct (York).

Treatments applied airblast at 100 gal/A applied as follows: 13 Apr (all treatments, TC, tight cluster, Golden Delicious; York ½ "-green; Idared TC-open cluster); 24 Apr (Bl, early bloom, all except #7); 28 Apr (Trt 7 only); 4 May (all except #7; PF, petal fall); 9 May (Trt 7 only); 18 May (1C, 1st cover; all except #7); 23 May (Trt 7 only); 31 May (2C, 2nd cover; all except #7); 7 Jun (Trt 7 only); 14 Jun (3C, 3rd cover; all except #7); 20 Jun (Trt 7 only); 4C-8C, 4th-8th covers, all treatments: 28 Jun, 12 Jul, 25 Jul, 11 Aug, 29 Aug.

Table 13. Sooty blotch and flyspeck control on Idared, Golden Delicious and York apples, 2014.

			% fruit infected					
			Sooty blotch			Flyspeck		
	Treatment and rate/A	Timing	G.Del	Idared	York	G.Del	Idared	York
0	Non-treated control	---	99 f	100 i	100 d	98 i	100 f	100 e
1	Rally 40WSP 5 oz + Manzate 75DF 3 lb	TC-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	12 cd	25 e-h	0 a	33 f-h	26 d	24 a-d
2	IKF-5411 40SC 12.5 oz + Silwet L-77 114 ml/100 gal	TC-8C	47 e	40 gh	39 b	40 gh	27 d	49 b-d
3	IKF-5411 400SC 12.5 oz	TC-8C	45 e	47 h	71 c	23 d-g	22 cd	52 cd
4	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Manzate 75DF 4 lb	TC-1C						
	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Captan 80WDG 3 lb	2C-8C	7 a-c	10 a-e	7 a	14 b-e	8 a-c	32 a-d
5	Manzate 75DF 6 lb	TC-1C						
	Captan 80WDG 40 oz	2C-8C	19 d	37 f-h	25 b	50 h	51 e	46 b-d
6	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC						
	A15457 100EC 7 fl oz	Bl,1C,3C,4C						
	Inspire Super 2.82 EW 12 fl oz	PF, 2C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	8 b-d	17 d-f	2 a	3 ab	14 a-d	21 a-d
7	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC						
	A15457 100EC 7 fl oz (Delayed apps. Bl-3C)	Bl,1C,						
	Inspire Super 2.82 EW 12 fl oz	PF, 2C						
	A15457 100EC 3.5 fl oz	3C,4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	11 b-d	21 d-g	3 a	23 b-f	22 cd	21 a-d
8	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC						
	A19334 194.5EC 7 fl oz	Bl,1C,3C,4C						
	Inspire Super 2.82 EW 12 fl oz	PF, 2C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	0 a	2 a	1 a	0 a	3 a	4 a
9	Luna Tranquility 11.2 fl oz + Manzate 3 lb+ Silwet	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C						
	Luna Sensation 4.0 oz + Captan 30 oz + Silwet	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	0 a	3 a-c	7 a	18 c-g	7 a-c	11 a-c
10	Luna Sensation 4 fl oz + Manzate 3 lb+ Silwet 114 ml	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C						
	Luna Sensation 4 oz + Captan 30 oz+ Silwet 114 ml	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	1 ab	11 b-e	2 a	5 a-c	10 a-d	14 ab
11	Luna Tranquility SC 11.2 fl oz + Manzate 75DF 3 lb	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C						
	Luna Sensation 4.0 oz + Captan 80WDG 30 oz	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	5 b-d	10 a-d	3 a	6 ab	5 ab	15 a-d
12	Luna Sensation 4 fl oz + Manzate 75DF 3 lb	TC,PF, 2C						
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C						
	Luna Sensation 4.0 oz + Captan 80WDG 30 oz	4C & 6C						
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	0 a	14 c-e	1 a	6 a-d	15 b-d	16 a-c
13	Merivon 4 fl oz + Captan 2 lb 80WDG + Silwet 114 ml	TC-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	1 ab	2 a	0 a	10 a-c	6 a-c	32 a-d
14	Merivon 4 fl oz + Manzate 3 lb + Silwet 114 ml/100 gal	TC-4C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	6 a-d	3 ab	5 a	24 e-g	5 ab	56 d

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree reps; postharvest counts of 25 fruit per replicate tree sampled: 17 Sep (Idared), 30 Sep (Golden Delicious), or 6 Oct (York).

Treatments applied airblast at 100 gal/A applied as follows: 13 Apr (all treatments, TC, tight cluster, Golden Delicious; York ½ "-green; Idared TC-open cluster); 24 Apr (Bl, early bloom, all except #7); 28 Apr (Trt 7 only); 4 May (all except #7; PF, petal fall); 9 May (Trt 7 only); 18 May (1C, 1st cover; all except #7); 23 May (Trt 7 only); 31 May (2C, 2nd cover; all except #7); 7 Jun (Trt 7 only); 14 Jun (3C, 3rd cover; all except #7); 20 Jun (Trt 7 only); 4C-8C, 4th-8th covers, all treatments: 28 Jun, 12 Jul, 25 Jul, 11 Aug, 29 Aug.

Table 14. Rots on Golden Delicious, Idared and York apples, at harvest and after indicated days warm storage incubation, 2014.

			Harvest sample counts % any rot		Post-storage counts								
					Golden Del. (21 days)			Idared (18 days)			York (31 days)		
	Treatment and rate/A	Timing	G. Del	Idared	Any rot	Bitter rot	White rot	Any rot	Bitter rot	White rot	Any rot	Bitter rot	White rot
0	Non-treated control	---	49 c	19 e	58 f	41 fg	19 e	28 f	22 g	6 b	55 e	36 d	17 e
1	Rally 40WSP 5 oz + Manzate 75DF 3 lb	TC-4C											
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	3 a	4 b-d	4 ab	1 a	2 a-c	7 a-e	7 b-f	0 a	1 a	1 a	0 a
2	IKF-5411 40SC 12.5 oz + Silwet L-77 114 ml/100 gal	TC-8C	20 b	7 d	33 de	26 ef	9 cd	16 ef	14 e-g	1 a	36 de	31 cd	7 c-e
3	IKF-5411 400SC 12.5 oz	TC-8C	22 b	5 cd	51 ef	46 g	14 de	16 ef	16 fg	0 a	52 e	43 d	16 d
4	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Manzate 75DF 4 lb	TC-1C											
	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Captan 80WDG 3 lb	2C-8C	3 a	0 a	13 a-c	10 b-d	3 a-c	3 a-c	2 a-c	0 a	5 a-c	4 ab	1 a-c
5	Manzate 75DF 6 lb	TC-1C											
	Captan 80WDG 40 oz	2C-8C	6 a	1 ab	13 a-c	10 b-d	2 a-c	3 a-c	3 a-d	0 a	8 a-c	5 ab	3 a-c
6	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC											
	A15457 100EC 7 fl oz	Bl,1C,3C,4C											
	Inspire Super 2.82 EW 12 fl oz	PF, 2C											
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	3 a	5 b-d	6 ab	6 a-d	0 a	13 b-e	11 c-f	1 a	19 cd	16 bc	4 a-c
7	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC											
	A15457 100EC 7 fl oz (Delayed apps. Bl-3C)	Bl,1C,											
	Inspire Super 2.82 EW 12 fl oz	PF, 2C											
	A15457 100EC 3.5 fl oz	3C,4C											
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	4 a	2 a-c	15 bc	13 de	2 ab	16 de	12 d-f	3 ab	14 bc	13 bc	1 ab
8	Manzate 75DF 6 lb + Captan 80WDG 40 oz	TC											
	A19334 194.5EC 7 fl oz	Bl,1C,3C,4C											
	Inspire Super 2.82 EW 12 fl oz	PF, 2C											
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	4 a	4 b-d	19 cd	11 c-e	8 b-d	11 c-e	11 e-g	0 a	1 a	0 a	1 ab
9	Luna Tranquility 11.2 fl oz + Manzate 3 lb+ Silwet	TC,PF, 2C											
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C											
	Luna Sensation 4.0 oz + Captan 30 oz + Silwet	4C & 6C											
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	3 a	0 a	3 a	1 a	2 a-c	1 a	1 ab	0 a	2 a	1 a	1 ab
10	Luna Sensation 4 fl oz + Manzate 3 lb+ Silwet 114 ml	TC,PF, 2C											
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C											
	Luna Sensation 4 oz + Captan 30 oz+ Silwet 114 ml	4C & 6C											
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	1 a	0 a	5 ab	2 ab	3 a-c	4 a-d	2 a-c	1 a	1 a	1 a	0 a
11	Luna Tranquility SC 11.2 fl oz + Manzate 75DF 3 lb	TC,PF, 2C											
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C											
	Luna Sensation 4.0 oz + Captan 80WDG 30 oz	4C & 6C											
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	2 a	0 a	9 a-c	8 a-d	1 a	1 a	0 a	0 a	3 a	1 a	2 a-c
12	Luna Sensation 4 fl oz + Manzate 75DF 3 lb	TC,PF, 2C											
	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	Bl, 1C, 3C											
	Luna Sensation 4.0 oz + Captan 80WDG 30 oz	4C & 6C											
	Captan 80WDG 30 oz + Ziram 3 lb	5C, 7C & 8C	3 a	0 a	4 ab	3 a-c	1 a	6 a-e	5 b-e	1 a	4 ab	3 a	1 ab
13	Merivon 4 fl oz + Captan 2 lb 80WDG + Silwet 114 ml	TC-4C											
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C-8C	1 a	2 a-c	9 a-c	5 a-d	1 a	4 a-d	2 a-c	1 a	6 a-c	2 ab	4 b-d
14	Merivon 4 fl oz + Manzate 3 lb + Silwet 114 ml/100 gal	TC-4C	2 a	0 a									

Table 15. Fruit finish on Golden Delicious, Idared and York apples, 2014.

			G. Del. russet*		Russet		O
			rating	%USDA	rating (0-5)*		ra
	Treatment and rate/A	Timing	0-5	X-Fcy	Idared	York	Id
0	Non-treated control	---	2.1 bc	38 bc	1.5 bc	1.4 a	1.3
1	Rally 40WSP 5 oz + Manzate 75DF 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	1.5 a	69 a	1.4 bc	1.2 a	0.7
2	IKF-5411 40SC 12.5 oz + Silwet L-77 114 ml/100 gal	TC-8C	2.2 c	31 cd	2.1 d	1.9 a	1.7
3	IKF-5411 400SC 12.5 oz	TC-8C	2.6 c	16 d	1.6 c	1.8 a	1.1
4	IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + Manzate 75DF 4 lb IKF-5411 400SC 12.5 oz + Silwet L-77 114 ml/100 gal + +Captan 80WDG 3 lb	 TC-1C 2C-8C	1.7 ab	52 a-c	1.6 c	1.6 a	1.1
5	Manzate 75DF 6 lb Captan 80WDG 40 oz	TC-1C 2C-8C	1.4 a	67 a	0.9 a	1.0 a	0.6
6	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	1.6 a	66 a	1.3 a-c	1.4 a	0.9
7	Manzate 75DF 6 lb + Captan 80WDG 40 oz A15457 100EC 7 fl oz (Delayed apps. Bl-3C) Inspire Super 2.82 EW 12 fl oz A15457 100EC 3.5 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C, PF, 2C 3C,4C 5C-8C	1.4 a	69 a	1.3 a-c	1.5 a	0.7
8	Manzate 75DF 6 lb + Captan 80WDG 40 oz A19334 194.5EC 7 fl oz Inspire Super 2.82 EW 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC Bl,1C,3C,4C PF, 2C 5C-8C	1.6 a	63 a	1.6 bc	1.3 a	0.8
9	Luna Tranquility 11.2 fl oz + Manzate 75DF 3 lb+ Silwet Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz + Silwet Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	1.7 ab	61 a	1.4 bc	1.2 a	0.7
10	Luna Sensation 4 fl oz + Manzate 3 lb+ Silwet 114 ml Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4 oz + Captan 30 oz+ Silwet 114 ml Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	1.4 a	60 a	1.3 a-c	1.3 a	0.8
11	Luna Tranquility SC 11.2 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	1.5 a	63 a	1.2 a-c	1.2 a	0.5
12	Luna Sensation 4 fl oz + Manzate 75DF 3 lb Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb Luna Sensation 4.0 oz + Captan 80WDG 30 oz Captan 80WDG 30 oz + Ziram 3 lb	TC,PF, 2C Bl, 1C, 3C 4C & 6C 5C, 7C & 8C	1.4 a	66 a	1.4 bc	1.3 a	0.8
13	Merivon 4 fl oz + Captan 2 lb 80WDG + Silwet 114 ml Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	1.6 a	58 ab	1.2 ab	1.4 a	0.6
14	Merivon 4 fl oz + Manzate 3 lb + Silwet 114 ml/100 gal Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-4C 5C-8C	1.7 ab	65 a	0.9 a	1.1 a	0.6

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four paired-tree reps; postharvest counts of 25 fruit replicate tree sampled: 17 Sep (Idared), 30 Sep (Golden Delicious), or 6 Oct (York).

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

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

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Evaluation of experimental fungicides and mixtures for full season disease management on three apple cultivars, 2014.

Nine treatments, aimed primarily at early season and early summer diseases, were compared for season-long fungal disease control and fruit finish effects on three apple cultivars. Treatments were evaluated on 25-yr-old, three-cultivar tree sets in a four-replicate randomized block design. The Rome trees used in the test had not been treated in 2013 to allow powdery mildew inoculum to stabilize in the 2014 test trees. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 400 psi as follows: 17 Apr (Pk, pink, Inspire in #9); 1 May (bloom, Inspire in #9); 12 May (petal fall, Inspire in #9); 23 May (first cover, 1C, no Inspire in #9); 2 Jun (2C, Inspire in #9); 17 Jun (3C, no Inspire in #9); 2 Jul (4C); 17 Jul (5C); 7 Aug (6C); 28 Aug (7C). Inoculum over each Golden Delicious test tree included cedar rust galls and wild blackberry canes with the sooty blotch and flyspeck fungi placed 25 Apr and bitter rot mummies placed 21 May. Other diseases developed from inoculum naturally present in the test area, including cedar-apple rust inoculum from red cedars in the vicinity. Maintenance sprays, applied separately to the entire test block with a commercial airblast sprayer, included: Admire Pro, Altacor, Asana XL, Assail, BioCover MLT, Delegate, Imidan, Lannate LV, Provado, Scorpion and Voliam Flexi. Foliar data represent averages of counts of ten terminal shoots 25 Jun (Golden Delicious), or 11 Jul (Rome). Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 2 Oct (Golden Delicious and Red Delicious) or 3 Oct (Rome). Following harvest, Golden Delicious fruit were first rated 3 Oct, Red Delicious 8 Oct, and Rome fruit 9 Oct. After initial evaluation, fruit were incubated at ambient temperatures 44-80°F (mean 70.9°F) until final storage rot assessment after 27 days (Red Delicious and Golden Delicious) or 26 days (Rome). Percentage data were converted by the square root arcsin transformation for statistical analysis.

The early season was favorable for development of powdery mildew, scab, cedar-apple and quince rust. Mildew conidia were present 9 Apr, and there were 42 dry weather “mildew infection days” from 9 Apr-18 Jun, resulting in moderate infection of non-treated trees. The higher rates of SR-9059 provided the best control of mildew on foliage, while several treatments involving Inspire Super (#1, 2 and 9) or difenoconazole (#7) gave best reduction of mildew russet on Rome fruit (Table 16). Difenoconazole gave better control of mildew on leaves and fruit then Omega alone (#7 vs. #8). The first scab infection period occurred 11 Apr and primary lesions were present during the heaviest secondary period 28 Apr-1 May, followed by 13 more secondary scab infection periods through June. Improved control by the combination of Manzate with Inspire Super (Trt. #2) compared to Inspire Super alone (#1) is evidence of reduced sensitivity to the SI fungicides in the test area (Table 17). The higher rates of SR-9059 also gave good scab control on fruit, but were somewhat weaker on Red Delicious and Rome fruit. Omega gave significant control on fruit, but did not control scab on leaves; SP2700 did not control scab on leaves or fruit. The extended wetting period 28 Apr-1 May, also resulted in heavy quince rust and cedar-apple rust infection on fruit and there was prolonged cedar-apple rust infection pressure on foliage into June. Inspire-related treatments gave the most consistent control of rusts on leaves and fruit (Table 17). SR-9059 and SP2700 were weak for cedar rust on leaves, particularly on Rome. SP2700 and the lower rates of SR-9059 were also the weakest for quince rust control. Under relatively strong test pressure, Inspire Super /Captan + Ziram and Omega-related treatments gave good suppression of sooty blotch and flyspeck (SBFS) and preliminary “rot spots” (Table 18). Control of SBFS and rot spots by SR-9059 was weak and rate related. Inspire Super /Captan + Ziram and Omega + Inspire gave the best overall control of post-harvest rots (Table 19). Including Manzate with Inspire Super through 3rd cover significantly improved rot control on Golden Delicious. Compared to non-treated fruit, SP2700 significantly increased russetting of Red Delicious and Golden Delicious (Table 16).

Table 16. Powdery mildew control and fruit finish on Rome Beauty and Golden Delicious apple, 2014.

	Treatment and formulated rate/100 gal	Timing	Powdery mildew, % leaves, leaf area or fruit infected: Rome Beauty % lvs inf.	Rome Beauty leaf area	Rome Beauty % fruit	Golden Del. leaves Inf.	Golden Del. % leaf area	Fruit finish ratings*: Russet rating (0-5) R. Del.	Russet rating (0-5) Rome	Russet rating (0-5) G. Del.	G. Del. % X-Fcy/ Fcy	Rome, opalescence, rating
0	Non-treated control	---	31 ef	8 d	37 e	43 e	12 c	0.9 a	0.7 a	2.3 a-d	61 bc	0.8 ab
1	Inspire Super 2.82EW 3 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	23 c-e	3 b	2 a	16 cd	2 b	1.0 a	1.1 a	2.4 b-d	65 a-c	1.0 ab
2	Inspire Super 3 fl oz + Manzate 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	34 ef	6 cd	6 ab	18 d	2 ab	0.9 a	0.9 a	2.0 a-c	80 ab	1.0 ab
3	SR-9059 20SC 0.75 fl oz	Pk-7C	9 ab	2 ab	12 b-d	5 a	1 a	1.2 ab	0.8 a	2.3 a-d	52 c	1.2 b
4	SR-9059 20SC 0.5 fl oz	Pk-7C	8 a	1 a	15 cd	8 ab	2 ab	1.3 ab	0.7 a	2.5 cd	54 c	1.2 b
5	SR-9059 20SC 0.25 fl oz	Pk-7C	19 b-d	2 ab	19 d	11 bc	2 ab	1.1 ab	0.9 a	2.9 d	52 c	1.0 ab
6	SP2700 10WP 13.35 oz	Pk-7C	21 c-e	3 b	21 d	22 d	3 b	1.8 b	0.8 a	3.7 e	20 d	0.8 ab
7	Omega 2.5 fl oz + Inspire (difenoconazole) 1 fl oz	Pk-7C	15 bc	2 ab	1 a	7 ab	2 ab	0.9 a	0.8 a	1.8 ab	87 a	0.9 ab
8	Omega 500F 2.5 fl oz	Pk-7C	30 d-f	3 bc	10 bc	16 cd	2 b	1.2 ab	0.9 a	1.8 ab	71 a-c	0.8 ab
9	Omega 500F 2.5 fl oz (+ Inspire Super 1.5 fl oz as needed post-infection for rusts)	Pk-7C	40 f	6 cd	4 ab	21 d	3 b	1.0 a	0.8 a	1.7 a	83 ab	0.7 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications. Data based on 10 shoots per rep 25 Jun (Golden Delicious), or 25 Jul (Rome). Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 2 Oct (Golden Delicious and Red Delicious) or 3 Oct (Rome). Rome test trees were not in test in 2013 to stabilize mildew inoculum pressure for 2014.

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

Treatments were applied dilute to run-off at 400 psi: 17 Apr (Pk, pink, Inspire in #9); 1 May (bloom, Inspire in #9); 12 May (petal fall, Inspire in #9); 23 May (1C, first cover, no Inspire in #9); 2 Jun (2C, Inspire in #9); 17 Jun (3C, no Inspire in #9); 2 Jul (4C); 17 Jul (5C); 7 Aug (6C); 28 Aug (7C).

Table 17. Control of scab, cedar-apple rust and quince rust on Red Delicious, Golden Delicious and Rome Beauty apple, 2014.

		Scab, % leaves or fruit infected					Cedar-apple rust, % inf.				Quince rust, % fruit infected		
		leaves		fruit			leaves		fruit				
Treatment and formulated rate/100 gal	Timing	Rome	G. Del	R.Del	G.Del	Rome	G. Del	Rome	G.Del	Rome	G.Del	Rome	R.Del
0 Non-treated control	---	47 e	22 f	92 e	77 e	95 f	72 f	86 de	8 b	22 e	39 d	34 e	9 c
1 Inspire Super 2.82EW 3 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	21 b	6 bc	19 b	6 ab	16 bc	13 ab	29 a	0 a	0 a	0 a	0 a	0 a
2 Inspire Super 3 fl oz + Manzate 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	10 a	8 bc	6 a	1 a	7 a	20 b	23 a	0 a	0 a	0 a	0 a	0 a
3 SR-9059 20SC 0.75 fl oz	Pk-7C	13 a	2 a	21 bc	1 a	15 bc	39 c	76 cd	0 a	10 cd	6 b	4 bc	0 a
4 SR-9059 20SC 0.5 fl oz	Pk-7C	11 a	4 ab	26 bc	13 bc	22 c	52 e	69 c	0 a	15 de	17 c	10 d	3 ab
5 SR-9059 20SC 0.25 fl oz	Pk-7C	23 bc	8 bc	58 d	38 d	50 d	50 de	84 de	0 a	14 c-e	19 c	26 e	5 bc
6 SP2700 10WP 13.35 oz	Pk-7C	46 e	22 f	85 e	62 e	74 e	41 cd	87 e	0 a	5 bc	14 c	7 cd	3 ab
7 Omega 500F 2.5 fl oz + Inspire (difen.) 1 fl oz	Pk-7C	30 cd	9 cd	22 bc	17 bc	7 ab	19 ab	21 a	0 a	0 a	2 ab	0 a	0 a
8 Omega 500F 2.5 fl oz	Pk-7C	37 de	19 ef	56 d	24 cd	39 d	22 b	51 b	0 a	3 b	13 c	3 ab	4 b
9 Omega 2.5 fl oz (+ Inspire Super 1.5 fl oz as needed post-infection for rust control)	Pk-7C	34 d	14 de	40 cd	23 cd	41 d	12 a	29 a	0 a	1 ab	0 a	1 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test ($p=0.05$). Four replications. Foliar data based on 10 shoots per rep 25 Jun (Golden Delicious) or 11 Jul (Rome Beauty). Post-harvest fruit counts are means of 25-fruit samples picked from each of four single-tree replications 2 Oct (Golden Delicious and Red Delicious) or 3 Oct (Rome).

Treatments applied dilute to runoff at 400 psi as follows: 17 Apr (Pk, pink, Inspire in #9); 1 May (bloom, Inspire in #9); 12 May (petal fall, Inspire in #9); 23 May (1st cover, 1C, no Inspire in #9); 2 Jun (2C, Inspire in #9); 17 Jun (3C, no Inspire in #9); 2 Jul (4C); 17 Jul (5C); 7 Aug (6C); 28 Aug (7C).

Table 18. Sooty blotch, flyspeck, Brooks spot and rot spots on Rome Beauty, Golden Delicious and Red Delicious apple, 2014.

		% fruit infected						Golden Delicious, %	
		Sooty blotch			Flyspeck			rot	Brooks
Treatment and formulated rate/100 gal	Timing	R. Del.	G. Del.	Rome	R. Del.	G. Del.	Rome	spots	spot
0 Non-treated control	---	100 d	100 d	99 e	100 e	95 d	94 d	88 f	5 a
1 Inspire Super 2.82EW 3 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	5 a	0 a	2 ab	1 ab	0 a	1 a	1 ab	0 a
2 Inspire Super 3 fl oz + Manzate 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
3 SR-9059 20SC 0.75 fl oz	Pk-7C	57 b	31 b	41 c	62 cd	44 b	33 b	11 cd	0 a
4 SR-9059 20SC 0.5 fl oz	Pk-7C	64 bc	39 b	38 c	52 c	48 b	28 b	22 d	2 a
5 SR-9059 20SC 0.25 fl oz	Pk-7C	79 c	63 c	79 d	75 d	76 c	81 c	43 e	3 a
6 SP2700 10WP 13.35 oz	Pk-7C	99 d	96 d	91 d	97 e	98 d	88 cd	58 e	0 a
7 Omega 500F 2.5 fl oz + Inspire (difen.) 1 fl oz	Pk-7C	0 a	0 a	0 a	0 a	0 a	0 a	4 a-c	0 a
8 Omega 500F 2.5 fl oz	Pk-7C	2 a	1 a	9 b	7 b	4 a	20 b	6 bc	3 a
9 Omega 2.5 fl oz (+ Inspire Super 1.5 fl oz as needed post-infection for rusts)	Pk-7C	1 a	0 a	2 ab	4 b	1 a	1 a	1 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 2 Oct (Golden Delicious and Red Delicious) or 3 Oct (Rome).

Treatments applied dilute to runoff at 400 psi as follows: 17 Apr (Pk, pink, Inspire in #9); 1 May (bloom, Inspire in #9); 12 May (petal fall, Inspire in #9); 23 May (1st cover, 1C, no Inspire, #9); 2 Jun (2C, Inspire in #9); 17 Jun (3C, no Inspire in #9); 2 Jul (4C); 17 Jul (5C); 7 Aug (6C); 28 Aug (7C).

Table 19. Post-storage rot control on Rome Beauty, Golden Delicious, and Red Delicious apple, 2014.

		Rot spots	Post-incubation storage rots, % fruit infected										
		G. Del.,	Any rot			Bitter rot			White (Bot) rot			Alternaria rot	
Treatment and formulated rate/100 gal	Timing	at harvest	Rome	G.Del	R.Del	Rome	G.Del	R.Del	Rome	G.Del	R.Del	G.Del	R.Del.
0 Non-treated control	---	88 f	24 cd	51 f	51 c	12 c	27 e	24 b	13 ab	31 d	25 c	4 b	10 b
1 Inspire Super 2.82EW 3 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	1 ab	7 ab	18 cd	8 ab	0 a	2 ab	2 a	7 a	16 a-c	6 ab	0 a	0 a
2 Inspire Super 3 fl oz + Manzate 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	Pk-3C 4C-7C	0 a	4 a	2 a	8 ab	0 a	0 a	2 a	4 a	2 a	4 ab	0 a	0 a
3 SR-9059 20SC 0.75 fl oz	Pk-7C	11 cd	23 cd	28 c-e	13 ab	7 b	5 bc	7 a	15 ab	23 cd	5 ab	1 ab	1 a
4 SR-9059 20SC 0.5 fl oz	Pk-7C	22 d	20 c	34 ef	10 ab	5 b	13 d	7 a	15 ab	22 cd	3 a	0 a	0 a
5 SR-9059 20SC 0.25 fl oz	Pk-7C	43 e	36 d	31 de	5 a	6 bc	12 d	1 a	28 b	21 cd	3 a	0 a	1 a
6 SP2700 10WP 13.35 oz	Pk-7C	58 e	13 bc	41 ef	27 bc	5 b	9 cd	14 ab	8 a	33 d	14 bc	0 a	1 a
7 Omega 500F 2.5 fl oz + Inspire (difen.) 1 fl oz	Pk-7C	4 a-c	6 ab	6 ab	6 a	0 a	0 a	0 a	6 a	6 ab	4 ab	0 a	2 a
8 Omega 500F 2.5 fl oz	Pk-7C	6 bc	13 bc	16 cd	15 ab	0 a	2 ab	6 a	13 ab	10 a-c	7 ab	4 ab	0 a
9 Omega 2.5 fl oz (+ Inspire Super 1.5 fl oz as needed post-infection for rusts)	Pk-7C	1 ab	9 ab	14 bc	8 ab	0 a	2 ab	1 a	7 a	11 bc	5 ab	0 a	1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on 25 fruit per tree.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 2 Oct (Golden Delicious and Red Delicious) or 3 Oct (Rome). Following harvest, Golden Delicious fruit were first rated 3 Oct, Red Delicious 8 Oct, and Rome fruit 9 Oct. After initial evaluation, fruit were incubated at ambient temperatures 44-80°F (mean 70.9°F) until final storage rot assessment after 27 days (Red Delicious and Golden Delicious) or 26 days (Rome).

Treatments applied dilute to runoff at 400 psi as follows: 17 Apr (Pk, pink, Inspire in #9); 1 May (bloom, Inspire in #9); 12 May (petal fall, Inspire in #9); 23 May (1st cover, 1C, no Inspire in #9); 2 Jun (2C, Inspire in #9); 17 Jun (3C, no Inspire in #9); 2 Jul (4C); 17 Jul (5C); 7 Aug (6C); 28 Aug (7C).

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

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Control of powdery mildew and other diseases by experimental fungicides and mixed schedules on Idared apples, 2014.

Twelve treatments involving experimental and registered combinations were directed at control of pow mildew and other early season diseases in an area where SI and QoI fungicide effectiveness has been declining. The test was established as four randomized blocks on 33-yr-old trees using single-tree replica with border rows between treatment rows. Treatment rows had been used as non-treated border rows in to stabilize mildew inoculum pressure for 2014. Tree-row-volume was determined to require a 400 gal/A base for adequate coverage. Fungicide treatments were applied to both sides of the tree on each applica date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 18 Apr (pink), 27 Apr (full bl 6 May (petal fall): 1st - 8th covers: 17 May, 30 May, 14 Jun, 27 Jun, 12 Jul, 26 Jul, 11 Aug and 29 Aug. Maintenance materials applied to the entire test block with the same equipment included: Admire Pro, Alt Asana XL, Assail, BioCover MLT, Calypso, Delegate, Diazinon Imidan, and Provado, Voliam Flexi. Inocu over each Idared test tree included cedar rust galls and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies placed 21 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 30 Jun. Apparent suppressive effect on appearance of primary mildew was rated on six primary mildew shoots / t 5 Jun using a scale of 1-10 (1= none; 10= excellent effect). Post-harvest fruit counts are means of 25-frui samples picked from each of four single-tree reps 26 Sep refrigerated 21 days, then moved to warm stor (60-80°F) before initial evaluation 21 Oct, then further evaluated for rots 7 Nov after 21 days at ambient w temperatures. Percentage data were converted by the square root arcsin transformation for statistical ana

Weather was favorable for development of the early season diseases scab, mildew and the rusts. Bet 9 Apr, when mildew conidia were first observed, and 20 Jun, 42 days were favorable for mildew infection Under this mildew pressure, all treatments gave significant control. Alternating schedules involving Topguard/Luna Tranquility, Topguard/A15457, and Topguard/A19334 gave strong suppressive effects on primary mildew (Table 20). Including Microthiol Disperss with Topguard and Luna Tranquility (trt #4) gave strong mildew control on leaves and fruit. Control of mildew (as well as scab, the rusts and Brooks spot) Vivando was rate-related, with significantly better control by 15 fl oz/A rather than by 10 fl oz, and the rate difference appeared even in combination with Manzate. Experimental materials GWN-10250 and GWN-1 gave mildew control comparable to Rally in this test block. Quince rust infection occurred mostly during a extended wetting period 28 Apr-1 May, and all treatments except the lower rate of Vivando + Manzate ga adequate control. Cedar-apple rust infection of foliage occurred from April into June, and the benefits of D fungicides were apparent in the most effective treatments involving Rally, Topguard, and A19334 (Table The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck activity, accumulating from 18 M and was reached 3 Jul, and 12.8 inches of rainfall occurred 9 May- 30 Sep. Although all treatments were covered with Captan + Ziram in the last five applications, some differences were noted related to the earl treatment schedule through the sixth application at 3rd cover (Table 21). Control of sooty blotch was significantly weaker by Sulfur than by Manzate in combination with Rally (#2 vs. #1). A19334 (#12) had outstanding benefits against sooty blotch compared to A15457 (#10 and 11) and other treatments; and treatments #10-12 were excellent for control of flyspeck compared to nearly all other treatments. Few sim differences were noted for control of rots (Table 22), although some weakness of the lower rate of Vivand were noted for white rot. No deleterious treatment effects were evident on fruit finish, and several treatme had positive effects compared to non-treated fruit.

Table 20. Early season control on Idared apples, 2014.

	Treatment and rate /A	Timing	Primary mildew effect*	Mildew infection: % leaves: % lvs	Mildew infection: % leaves: area	Mildew infection: % fruit inf.: % fruit	Mildew infection: % fruit inf.: area	% scab: leaves	% scab: fruit	Cedar-apple rust (%): leaves	Cedar-apple rust (%): fruit	Quince rust, % fruit
0	Non-treated control	---	1.5 h	53 e	25 d	37 c	5 c	21 e	41 e	45 e	4 b	10 c
1	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	#1-6	4.9 fg	14 bc	2 ab	15 a	3 ab	4 bc	1 ab	2 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
2	Rally 40WSP 5 oz + Microthiol Disperss 80DF 8 lb	#1-6	4.6 g	12 ab	2 ab	18 ab	3 a-c	6 c	7 cd	2 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
3	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	#1,3,5										
	Luna Tranquility SC 11.2 fl oz + Silwet 114 ml	#2,4,6	6.1 a-e	12 ab	2 ab	8 a	1 a	3 b	2 ab	3 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
4	Topguard 1.04SC 10 fl oz + Microthiol Disperss 80DF 8 lb	#1,3,5										
	Luna Tranquility 11.2 fl oz + Microthiol Disperss 80DF 8 lb	#2,4,6	6.6 a-d	8 a	2 a	6 a	1 a	<1 a	4 bc	9 b	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
5	Vivando 2.5SC 10 fl oz + Manzate 75DF 3 lb+ Silwet 114 ml	#1-6	5.9 c-f	35 d	5 c	32 bc	5 bc	12 d	13 d	26 d	3 ab	4 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
6	Vivando 2.5SC 15 fl oz + Manzate 75DF 3 lb+ Silwet 114 ml	#1-6	5.6 d-f	19 bc	3 ab	9 a	1 a	6 c	4 bc	17 c	1 ab	1 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
7	Vivando 2.5SC 15 fl oz + Manzate 3 lb+ JMS Stylet-Oil 1 gal	#1-6	5.5 e-g	22 c	3 bc	13 a	2 a	4 bc	4 bc	20 cd	1 ab	2 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
8	GWN-10250 20SC 36 fl oz + Manzate Pro-Stick 75DF 3 lb	#1-6	5.9 b-e	16 bc	3 b	18 ab	3 a-c	3 b	2 ab	19 cd	1 ab	1 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
9	GWN-10176 10EC 72 fl oz + Manzate Pro-Stick 75DF 3 lb	#1-6	5.8 c-f	17 bc	3 ab	15 ab	2 a-c	3 b	5 bc	17 c	2 ab	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
10	Topguard 1.04SC 10 fl oz	#1,3,5										
	A15457 100EC 6.8 fl oz + Silwet 114 ml	#2,4,6	7.0 a	16 bc	3 ab	7 a	1 a	0 a	1 ab	3 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
11	Topguard 1.04SC 10 fl oz	#1,3,5										
	A15457 100EC 5.5 fl oz + Silwet 114 ml	#2,4,6	6.9 ab	18 bc	3 bc	12 a	2 a	<1 a	0 a	4 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										
12	Topguard 1.04SC 10 fl oz	#1,3,5										
	A19334 194.5 EC 8.5 fl oz + Silwet 114 ml	#2,4,6	6.7 a-c	15 bc	2 ab	10 a	1 a	<1 a	2 ab	2 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→										

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; ten shoots per tree rated 30 Jun, or 25 fruit per replication harvested 26 Sep, refrigerated until 17 Oct, then rated 21 Oct. Test rows were non-treated border rows in 2013 to stabilize mildew inoculum pressure for 2014.

* Suppressive effect rated on six primary mildew shoots/tree 5 Jun, scale: 1-10 (1= none; 10= excellent effect).

Table 21. Early season and summer disease control on Idared apples, 2014.

			% fruit infected at harvest							
				Quince	Brooks	Sooty blotch		Flyspeck		Any
	Treatment and rate /A	Timing	Scab	rust	spot	% fruit	area	% fruit	area	rot
0	Non-treated control	---	41 e	10 c	23 c	100 d	12 d	95 f	8 e	15 b
1	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	#1-6	1 ab	0 a	0 a					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				34 b	3 bc	16 c	1 c	1 a
2	Rally 40WSP 5 oz + Microthiol Disperss 80DF 8 lb	#1-6	7 cd	0 a	2 a					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				53 c	4 c	29 c-e	2 cd	1 a
3	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	#1,3,5	2 ab	0 a	0 a					
	Luna Tranquility SC 11.2 fl oz + Silwet 114 ml	#2,4,6								
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				26 b	2 b	17 cd	<1 cd	0 a
4	Topguard 1.04SC 10 fl oz + Microthiol Disperss 80DF 8 lb	#1,3,5	4 bc	0 a	0 a					
	Luna Tranquility SC 11.2 fl oz + Microthiol Disperss 8 lb	#2,4,6								
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				23 b	2 b	23 c-e	1 cd	0 a
5	Vivando 2.5SC 10 fl oz + Manzate 3 lb+ Silwet 114 ml	#1-6	13 d	4 b	11 b					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				40 bc	3 bc	37 e	2 d	0 a
6	Vivando 2.5SC 15 fl oz + Manzate 3 lb+ Silwet 114 ml	#1-6	4 bc	1 a	1 a					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				26 b	1 b	28 c-e	2 cd	1 a
7	Vivando 15 fl oz + Manzate 3 lb+ JMS Stylet-Oil 1 gal	#1-6	4 bc	2 a	3 a					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				45 bc	2 bc	35 de	2 d	1 a
8	GWN-10250 20SC 36 fl oz + Manzate Pro-Stick 75DF 3 lb	#1-6	2 ab	1 a	3 a					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				33 b	2 bc	17 bc	<1 bc	2 a
9	GWN-10176 10EC 72 fl oz + Manzate Pro-Stick 75DF 3 lb	#1-6	5 bc	0 a	2 a					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				23 b	1 b	25 c-e	1 cd	0 a
10	Topguard 1.04SC 10 fl oz	#1,3,5	1 ab	0 a	0 a					
	A15457 100EC 6.8 fl oz + Silwet 114 ml	#2,4,6								
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				27 b	1 b	5 ab	<1 ab	1 a
11	Topguard 1.04SC 10 fl oz	#1,3,5	0 a	0 a	0 a					
	A15457 100EC 5.5 fl oz + Silwet 114 ml	#2,4,6								
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				26 b	2 b	2 a	<1 a	0 a
12	Topguard 1.04SC 10 fl oz	#1,3,5	2 ab	0 a	1 a					
	A19334 194.5 EC 8.5 fl oz + Silwet 114 ml	#2,4,6								
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→				2 a	<1 a	1 a	<1 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications; 25 fruit per replication harvested 26 Sep, refrigerated until 17 Oct, then rated 21 Oct.

Treatments applied airblast at 100 gpa to both sides of the row on each application date.18 Apr (pink), 27 Apr (full bloom), 6 May (petal fall); 1st - 8th covers: 17 May, 30 May, 14 Jun, 27 Jun, 12 Jul, 26 Jul, 11 Aug and 29 Aug.

Table 22. Post-harvest storage rots and fruit finish of Idared apples, 2013.

	Treatment and rate/A	Timing	Any rot at harvest	% post-incubation rots* Any rot	Bitter rot	White Rot	Alternaria rot	Fruit finish** Russet	Opal-escence
0	Non-treated control	---	15 b	36 c	26 c	10 c	3 b	1.7 f	1.2 c
1	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	#1-6						0.8 ab	0.8 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	1 a	5 ab	5 b	0 a	0 a		
2	Rally 40WSP 5 oz + Microthiol Disperss 80DF 8 lb	#1-6						1.0 a-c	0.9 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	1 a	5 ab	4 ab	2 ab	0 a		
3	Topguard 1.04SC 10 fl oz + Manzate 75DF 3 lb	#1,3,5						1.0 bc	0.7 ab
	Luna Tranquility SC 11.2 fl oz + Silwet 114 ml	#2,4,6							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	0 a	3 ab	0 a	3 b	0 a		
4	Topguard 1.04SC 10 fl oz + Microthiol Disperss 80DF 8 lb	#1,3,5						1.6 ef	1.2 c
	Luna Tranquility SC 11.2 fl oz + Microthiol Disperss 80DF 8 lb	#2,4,6							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	0 a	2 a	0 a	2 ab	0 a		
5	Vivando 2.5SC 10 fl oz + Manzate 75DF 3 lb+ Silwet 114 ml	#1-6						1.6 ef	0.9 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	0 a	8 b	2 ab	5 bc	1 a		
6	Vivando 2.5SC 15 fl oz + Manzate 75DF 3 lb+ Silwet 114 ml	#1-6						1.5 d-f	1.0 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	1 a	3 ab	3 ab	0 a	0 a		
7	Vivando 2.5SC 15 fl oz + Manzate 3 lb+ JMS Stylet-Oil 1 gal	#1-6						1.4 c-f	0.9 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	1 a	2 a	1 ab	1 ab	0 a		
8	GWN-10250 20SC 36 fl oz + Manzate Pro-Stick 75DF 3 lb	#1-6						0.6 a	0.7 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	2 a	6 ab	2 ab	5 b	0 a		
9	GWN-10176 10EC 72 fl oz + Manzate Pro-Stick 75DF 3 lb	#1-6						1.3 c-e	0.9 a-c
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	0 a	1 a	0 a	1 ab	0 a		
10	Topguard 1.04SC 10 fl oz	#1,3,5						1.5 d-f	1.1 bc
	A15457 100EC 6.8 fl oz + Silwet 114 ml	#2,4,6							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	1 a	1 a	1 ab	0 a	0 a		
11	Topguard 1.04SC 10 fl oz	#1,3,5						1.0 a-c	0.8 a-c
	A15457 100EC 5.5 fl oz + Silwet 114 ml	#2,4,6							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	0 a	1 a	0 a	0 a	0 a		
12	Topguard 1.04SC 10 fl oz	#1,3,5						1.1 b-d	0.6 a
	A19334 194.5 EC 8.5 fl oz + Silwet 114 ml	#2,4,6							
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	#7→	0 a	2 a	1 ab	1 ab	0 a		

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). * Means of 25 fruit per replication harvested 26 Sep; refrigerated till 17 Oct, rated 21 Oct then rated for rots after 21 days warm storage on 11 Nov.

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

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

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Evaluation of mixed fungicide schedules for broad spectrum disease control on Stayman, Idared, and (Smith apples, 2014.

Eight combination treatments, directed at fungicide resistance management approaches and broad-spectru control, were tested on 28-yr-old trees in an area where scab and mildew fungus resistance to SI fungicides ha suspected since 2004. The test was conducted in a randomized block design with four three-cultivar replicate t separated by non-treated border rows. Treatment rows had been used as non-treated border rows in 2013 to s mildew inoculum pressure for 2014. Tree-row-volume was determined to require a 400 gal/A dilute base for ad coverage. Fungicide treatments were applied to both sides of the tree on each application date with a Swansoı DA-400 airblast sprayer at 100 gal/A as follows: 18 Apr, app. #1 (Pk, pink; Stayman- open cluster; Idared and (Smith -open cluster to pink); 26 Apr, app. #2 (bloom); 6 May, app. #3 (petal fall); 17 May, app. #4 (1C,1st cove May, app. #5 (2C, 2nd cover); 14 Jun, app. #6 (3C,3rd cover); 28 Jun, app. #7 (4C,4th cover); 12 Jul, app. #8 (cover); 26 Jul, app #9 (6th Cover, 6C); 9 Aug, app #10 (7th Cover, 7C); 24 Aug, app #11 (8th Cover, 8C). Mair materials applied to the entire test block with the same equipment included: Admire Pro, Altacor, Assail, Asana BioCover MLT, Calypso, Delegate, Imidan, Lannate LV, Movento Provado and Voliam Flexi. Inoculum over ea Idared test tree included cedar rust galls and wild blackberry canes with the sooty blotch and flyspeck fungi (25 and bitter rot mummies placed 21 May. Other diseases developed from inoculum naturally present in the test a Foliar data represent averages of counts of ten terminal shoots per tree 2 Jul (Idared), 9 Jul (Stayman), 27 Aug (Granny Smith). Quince rust was rated on 50 fruit per tree 22 Aug. Post-harvest fruit counts are means of 25-f samples picked from each of four single-tree reps. Idared sampled 22 Sep, first rated after 28 days in cold stor rated for rots after 21 days incubation at ambient 64-80°F (mean 71.5°F). Stayman sampled 7 Oct, first rated 1 then rated for rots after 23 days incubation at ambient temperatures 58-80°F (mean 71.9°F). Granny Smith sar Oct, first rated 15 Oct, then rated for rots after 27 days incubation at ambient temperatures 44-80°F (mean 70.! Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew pressure was moderately heavy in this test block. Between 9 Apr, when mildew conidia were first ol and 20 Jun (3rd cover), 42 days were favorable for infection. Under these conditions, all treatments gave signif control of mildew incidence on leaves and fruit of all cultivars (Table 23). The most effective mildew control was achieved by Treatment #5 (Luna Tranquility/Topguard), Fontelis + BioCover (#2), and Indar + Fontelis + BioCo Based on percent leaves infected with mildew, treatments involving Rally or Indar as the only mildewcides (#1 were no more effective than those with Microthiol Disperss Sulfur + ProPhyt (#6-8). Scab pressure was relative (especially on Granny Smith), with primary scab infection periods occurring 11 Apr and 14 Apr, a heavy second infection period 28 Apr -1 May and more secondary scab infections 10 May, 13 May, and 15 May. Impact of sc resistance to SI fungicides reflects the local commercial situation over the past 10 years, but this was partially ı by combination of Manzate with Rally (#1) and Indar (#4). Fontelis + BioCover (#2), gave good scab control on but on fruit this combination was less effective than Luna Tranquility + Koverall/Topguard + Koverall (#5) or Ma Microthiol + ProPhyt (Table 24). All treatments gave adequate control of Brooks spot. Twelve of the extended v periods 28 Apr-22 Jun were also cedar-apple rust infection periods. Schedules involving Rally or Indar gave th cedar-apple rust control on foliage and fruit (Table 25). Most quince rust infection occurred 28 Apr-May 1, befo first application, but many treatments gave good-excellent control under this pressure. Fontelis (#2) showed we for control of both cedar-apple rust on foliage and quince rust on fruit. Local summer disease pressures were t this test block. The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accum from 18 May, was reached 16 Jun, with 910 wetting hours by 1 Sep, and 12.8 inches of rainfall occurred 9 May Manzate/Captan + Ziram (#1) performed as expected under these conditions, with good control of SBFS (Table and post-harvest rots (Table 27). There was evidence of reduced effectiveness in the earlier cover sprays by F BioCover (#2) for SBFS, bitter rot and white rot. Generally, good summer disease control was accomplished w (#4), and with rotating treatments involving Cercobin, Sovran or Merivon in combination with ProPhyt or Captar The only fruit finish effect was with Fontelis + BioCover on Granny Smith (Table 28).

Table 23. Powdery mildew control on Stayman, Idared, and Granny Smith apples, 2014.

		% leaves or leaf area or fruit infected									
		Idared				Stayman			Granny Smith		
Treatment and formulated rate/acre	Timing	leaves	area	fruit	area	lvs	area	fruit	lvs	area	fruit
0 No fungicide	---	42 d	16 d	57 c	10 c	49 d	12 d	15 b	40 d	17 d	20 c
1 Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	Pk-4C	30 c	4 c	11 ab	2 ab	23 c	3 c	2 a	21 bc	3 c	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →										
2 Fontelis 1.67SC 20 fl oz + BioCover 2 qt/100 gal	Pk-4C	10 a	2 ab	7 a	1 ab	11 ab	1 ab	3 a	4 a	1 ab	4 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →										
3 Indar 2F 8 fl oz + Fontelis 1 pt + BioCover 2 qt	Pk-4C	6 a	1 a	16 ab	2 ab	10 a	1 a	5 ab	4 a	1 a	3 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →										
4 Indar 2F 10 fl oz + Manzate 3 lb + LI-700 1 pt	Pk-4C	19 b	3 bc	12 ab	2 ab	18 c	2 a-c	8 ab	16 b	3 c	5 b
Indar 2F 10 fl oz + Captan 30 oz + LI-700 1 pt	5C →										
5 Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3,5	9 a	2 ab	7 ab	1 a	16 bc	2 a-c	3 a	4 a	1 ab	1 ab
Topguard 1.04SC 13 fl oz + Koverall 75DF 3 lb	#2,4,6,7										
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	#8,9										
Cercobin 4.16SC 21 fl oz + Captan 80WDG 30 oz	#10 →										
6 Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	28 bc	4 c	17 ab	3 b	17 c	2 bc	2 a	27 c	5 c	1 ab
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C										
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	6C,8C										
7 Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	21 bc	3 bc	19 b	3 b	18 c	2 bc	7 ab	16 b	3 bc	4 ab
Ziram 76DF 3.5 lb + ProPhyt 4 pt	5C,7C										
Sovran 50WG 6.4 oz + Ziram 76DF 3.5 lb	6C,8C										
8 Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	27 bc	4 c	16 ab	2 ab	16 c	2 a-c	9 ab	15 b	2 bc	3 ab
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C										
Merivon 4.18SC 5.5 fl oz + Captan 80WDG 30 oz	6C,8C										

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 2 Jul (Idared) 9 Jul (Stayman) or 27 Aug (Granny Smith) or harvest counts of 25-fruit samples picked from each of four single-tree reps 22 Sep (Idared), 7 Oct (Stayman), or 3 Oct (Granny Smith).

Test rows were used as non-treated border rows in 2013 to stabilize mildew inoculum pressure for 2014.

Treatments applied airblast at 100 gpa to both sides of the row on each date: 18 Apr, app. #1 (Pk, pink; Stayman- open cluster; Idared and Granny Smith -open cluster to pink); 26 Apr, app. #2 (bloom); 6 May, app. #3 (petal fall); 17 May, app. #4 (1C,1st cover); 30 May, app. #5 (2C, 2nd cover); 14 Jun, app. #6 (3C,3rd cover); 28 Jun, app. #7 (4C,4th cover); 12 Jul, app. #8 (5C,5th cover); 26 Jul, app #9 (6th Cover, 6C); 9 Aug, app #10 (7th Cover, 7C); 24 Aug, app #11 (8th Cover, 8C).

Table 24. Scab and Brooks spot control on Stayman, Idared and Granny Smith apples, 2014.

		Scab, % leaves infected			Scab, % fruit infected			Brooks spot, %	
Treatment and formulated rate/acre	Timing	Stay-man	Idared	Granny Smith	Stay-man	Idared	Granny Smith	Stay-man	Idared
0 No fungicide	---	62 e	16 bc	70 d	94 c	72 d	89 d	9 b	32 b
1 Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	Pk-4C	36 d	21 c	43 c	30 b	6 ab	25 ab	0 a	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →								
2 Fontelis 1.67SC 20 fl oz + BioCover MLT 2 qt/100 gal	Pk-4C	12 a	10 ab	28 a	24 ab	15 bc	46 b	0 a	1 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →								
3 Indar 2F 8 fl oz + Fontelis 1 pt + BioCover 2 qt /100 gal	Pk-4C	23 c	10 ab	34 a-c	17 ab	21 c	70 c	0 a	3 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	5C →								
4 Indar 2F 10 fl oz + Manzate 75DF 3 lb + LI-700 1 pt	Pk-4C	22 c	13 ab	32 a-c	12 a	10 bc	28 ab	1 a	2 a
Indar 10 fl oz + Captan 80WDG 30 oz + LI-700 1 pt	5C →								
5 Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3,5	22 bc	10 ab	30 ab	20 ab	2 a	14 a	0 a	0 a
Topguard 1.04SC 13 fl oz + Koverall 75DF 3 lb	#2,4,6,7								
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	#8,9								
Cercobin 4.16SC 21 fl oz + Captan 80WDG 30 oz	#10								
6 Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	13 a	9 a	39 a-c	8 a	8 b	23 a	0 a	3 a
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C								
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	6C,8C								
7 Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	18 a-c	10 ab	43 bc	15 ab	9 b	22 a	0 a	2 a
Ziram 76DF 3.5 lb + ProPhyt 4 pt	5C,7C								
Sovran 50WG 6.4 oz + Ziram 76DF 3.5 lb	6C,8C								
8 Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	14 a-c	10 ab	31 a-c	11 ab	10 bc	21 a	0 a	3 a
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C								
Merivon 4.18SC 5.5 fl oz + Captan 80WDG 30 oz	6C,8C								

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 2 Jul (Idared), 9 Jul (Stayman) or 27 Aug (Granny Smith) or harvest counts of 25-fruit samples picked from each of four single-tree replications 22 Sep (Idared), 7 Oct (Stayman), or 3 Oct (Granny Smith).

Treatments applied airblast at 100 gpa to both sides of the row on each date: 18 Apr, app. #1 (Pk, pink; Stayman- open cluster; Idared and Granny Smith -open cluster to pink); 26 Apr, app. #2 (bloom); 6 May, app. #3 (petal fall); 17 May, app. #4 (1C,1st cover); 30 May, app. #5 (2C, 2nd cover); 14 Jun, app. #6 (3C,3rd cover); 28 Jun, app. #7 (4C,4th cover); 12 Jul, app. #8 (5C,5th cover); 26 Jul, app #9 (6th Cover, 6C); 9 Aug, app #10 (7th Cover, 7C); 24 Aug, app #11 (8th Cover, 8C).

Table 25. Control of cedar-apple rust and quince rust on Stayman, Idared and Granny Smith apples, 2014.

			Cedar-apple rust, % leaves or lesions/leaf				Quince rust, on-tree counts 22 Aug, % fruit infected			Harvest counts Idared, % fruit	
			Stayman		Idared					Cedar	Quince
	Treatment and formulated rate/acre	Timing	% inf.	les/lf	% inf.	les/lf	Stayman	Idared	G. Smith	rust	rust
0	No fungicide	---	42 c	4.3 b	62 f	9.2 e	16 c	41 d	11 c	13 b	44 d
1	Rally 40WSP 5 oz + Manzate Pro-Stick 75DF 3 lb	Pk-4C	5 a	0.1 a	2 a	0.1 a	0 a	0 a	0 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	5C →									
2	Fontelis 1.67SC 20 fl oz + BioCover 2 qt/100 gal	Pk-4C	6 ab	0.2 a	23 d	0.7 ab	8 b	20 c	2 b	1 a	9 bc
	Captan 80WDG 30 oz + Ziram 3 lb	5C →									
3	Indar 2F 8 fl oz + Fontelis 1 pt + BioCover MLT 2 qt	Pk-4C	6 a	0.3 a	11 c	0.5 a	1 a	3 ab	0 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	5C →									
4	Indar 2F 10 fl oz + Manzate 3 lb + LI-700 1 pt	Pk-4C	3 a	0.1 a	7 a	0.3 a	0 a	1 ab	0 a	0 a	0 a
	Indar 10 fl oz + Captan 80WDG 30 oz + LI-700 1 pt	5C →									
5	Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3,5	3 a	0.1 a	13 c	0.5 a	0 a	0 a	0 a	0 a	0 a
	Topguard 1.04SC 13 fl oz + Koverall 75DF 3 lb	#2,4,6,7									
	Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	#8,9									
	Cercobin 4.16SC 21 fl oz + Captan 80WDG 30 oz	#10 →									
6	Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	14 b	0.7 a	33 e	2.8 cd	1 a	5 b	2 ab	0 a	6 b
	Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C									
	Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	6C,8C									
7	Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	13 b	0.6 a	38 e	4.4 d	1 a	3 ab	0 a	2 a	9 c
	Ziram 76DF 3.5 lb + ProPhyt 4 pt	5C,7C									
	Sovran 50WG 6.4 oz + Ziram 76DF 3.5 lb	6C,8C									
8	Manzate 3 lb + Microthiol 80DF 8 lb+ ProPhyt 2 pt	Pk-4C	16 b	1.6 a	33 e	2.4 bc	0 a	1 ab	0 a	1 a	5 bc
	Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C									
	Merivon 4.18SC 5.5 fl oz + Captan 80WDG 30 oz	6C,8C									

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. Infection rated on 10 shoots 2 Jul (Idared), 9 Jul (Stayman), or 27 Aug (Granny Smith) or 50 fruit for quince rust 22 Aug or harvest counts of 25-fruit samples picked from each Idared replication 22 Sep.

Treatments applied airblast at 100 gpa to both sides of the row on each date: 18 Apr, app. #1 (Pk, pink; Stayman- open cluster; Idared and Granny Smith -open cluster to pink); 26 Apr, app. #2 (bloom); 6 May, app. #3 (petal fall); 17 May, app. #4 (1C,1st cover); 30 May, app. #5 (2C, 2nd cover); 14 Jun, app. #6 (3C,3rd cover); 28 Jun, app. #7 (4C,4th cover); 12 Jul, app. #8 (5C,5th cover); 26 Jul, app #9 (6th Cover, 6C); 9 Aug, app #10 (7th Cover, 7C); 24 Aug, app #11 (8th Cover, 8C).

Table 26. Control of sooty blotch and flyspeck by fungicides on Stayman, Idared, and Granny Smith apples, 2014.

		% fruit or fruit area infected, post-harvest counts											
		Sooty blotch						Flyspeck					
		Stayman		Idared %		Granny Smith		Stayman		Idared		Granny S.	
Treatment and rate/A		fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0 No fungicide	---	100 d	21 d	100 e	19 d	100 c	17 d	99 e	9 e	96 e	9 e	97 e	12 d
1 Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	Pk-4C												
Captan 80WDG 30 oz + Ziram 3 lb	5C →	63 bc	6 bc	52 a-c	4 ab	30 a	2 a	13 bc	<1 bc	9 b	<1 b	14 b	<1 a
2 Fontelis 1.67SC 20 fl oz + BioCover 2 qt/100 gal	Pk-4C												
Captan 80WDG 30 oz + Ziram 3 lb	5C →	82 c	7 c	84 d	10 c	84 b	6 c	58 d	4 d	38 d	2 d	75 d	6 c
3 Indar 8 fl oz + Fontelis 1 pt + BioCover 2 qt/100	Pk-4C												
Captan 80WDG 30 oz + Ziram 3 lb	5C →	69 bc	5 a-c	65 b-d	5 bc	65 b	4 bc	22 c	1 c	20 c	1 c	51 c	3 b
4 Indar 2F 10 fl oz + Manzate 3 lb + LI-700 1 pt	Pk-4C												
Indar 10 fl oz + Captan 30 oz + LI-700 1 pt	5C →	45 ab	4 ab	57 a-d	4 ab	31 a	2 ab	3 ab	<1 ab	2 a	<1 a	5 ab	<1 a
5 Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3,5												
Topguard 1.04SC 13 fl oz + Koverall 75DF 3 lb	#2,4,6,7												
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	#8,9												
Cercobin 4.16SC 21 fl oz +Captan 80WDG 30 oz	#10 →	35 a	3 ab	40 a-c	3 ab	21 a	1 a	5 ab	<1 ab	0 a	0 a	1 a	<1 a
6 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C												
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C												
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	6C,8C	37 ab	2 a	34 ab	2 ab	30 a	2 a	3 ab	<1 ab	0 a	0 a	2 ab	<1 a
7 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C												
Ziram 76DF 3.5 lb + ProPhyt 4 pt	5C,7C												
Sovran 50WG 6.4 oz + Ziram 76DF 3.5 lb	6C,8C	61 a-c	4 a-c	66 cd	5 bc	25 a	1 a	4 ab	<1 ab	1 a	<1 a	1 a	<1 a
8 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C												
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C												
Merivon 5.5 fl oz + Captan 80WDG 30 oz	6C,8C	53 a-c	4 ab	27 a	2 a	32 a	2 ab	1 a	<1 a	2 ab	<1 ab	5 ab	<1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar infection rated on 10 shoots 2 Jul (Idared) 9 Jul (Stayman) or 29 Aug (Granny Smith) or harvest counts of 25-fruit samples picked from each of four single-tree replications 22 Sep (Idared), 7 Oct (Stayman), or 3 Oct (Granny Smith).

Treatments applied airblast at 100 gpa to both sides of the row on each date: 18 Apr, app. #1 (Pk, pink; Stayman- open cluster; Idared and Granny Smith -open cluster to pink); 26 Apr, app. #2 (bloom); 6 May, app. #3 (petal fall); 17 May, app. #4 (1C,1st cover); 30 May, app. #5 (2C, 2nd cover); 14 Jun, app. #6 (3C,3rd cover); 28 Jun, app. #7 (4C,4th cover); 12 Jul, app. #8 (5C,5th cover); 26 Jul, app #9 (6th Cover, 6C); 9 Aug, app #10 (7th Cover, 7C); 24 Aug, app #11 (8th Cover, 8C).

Table 27. Control of post-harvest fruit rots on Stayman, Idared and Granny Smith apples, 2014.

		Idared,	% fruit infected, postharvest counts										
		any rot,	Any rot			Bitter rot			White rot			Alternaria	
		% fruit,	Stay-	Ida-	Gran.	Stay-	Ida-	Gran.	Stay-	Ida-	Granny	Stay-	Ida-
Treatment and rate/A	Timing	harvest	man	red	Smith	man	red	Smith	man	red	Smith	man	red
0 No fungicide	---	39 c	30 c	44 c	47 d	22 b	37 d	33 c	7 b	11 b	20 d	3 b	4 b
1 Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	Pk-4C												
Captan 80WDG 30 oz + Ziram 3 lb	5C →	0 a	7 ab	1 a	3 ab	3 a	0 a	1 a	4 ab	1 a	2 a	0 a	0 a
2 Fontelis 20 fl oz + BioCover MLT 2 qt/100 gal	Pk-4C												
Captan 80WDG 30 oz + Ziram 3 lb	5C →	5 ab	2 ab	5 ab	18 c	1 a	4 ab	7 b	1 ab	1 a	12 b-d	0 a	0 a
3 Indar 8 fl oz + Fontelis 1 pt + BioCover 2 qt/100	Pk-4C												
Captan 80WDG 30 oz + Ziram 3 lb	5C →	12 b	3 ab	10 b	24 c	0 a	10 c	12 b	3 ab	0 a	14 cd	0 a	0 a
4 Indar 2F 10 fl oz + Manzate 3 lb + LI-700 1 pt	Pk-4C												
Indar 2F 10 fl oz Captan 30 oz + LI-700 1 pt	5C →	1 a	4 ab	2 a	7 b	2 a	2 ab	1 a	1 ab	0 a	6 ab	1 a	0 a
5 Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3,5												
Topguard 1.04SC 13 fl oz + Koverall 75DF 3 lb	#2,4,6,7												
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	#8,9												
Cercobin 4.16SC 21 fl oz + Captan 30 oz	#10 →	0 a	3 ab	2 a	1 a	2 a	1 ab	0 a	1 ab	1 a	1 a	0 a	0 a
6 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C												
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C												
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	6C,8C	2 a	3 ab	3 a	7 ab	2 a	3 ab	2 a	1 ab	0 a	6 a-c	0 a	0 a
7 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C												
Ziram 76DF 3.5 lb + ProPhyt 4 pt	5C,7C												
Sovran 50WG 6.4 oz + Ziram 76DF 3.5 lb	6C,8C	2 a	4 ab	4 ab	1 a	1 a	4 bc	0 a	3 ab	0 a	1 a	0 a	0 a
8 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C												
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C												
Merivon 5.5 fl oz + Captan 80WDG 30 oz	6C,8C	0 a	1 a	1 a	4 ab	1 a	0 a	1 a	0 a	1 a	4 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Post-harvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps. Idared sampled 22 Sep, first rated after 28 days in cold storage then rated for rots after 21 days incubation at ambient 64-80°F (mean 71.5°F). Stayman sampled 7 Oct, first rated 10 Oct, then rated for rots after 23 days incubation at ambient temperatures 58-80°F (mean 71.9°F). Granny Smith sampled 3 Oct, first rated 15 Oct, then rated for rots after 27 days incubation at ambient temperatures 44-80°F (mean 70.9°F).

Treatments applied airblast at 100 gpa to both sides of the row on each date: 18 Apr, app. #1 (Pk, pink; Stayman- open cluster; Idared and Granny Smith -open cluster to pink); 26 Apr, app. #2 (bloom); 6 May, app. #3 (petal fall); 17 May, app. #4 (1C,1st cover); 30 May, app. #5 (2C, 2nd cover); 14 Jun, app. #6 (3C,3rd cover); 28 Jun, app. #7 (4C,4th cover); 12 Jul, app. #8 (5C,5th cover); 26 Jul, app #9 (6th Cover, 6C); 9 Aug, app #10 (7th Cover, 7C); 24 Aug, app #11 (8th Cover, 8C).

Table 28. Fruit finish effects by fungicide treatments on Stayman, Idared, and Granny Smith apples, 2014.

		Fruit finish ratings (0-5)*					
		Russet			Opalescence		
Treatment and rate/A	Timing	Stayman	Idared	Granny S.	Stayman	Idared	Granny S.
0 No fungicide	---	1.7 a	1.5 a-c	0.5 ab	1.0 a	1.1 a	0.5 b
1 Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	Pk-4C	1.4 a	1.0 a	0.1 a	1.0 a	0.8 a	0.2 a
Captan 80WDG 30 oz + Ziram 3 lb	5C →						
2 Fontelis 1.67SC 20 fl oz + BioCover 2 qt/100 gal	Pk-4C	2.0 a	1.9 c	1.0 c	1.4 a	0.9 a	0.9 c
Captan 80WDG 30 oz + Ziram 3 lb	5C →						
3 Indar 2F 8 fl oz + Fontelis 1 pt + BioCover 2 qt/100 gal	Pk-4C	1.4 a	1.7 bc	1.1 c	0.8 a	0.9 a	0.8 bc
Captan 80WDG 30 oz + Ziram 3 lb	5C →						
4 Indar 2F 10 fl oz + Manzate 3 lb + LI-700 1 pt	Pk-4C	1.7 a	1.1 a	0.7 bc	1.1 a	1.0 a	0.5 b
Indar 10 fl oz Captan 80WDG 30 oz + LI-700 1 pt	5C →						
5 Luna Tranquility 11.2 fl oz + Koverall 75DF 3 lb	#1,3,5	1.3 a	1.2 ab	0.5 ab	0.8 a	1.0 a	0.5 b
Topguard 1.04SC 13 fl oz + Koverall 75DF 3 lb	#2,4,6,7						
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	#8,9						
Cercobin 4.16SC 21 fl oz + Captan 30 oz	#10 →						
6 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C	1.7 a	1.1 a	0.8 bc	1.3 a	0.9 a	0.7 bc
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C						
Sovran 50WG 6.4 oz + Captan 80WDG 30 oz	6C,8C						
7 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C	1.6 a	1.0 a	0.4 ab	1.2 a	0.8 a	0.5 b
Ziram 76DF 3.5 lb + ProPhyt 4 pt	5C,7C						
Sovran 50WG 6.4 oz + Ziram 76DF 3.5 lb	6C,8C						
8 Manzate 3 lb + Microthiol 8 lb+ ProPhyt 2 pt	Pk-4C	1.4 a	1.4 ab	0.5 ab	1.2 a	0.9 a	0.5 b
Captan 80WDG 3.5 lb + ProPhyt 4 pt	5C,7C						
Merivon 5.5 fl oz + Captan 80WDG 30 oz	6C,8C						

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Harvest counts of 25-fruit samples picked from each of four single-tree replications 22 Sep (Idared), 7 Oct (Stayman), or 3 Oct (Granny Smith).

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

Treatments applied airblast at 100 gpa to both sides of the row on each date: 18 Apr, app. #1 (Pk, pink; Stayman- open cluster; Idared and Granny Smith -open cluster to pink); 26 Apr, app. #2 (bloom); 6 May, app. #3 (petal fall); 17 May, app. #4 (1C,1st cover); 30 May, app. #5 (2C, 2nd cover); 14 Jun, app. #6 (3C,3rd cover); 28 Jun, app. #7 (4C,4th cover); 12 Jul, app. #8 (5C,5th cover); 26 Jul, app #9 (6th Cover, 6C); 9 Aug, app #10 (7th Cover, 7C); 24 Aug, app #11 (8th Cover, 8C).

APPLE (*Malus domestica* 'Golden Delicious', 'Red Delicious'
Quince rust; *Gymnosporangium clavipes*

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Post-infection control of quince rust on Red Delicious and Golden Delicious apples, 2014.

Quince rust overwinters in perennial cankers on Eastern Red Cedar and can produce an abundanc inoculum each year, but quince rust has a rather narrow infection window —just from about pink sta shortly after petal fall. Because of this narrow infection window and the need for infection periods >5 quince rust occurs only sporadically, with serious outbreaks in 2000, 2003, 2008 and 2014. Most of infection in 2014 occurred during a 67-hour wetting period with a total of 1.8 in. of rain near mid-bloo April- 1 May. Two apple blocks had not received any fungicides prior to this extended wetting perioc treatments were applied in the following week or two. These were the only fungicides applied throug test period. The primary objective was to test half rates of SI fungicides, but also to test the combina Regalia + JMS Stylet-Oil which has shown promise for cedar-apple rust control for organic productio Dilute rates were based on 400 gal/A. Both test blocks were set up with four randomized blocks. In Delicious, treatments were applied dilute to runoff 2 May (#1-5) or 5 May (#6-8), approximately thre six days post-infection. Treatments were applied to Red Delicious 16 May, approximately 17 days p infection. Quince rust infection was rated on 100 Golden Delicious fruit per tree 3 Jun and on 50 Re Delicious fruit per tree 3 Jul.

On Golden Delicious, Manzate, generally considered to be a protectant fungicide, was the weakest treatment but gave 44% quince rust suppression when applied three days after infection (Table 29). other treatments ranged from 81-94% control when applied three or six post-infection. Rally, 0.6 oz (equivalent to 2.5 oz/A), was significantly more effective than Topguard 1 fl oz (equivalent to 4 fl oz and Inspire Super 1.5 fl oz (equivalent to 6 fl oz oz/A). There was no difference in control by half or rates of Rally (0.6 oz or 1.25 oz) when applied six days after infection. Regalia + JMS Stylet-Oil gav 94% control. Treatments applied to Red Delicious approximately 17 days post-infection gave 54-71 suppression of quince rust (Table 30), with no significant difference among treatments, including the rates of Rally.

Table 29. Control of quince rust on Golden Delicious, 2014.

	Treatment and rate/ 100 gal dilute	Timing	% fruit infected		% control
0	Non-treated control	---	36	d	---
1	Manzate 75DF 12 oz	2 May	20	c	44
2	Rally 40WSP 0.6 oz	2 May	3	a	92
3	Topguard 1.04SC 1 fl oz	2 May	6	b	83
4	Inspire Super 2.82EW 1.5 fl oz	2 May	7	b	81
5	Regalia 4 qt + JMS Stylet-Oil 1 gal	2 May	4	ab	89
6	Rally 40WSP 1.25 oz	5 May	5	ab	86
7	Rally 40WSP 0.6 oz	5 May	5	ab	86
8	Topguard 1.04SC 1 fl oz	5 May	7	b	81
9	Regalia 4 qt + JMS Stylet-Oil 1 gal (two reps only)	5 May	2	ab	94

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts of 100 fruit per rep 3 Jun.

Table 30. Control of quince rust on Red Delicious, 2014.

	Treatment and rate/ 100 gal dilute	Timing	% fruit infected		% control
0	Non-treated control	---	35	b	---
1	Regalia 4 qt + JMS Stylet-Oil 1 gal	16 May	16	a	54
2	Inspire Super 2.82EW 1.5 fl oz	16 May	14	a	60
3	Topguard 1.04SC 1 fl oz	16 May	10	a	71
4	Rally 40WSP 0.6 oz	16 May	13	a	63
5	Rally 40WSP 1.25 oz	16 May	15	a	57

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts of 50 fruit per rep 3 Jul.

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

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Evaluation of experimental and registered cover spray fungicide combinations for disease control on York apple, 2014.

Thirteen registered and experimental treatments applied in summer schedules were compared during the mid-season cover spray period on 15-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by in-row border trees. No fungicides were applied until the first treatment application date 9 May. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 350 psi as petal fall- sixth cover sprays: 9 May (petal fall); first-sixth covers: 19 May, 6 Jun, 20 Jun, 8 Jul, 29 Jul, and 20 Aug. All diseases developed from inoculum naturally present in the test area. Foliar data are based on six shoots per rep 3 Sep; only leaves younger than the 6th leaf, (corresponding approximately to the time of the first treatment application), were counted. Fruit data are based on 25-fruit sample per rep harvested 8 Oct and held at ambient temperatures (58-80ºF, mean 71.3ºF); first evaluated 27 Oct, then re-evaluated for post-storage rots 6 Nov. Maintenance materials applied to the entire test block included: Admire Pro, Altacor, Assail Asana XL, Biocover MLT, Delegate, Imidan Lannate LV, Provado and Scorpion. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The test was set up primarily to evaluate the treatments for summer disease control, starting at petal fall, but scab lesions from 11 Apr and 14 Apr infections were already present in the test block when the treatment series began 9 May, and 14 secondary scab infection periods occurred 28 Apr-22 Jun. Under these delayed application conditions, fruit scab was effectively controlled by Inspire Super and A19334A and by rotating schedules of these with A15457B (Table 31). Scab control was significantly improved by including JMS Stylet-Oil with Indar + Fontelis + Manzate (#4 vs. 3) and by including ProPhyt with Manzate + Ziram (#6 vs. 5). Twelve of the extended wetting periods 28 Apr-22 Jun were also cedar-apple rust infection periods. Schedules involving Inspire Super, A19334A or Indar gave the best cedar-apple rust on foliage and fruit. Including JMS Stylet-Oil with Indar + Fontelis + Manzate significantly improved foliar rust control. Treatments which were notably weak for rust control on foliage included: Captan, Omega, A15457B, Manzate + Ziram. Most quince rust infection occurred 28 Apr-May 1, before the first application, but many treatments gave good control, including: Inspire Super, A19334A, Indar, as well as Omega. Captan, Manzate + Ziram and A15457B showed signs of weakness for control of both quince and cedar-apple rust on fruit. Local summer disease pressures were typical for this test block. The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 18 May, was reached 3 Jul, and 12.8 inches of rainfall occurred 9 May-30 Sep. Captan/Captan + Ziram performed as expected under these conditions, with good control of sooty blotch, and moderate suppression of flyspeck and post-harvest rots(Table 32). Adding ProPhyt to Captan/Captan + Ziram (#1 vs. #2) significantly improved control of sooty blotch and flyspeck (SBFS) but did not increase overall effectiveness against post-harvest rots. Inspire Super (#12) gave excellent overall control of SBFS and rots. Although they gave some suppression of SBFS and rots, compared to non-treated trees, A15457B (#10) showed some significant weaknesses for SBFS and rots (especially bitter rot), and Omega was significantly weaker than Inspire Super for flyspeck. Compared to non-treated fruit, several treatments significantly increased the amount of opalescence, including: Indar + Fontelis + Manzate (#3), Indar + Fontelis + Manzate + Stylet-Oil (#4), Manzate + Ziram + ProPhyt (#6), and A15457B (#10).

Table 31. Scab and rust control by treatments first applied at petal fall, York apple, 2014.

	Treatment and rate/100 gal dilute	Timing	Cedar rust, % lvs	% fruit infected with rusts or scab: c-a rust	quince	scab	Fruit finish rating (0-5)*: russet	opalescence
0	No fungicide	---	59 f	13 d	34 e	81 f	1.9 b	1.0 ab
1	Captan 80WDG 10 oz	PF-4C	36 de	5 bc	9 d	9 a-e	1.6 ab	1.3 a-d
	Captan 7.5 oz + Ziram 76DF 12 oz	5C-6C						
2	Captan 80WDG 10 oz + ProPhyt 1 pt	PF-4C	34 de	9 d	4 c	12 c-e	1.4 ab	1.3 a-d
	Captan 80WG 7.5 oz + Ziram 12 oz+ ProPhyt 1 pt	5C-6C						
3	Indar 2F 1.5 fl oz + Fontelis 4 fl oz + Manzate 75DF 12 oz	PF-4C	11 bc	0 a	0 a	14 de	1.7 ab	1.7 c-e
	Indar 2F 1.5 fl oz + Ziram 76DF 12 oz	5C-6C						
4	Indar 2F 1.5 fl oz + Fontelis 4 fl oz + Manzate 12 oz + JMS Stylet-Oil 2 qt	PF-4C	2 a	0 a	0 a	6 a-d	1.7 ab	1.9 de
	Indar 2F 1.5 fl oz + Ziram 12 oz + JMS Stylet-Oil 2 qt	5C-6C						
5	Manzate 12 oz + Ziram 76DF 12 oz	PF-4C	40 e	7 cd	5 c	18 e	1.8 ab	1.6 b-e
	Captan 80WG 7.5 oz + Ziram 12 oz	5C-6C						
6	Manzate 12 oz + Ziram 76DF 12 oz + ProPhyt 1 pt	PF-4C	41 e	12 d	15 d	6 a-d	1.7 ab	1.9 e
	Captan 80WG 7.5 oz + Ziram 12 oz + ProPhyt 1 pt	5C-6C						
7	A15457B 100EC 1.38 fl oz	PF,1C,4C	16 bc	0 a	1 ab	6 a-c	1.5 ab	1.4 a-e
	Inspire Super 2.82 EW 3 fl oz	2-3C						
	Captan 80WG 7.5 oz + Ziram 12 oz	5C-6C						
8	A15457B 100EC 1.38 fl oz	PF,2C	21 cd	0 a	0 a	4 a	1.2 a	0.9 a
	Inspire Super 2.82 EW 3 fl oz	1C,3C						
	Omega 4SC 3.45 fl oz	4C						
	Captan 80WG 7.5 oz + Ziram 12 oz	5C-6C						
9	A19334A 195EC 1.75 fl oz	PF,1C,4C	28 de	1 ab	0 a	3 ab	1.8 ab	1.6 b-e
	Omega 500F 3.45 fl oz	2-3C						
	Captan 80WG 7.5 oz + Ziram 12 oz	5C-6C						
10	A15457B 100EC 1.38 fl oz	PF-6C	34 de	3 b	3 bc	9 a-e	1.8 ab	1.7 c-e
11	A19334A 195EC 1.75 fl oz	PF-6C	8 ab	0 a	0 a	4 a-c	1.6 ab	1.4 a-e
12	Inspire Super 2.82 EW 3 fl oz	PF-6C	7 ab	0 a	0 a	3 ab	1.4 ab	1.2 a-c
13	Omega 500F 3.45 fl oz	PF-6C	39 e	0 a	0 a	9 b-e	1.3 ab	1.1 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications.
Post-harvest data based on 25-fruit sample harvested 8 Oct, evaluated 27 Oct and re-evaluated 6 Nov.

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

No fungicides applied until the first treatment application date. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 350 psi as petal fall- sixth cover sprays: 9 May (petal fall); first-sixth covers: 19 May, 6 Jun, 20 Jun, 8 Jul, 29 Jul, and 20 Aug.

Table 32. Summer disease control on Ramey York apple, 2014. Virginia Tech AREC.

			% fruit or fruit area infected at harvest					% post-storage rots			
			Sooty blotch		Flyspeck		Any	Any	Bitter	White	Alter-
	Treatment and rate/100 gal dilute	Timing	fruit	area	fruit	area	rot	rot	rot	rot	naria
0	No fungicide	---	100 d	12 d	100 d	10 e	17 c	34 c	25 e	8 a	3 b
1	Captan 80WDG 10 oz Captan 80WG 7.5 oz + Ziram 76DF 12 oz	PF-4C 5C-6C	14 c	<1 c	52 c	3 d	10 bc	9 ab	6 cd	3 a	1 ab
2	Captan 80WDG 10 oz + ProPhyt 1 pt Captan 80WG 7.5 oz + Ziram 12 oz+ ProPhyt 1 pt	PF-4C 5C-6C	1 ab	<1 ab	4 ab	<1 a-c	3 ab	5 ab	4 b-d	1 a	0 a
3	Indar 2F 1.5 fl oz + Fontelis 4 fl oz + Manzate 12 oz Indar 2F 1.5 fl oz + Ziram 76DF 12 oz	PF-4C 5C-6C	0 a	0 a	0 a	0 a	5 ab	7 ab	2 a-c	5 a	0 a
4	Indar 1.5 fl oz + Fontelis 4 fl oz + Manzate 12 oz + JMS Stylet-Oil 2 qt Indar 2F 1.5 fl oz + Ziram 12 oz+ JMS Stylet-Oil 2 qt	PF-4C 5C-6C	0 a	0 a	0 a	0 a	1 a	2 a	2 a-d	1 a	0 a
5	Manzate 75DF 12 oz + Ziram 76DF 12 oz Captan 80WG 7.5 oz + Ziram 76DF 12 oz	PF-4C 5C-6C	4 b	<1 b	14 b	<1 bc	5 ab	4 ab	1 ab	3 a	0 a
6	Manzate 12 oz + Ziram 76DF 12 oz ProPhyt 1 pt Captan 80WG 7.5 oz + Ziram 12 oz + ProPhyt 1 pt	PF-4C 5C-6C	0 a	0 a	4 ab	<1 a-c	4 ab	4 ab	3 a-d	1 a	0 a
7	A15457B 100EC 1.38 fl oz Inspire Super 2.82 EW 3 fl oz Captan 80WG 7.5 oz + Ziram 76DF 12 oz	PF,1C,4C 2-3C 5C-6C	1 ab	<1 ab	2 a	<1 ab	1 a	8 ab	5 b-d	4 a	0 a
8	A15457B 100EC 1.38 fl oz Inspire Super 2.82 EW 3 fl oz Omega 500F 3.45 fl oz Captan 80WG 7.5 oz + Ziram 76DF 12 oz	PF,2C 1C,3C 4C 5C-6C	0 a	0 a	1 a	<1 a	4 ab	6 ab	1 ab	4 a	1 ab
9	A19334A 195EC 1.75 fl oz Omega 500F 3.45 fl oz Captan 80WG 7.5 oz + Ziram 76DF 12 oz	PF,1C,4C 2-3C 5C-6C	0 a	0 a	7 ab	<1 a-c	5 ab	4 ab	1 ab	3 a	0 a
10	A15457B 100EC 1.38 fl oz	PF-6C	5 b	<1 b	4 ab	<1 a-c	7 a-c	14 b	9 d	3 a	2 ab
11	A19334A 195EC 1.75 fl oz	PF-6C	0 a	0 a	4 ab	<1 a-c	3 ab	3 ab	1 ab	2 a	0 a
12	Inspire Super 2.82 EW 3 fl oz	PF-6C	0 a	0 a	0 a	0 a	1 a	2 a	0 a	2 a	0 a
13	Omega 500F 3.45 fl oz	PF-6C	3 b	<1 b	10 b	<1 c	1 a	3 ab	2 a-c	1 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications. Post-harvest data are based on a 25-fruit sample harvested 8 Oct. and evaluated 27 Oct, then re-evaluated after 29 days storage at ambient temperatures 58-80°F (mean 71.3°F).

No fungicides applied until the first treatment application date. Dilute treatments were applied to the point of runoff with a single

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

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Evaluation of experimental and registered cover spray fungicide combinations for disease c on Fuji apple, 2014.

Sixteen experimental and registered treatments were compared during the mid-season cover sp period on 19-yr-old trees on M.9 rootstock. The test was conducted in a randomized block design w four single-tree replicates separated by border rows and in-row border trees. No fungicides were ap before the treatment series began at petal fall 6 May. Test treatments were applied to both sides of tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows May (PF, after petal fall, fruit 4-5 mm; Trts. 2-13 only); First-eighth covers (1C-8C): 17 May, 30 May Jun, 28 Jun, 16 Jul, 7 Aug, 27 Aug and 16 Sep. All diseases developed from inoculum naturally pre the test area. Fruit data are based on 25 fruit per replication, harvested 14 Oct and rated 17 Oct the at ambient temperatures 59-80ºF until the final rot rating 13 Nov. Insecticides applied to the entire te block with the same equipment during the test period included: Admire Pro, Altacor, Assail, Carbary Delegate, Imidan, Lannate LV, Provado, and Scorpion. Percentage data were converted by the squ root arcsin transformation for statistical analysis.

This test was set up primarily to evaluate the treatments for summer disease control, starting so after petal fall, but scab lesions from 11 Apr and 14 Apr infections were already present in the test b when the treatment series began 6 May, and 14 secondary scab infection periods occurred 28 Apr- Jun. Also, scab strains resistant to DMI, QoI, and benzimidazole fungicides are known to present in test area. The delayed application conditions increased the test pressure on the protectant mixing partners of fungicides at risk for resistance. Rate effects were noted in effectiveness of Captan formulations and also in rate comparisons of three experimental materials with “ARY” code numbers Including ProPhyt with Captan Gold 2.5 lb significantly reduced scab incidence and lesions per fruit (Table 33). Twelve of the 14 extended wetting periods 28 Apr-22 Jun were also cedar-apple rust inf periods. Most quince rust infection occurred 28 Apr-May 1, several days before the first application petal fall. Rally, at petal fall in treatments #2-10, gave strong suppression of both quince rust and ce apple rusts on fruit; delaying it 11 days to first cover reduced control somewhat but still gave good suppression by Rally (#1) and Inspire Super (#14). Treatments involving Merivon, Omega and Pristi in combination with Captan, showed significant weakness for control of rusts. Merivon + Ziram (#11 better control of cedar-apple rust and quince rust than Merivon + Captan (#12), and adding Silwet to Merivon + Captan (#13) significantly improved rust control. The 250-hr accumulated wetting hour threshold for sooty blotch/flyspeck (SBFS) activity, accumulating from 18 May and was reached 3 J 12.8 inches of rainfall occurred 9 May- 30 Sep. Under these conditions, the reduced rate of Captan lb/A in #1 and #9) performed as expected at extended intervals, with moderate suppression of SBF post-storage rots (Table 34). Including ProPhyt with Captan (#10 vs. #9) significantly improved cont SBFS and post-harvest rots, including bitter rot, and was the best treatment for summer disease co overall. None of the treatments significantly affected fruit finish.

Table 33. Control of scab and rusts and fruit finish effects by fungicides first applied to Fuji apples at petal fall, 2014.

			Scab		Cedar-apple rust		Quince	Fruit finish (0-5) *	
	Treatment and rate /A	Timing	% fruit	les/fruit	% fruit	les/fruit	rust, %	russet	opalescence
0	Non-treated control	---	56 f	2.4 e	25 ef	0.3 cd	42 f	2.0 a	1.6 a
1	Rally 40WSP 2.5 oz + Captan 80WDG 2.5 lb Agri-Star Captan 80WDG 2.5 lb	1C 2C-8C	48 ef	1.2 b-d	10 cd	0.5 f	22 de	2.2 a	1.3 a
2	Rally 2.5 oz + ARY-0400-316 80WDG 5 lb ARY-0400-316 80WDG 5 lb	PF 1C-8C	22 a	0.4 a	1 a	<0.1 a	0 a	1.8 a	1.1 a
3	Rally 2.5 oz + ARY-0400-316 80WDG 2.5 lb ARY-0400-316 80WDG 2.5 lb	PF 1C-8C	35 a-e	0.8 a-c	1 a	<0.1 a	0 a	1.7 a	0.9 a
4	Rally 2.5 oz + ARY-0400-216 80WDG 5 lb ARY-0400-216 80WDG 5 lb	PF 1C-8C	31 a-d	0.6 ab	6 bc	<0.1 a-c	2 a	1.5 a	0.8 a
5	Rally 2.5 oz + ARY-0400-216 80WDG 2.5 lb ARY-0400-216 80WDG 2.5 lb	PF 1C-8C	26 a-c	0.5 a	1 a	<0.1 a	1 a	1.7 a	1.2 a
6	Rally 2.5 oz + ARY-0400-117 80WDG 5 lb ARY-0400-117 80WDG 5 lb	PF 1C-8C	26 a-c	0.5 a	2 ab	<0.1 ab	0 a	1.8 a	1.1 a
7	Rally 2.5 oz + ARY-0400-117 80WDG 2.5 lb ARY-0400-117 80WDG 2.5 lb	PF 1C-8C	51 ef	1.5 d	4 a-c	<0.1 ab	2 a	1.4 a	0.8 a
8	Rally 2.5 oz + Captan Gold 80WDG 5 lb Captan Gold 80WDG 5 lb	PF 1C-8C	38 b-e	0.7 ab	1 a	<0.1 a	0 a	1.4 a	0.7 a
9	Rally 2.5 oz + Captan Gold 80WDG 2.5 lb Captan Gold 80WDG 2.5 lb	PF 1C-8C	46 d-f	1.3 cd	1 a	<0.1 a	1 a	1.9 a	1.3 a
10	Rally 2.5 oz + Captan Gold 2.5 lb + ProPhyt 4 pt Captan Gold 80WDG 2.5 lb+ ProPhyt 4 pt	PF 1C-8C	21 a	0.3 a	1 a	<0.1 a	0 a	1.6 a	1.1 a
11	Merivon 5.5 fl oz + Ziram 76DF 3 lb	PF-8C	29 a-d	0.4 a	17 de	0.2 a-d	9 bc	1.4 a	0.9 a
12	Merivon 5.5 fl oz + Captan 80WDG 30 oz	PF-8C	23 ab	0.4 a	38 f	0.5 ef	15 cd	1.7 a	1.2 a
13	Merivon 5.5 fl oz + Captan 30 oz +Silwet 114 ml	PF-8C	24 ab	0.4 a	21 de	0.2 b-d	5 ab	1.9 a	1.3 a
14	Inspire Super 12 fl oz + Captan 80WDG 30 oz Omega 4SC 13.8 fl oz + Captan 80WDG 30 oz	1C 2C-8C	42 c-f	0.9 a-d	6 a-c	<0.1 a-c	15 cd	1.6 a	1.1 a
15	Omega 4SC 13.8 fl oz + Captan 80WDG 30 oz	1C-8C	35 a-e	0.8 a-c	24 e	0.3 cd	34 ef	2.1 a	1.5 a
16	Pristine 38WG 14.5 oz + Captan 80WDG 30 oz	1C-8C	35 a-e	0.7 ab	29 ef	0.3 de	32 ef	2.2 a	1.7 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. Data based on 25 fruit per rep picked 14 Oct and rated 17 Oct. Applied airblast at 100 gpa to both sides of the row on each application date: 6 May (PF, after petal fall, fruit 4-5 mm; Trts. 2-13 only); 1st to 8th covers (1C-8C): 17 May, 30 May, 14 Jun, 28 Jun, 16 Jul, 7 Aug, 27 Aug and 16 Sep.

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

Table 34. Control of sooty blotch, flyspeck and post-storage rots on Fuji apples, 2014. Virginia Tech AREC.

			Disease incidence or % area infected								
			Sooty blotch		Flyspeck		Rots after storage incubation				
	Treatment and rate /A	Timing	fruit	area	fruit	area	Any rot	Bitter rot	White rot	Alternaria	Blue mold
0	Non-treated control	---	96 g	7.5 h	93 g	6.1 f	25 c	23 c	5 ab	2 a	0 a
1	Rally 40WSP 2.5 oz + Captan 80WDG 2.5 lb Agri-Star Captan 80WDG 2.5 lb	1C 2C-8C	29 f	1.9 fg	27 f	1.5 e	9 b	5 b	4 ab	0 a	2 a
2	Rally 2.5 oz + ARY-0400-316 80WDG 5 lb ARY-0400-316 80WDG 5 lb	PF 1C-8C	17 d-f	0.9 c-g	20 ef	1.1 de	0 a	0 a	0 a	0 a	0 a
3	Rally 2.5 oz + ARY-0400-316 80WDG 2.5 lb ARY-0400-316 80WDG 2.5 lb	PF 1C-8C	22 f	1.6 g	30 f	1.5 e	8 b	3 ab	4 ab	1 a	0 a
4	Rally 2.5 oz + ARY-0400-216 80WDG 5 lb ARY-0400-216 80WDG 5 lb	PF 1C-8C	12 c-f	0.7 d-g	10 c-e	0.5 cd	3 ab	1 ab	2 ab	1 a	0 a
5	Rally 2.5 oz + ARY-0400-216 80WDG 2.5 lb ARY-0400-216 80WDG 2.5 lb	PF 1C-8C	10 b-f	0.6 b-g	24 f	1.3 e	6 b	1 ab	2 ab	3 a	0 a
6	Rally 2.5 oz + ARY-0400-117 80WDG 5 lb ARY-0400-117 80WDG 5 lb	PF 1C-8C	8 b-f	0.4 a-e	15 d-f	0.9 de	5 ab	1 ab	2 ab	0 a	1 a
7	Rally 2.5 oz + ARY-0400-117 80WDG 2.5 lb ARY-0400-117 80WDG 2.5 lb	PF 1C-8C	24 f	1.3 e-g	30 f	1.6 e	3 ab	2 ab	1 ab	0 a	0 a
8	Rally 2.5 oz + Captan Gold 80WDG 5 lb Captan Gold 80WDG 5 lb	PF 1C-8C	7 a-e	0.4 a-e	6 b-d	0.4 bc	2 ab	0 a	2 ab	0 a	0 a
9	Rally 2.5 oz + Captan Gold 80WDG 2.5 lb Captan Gold 80WDG 2.5 lb	PF 1C-8C	20 ef	1.1 e-g	30 f	1.7 e	9 b	5 b	3 ab	1 a	0 a
10	Rally 2.5 oz + Captan Gold 2.5 lb + ProPhyt 4 pt Captan Gold 80WDG 2.5 lb+ ProPhyt 4 pt	PF 1C-8C	4 ab	0.2 ab	2 ab	0.1 ab	0 a	0 a	0 a	0 a	0 a
11	Merivon 5.5 fl oz + Ziram 76DF 3 lb	PF-8C	4 a-d	0.2 a-d	4 a-c	0.2 a-c	6 b	2 ab	4 ab	0 a	0 a
12	Merivon 5.5 fl oz + Captan 80WDG 30 oz	PF-8C	3 a-c	0.2 a-c	4 a-c	0.2 a-c	4 ab	2 ab	3 ab	0 a	0 a
13	Merivon 5.5 fl oz + Captan 30 oz +Silwet 114 ml	PF-8C	3 a-c	0.2 a-c	1 ab	0.1 ab	3 ab	2 ab	0 a	1 a	0 a
14	Inspire Super 12 fl oz + Captan 80WDG 30 oz Omega 4SC 13.8 fl oz + Captan 80WDG 30 oz	1C 2C-8C	2 a	0.2 a	0 a	0 a	11 b	5 ab	7 b	0 a	1 a
15	Omega 4SC 13.8 fl oz + Captan 80WDG 30 oz	1C-8C	8 a-d	0.7 a-f	3 ab	0.2 ab	7 b	1 ab	4 ab	1 a	1 a
16	Pristine 38WG 14.5 oz + Captan 80WDG 30 oz	1C-8C	3 ab	0.2 ab	2 ab	0.1 ab	3 ab	3 ab	0 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. Fruit data are based on 25 fruit per replication, harvested 14 Oct and rated 17 Oct then held at ambient temperatures 59-80ºF until the final rot rating 13 Nov.

Applied airblast at 100 gpa to both sides of the row on each application date: 6 May (PF, after petal fall, fruit 4-5 mm; Trts. 2-13 only); 1st to 8th covers (1C-8C): 17 May, 30 May, 14 Jun, 28 Jun, 16 Jul, 7 Aug, 27 Aug and 16 Sep.

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

K. S. Yoder, A. E. Cochran II, W. S. Royston, Jr.,
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Disease control by integrated fungicide programs on Redhaven peach, 2014.

Eight treatments involving recently registered fungicides and biological products were compared to several standard programs for broad-spectrum disease control on 3-yr-old trees. The entire planting was left untreated in 2013 to allow the buildup of leaf curl and scab inoculum for the test in 2014. The test was set up in a randomized block design with four replications with non-treated in-row border trees between the test trees. Three brown rot mummies were placed in each test tree 14 Apr. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 200-350 psi as follows: 1 Apr (BS, bud swell, trts.#1,5 ,6 & 8, 9, 11 and 12 only); 11 Apr (pink, all treatments); 18 Apr (Bl, bloom); 2 May (SS, shuck split); 1st through 3rd covers (1C-3C): 19 May, 6 Jun, 20 Jun; 10 Jul (3PH,3-wk pre-harvest) and 24 Jul (1PH, 1 wk pre-harvest). (Actual harvest date was 30 Jul). Commercial insecticides applied to the entire test block at 1-2 wk intervals with a commercial airblast sprayer, included: Assail, Carbaryl, Delegate, Imidan, and Lannate LV and Voliam Flexi. Leaf curl "strikes" were per tree counted on 27 May. Samples of 40 apparently rot-free fruit per replicate tree were harvested 30 Jul, rated for scab, fruit were selected for uniform ripeness, grouped into 20-fruit subsamples, and placed on fiber trays. One set was misted with de-ionized water, and the other subsample was inoculated with a suspension containing 20,000 *M. fructicola* conidia/ml. All fruit were incubated in polyethylene bags at ambient temperatures 68-79ºF (20-26C) before rating rot development at the indicated intervals.

Early season rains favored moderate leaf curl infection. Treatments involving Bravo (trt #1), Ziram (#11) and C-O-C-S (#12), applied at bud swell, gave expected control of leaf curl; other materials applied at bud swell were ineffective or gave variable results (Table 35). Scab inoculum was abundant on the test trees, and weather conditions during the shuck split/early cover spray period were favorable for scab development and weathering of the test treatments. Under these strong test conditions with 99% of non-treated fruit infected, all treatments gave significant suppression of percent fruit infected and scab lesions/fruit. Treatments involving Merivon applied at bloom, followed by Sulfur at shuck split had the least amount of scab infection. There was a rate effect on scab control by Actinovate, with the 6 oz (trt #6) significantly stronger than 3 oz rate (trt #5). Botector, applied through second cover (#7), did not control scab as well as a parallel schedule switched to Sulfur at shuck split stage (#8). Some brown rot was observed on non-treated trees in mid-season, but post-harvest inoculation with conidial suspensions also increased fruit rot incidence (Table 36). Under these conditions, all treatments gave significant control compared to non-treated fruit. Treatments involving Merivon were the most effective, and were significantly more effective than Pristine as the pre-harvest spray. Pristine was more effective than pre-harvest sulfur schedules, which were slightly more effective or similar to Actinovate and Botector. There was a rate effect by Actinovate on scab control, but this was not consistent with brown rot as the 6 oz (trt #6) was actually less effective than 3 oz rate (trt #5) on non-inoculated fruit. There was no evidence of any phytotoxicity related to inclusion of the adjuvants LI-700 or Cohere with Merivon + Danitol.

Table 35. Control of leaf curl and scab on Redhaven peach, 2014

	Treatment and rate/100 gal dilute	Timing	Leaf curl * strikes/tree	Scab * % fruit	Scab * lesions/fruit
0	No fungicide	---	9 d	99 e	39.9 b
1	Bravo Weather Stik 6F 1 pt	BS	0 a		
	Microfine Sulfur 90W 3 lb	SS-3C		16 bc	0.8 a
	Pristine 38WG 6oz + LI-700 8 fl oz	3 & 1PH			
2	Merivon 3.25 oz + LI-700 1 qt + Danitol 10 fl oz	Pink	2 ab	4 ab	0.4 a
	Merivon 3.25 oz + LI-700 1 qt	Bloom			
	Microfine Sulfur 90W 3 lb	SS-3C			
	Merivon 3.25 fl oz + LI-700 1 qt + Danitol 10 fl oz	3 & 1PH			
3	Merivon 3.25 oz + Cohere 1 pt + Danitol 10 fl oz	Pink	1 a	7 ab	0.3 a
	Merivon 3.25 oz + Cohere 1 pt	Bloom			
	Microfine Sulfur 90W 3 lb	SS-3C			
	Merivon 3.25 fl oz + Cohere 1 pt + Danitol 10 fl oz	3 & 1PH			
4	Merivon 3.25 oz + Danitol 10 fl oz	Pink	5 b-d	1 a	<0.1 a
	Merivon 3.25 oz	Bloom			
	Microfine Sulfur 90W 3 lb	SS-3C			
	Merivon 3.25 fl oz ml + Danitol 10 fl oz	3 & 1PH			
5	Actinovate 3 oz	BS- 1PH	3 ab	48 d	3.9 a
6	Actinovate 6 oz	BS- 1PH	8 cd	14 bc	1.0 a
7	Botector 5 oz	Pink-2C	19 e	38 d	2.8 a
	Microfine Sulfur 90W 3 lb	3C			
	Botector 5 oz	3 & 1PH			
8	Botector 5 oz	BS-Bl	7 cd	19 c	1.0 a
	Microfine Sulfur 90W 3 lb	SS-1PH			
9	Microfine Sulfur 90W 3 lb	BS-1PH	6 cd	14 bc	1.1 a
10	Microfine Sulfur 90W 3 lb	Pink-1PH	4 bc	14 bc	0.5 a
11	Ziram 76DF 1.5 lb	BS-Bl	0 a		
	Microfine Sulfur 90W 3 lb	SS-3C		9 bc	0.5 a
	Pristine 38WG 6oz + LI-700 8 fl oz	3 & 1PH			
12	C-O-C-S 50WDG 1 lb	BS-Bl	1 a		
	Microfine Sulfur 90W 3 lb	SS-3C		13 bc	0.8 a
	Pristine 38WG 6oz + LI-700 8 fl oz	3 & 1PH			

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

* Leaf curl counted 27 May; harvest counts of scab on 40 fruit / replication 30 Jul.

Treatments applied dilute to runoff at 200-350 psi: 1 Apr (BS, bud swell, trts.#1,5 ,6, 8, 9, 11 & 12 only); 11 Apr (pink, all treatments); 18 Apr (Bl, bloom); 2 May (SS, shuck split); 1st through 3rd covers (1C-3C): 19 May, 6 Jun, 20 Jun; 10 Jul (3PH,3-wk pre-harvest); 24 Jul (1PH, 1 wk pre-harvest). Actual harvest date was 30 Jul.

Note: Data are aligned with the treatment timing most likely to have affected indicated disease.

Table 36. Post-harvest brown rot development on Redhaven peach, 2014

	Treatment and rate/100 gal dilute	Timing	% fruit with brown rot after indicated days incubation							
			Non-inoculated fruit				Inoculated fruit			
			4 day	5 day	6 day	7 day	4 day	5 day	6 day	7 day
0	No fungicide	---	20 c	49 f	73 g	84 g	61 f	80 h	98 g	100 h
1	Bravo Weather Stik 6F 1 pt	BS								
	Microfine Sulfur 90W 3 lb	SS-3C								
	Pristine 38WG 6oz + LI-700 8 fl oz	3 & 1PH	0 a	6 a-c	6 bc	14 b-d	8 b	16 bc	18 c	29 c-e
2	Merivon 3.25 oz + LI-700 1 qt + Danitol 10 fl oz	Pink								
	Merivon 3.25 oz + LI-700 1 qt	Bloom								
	Microfine Sulfur 90W 3 lb	SS-3C								
	Merivon 3.25 fl oz + LI-700 1 qt + Danitol 10 fl oz	3 & 1PH	0 a	0 a	0 a	0 a	0 a	0 a	8 a	9 a
3	Merivon 3.25 oz + Cohere 1 pt + Danitol 10 fl oz	Pink								
	Merivon 3.25 oz + Cohere 1 pt	Bloom								
	Microfine Sulfur 90W 3 lb	SS-3C								
	Merivon 3.25 fl oz + Cohere 1 pt + Danitol 10 fl oz	3 & 1PH	0 a	0 a	0 a	0 a	1 a	1 a	8 ab	9 ab
4	Merivon 3.25 oz + Danitol 10 fl oz	Pink								
	Merivon 3.25 oz	Bloom								
	Microfine Sulfur 90W 3 lb	SS-3C								
	Merivon 3.25 fl oz ml + Danitol 10 fl oz	3 & 1PH	0 a	0 a	1 ab	1 a	0 a	0 a	8 ab	11 ab
5	Actinovate 3 oz	BS- 1PH	0 a	4 ab	13 c-e	18 b-d	15 c-e	34 ef	46 e	51 f
6	Actinovate 6 oz	BS- 1PH	6 bc	21 e	29 f	39 f	20 e	33 d-f	36 de	43 ef
7	Botector 5 oz	Pink-2C								
	Microfine Sulfur 90W 3 lb	3C								
	Botector 5 oz	3 & 1PH	8 bc	24 de	31 f	35 ef	13 b-e	45 g	63 f	66 g
8	Botector 5 oz	BS-Bl								
	Microfine Sulfur 90W 3 lb	SS-1PH	3 ab	14 c-e	14 de	15 b-d	16 de	23 cd	24 cd	26 cd
9	Microfine Sulfur 90W 3 lb	BS-1PH	4 ab	14 b-e	16 c-e	23 de	16 c-e	28 de	36 de	38 d-f
10	Microfine Sulfur 90W 3 lb	Pink-1PH	1 ab	10 b-e	16 ef	19 cd	23 e	39 fg	49 ef	53 fg
11	Ziram 76DF 1.5 lb	BS-Bl								
	Microfine Sulfur 90W 3 lb	SS-3C								
	Pristine 38WG 6oz + LI-700 8 fl oz	3 & 1PH	0 a	0 a	1 ab	9 b	8 bc	10 b	24 cd	24 cd
12	C-O-C-S 50WDG 1 lb	BS-Bl								
	Microfine Sulfur 90W 3 lb	SS-3C								
	Pristine 38WG 6oz + LI-700 8 fl oz	3 & 1PH	0 a	6 a-d	9 cd	10 bc	10 b-d	10 b	18 bc	20 bc

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single tree replications.
Bud swell through cover treatments applied as indicated in Table 35; 10 Jul (3PH,3-wk pre-harvest); 24 Jul (1PH, 1 wk pre-harvest).

PEACH (*Prunus persica* 'Loring') K. S. Yoder, A. E. Cochran II, W. S. Royston, Jr.,
Nectarine: (*P. persica* var. *nucipersica* ‘Redgold’) S. W. Kilmer and G. Engelman
Scab; *Cladosporium carpophilum* Va. Tech Ag. Res. and Ext. Center
Brown rot; *Monilinia fructicola* 595 Laurel Grove Road
Rusty spot; *Podosphaera leucotricha* Winchester, VA 22602

Evaluation of experimental fungicides for disease control on Loring peach and Redgold nect 2014. Several fungicides were compared for broad-spectrum disease control on 22-yr-old trees, foc especially on scab in the petal fall to second cover spray period. The test trees were not treated witl fungicides in 2013 to allow the buildup of scab inoculum for 2014. Dilute treatments were applied to point of run-off (approximately 200 gal/A) with a single nozzle handgun at 350 psi in a randomized b design with four replications as follows: 1 Apr (BS, bud swell); 24 Apr (PF, petal fall); 2 May (SS, sh split); 1st through 5th covers (1C-5C): 19 May, 6 Jun, 20 Jun, 10 Jul, 24 Jul (3-wk pre-harvest, 3PH (1-wk pre-harvest, 1PH). Commercial insecticides were applied to the entire test block with an airbla sprayer. Leaf curl incidence was rated on 50 shoots per tree 27 May. Scab and rusty spot were ass on 40 fruit on each tree 11 Aug. Samples of 40 apparently rot-free fruit per replicate tree were harve from both Loring and Redgold on 13 Aug. Fruit were selected for uniform ripeness, grouped into 20- subsamples, and placed on fiber trays. One set was misted with de-ionized water, and the other set inoculated with a suspension of 40,000 *M. fructicola* conidia/ml. All fruit were incubated in polyethyle bags at ambient temperatures (68-79ºF) while rating rot development at the indicated intervals.

Ziram, applied at bud swell, gave good control of leaf curl. Scab inoculum was high on the test trees weather during the early cover spray period was very favorable for scab infection. Under these stror conditions with 72% of untreated Loring peach fruit infected with scab, most treatments gave signific but not outstanding control of percent fruit infected. But under heavier scab pressure on Redgold ne only treatment #3 with Gem from petal fall through 2nd cover, gave significant suppression of scab. suggests weaknesses by Sonata and Rally, the other scab schedule components of treatments #1, 4. The pre-harvest sprays of Luna Sensation gave excellent control of brown rot on Loring peach ar Redgold nectarine five or six days into incubation, and there were no apparent treatment differences related to the petal fall to second cover spray schedules after seven days’ incubation.

Table 37. Control of scab, and rusty spot on Loring peach and Redgold nectarine, 2014

	Treatment and rate/100 gal dilute	Timing	Leaf curl, % shoots infected: Loring	Leaf curl, % shoots infected: Redgold	Scab, % fruit inf. or lesions/fruit: Loring fruit	Loring lesions	Redgold fruit	Redgold lesions	Ru spo Lo
0	No fungicide	---	53 b	18 b	72 b	9.7 a	94 b	24.1 a	1[illegible]
1	Ziram 76DF 1 lb	BS	6 a	6 ab					
	Gem 1.5 oz	PF, 1C			22 a	1.0 a	88 ab	17.6 a	[illegible]
	Rally 40WSP 1.5 oz	SS, 2C							
	Microfine Sulfur 90W 3 lb	3C-4C							
	Luna Sensation 2.5 oz	3 & 1PH							
2	Ziram 76DF 1 lb	BS	5 a	9 ab					
	Gem 1.5 oz	PF, 1C			38 a	3.0 a	78 ab	17.6 a	[illegible]
	Sonata 1 qt	SS, 2C							
	Microfine Sulfur 90W 3 lb	3C-4C							
	Luna Sensation 2.5 oz	3 & 1PH							
3	Ziram 76DF 1 lb	BS	10 a	5 a					
	Gem 1.5 oz	PF-2C			19 a	0.5 a	56 a	6.7 a	[illegible]
	Microfine Sulfur 90W 3 lb	3C-4C							
	Luna Sensation 2.5 oz	3 & 1PH							
4	Ziram 76DF 1 lb	BS	2 a	4 a					
	Rally 40WSP 1.5 oz	PF-2C			32 a	1.5 a	77 ab	24.7 a	[illegible]
	Microfine Sulfur 90W 3 lb	3C-4C							
	Luna Sensation 2.5 oz	3 & 1PH							

Four single tree reps. Column mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Note: Data are aligned with the treatment timing most likely to have affected indicated disease.

Table 38. Treatment effects on postharvest brown rot development on Loring Peach, 2014

	Treatment and rate/100 gal dilute	Timing	% fruit with brown rot after days incubation: Non-inoculated fruit 3 day	4 day	5 day	6 day	7day	Inoculated fruit 3 day	4 day	5 day	6 day	7day
0	No fungicide	---	39 b	60 b	74 b	98 b	100 b	43 b	58 b	75 b	99 b	100 b
1	Ziram 76DF 1 lb	BS										
	Gem 1.5 oz	PF, 1C										
	Rally 40WSP 1.5 oz	SS, 2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	3 a	5 a	9 a	19 a	0 a	0 a	1 a	5 a	21 a
2	Ziram 76DF 1 lb	BS										
	Gem 1.5 oz	PF, 1C										
	Sonata 1 qt	SS, 2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	0 a	1 a	1 a	5 a	0 a	4 a	4 a	6 a	15 a
3	Ziram 76DF 1 lb	BS										
	Gem 1.5 oz	PF-2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	1 a	1 a	3 a	11 a	0 a	3 a	3 a	4 a	16 a
4	Ziram 76DF 1 lb	BS										
	Rally 40WSP 1.5 oz	PF-2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	0 a	0 a	1 a	11 a	0 a	1 a	1 a	5 a	21 a

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single tree replications.
Actual harvest date 13 Aug, 5 days after the last application.

Table 39. Treatment effects on postharvest brown rot development on Redgold Nectarine, 2014

	Treatment and rate/100 gal dilute	Timing	% fruit with brown rot after days incubation: Non-inoculated fruit 3 day	4 day	5 day	6 day	7day	Inoculated fruit 3 day	4 day	5 day	6 day	7day
0	No fungicide	---	33 b	51 b	71 b	100 b	100 b	50 b	70 b	81 b	100 b	100 b
1	Ziram 76DF 1 lb	BS										
	Gem 1.5 oz	PF, 1C										
	Rally 40WSP 1.5 oz	SS, 2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	1 a	3 a	6 a	19 a	0 a	1 a	1 a	16 a	33 a
2	Ziram 76DF 1 lb	BS										
	Gem 1.5 oz	PF, 1C										
	Sonata 1 qt	SS, 2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	0 a	3 a	9 a	11 a	0 a	0 a	0 a	9 a	16 a
3	Ziram 76DF 1 lb	BS										
	Gem 1.5 oz	PF-2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	0 a	1 a	6 a	10 a	0 a	1 a	4 a	15 a	19 a
4	Ziram 76DF 1 lb	BS										
	Rally 40WSP 1.5 oz	PF-2C										
	Microfine Sulfur 90W 3 lb	covers										
	Luna Sensation 2.5 oz	3 & 1PH	0 a	1 a	1 a	5 a	8 a	0 a	0 a	0 a	8 a	16 a

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single tree replications.
Actual harvest date 13 Aug, 5 days after the last application.

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DEVELOPING RESEARCH AND EXTENSION PROGRAMS FOR HARD CIDER PRODUCERS

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The below text was adopted from: Peck, G. & Miles, C. 2015. Assessing the Production Scale and Research and Extension Needs of U.S. Hard Cider Producers through the use of Audience Response Devices at CiderCON, the National Hard Cider Industry Convention. Submitted to the Journal of Extension.

Hard cider is fermented apple juice, typically between 4 and 10% alcohol content by volume. In the U.S., unfermented (and usually unfiltered) apple juice is referred to as cider or sweet cider, but in many other countries, particularly in Europe, the fermented product is called cider and the unfermented product is called apple juice. In this article, we use the term “cider” to refer to the fermented product. A similar product fermented from pear juice is called perry.

In 2012, 5.2 million gallons of cider were produced in the U.S., compared to 0.8 million gallons in 2007, a nearly 7-fold increase (Figure 1; TTB, 2013). Although cider accounts only for 1% of the total alcoholic beverage market in the U.S., the beverage has a more rapid growth trajectory than the microbrew beer industry (Tuttle, 2014). Some market analysts predict that the exponential growth trend for cider will continue well into the foreseeable future (Canadean, 2013). In January 2015, there were nearly 400 cideries operating in 39 states, most of which have been in operation for less than six years (Brown, 2015). This significant increase in cider production has created a need for the development of more research and extension resources from land grant universities.

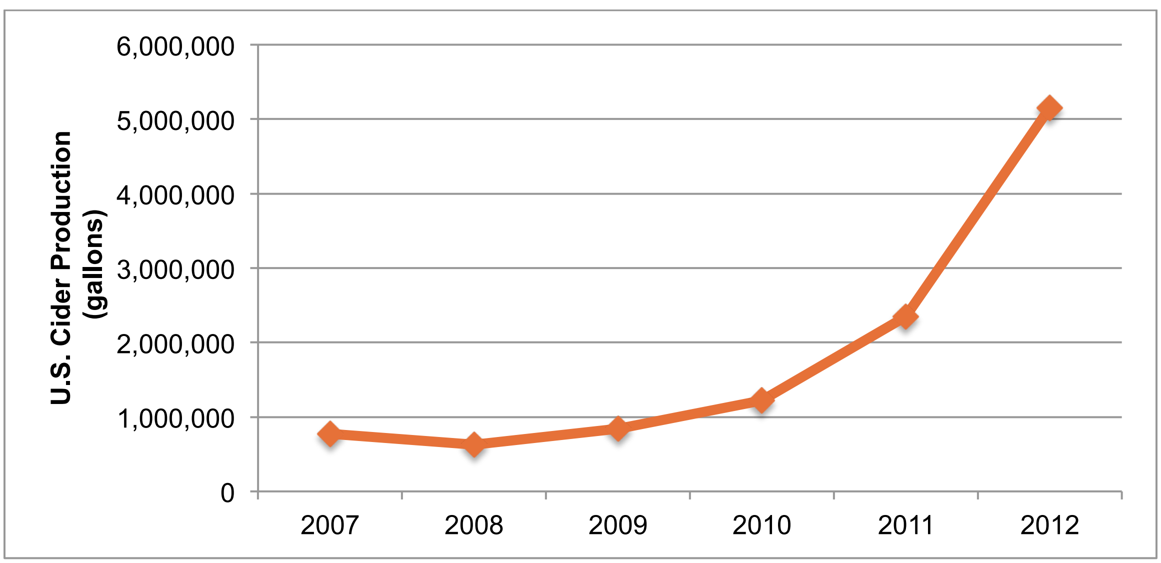

Figure 1. Gallons of cider produced in the United States from 2007 to 2012.

Based upon previously assessed needs of cider producers, researchers and extension specialists have already started to publish research-based resources for the cider industry. These include a production guide (Moulton et al., 2010), complete and partial enterprise budgets for growing cider apples

(Farris et al., 2013; Galinato et al., 2014), cidery feasibility studies (Matson Consulting, 2012), websites (Miles et al., 2008; Peck, 2012), an eXtension article (Peck et al., 2014), and journal articles regarding cider apple mechanical harvest (Miles and King, 2014) and apple polyphenolics (Thompson-Witrick et al., 2014). Additionally, workshops, short courses, and other educational opportunities for hard cider producers are held at several universities, including Washington State University, Cornell, and Virginia Tech.

In addition to the efforts from educators and researchers, the U.S. cider industry has been active in organizing themselves to more effectively share resource information, lobby state and federal legislatures and agencies for more favorable regulations, generate interest from vendors and distributors, and fund scientific research for the cider industry (J. Kohn, personal communication, December 15, 2014). One primary venue for cider information sharing is CiderCON, an annual trade show and educational conference established by commercial cider producers in 2011 (http://ciderconference.com). In 2013, cider producers formed a national cider association (http://ciderassociation.org), and several regional and state associations have also formed, such as in the Pacific Northwest, the Great Lakes, Virginia, the Rocky Mountains, and Vermont.

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FIELD PERFORMANCE OF ASIAN PEAR CULTIVARS IN LONG-TERM TRIALS AT KEEDYSVILLE AND WYE

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Production of European pears (*Pyrus communis* L.) in the Eastern United States is limited by a number of physiological and pathological problems. In an attempt to expand sustainable pear production in Maryland, a series of long-term field trials of Asian pear [*Pyrus pyrifolia* (Burm. F) Nak. {syn. *P. serotina* L.}] were established at two sites in the 1980s and 1990s. To compare precocity, productivity and survival, an additional trial of nine Asian pear cultivars and three European pear cultivars was set at the Wye Research and Education Center in 2010.

Asian pears are precocious and productive. Many cultivars flower and fruit in their second or third leaf. In 2013, survival of Isiiwasi, Shinsui, Kosui and Olympic was good in the most-recent planting at Wye. On the other hand, many Hosui and Ya Li (Asian pear) trees as well as Bartlett and Golden Russett (European pear) trees in that 2010 planting had died, as a result of blossom blight infections caused by *Erwinia amylovora*.

Eighteen pear cultivars in two established plantings were previously evaluated for their field-tolerance to fire blight following a severe hailstorm at Keedysville. The cultivars Shin Li, Daisu Li, Shinsui and Olympic fared as well as Magness, a fire blight-tolerant European pear that served as a benchmark in that evaluation. On the other hand, Hosui, Choju, Kosui, Seigyoku, Ya Li and Tsu Li (or Ts'e Li) were severely damaged by fire blight. Observations to cultivars in this trial, which were made following trauma blight at Keedysville were similar to the cultivar results noted in the 2010 planting at Wye that was infected with blossom blight.

Using fruit from the 2010 trial at Wye, consumer tastings of mid- and late-season fruits were conducted in early-October. Yoinashi, Atago, Shinko and Olympic fruit slices were well-received by consumers. After tasting Asian pears, most people reported that they would be interested in purchasing the fruit. Many participants also asked for the names of local producers.

Based on these long-term results, there appears to be a good potential for locally-produced Asian pear fruit. With the correct cultivar selection for fire blight management, local growers should be able to produce this crop sustainably and market their fruit profitably.

PERFORMANCE OF RABBITEYE, SOUTHERN HIGHBUSH, AND NORTHERN HIGHBUSH BLUEBERRY CULTIVARS IN SOUTHERN MARYLAND

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University of Maryland

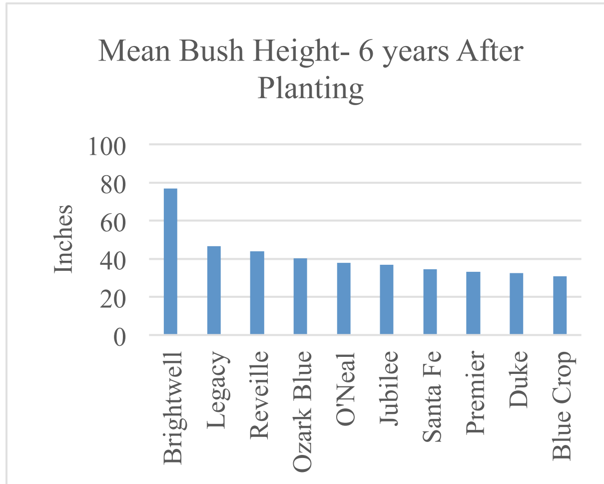
Introduction: Blueberries continue to be in high demand at retail farm stands and farmers markets and offer significant wholesale marketing opportunities for farmers in urbanizing regions in Maryland. Southern Maryland is located in Zone 7a/7b, with varying soils types and often hot, dry summers. In Southern Maryland, the Northern Highbush varieties have typically been grown, but growers have expressed interest in utilizing additional varieties of blueberries that can tolerate higher summer temperatures and less desirable soils with low organic matter. In 2005, a blueberry variety trial was established at the Central Maryland Research and Education Facility in Upper Marlboro, Maryland.

Trial objectives included: evaluating the potential yield of cultivars novel to Southern Maryland; evaluating cold hardiness and spring frost injury potential of Southern Highbush and Rabbiteye cultivars; and evaluating the tolerance of southern cultivars to low organic matter sandy soils and the hot summer climate typical of the Southern Maryland coastal plain region.

Procedures/methods: The trial included ten commercially available blueberry cultivars: two Northern Highbush cultivars: Bluecrop and Duke; six Southern Highbush cultivars: Legacy (Northern and Southern parentage), Jubilee, O'Neal, Ozark Blue, Reveille and Santa Fe; and two Rabbiteye cultivars: Brightwell and Premiere. The study utilized a randomized complete block design consisting of 4 rows with each row considered a replication; there were 4 bushes per plot. The planting site consisted of a well-drained fine sandy loam soil (Collington-Wist complex) on a 3-5 percent slope with 1.4% organic matter. Soil pH was lowered from a starting pH of 6.2 with the addition of elemental sulfur at a rate of 400 pounds per acre applied over the entire field area and tilled in 2 months before planting, with a resulting pH of 4.1 one year after planting, and 4.3 three years after planting. At planting, 8-10 inch high and 3 feet wide raised beds were formed on 12 foot row centers. A 12 inch diameter planting hole, 12-15 inches deep, was created and the soil was amended with the addition of 0.66 cubic feet of peat moss.

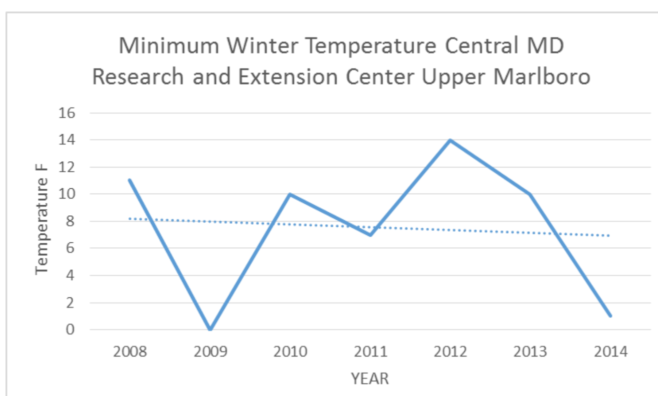
Bare-root, 24-30 inch tall, 2 year old bushes from a commercial nursery were established on a 5 foot in-row spacing. After planting, the rows were covered with 3 inches of a well composted hardwood mulch. Drip irrigation was installed consisting of one tape in each row. In 2008, an additional 3 inches of hardwood leaf compost material (LeafGro) was applied to the beds. In 2011, a soil test indicated the pH had risen to 5.1, and an additional application of 100 pounds per acre of sulfur was made. Plots were fertilized with a total of 40 pounds of nitrogen and 45 pounds of K_2O per acre per year split applied in mid-April, May and June utilizing ammonium sulfate and muriate of potash. The soil fertility level was in the excessive range for P and optimal range for K (P: 146 and K: 134 on the UMD FIV Fertility index scale). Plots were treated with 2 herbicide applications per year for weed control and received 4 fungicide applications for disease control. Bird netting was applied to all plots during the first week of June. In years 2007 through 2010 a solid one piece netting was used to cover the entire plot. In years 2011-2014, each row was covered with an individual net, and the sides pinned to the ground.

Discussion/Results: The blueberry planting established well, with a 100% survival rate during the first year. Differences in bush size and vigor were evident early and continued throughout the life of the trial. The trial received supplemental irrigation only once per week, which was not ideal in summer months. Limited irrigation may have reduced yields of some varieties and demonstrated differences between the cultivars ability to tolerate stress.



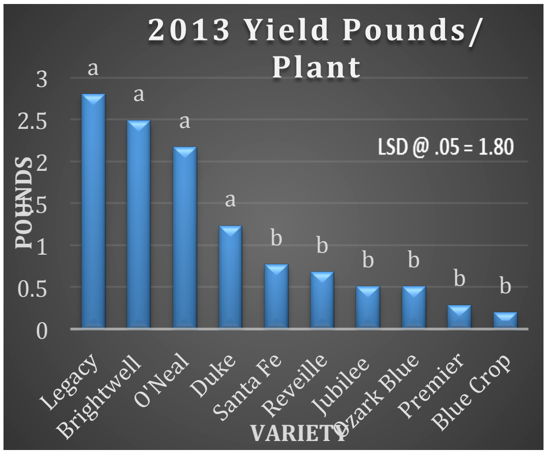
Yield data collected during the 2011, 2012 and 2013 growing season is presented below. Over the life of the trial, Brightwell, Legacy, O'Neal and Ozark Blue consistently emerged as the most vigorous and best yielding varieties. Duke also performed well relative to other highbush varieties. Brightwell significantly out yielded all other varieties in 2011 and 2012, and performed as well as Legacy, Oneal and Duke in 2013. The yield reduction of Brightwell in 2013 was most likely due to biennial fruit set pattern induced by a heavy harvest the previous year. Bird predation was a major challenge each year, with the exception of the latest maturing variety, Brightwell. Although bird netting was applied each year, earlier maturing varieties were more prone to bird predation by robins who learned to crawl under the netting material. The robin population diminished in July when Brightwell harvest peaked. Netting applied in the 2011 season and thereafter was pinned to the ground, minimizing bird losses.

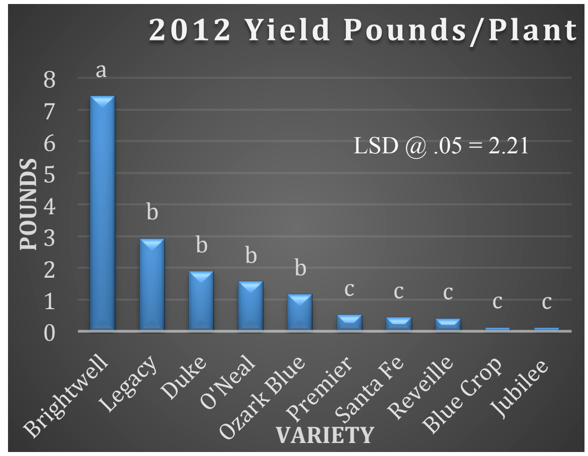
Winter injury was not noted in any varieties, with the minimum winter temperature reaching 0° F during the winter of 2008-09 and 1° F during the winter of 2013-14. Bud break and flowering did not occur substantially earlier on Rabbiteye or Southern Highbush compared to Northern Highbush at this site. There were not any fruit set problems or spring frost injury observed at this site in any production year.

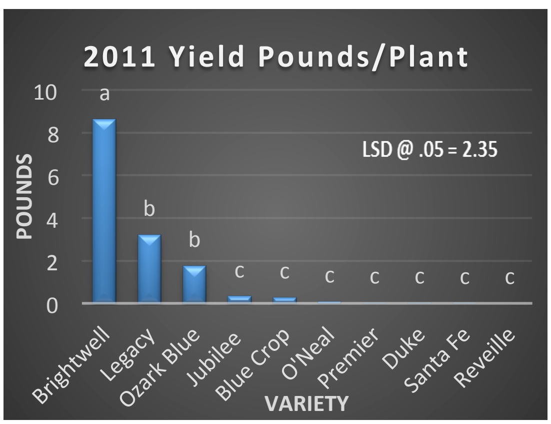


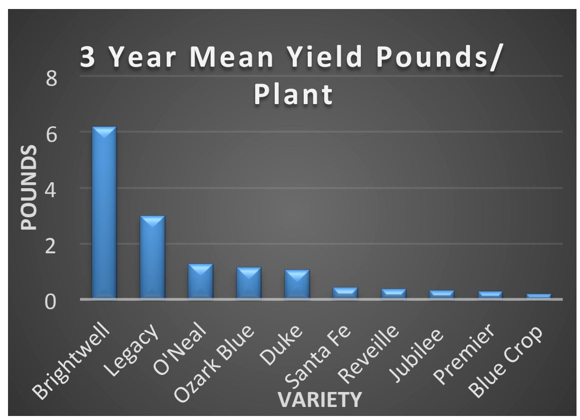
Conclusions: Rabbiteye and Southern Highbush cultivars can be grown successfully in the Southern Maryland region. Bushes have survived low winter temperatures as low as 0 degree F. Cultivar selection still remains critical, as not all Rabbiteye or Southern Highbush performed well, and Northern Highbush did not all perform poorly. The Rabbiteye cultivar Brightwell exhibited the highest yield and most vigor of any cultivar in this trial.

The Southern Maryland Fruit Team wishes to acknowledge the financial support of the Southern Maryland Agriculture Development Commission and the University of Maryland Ag Profit Impact team.









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YIELD RESULTS FROM THE FIRST TWO FRUITNG YEARS OF BLUEBERRY VAREITY TRIALS ETABLISHED IN SOUTHERN DELAWARE

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In 2011, blueberry research variety trials were established at University of Delaware's research farm in Georgetown, Delaware and at Bennett Orchards in Frankford, Delaware as a part of a project funded by a Specialty Crop Block Grant administered through the Delaware Department of Agriculture and awarded to Hail Bennett. A second grant was awarded to the University of Delaware Vegetable and Fruit Program to continue data collection from the variety trials which were established as a part of the original project.

Sixteen blueberry varieties were planted at the Georgetown location in 2011 and ten varieties were planted at the Frankford location. Yield data were collected from both trials in 2013 and 2014. The Georgetown trial is arranged in a randomized complete block design with three plants per plot and four replications. Yields data was collected for each plant individually. This trial includes Northern Highbush varieties, Southern Highbush varieties and 'Legacy', an intermediate Northern/Southern Highbush variety. The trial at the Frankford location does not include replicated blocks. Varieties are planted in a single plot of ten plants and yield data for the entire block was combined. The Frankford trial includes Northern Highbush varieties and 'Legacy', an intermediate Northern/Southern Highbush variety.

Chart 1: Yield of Blueberry Varieties in the Georgetown Variety Trial in 2013 and 2014

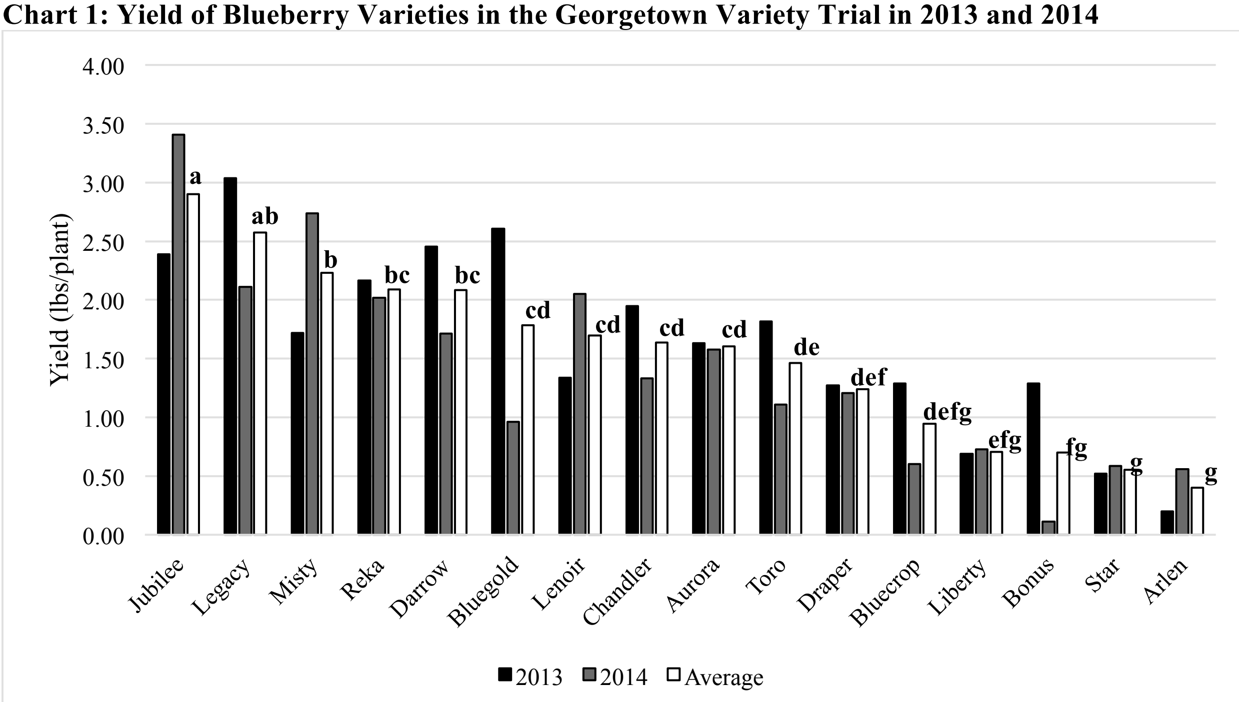

Chart 2: Yield of Blueberry Varieties in the Frankfort Variety Trial in 2013 and 2014

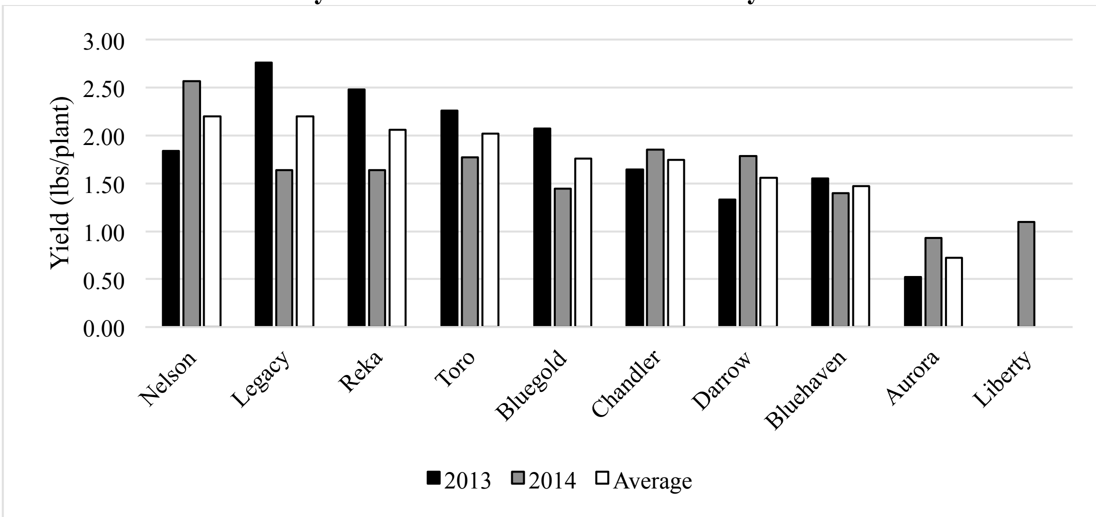

Table 1: Average 1st and 2nd Fruiting Year Yield and Freeze Damage Observations from the Blueberry Variety Trial at Georgetown, DE

Variety[1]	Yield lbs/plant[2]	2012 Freeze Damage	2013 Freeze Damage	2014 Freeze Damage
Jubilee	2.90 a	none	moderate	none
Legacy	2.57 ab	none	minor	none
Misty	2.23 b	moderate	moderate	moderate
Reka	2.09 bc	minor	none	none
Darrow	2.08 bc	none	none	none
Bluegold	1.78 cd	none	none	none
Lenior	1.69 cd	none	none	none
Chandler	1.64 cd	none	none	none
Aurora	1.60 cd	none	none	none
Toro	1.46 de	none	none	none
Draper	1.24 def	none	none	none
Bluecrop	0.94 defg	none	none	none
Liberty	0.71 efg	none	none	none
Bonus	0.70 fg	none	none	none
Star	0.55 g	moderate	moderate	moderate
Arlen	0.40 g	none	moderate	moderate

[1]Southern Highbush varieties are highlighted, Legacy is a Northern/Southern intermediate.
[2]Mean separation by Fisher's Protected $LSD_{0.05}$

In the Georgetown trial, the Northern Highbush varieties, Reka, Darrow, Bluegold, Chandler and Aurora have produced good yields. The Southern Highbush varieties Jubilee, Misty and Lenoir have also yielded well, although Misty has sustained a moderate amount of freezing damage to buds in all years tested. Legacy, the Northern/Southern Intermediate variety has also produced a good yield in the trial. Southern Highbush varieties Star and Arlen have grown vigorously in the trial but have suffered yield loss due to freezing of flower buds in both 2013 and 2014 and are not recommended for planting on Delmarva.

Legacy and Reka have been top yielding varieties in the trial at Frankford as well as at Georgetown. Nelson has as also produced good yields in the Frankford trial; this variety is not in the trial at Georgetown.

EVALUATING THE POLLEN TUBE GROWTH CHARACTERISTICS OF DIFFERENT CRABAPPLE CULTIVARS

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Apple (*Malus x domestica* Borkh.) growers typically reduce the number of fruit on apple trees in order to increase fruit size and manage biennial bearing cycles. In the Western United States this is often accomplished through the use of caustic chemicals during bloom which prevent flowers from becoming fertilized by damaging flower parts. When the number of set fruit is reduced early in the growing season, there is a greater potential for increasing return bloom the following year. Bloom thinning chemicals are not often used in the Eastern United States because of unpredictable weather, greater phytotoxic effects due to the higher humidity, and a lack of effective products registered for this use. The ideal time to apply thinning chemicals is somewhat subjective and more research is needed to determine the best application time. Environmental factors and cultivar differences impact the pollination and fertilization process of apples which then contributes to the effectiveness of blossom thinning chemicals. Knowing the pollen tube growth rate can help estimate when to apply chemicals. This growth rate has been used to develop a model that can predict the ideal application time (Yoder et al., 2012). The pollen tube growth model uses the growth rate of the crabapple 'Snowdrift' to predict when the king blooms have been fertilized. Genetic differences among crabapples and cultivars may affect the pollen tube growth rate. Currently, we are collecting data on the pollen tube growth rate of five different crabapple cultivars on each of three maternal apple cultivar parents at four temperatures.

Materials and Methods

Pollen was collected from Thunderchild, Evereste, Indian Summer, Selkirk, and Snowdrift trees located at the Alson H. Smith, Jr. AREC in Winchester, VA. Pink Lady, Fuji and Golden Delicious trees grown on dwarfing rootstocks in root bags were used as the maternal cultivars in this experiment. All trees were grown at the Alson H. Smith Jr. AREC in Winchester, Virginia. After chilling hours had been met, the trees were placed into five-gallon buckets and brought into a greenhouse. Blossoms were selected for the experiment during the late pink flower stage (when petals still covered the sexual organs). Anthers and side blooms were removed to prevent self-pollination. Flowers were tagged with pollen source identification, and then using a clean paintbrush pollen was applied directly to the stigma. Unpollinated blossoms were also left on the trees to serve as a control. Within a few minutes after pollination, the trees were placed into a controlled temperature growth chamber for 24 hours. The experiment was repeated at four different air temperatures, 12, 18, 24 and 30°C. After 24 hours in the growth chamber, blossoms were removed from the tree in the order that they were pollinated and placed into glass vials filled with a 5% sodium sulfite solution. Prior to histological examination, the vials containing the blossoms were placed in boiling water for 20 minutes to soften the tissues.

The pistillate portions were then excised from each blossom, rinsed in distilled water, and then the styles were carefully detached from the ovary with tweezers and a scalpel. The styles were stained with a water-soluble fluorescent solution containing 0.01% Aniline Blue dye in 0.067 M K_2HPO_4 for pollen tube visualization then pressed between two microscope slides (Yoder et al., 2012). Slides were viewed with a Nikon Eclipse Ci microscope (Tokyo, Japan) and a Nikon Intensilight C-HGFI (Tokyo, Japan). Data collected was similar to Yoder et al. (2009 & 2012), including pollen germination/tube growth on the stigmatic surface (0 to 100% of visible stigmatic surface covered with pollen), number of pollen tubes penetrating through the base of the stigma, length of the longest pollen tube, style length, and the number of pollen tubes that grew to the base of the style. The General Linear Model Procedure of Statistical Analysis Systems Software for PC (SAS Inst., Cary, NC) was used to perform an analysis of variance on the collected data.

Results and Discussion

On successfully pollinated blossoms from all maternal cultivars (Fuji, Golden Delicious, and Pink Lady), averaged over the four temperatures (12, 18, 24 and 30°C), pollen from cultivars Selkirk and Thunderchild grew the furthest distance relative to the length of the style, followed by Indian Summer, Evereste and Snowdrift (Figure 1). Although some pollen tubes started to grow through the styles of unpollinated control blossoms, the average pollen tube growth length was significantly less than the growth length of the five evaluated pollen sources (Figure 1). Pollen tubes growing through the styles of control blossoms grew on average 7.96% of the style length in contrast to the evaluated pollen sources which on average grew between 29.6 and 57.2% of the style length. Pollen tubes growing on control blossoms could be the result of self-pollination during anther removal, or from pollen falling from one blossom to another. On successfully pollinated Fuji blossoms, Selkirk, Thunderchild, and Indian Summer pollen tubes grew the furthest distance relative to the style length (Figure 2). Snowdrift and Evereste pollen tubes did not grow longer than pollen tubes found on unpollinated control Fuji blossoms (Figure 2). On successfully pollinated Golden Delicious blossoms, Selkirk, Thunderchild and Indian Summer pollen tubes grew the furthest distance relative to the style length (Figure 3). Likewise, on successfully pollinated Pink Lady blossoms Selkirk, Thunderchild, and Indian Summer pollen tubes grew the furthest distance relative to the style length (Figure 4).

Although significant differences did not exist between Selkirk, Thunderchild, and Indian Summer when evaluating blossoms from only one maternal cultivar, there were some potential trends that should be further evaluated. Selkirk grew the furthest independent of maternal cultivar followed by Thunderchild and Indian Summer (Figures 2, 3, and 4). A second year of evaluation needs to be completed to confirm differences in the pollen tube growth rates of these five crabapples. If differences between these pollen sources do exist, considering the pollen tube growth rate of the pollen source in an orchard could be beneficial when applying blossom thinning chemicals. Also, knowing the pollen tube growth rate of specific cultivars could help growers select more efficient pollinizers for their orchards.

Figure 1. Average pollen tube length relative to total style length on apple flowers from Fuji, Golden Delicious, and Pink Lady trees (averaged for all three cultivars and all four temperatures).

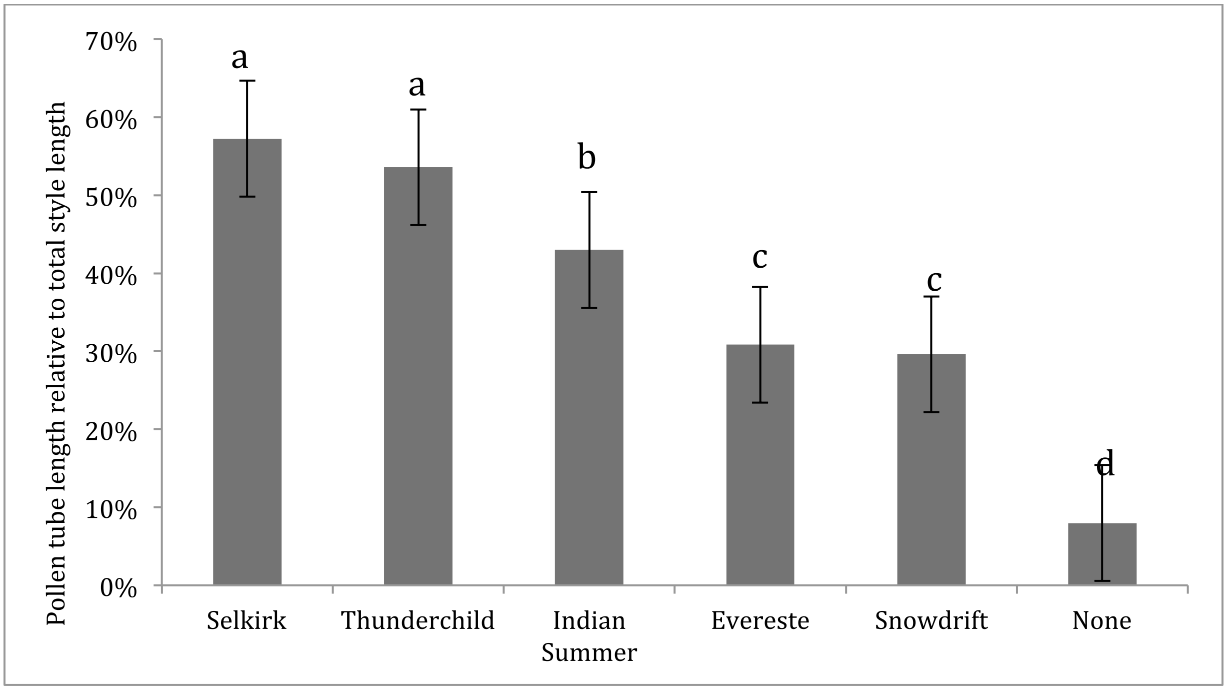


Figure 2. Average pollen tube length compared to total style length on apple flowers from Fuji trees (Averaged for all four temperatures).

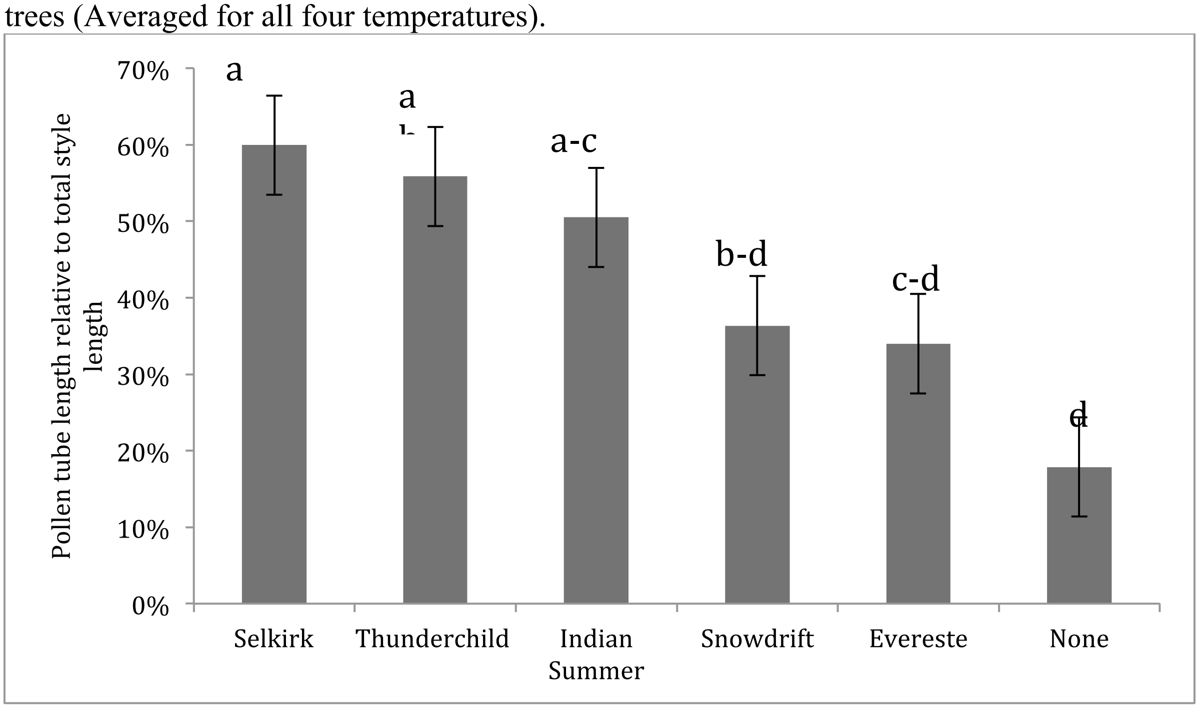


Figure 3. Average pollen tube length compared to total style length on apple flowers from Golden Delicious trees (Averaged for all four temperatures).

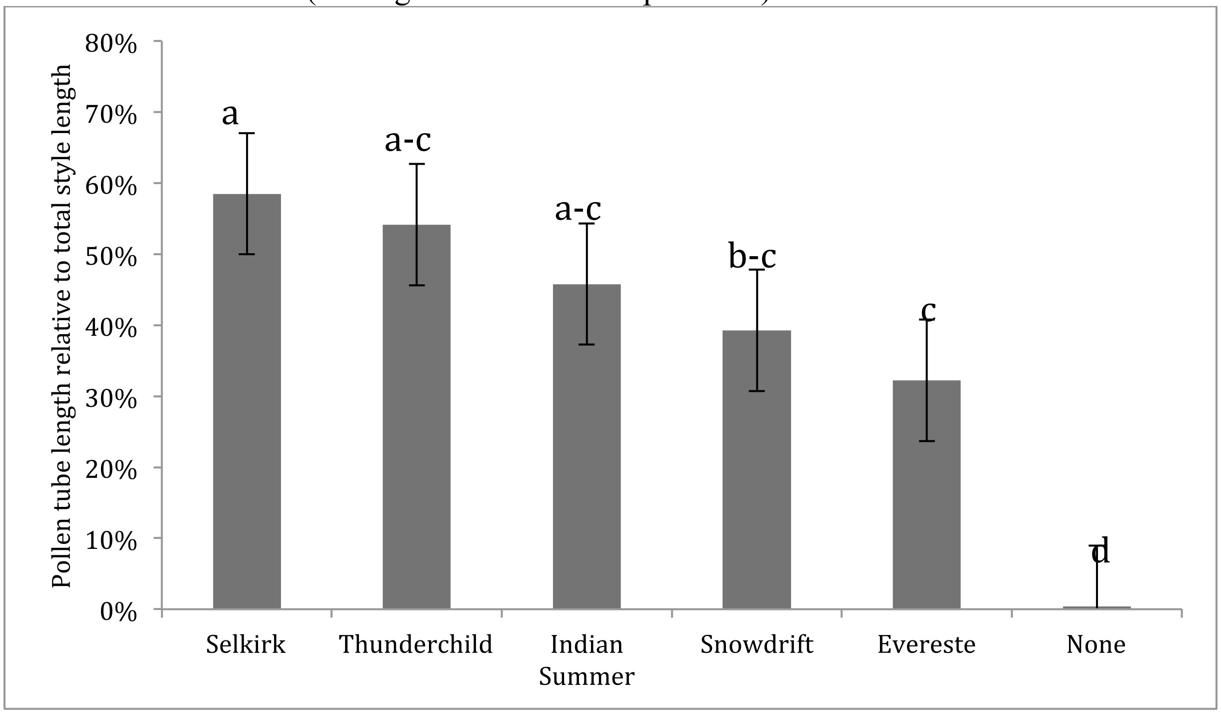
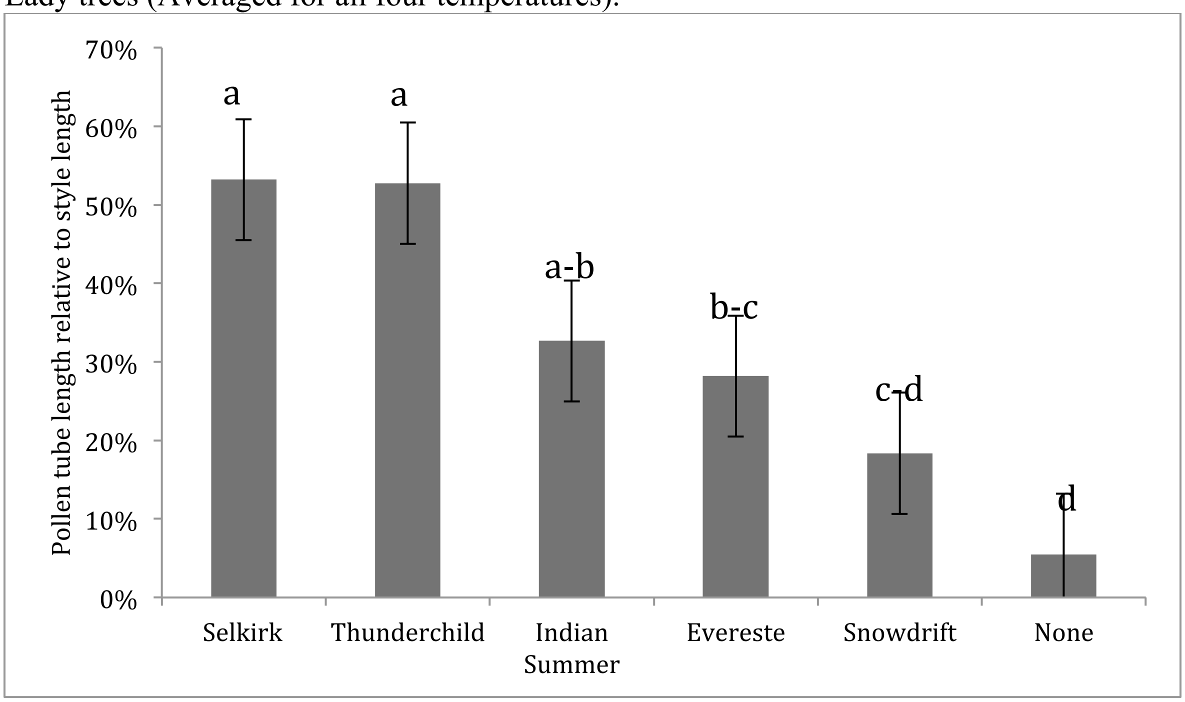


Figure 4. Average pollen tube length compared to total style length of apple flowers from Pink Lady trees (Averaged for all four temperatures).



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PRODUCTIVITY OF ‘TRIPLE CROWN’ BLACKBERRY ON THE ROTATING CROSS-ARM TRELLIS SYSTEM

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In the last 4 years, more than 250 acres of new blackberry plantings on the rotating cross-arm (RCA) trellis and cane training system (Fig. 1) have been established from Massachusetts in the east to Iowa and Oklahoma in the west. The eastern thornless cultivars developed by the USDA-ARS and University of Arkansas as well as the trailing blackberries from Oregon can now be grown in areas that experience low winter temperatures. Triple Crown’ and other semi-erect and erect floricane-fruiting (both thorny and thornless) blackberries (*Rubus* subgenus *Rubus*) are productive and vigorous. In 1992, we began working on trellis and cane training systems for eastern thornless blackberries that allowed the canopy to be rotated in order to facilitate harvesting of higher quality fruit by means of a mechanical harvesting technology. That research led to the development of the RCA trellis and cane training system (Takeda and Peterson, 1996; 1999). We found that the primocanes of ‘Triple Crown’ blackberry were flexible enough to train horizontally in line with the trellis row (Fig. 2). The secondary laterals that formed lent themselves well to forming a narrow, curtain-like canopy that could be rotated from more or less vertical in the summer to horizontal in winter.

By 2001, we realized that lowering the pivot point would have two advantages: having the canopy close to the ground in winter would allow for a rowcover to be applied over the plants for protection from extremely low temperatures (e.g. < 23 $°C$) (Takeda and Phillips, 2011) and the lowering of the fruiting canopy would increase hand-harvest efficiency.

Based on our studies, ‘Triple Crown’ plants have a potential yield upwards of 34 lb/plant on RCA trellis system (data not shown.). Since the introduction of this training system 20 years ago, growers have asked whether the system could be tweaked even more for greater productivity. The yield of blackberries is dependent on the number of nodes (buds) left on the floricanes after winter pruning. On other trellis systems, reducing the floricane number and shortening the lateral canes by summer or winter pruning has been shown to decrease yields (Takeda, 2002). When the lateral canes on 3 primocanes of mature ‘Black Satin’ blackberry plants on a wide “V” trellis were pruned to 3 to 12 12-node lateral canes (100 to about 500 buds), the yield increased linearly from 22 lb/plant for plants with 3 lateral canes/floricane to 45 lb/plant for floricanes with 12 lateral canes. Pruning level did not affect individual fruit weight, but fruit number/cluster and fruit weight/cluster decreased with increasing numbers of lateral canes on the floricane. Many of the lateral canes of ‘Triple Crown’, whether trained on the RCA or conventional “T” trellis, can grow more than 10 ft. with >50 nodes. The recommendation to growers using the RCA trellis and cane training system has been to prune these long lateral canes at the top wire on the long cross-arm. Growers wanted to know if retaining the growth beyond the last wire would increase yield potential.

In Summer 2011, eight ‘Triple Crown’ plants arranged in four blocks were selected to examine the comparative productivity of plants that had lateral canes pruned at the top wire on the RCA trellis (control) versus plants that left the long lateral canes un-pruned. Our idea was to secure these long lateral canes to trellis wires, keeping close to the plane created by the cross-arms, so that all flower inflorescences would develop on one side of the lateral cane canopy and in a similar fashion as inflorescences on pruned plants. In 2012, each plant was hand harvested four times on Jul 12, 16, 19, and 26 to determine the yield per plant. The average yield per plant was nearly identical (6.8 kg/plant). These findings encouraged us to start looking at possible developmental differences within sections of the canopy.

Following the final harvest in 2012, five laterals were randomly removed from each pruning level to determine total nodes per cane, percentage of nodes to become reproductive, and flower numbers per cluster. The node of each cluster was recorded to be able to compare reproductive capacity between different areas of the lateral. Similarly, in 2013, one whole plant of each pruning level was looked at in order to record the total node number and determine the percentage of nodes to become reproductive for each lateral produced. Additionally, the node location and corresponding number of berries per cluster from every lateral was recorded to compare potential productivity between different areas of the lateral. In both years, we found that the percent of nodes to produce inflorescences was reduced on plants that had laterals left un-pruned (Table 1). We found that the number of berries per cluster was also reduced.

Moving forward, we are taking an even more detailed look at how location within the canopy may influence the likelihood of any given node to produce an inflorescence and the overall resulting fruiting capacity of the plants.

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Table 1. The influence of pruning long canes of 'Triple Crown' blackberry on nodes per cane, the percent of nodes to become reproductive, and berry number per cluster in 2012 and 2013.

	Nodes (no.)		Reproductive (%)		Berries/cluster	
	2012	2013	2012	2013	2012	2013
Pruned	29 b	38 b	68 a	45 a	8.1	9.4 a
Unpruned	48 a	56 a	32 b	35 b	7.1	7.6 b
P > F						
Treatment	0.0030	0.0019	0.0104	0.0039	0.1266	<.0001

Fig. 1. A drawing of the commercial version of the rotating cross-arm (RCA) trellis.

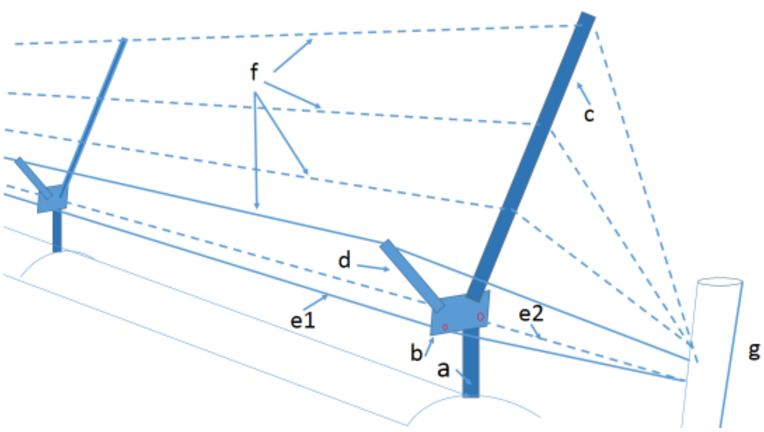

Fig. 2. A 'Triple Crown' blackberry plant trained using the RCA trellis and cane training system. Note the abundance of vertically-oriented lateral canes that developed on the bent primocanes.

High Density Orchard Systems: Field-testing advanced selections from the Geneva apple rootstock breeding program

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In high density orchard systems, dwarfing rootstocks are responsible for providing size control, reduced vigor, and disease resistance. They may also affect other characteristics of the trees and fruit such as yield and quality. After selection in breeding programs, rootstocks must be field tested with various scion varieties, in multiple geographic regions to determine their potential for commercial use.

In this research four rootstocks from the Geneva rootstock breeding program were tested for their suitability for the hot, humid conditions of the Mid-Atlantic. G.41, G.202, and G.935, propagated in traditional stool bed, were grafted with Cripps Pink and Brookfield Gala. G.202 was also propagated in tissue culture (TC) for a total of four rootstock treatments (G.41, G.202, G202TC, and G.935). These rootstock are especially suitable for this area because of their high tolerance to fire blight and wooly apple aphid. Trees were planted at the Western Maryland Research and Education Center in Keedysville, MD in 2010. The planting consisted of 7-tree panels, replicated 4 times in a Latin square design. Trees were spaced 6x12' and trellised in a tall spindle fashion with 4 wires. From 2011 to 2014, data was taken on tree size, fruit quality, productivity, and tree survival.

Fruit size and quality was not significantly different for any of the rootstocks evaluated for either Brookfield Gala or Cripps Pink apples. Quality indices included mean fruit weights, percent red color, color across L*a*b* 3-dimensional spectrum, soluble solids (°Brix), firmness, starch content, height and diameter. TC trees were consistently larger in terms of height, diameter, and trunk cross sectional area for both scions. This may be due to propagation method (stoolbed vs. TC), or other factors, including nursery management. Yield did not appear to be affected by rootstock for either Brookfield Gala or Cripps Pink. The most notable differences observed between rootstocks was tree survival. Multiple storm events including high wind and/or hail during July 2011, August 2013, and July 2014 led to breakage of trees at the graft union. An insignificant number of Brookfield Gala trees were lost. In the Cripps Pink plots, G.202 and G.202TC experienced near 100% survival. A total of 13 G.41 and 9 G.935 trees (of 28 trees per rootstock) were lost (Figure 1). Weakness of the graft union of these rootstock has also been reported by nurserymen in the Mid-Atlantic, with growers reporting up to 20% tree loss. Other research has shown that even rootstocks with very weak graft unions become stronger over time, presumably due to increased girth and schlerenchyma tissue. More extensive research will be necessary to determine the graft union strength of these rootstock-scion combinations and the anatomical cause of decreased strength, as well as the differences between TC and stoolbed propagated rootstocks. Recommendations for use of these rootstocks in commercial plantings should take into consideration grafted cultivars and tradeoffs between disease and insect resistance, union strength, trellising requirements, among other factors.

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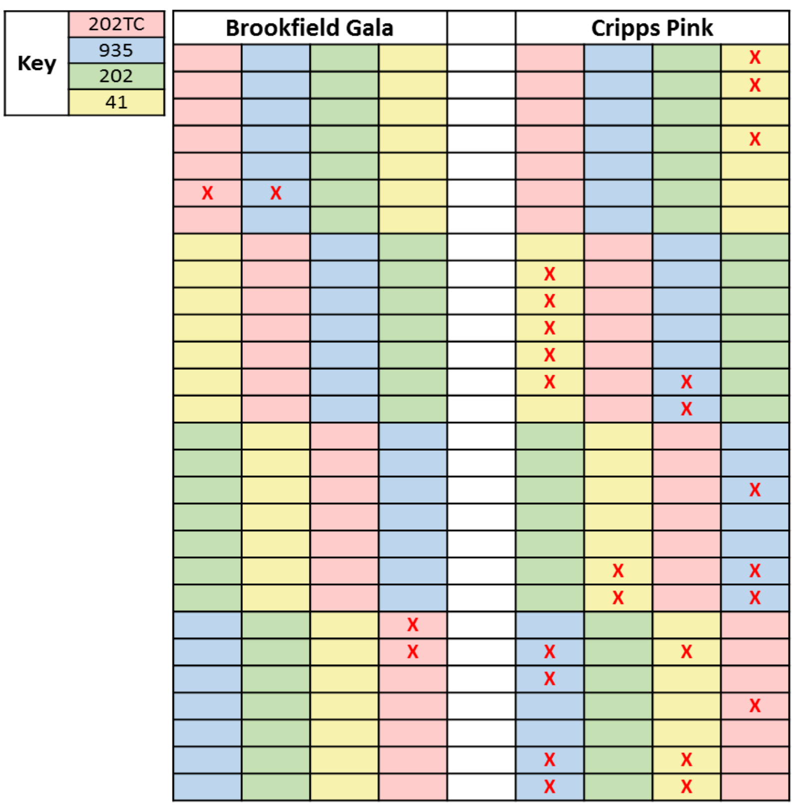
Figure 1. Tree losses in field plots at the WMREC. Each rectangle represents one tree, the four colors represent four rootstocks G.202, G.935, G.41, and G.202TC (Tissue Culture). Red 'X's' represent trees lost to breakage at the graft union.



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CREATING MODELS OF DORMANT TREES USING COMPUTER VISION

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The automation computation of fruit tree shape has many applications. In this presentation, we discuss two of those applications, pruning and structural phenotyping. In the pruning application, there has been a rise in simple pruning protocols on central leader systems that are concerned only with renewal pruning; these pruning protocols are straightforward enough to performed by a robot assuming that the tree shape and its attributes can be determined automatically. In structural phenotyping, an in-field system determines the tree shape and attributes. The tree information is used to track responses of trees with and without treatments more accurately and in a more timely fashion that using human labor for measurement.

This report presents progress made on the problem of determining tree shape without human input by using color cameras as sensors. The ability of our algorithms to reconstruct tree shape are demonstrated on disparate classes of trees in the laboratory, including transgenic plum, peach, and apple trees with different growth habits. This preliminary result will be used for future work on the two applications mentioned above.