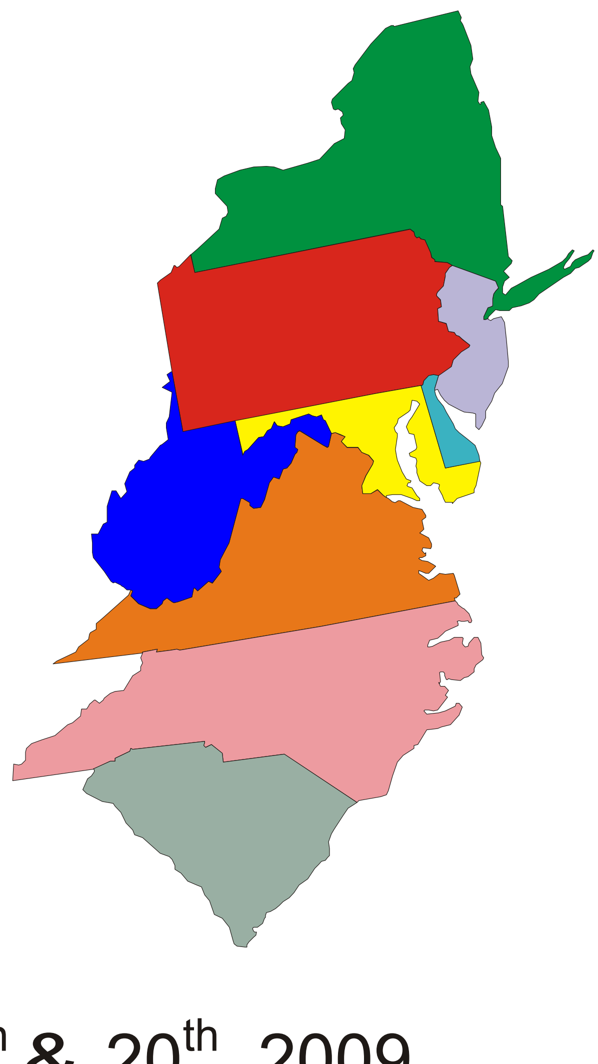
PROCEEDINGS

85th

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE



November 19th & 20th, 2009

WINCHESTER, VIRGINIA

(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the

Cumberland-Shenandoah

Fruit Workers Conference

85th Annual meeting

November 19th and 20th, 2009

Hampton Inn and Conference Center

Winchester, VA

J. Chris Bergh, Keith S. Yoder, Rongcai Yuan

Alson H. Smith Jr. Agricultural Research and Extension Center

Virginia Tech

Winchester, VA

Table of Contents

Horticulture

Plant Pathology

List of Participants

Name	Affiliation
Agnello, Arthur	Cornell
Baugher, Tara	Penn State Coop Extn
Bergh, Chris	VA Tech
Biddinger, David	Penn State
Biggs, Alan	WVU
Breth, Deborah	Cornell Coop Extn
Brown, Mark	AFRS-ARS-USDA
Brunner, Jay	WSU
Burchard, Eric	AFRS-ARS-USDA
Butler, Bryan	UMD Coop Extn
Carbaugh, David	VA Tech
Carroll, Juliet	Cornell
Clements, Jon	UMASS Extn
Combs, Dave	Cornell
Cooley, Dan	UMASS
Cox, Kerik	Cornell
Crim, Larry	AFRS-ARS-USDA
David, Paul	Gowan
Demarsay, Anne	The Fruit Docter
Dimock, Michael	Certis USA
Dripps, James	Dow
Engelman, Jean	VA Tech
Frank, Daniel	VA Tech
Ganske, Donald	Dupont Crop Protection
Halbrendt, Noemi	Penn State
Hancock, Dustin	AFRS-ARS-USDA
Hancock, Torri	AFRS-ARS-USDA
Hanning, Greg	Dupont Crop Protection
Hed, Bryan	Penn State
Heinemann, Paul	Penn State
Hily, Jean-Michel	Cornell
Hitchner, Erin	Sygenta Crop Protection
Hogmire, Henry	WVU
Hott, Chris	AFRS-ARS-USDA
Hull, Larry	Penn State
Jordan, Timothy	VA Tech
Kliethermes, Brian	Carnegie Mellon
Krawczyk, Greg	Penn State
Lalancette, Norman	Rutgers
Leahy, Kathleen	Polaris Orchard Management
Lehman, Brian	Penn State
Leskey, Tracy	AFRS-ARS-USDA
Magalhaes, Leonardo	NCSU

Mahoney, Matt	Bayer
Marine, Sasha	VA Tech
Maxey, Laura	VA Tech
Mays, Ryan	VA Tech
McArtney, Steve	NCSU
McFarland, Kathleen	Rutgers
Miller, Stephen	AFRS-ARS-USDA
Ngugi, Henry	Penn State
Nita, Mizuho	VA Tech
Olson, Brian	Dow
Paddock, Randy	Paddock Ag Services
Parker, Mike	NCSU
Pfeiffer, Doug	VA Tech
Polk, Dean	Rutgers
Reid, Margaret	Penn State
Rodrigues-Saona, Cesar	Rutgers
Rucker, Ann	Rutgers
Rugh, Tony	AFRS-ARS-USDA
Schmitt, David	Rutgers Coop Extn
Shannon, Mark	Suterra LLC
Shearer, Peter	OSU
Short, Brent	AFRS-ARS-USDA
Stamm, Gregory	CBC America
Sutton, Turner	NCSU
Thomas, Gar	BASF
Tollerup, Kris	Rutgers
Travis, James	Penn State
Tworkoski, Tom	AFRS-ARS-USDA
Uz Zaman, Faruque	Rutgers
Villani, Sara	Cornell
Walgenbach, Jim	NCSU
Webb, Kevin	AFRS-ARS-USDA
Wise, John	Mich State
Wright, Starker	AFRS-ARS-USDA
Xia, Rui	VA Tech
Yoder, Keith	VA Tech
Yuan, Rongcai	VA Tech
Zhu, Hong	VA Tech

85th Annual Cumberland-Shenandoah Fruit Workers Conference

November 19–20, 2009

Hampton Inn and Conference Center, Winchester, VA

CONFERENCE AGENDA

Thursday, November 19th

8:00 - 9:00 a.m.	Registration – Pre-registration Room
9:00 - 9:05 a.m.	Call to order — 85th Cumberland-Shenandoah Fruit Workers Conference Washington Room
9:05 - 10:00 a.m.	Call of the States
10:00 - 10:45 a.m.	General Session – Trends and future directions of Washington tree fruit production. Jay F. Brunner. Washington State University, Wenatchee, WA
10:45 - 11:00 a.m.	Break
11:00 - 11:30 a.m.	Past, present, and future of pest management in Mid-Atlantic orchards. Henry Hogmire. West Virginia University, Kearneysville, WV
11:00 - 11:45 a.m.	Cultural management in Mid-Atlantic fruit production: Past, present, and future. Stephen S. Miller. AFRS, USDA-ARS, Kearneysville, WV
Noon - 1:00 p.m.	Lunch — Washington Room
1:00 - 5:00 p.m.	Concurrent Sessions Entomology – Washington Room Horticulture – Jefferson Room Plant Pathology – Madison Room
5:15 - 7:15 p.m.	Mixer (Sponsored by AgraQuest, BASF, Bayer CropScience, CBC America, Certis, Cheminova, Dow AgroSciences, DuPont, Nichino America, Suterra, Syngenta, United Phosphorus, and Valent) Pre-registration Room

Friday, November 20th

8:00 - 9:00 am	Business Meeting – Washington Room
9:00 – Noon	Concurrent Sessions (Entomology and Plant Pathology)

CONCURRENT SESSIONS AGENDA

Entomology Session: Washington Room

Thursday Afternoon, November 19, 2009

1:00 – 1:15	**Development and validation of a "Real-Time" apple IPM website for NY.** A. Agnello, H. Reissig, J. Carroll and K. Cox. Cornell University, Geneva, NY
1:15 – 1:30	**Testing web-based apple IPM strategies.** H. Reissig and A. Agnello. Cornell University, Geneva, NY
1:30 – 1:45	**An automated sex pheromone trap for monitoring adult CM and OFM and the influence of trap color on moth and non-target captures.** B.L. Lehman, L.A. Hull, J. Park, G. Holguin and V.P. Jones. Penn State University, Biglerville, PA
1:45 – 2:00	**Evaluating insect behavior in the field using home security recording systems.** J.F. Brunner, Washington State University, Wenatchee, WA
2:00 – 2:15	**Trapping the brown marmorated stink bug.** M. Brown, B. Short, T. Leskey, S. Wright, J. Aldrich and S Khrimian. AFRS, USDA-ARS, Kearneysville, WV

2:15 – 2:30	**Maximizing efficiency of trap performance for control of apple maggot fly.** S. Wright, T. Leskey and H. Reissig. AFRS, USDA-ARS, Kearneysville, WV
2:30 – 2:45	***Heringia* wants to be a Kiwi.** J.C. Bergh. Virginia Tech, Winchester, VA
2:45 – 3:00	**Efficacy of mating disruption in North Carolina apples.** J. Walgenbach and V. Barlow. North Carolina State University, Mills River, NC
3:00 – 3:15	**BREAK**
3:15 – 3:30	**Measuring success in two year large scale mating disruption for CM in NY. D.I. Breth.** Cornell University, Albion, NY
3:30 – 3:45	**Successes and challenges with whole farm mating disruption.** M. Reid and G. Krawczyk. Penn State University, Biglerville, PA
3:45 – 4:00	**Splat OrB: A new pheromone formulation for oriental beetle mating disruption in blueberries.** C. Rodriquez-Saona and D. Polk. Rutgers University, Chatsworth, NJ
4:15 – 4:30	**Mating disruption for grape root borer.** D.G. Pfeiffer, C.A. Laub, T.A. Jordan and A.K. Wallingford. Virginia Tech, Blacksburg, VA
4:30 – 4:45	**Landscape ecology of wild grape, *Vitis* species, surrounding Virginia vineyards.** T. A. Jordan and D. G. Pfeiffer, Virginia Tech, Blacksburg, VA
4:45 – 5:00	**Monitoring insects pests in highbush blueberries using spatially-based methods.** F. U. Zaman, C. Rodriquez-Saona, D. Polk and P. Oudemans. Rutgers University, Chatsworth, NJ
5:00 – 5:15	**Effects of geranium exposure on Japanese beetle feeding on Prelude raspberries, with a short video message on stink bug feeding behavior.** L. Maxey, C. Laub and D. Pfeiffer. Virginia Tech, Blacksburg, VA

Horticulture Session: Jefferson Room

Thursday Afternoon, November 19, 2009

1:00 – 1:15	**Response of apple rootstocks in the 2003 NC140 planting at Blairsville, GA to freeze-thaw cycles during winter 2008-2009.** S. McArtney and J.D. Obermiller. North Carolina State University, Mills River, NC
1:15 – 1:30	**Effect of timing and concentration of AVG and NAA alone or in combination on preharvest fruit drop and extension of harvest season in 'Delicious' apples.** R. Yuan. Virginia Tech, Winchester, VA
1:30 – 1:45	**Performance of 'Golden Delicious' on 18 rootstocks in PA.** R.M. Crassweller and D.E. Smith. Pennsylvania State University, University Park, PA
1:45 – 2:00	**Apple replant trials in North Carolina.** M Parker. North Carolina State University, Raleigh, NC.
2:00 – 2:15	**Return bloom on 'Stayman', 2009 and three year summary.** S. Miller. AFRS, USDA-ARS, Kearneysville, WV
2:15 – 2:30	**Weed suppression by grasses for orchard floor management.** T. Tworkoski and D.M. Glenn. AFRS, USDA-ARS, Kearneysville, WV
2:30 – 3:00	**Performance of energy absorbing materials for passive bulk bin filling.** B. Kliethermes, W. Messner, T. Baugher, D.M. Glenn, A. Leslie, R. Rohrbaugh, J. Koan and P. Heinemann. Carnegie Mellon University, Pittsburgh, PA
3:00 – 3:15	**BREAK**
3:15 – 3:30	**High tunnel production of raspberry – Virginia State University's Experience.** C. Mullins and R. Rafie. Virginia State University, Petersburg, VA
3:30 – 3:45	**Developing management strategies to optimize the uses of a mobile high tunnel system.** B. Butler. University of Maryland, Westminster, MD
3:45 – 4:00	**Abscisic acid, ethylene, and polygalacturonase are involved in young fruit abscission induced by NAA and shading in 'Golden Delicious' apples.** H. Zhu and R. Yuan. Virginia Tech, Winchester, VA

4:00 – 4:15	**Benefits of 1-MCP (SmartFresh) for direct marketing of apples.** S. McArtney and J.D. Obermiller. North Carolina State University, Mills River, NC
4:15 – 4:30	**Ten years of results with three apple cultivars on four training systems.** R.M. Crassweller & D.E. Smith. Pennsylvania State University, University Park, PA
4:30 – 4:45	**Eugenol bloom thinner on peach.** S. Miller and T. Tworkoski. AFRS, USDA-ARS, Kearneysville, WV
4:45 – 5:00	**Update on innovative technologies for thinning of fruit.** P. Heinemann, T. Baugher, J. Schupp and J. Liu. Pennsylvania State University, University Park, PA
5:00 – 5:15	**An evaluation of the 'size' method for hand thinning apples.** S. McArtney and J.D. Obermiller. North Carolina State University, Mills River, NC

Plant Pathology – Madison Room

Thursday Afternoon, November 19, 2009

1:00 – 1:15	**Benefits and limitations of new apple fungicides.** D. Rosenberger. Cornell University, Highland, NY
1:15 – 1:30	**Summer disease control with phosphites.** T.B. Sutton, E. Brown and O. Anas. North Carolina State University, Raleigh, NC
1:30 – 1:45	**Apple scab fungicide resistance in the Northeastern United States: Prevalence and practical resistance.** K.D. Cox and S.M. Villani. Cornell University, Geneva, NY
1:45 – 2:00	**Evaluation of fungicide programs for apple diseases in PA, 2009.** N.O. Halbrendt and J.W. Travis. Penn State University, Biglerville, PA.
2:00 – 2:15	**Reduced fungicide resistance risk and organic alternative programs for apple diseases, 2009.** N.O. Halbrendt, J.W. Travis and H. Ngugi. Penn State University, Biglerville, PA
2:15 – 2:30	**Testing potential ascospore dose as a tool for apple scab management.** D. Cooley. University of Massachusetts, Amherst, MA
2:30 – 2:45	**Evaluation of alternatives to oxytetracycline and streptomycin for control of bacterial spot in peach and fire blight in apple.** B.L. Lehman, S.J. Bardsley, N. O. Halbrendt, B. Jarjour and H.K. Ngugi. Penn State University, Biglerville, PA
2:45 – 3:00	**Evaluation of pruning techniques and bactericides for managing bacterial canker of sweet cherry.** J. Carroll, S. Hoying, T. Robinson, T. Burr, K. Cox, T. Bucien, A. Rugh and D. Rosenberger. Cornell University, Geneva, NY
3:00 – 3:15	**BREAK**
3:15 – 3:30	**Evaluating new stone fruit rootstocks and cultivars for susceptibility to x-disease and tomato ringspot virus.** D. Rosenberger and S. Hoying. Cornell University, Highland, NY
3:30 – 3:45	**First reports of *Monilinia laxa* in stone fruit orchards in western NY.** S.M. Villani and K.D. Cox. Cornell University, Geneva, NY.
3:45 – 4:00	**Characterization of the cytochrome b CYTB gene from fruit infecting *Monilinia* species.** J.-M. Hily, S.M. Villani and K.D. Cox. Cornell University, Geneva, NY
4:00 – 4:15	**Management of diseases on a late-season peach cultivar with experimental fungicides.** N. Lalancette and K. McFarland. Rutgers University, Bridgeton, NJ.
4:15 – 4:30	**Effect of cultural and chemical methods on cluster architecture and bunch rot of grapes.** B. Hed, J. Travis and N. Halbrendt. Penn State University, Biglerville, PA
4:30 – 4:45	**Fungicide performance trials for grape downy and powdery mildew at Winchester AREC, 2009.** M. Nita. Virginia Tech, Winchester, VA
4:45 – 5:00	**What statistics should a PDMR contain to be included in a meta-analysis?** H.K. Ngugi. Penn State University, Biglerville, PA

Plant Pathology – Friday Morning, November 20, 2009 – Madison Room

9:00 – 9:15	**Efficacy of DMI mixtures on development of brown rot on 'Suncrest" peach.** N. Lalancette and K. McFarland. Rutgers University, Bridgeton, NJ
9:15 – 9:30	**Efficacy of Difenoconazole mixtures on development of scab on "Autumnglo" peach.** N. Lalancette and K. McFarland. Rutgers University, Bridgeton, NJ
9:30 – 9:45	**Postharvest control of brown rot on peach and nectarine.** N.O. Halbrendt, J.W. Travis and H. Ngugi. Penn State University, Biglerville, PA
9:45 – 10:00	**Update on the availability of Maryblyt v.7 for Windows.** A.R. Biggs. West Virginia University, Kearneysville, WV
10: 00 – 10:15	**BREAK**
10:15 – 10:30	**Synopsis of the NE-183 disease assessments for scab, mildew, and rust diseases.** A.R. Biggs. West Virginia University, Kearneysville, WV
10:30 – 10:45	**Highlights of fungicide testing on apples, 2009.** K. Yoder. Virginia Tech, Winchester, VA
10:45 – 11:00	**Continued investigation of fungicide resistance in apple scab in Virginia.** S. Marine, D. Schmale III, and K. Yoder. Virginia Tech, Winchester, VA.
11:00 – 11:15	**Are we losing SI fungicide sensitivity in apple powdery mildew?** K. Yoder. Virginia Tech, Winchester, VA.
11:15 – 12:00	**Additional papers and general discussion**

Entomology – Friday Morning, November 20, 2009 – Washington Room

9:00 – 9:15	**Residual properties of selected new insecticides.** G. Krawczyk and L. Hull. Penn State University, Biglerville, PA
9:15 – 9:30	**Impact of precipitation on the performance of insecticides.** J. C. Wise and C. VanderVoort. Michigan State University, E. Lansing, MI
9:30 – 9:45	**Impact of insecticides and fungicides on plum curculio movement.** T. C. Leskey, S. E. Wright and C. Vincent. AFRS, USDA-ARS, Kearneysville, WV
9:45 – 10:00	**Development of a fast method to aid in resistance monitoring for codling moth.** L. C. Magalhaes, R. M. Roe and J. F. Walgenbach. North Carolina University, Raleigh, NC
10:00 – 10:15	**BREAK**
10:15 – 10:30	**Managing internal feeding lepidoptera and leafrollers with Altacor and Delegate using two methods of application.** L. Hull, G. Krawczyk and D. Biddinger. Penn State University, Biglerville, PA
10:30 – 10:45	**Wooly apple aphid control.** D. Biddinger and L. Hull. Penn State University, Biglerville, PA.
10:45 – 11:00	**Movento 240SC for control of San Jose scale, green apple aphid, and wooly apple aphid.** D. Combs and H. Reissig. Cornell University, Geneva, NY.
11:00 – 11:15	**Tree fruit entomology research highlights: 2009.** P. W. Shearer and K. Amarasekare. Oregon State University, Hood River, OR.
11:15 – 11:30	**Fruit quality and spray programs in NJ orchards.** D. Polk, D. Schmitt and A. Atanassov. Rutgers University, Cream Ridge, NJ.
11:30 – 12:00	**Additional papers and general discussion**

Business and Financial

85th Annual Cumberland-Shenandoah Fruit Workers Conference
Program Highlights and Business Meeting Minutes, November 20, 2009
Host State – Virginia/Virginia Tech

Virginia Tech hosted the 85th Annual Cumberland-Shenandoah Fruit Workers Conference at the Hampton Inn and Conference Center in Winchester, Virginia on November 19-20, 2009. The 87 registered participants represented about 25 different organizations, and 63 papers were presented in concurrent sessions. Registration fees of $60 for pre-registration or $75 at the door were intended to cover the cost of the meeting rooms, Thursday lunch, breaks, and publication of the Proceedings. Rongcai Yuan, Chris Bergh and Keith Yoder served as co-chairs, and Tracy Leskey served as treasurer. Chris Bergh moderated the Entomology sessions, Keith Yoder the Plant Pathology sessions; and Rongcai Yuan the Horticulture Session.

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 and other items of interest for each state or region during the 2009 season. The broad-based General Session was directed at the past, present and future of pest and cultural management in tree fruit production. Following a presentation on trends and future directions of tree fruit production in Washington State tree fruit by Jay Brunner, Henry Hogmire and Steve Miller gave their perspectives on the past, present and future of pest and cultural management in the Mid-Atlantic region.

After lunch the meeting split into concurrent sessions with 63 presentations that continued through Friday morning and included 25 in entomology, 23 in fruit pathology and 15 in horticulture. A social mixer was held on Thursday evening, which was sponsored by AgraQuest, Inc., BASF Ag Products, Bayer CropScience, CBC America, Cheminova, Inc., Certis USA, Dow AgroSciences, DuPont Crop Protection, Nichino America, Inc., Suterra LLC, Syngenta Crop Protection, Inc., United Phosphorus, Inc., and Valent BioSciences Corp.

A different, ongoing, feature of the 85th meeting was a name-the-mystery-apple contest. A box of locally grown apples was displayed and it was announced that there was $5 for the person (excluding Virginia Tech people) who could correctly name the cultivar. Several incorrect suggestions were offered at the meeting and no one but a Virginia Tech employee (Dave Carbaugh) could correctly identify it. Jon Clements posted an inquiry and linked picture to the Apple-Crop Discussion Group Thursday evening which expanded interest beyond the meeting into the following week. This generated more than 600 hits on the linked posted pictures at Jon's web site and a Virginia Tech AREC web site and messages to the Apple-Crop list. More than 20 incorrect names were offered. Steve Miller correctly named the mystery apple- "Pilot" November 23 after recalling the announcement of the contest "a pilot study on apple cultivars" (and Dr. Miller received the $5 for his efforts).

The business meeting was called to order by Keith Yoder on Friday at 8:00AM. Topics of discussion included publication of reports, eligibility of invited participants, and future meeting time and location.

It was decided that the Scholar site is generally acceptable for posting of the Proceedings but that those who request it could also receive a hard copy. There was discussion about opening the Scholar report site to the general public but it was noted that many of the reports are specifically written as “Not for Publication” or “Not for citation without consent of the author” and it was decided that the Scholar site should remain as participant accessible only and that the reports would not be accessible to public search engines.

After some discussion about eligibility of meeting participants, it was decided that, with the blurring responsibilities among technical representative /consultant/sales, the next meeting would be opened to attendance by any interested agriculture professional involved with fruit and not to specifically exclude sales.

The organization’s Financial Report (which follows) was presented by Tracy Leskey. With the current balance, registration receipts from 87 paid attendees ($5,505), and generous contributions from industry associates for the mixer ($2,725), the organization is in good standing and should be able to meet all the anticipated bills for 2009.

The 2010 CSFWC will be held on November 18-19, again at the Hampton Inn, Winchester, Virginia. Succession of meeting host was to go to West Virginia, but due to reduction in available personnel with Henry Hogmire’s retirement, North Carolina agreed to host the 2010 meeting, with Jim Walgenbach serving as General Chair. WVU will join USDA and Maryland as hosts for the 2011 meeting.

Cumberland-Shenandoah Fruit Workers Conference
2008-2009
Financial Report

Income 2008-2009

Receipt From 2008 Registrations (84)	5510.00
Support For Mixer	1400.00
Sales of Proceedings	15.00
Interest (December 08-November 09)	8.99
Total Income	**6933.99**

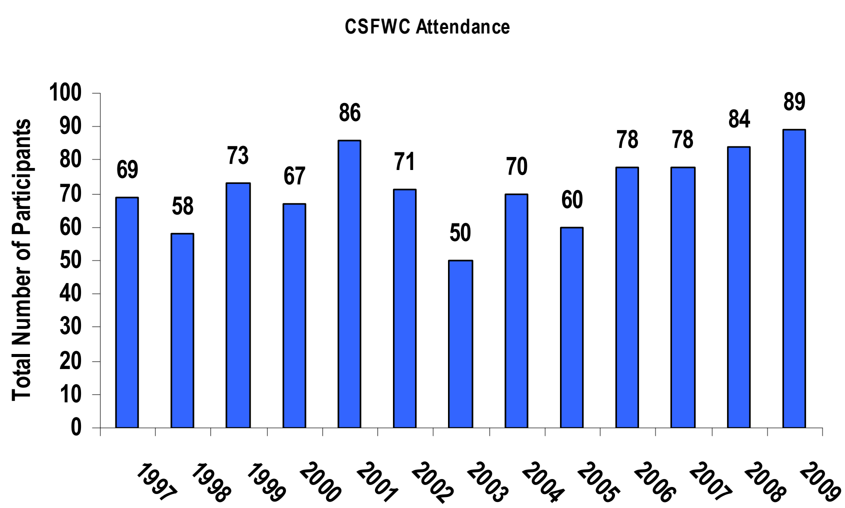
Expenses 2008-2009

Hampton Inn 2008 – room rental, luncheon, breaks, mixer	6093.40
Proceedings Covers	111.00
Proceedings, Name Tags, etc.	285.61
Blank Checks	25.05
Total Expenses	**6515.06**

Income 2009-2010

Receipt From 2009 Registrations (87 *)	5505.00
Support For Mixer	2725.00
Total Income	**8230.00**

*Two registrations not yet received; 89 registered participants.



Cumberland-Shenandoah Fruit Workers Conference
Facilities and Food Costs

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

Cumberland-Shenandoah Fruit Workers Conference
Future Host States

- 2010 North Carolina
- 2011 Maryland / WV / USDA
- 2012 Pennsylvania
- 2013 New Jersey / SC
- 2014 New York
- 2015 Virginia

Call of the States

Pest Management and Horticultural Status in New England, 2009

Kathleen Leahy, Polaris Orchard Management, Colrain MA
additional input from Daniel Cooley and Jon Clements, University of Massachusetts, Amherst MA

April and May were quite dry in this region, with rainfall below average for both months. From late May thru July, however, conditions were very wet indeed (7+ inches in June, 11+ inches in July), with chronically overcast conditions even when it wasn't actively raining. Early season fruits like cherries and strawberries fared poorly, but other tree fruits and also blueberries did surprisingly well. Wholesale apple prices were not strong, but retail sales were excellent for most growers with access to direct sale markets (retail stands, pick-your-own, farmers' markets).

The onset of wet weather toward the end of primary **scab** season created problems for some growers, and where primary scab was not well controlled, significant secondary scab was present at harvest. However, growers who did manage primary scab well did not see secondary activity, despite the extremely wet conditions. A moderate **fire blight** infection occurred early during bloom (May 9) and resulted in new fire blight strikes in a few orchards where fire blight has been a problem and no strep was applied during that infection. **Sooty blotch** was much more prevalent than **flyspeck** this year; usually the reverse is true in this region. It appears that sooty blotch was able to grow more rapidly in the wet conditions, often with no fungicide present because repeated drenching rains removed fungicide cover. Sooty blotch control was surprisingly good, in view of the wet weather conditions; dryer weather in August and September may have contributed to control. Several trees across the region showed symptoms of **silver leaf**, an unusual occurrence in this area, but probably not of economic importance.

Warm rainy weather after bloom was favorable for **plum curculio** this year, and curculio activity was nasty, brutish and short. On the whole, control was good because of the concentrated immigration period. **Apple maggot fly** was fairly 'normal' in most orchards, but a few growers experienced a late flush of apple maggot activity in September, creating problems in some varieties. **Obliquebanded leafroller** continues to be a struggle for some growers; this year control was difficult because of the torrential rainfall, but the newer materials appeared to hold up well. **Oriental fruit moth** is on the increase in peaches but does not yet appear to be a problem in apples. An unusual outbreak of a **prionus** borer was reported in a commercial apple orchard in southern New Hampshire by Dr. Alan Eaton.

NEW JERSEY STATE SUMMARY – 2009

David Schmitt, Dean Polk, Atanas Atanassov

Peach: Full Bloom 4/18. The region experienced a normal bloom. Frosts occurred in some areas near full bloom. Temperatures on April 13 ranged from a low of 22 ° F in Gloucester County to 30 ° F in Cumberland County, and varied by the height in the tree. Most blocks were @ pink to 50% bloom on this date. Although temperatures were not extreme during this event, crop thinning was evident post bloom, and many blocks in Gloucester County did not require much hand thinning. Fruit size was excellent in 2009 due to ample moisture and early thinning.

Apple: Red Delicious Full Bloom 4/27. The apple crop is good overall. Red Delicious was at tight cluster/pink on April 13th and was injured by frost on the coldest sites. Injury was apparent on the first hot day during bloom when blossoms began to abort.

Pear: Pear psylla pressure was extraordinarily high in 2009. Informal Field trials using Movento indicated that it is a good psylla control material when used at the high rate with 1-2 pts Regulaid. Under very high pressure it required two applications.

In general: Late April and Early May were unseasonably cool and wet. Plum curculio oviposition was first observed on May 8 and activity continued well into June with some injury occurring later than is normally observed. Cool temperatures throughout the spring may have helped prolong oviposition activity. Wet weather continued throughout the summer. Not surprisingly disease control drove most spray programs. Peach scab levels were well above normal with control failures in some orchards. However summer disease control on apples and bacterial spot control on stone fruit was good to excellent in spite of frequent wetting periods. Constriction canker was moderate to severe in a few peach blocks and dieback continued to appear much later than is normally observed. Apple scab was a particular challenge, particularly on a number of North Jersey farms. In peaches, we experienced very low pressure from leafrollers, Oriental fruit moth and most other insects, but slightly higher pressure from plum curculio. Production was close to the same levels seen in 2008, or close to 34,000 tons, but prices were improved. This was offset by higher production costs from packaging to fertilizers and pesticides.

Blueberries: Wet and cool weather during bloom resulted in poor pollination on many farms. Wet weather produced heavy anthracnose pressure. Insect pressure was normal, with very low cranberry fruitworm levels, but slightly higher levels of blueberry maggot. Increasing problems are being seen from plum curculio. Present controls are not satisfactory, and infestations have produced some infested frozen packs. Production was down from 59 million lb in 2008 to about 49 million lb in 2009, or about 17%. This breaks down to 43 million lb for fresh market and 6 million lb process. Process prices were down from $1.20/lb in 2008 to a range of .65-.72/lb in 2009. Fresh prices are stable but down slightly from $13.90/flat to $13. At the present time freezer storage is high with about 192 million lb in storage, or about 30-40% over the norm. One major grower representative summed it up: “Growers are just out of control.”

Call of the States – New York 2009

Art Agnello and Debbie Breth
Cornell University, NY Agric. Expt Sta., Geneva, New York

Entomology

The 2009 growing season distinguished itself as being among the coolest and wettest of summers we've ever had. Despite it's having been a challenge keeping fruit diseases under control, most insect pests were not too bad this season, although there was still plenty of work needed to keep on top of things.

True to our typical go-stop-go weather patterns, the spring actually started off with a warmer May than we usually get, and the big cool-down didn't settle in until June. This helped to kick the early season pests into action, but didn't give them much impetus to move beyond that. **Plum curculio** proceeded about two-thirds of the way through its egglaying period, and then seemed to be in a holding pattern for weeks, so that most orchards ended up needing two additional cover sprays to protect the fruit beyond petal fall. Flights of **oriental fruit moth** and **codling moth** similarly started pretty much on schedule, but generally didn't develop the numbers we have been seeing in recent years. In fact, reports of all the "worm" pests, including **obliquebanded leafroller**, tended to be uncharacteristically low during the first half of the summer.

The rainy season had its usual effect of suppressing many of the foliar pests also, such as **European red mite** and **pear psylla**, although the flush of foliar growth that resulted encouraged populations of **rosy apple aphids** and **green aphids**, and **woolly apple aphids** were not difficult to find relatively early in the season. Taking advantage of the many weather fronts moving through the area, **potato leafhoppers** seemed to occur in several waves.

A brief but intense dose of true summer temperatures starting in mid-August created some interesting situations just as we thought everything was coasting toward a calm finish. The most notable was **apple maggot**, which evidently decided to claim 2009 as a breakout year, as we saw adult emergence at higher levels and for a longer period than has occurred in a long time. Not every orchard was targeted, but in the traditional problem spots, large numbers of flies emerged from the rain-softened soil and were caught by the dozens on a weekly basis, continuing well into September. **European red mites** were also late-breaking news, as the summer eggs took advantage of the high temperatures to hatch out and blossom into some large motile populations that covered the foliage just as it was beginning its autumn decline, which effectively shut down most infestations.

Japanese beetle continued its run as a perennial nuisance, and **internal leps** were still in evidence in early October, although apparently not at crisis levels in most cases. Some other sporadic pests were also found, including **stink bugs** and **San Jose scale**, but final reports from the harvest period will be needed before we know the actual impact of these species.

PENNSYLVANIA STATE REPORT FOR CSFWC, 2009

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Horticulture: Low temperatures on January 16 to 17 resulted in some peach losses in the more northern areas of the state. Unseasonable temperatures on April 25th to 28th advanced flower development of all tree fruit crops rapidly. In some cases trees went from ½ inch green to full bloom in a matter of days. Bloom was so fast that peaches and sweet cherries overlapped. Apples in central PA had king bloom on April 27 for early cultivars like Ginger Gold, Empire and Zestar!. Making bloom about 7 to 10 days ahead of normal. Overall moisture was below normal for the year due to low winter precipitation. While bloom was early, it did not result in an earlier harvest season. Most maturity parameters were slow to change.

Plant pathology: The 2009 growing season was cooler, and wetter than normal. Rainfall for April, May, June, July and August was 4.4 in., 6.9 in., 4.42 in., 4.98 in., and 2.75 in., respectively. Weather condition was exceptionally favorable for apple scab disease. Several scab infection periods occurred during the primary period 16 Mar to 15 Jun. There were 6 moderate scab infection events that occurred over 11 days that included 1-4 continuous days of wetting and 9 severe infection events occurring over 33 days that ranged from 2-5 continuous days of wetting. Overall, apple scab pressure was severe and powdery mildew pressure was moderate in the test site.

This was also a bad year for fire blight in Pennsylvania. Many orchards reported severe fire blight outbreaks on both apple and pear making this the third year in a row (from 2007) in which this disease was a menace. Between 25 April and 17 May, there were four infection periods and ten high risk events recorded at Biglerville based on Maryblyt forecasting model. On peaches, bacterial spot pressure was generally low probably because the relatively low temperatures early in the season (May to early June) did not favor infection and disease development. A significant event in Plant Pathology took place at PSU-FREC in Biglerville on October. The Pennsylvania Department of Agriculture officially lifted the plum pox quarantine of the area's stone fruit on Oct. 29, certifying the state as free of plum pox. We also received reports about powdery mildew outbreaks in which to growers felt the disease was not sufficiently controlled by their best fungicide program.

Entomology: During the 2009 season the first sustained flight of Oriental fruit moth, OFM, (biofix) was observed on April 24, for codling moth, CM on May 09, tufted apple bud moth, TABM on May 14, and for obliquebanded leafroller, OBLR on May 31. The insect pests occurrence during the 2009 season was relatively normal, without any special, unexpected events or problems but it was a second year in a row with increased numbers of fruit injuries associated with the feeding of stink bugs and plant bugs. Also, what was a relatively new for PA growers, some orchards experienced much higher pressure from plum curculio than in previous years. The only other pest causing some control problem was pear psylla, but due to limited acreage of per orchards in Pennsylvania the challenge was limited to only few orchards.

The internal fruit feeding larvae of codling moth and oriental fruit moth remained the main reason for the load rejections by local fruit processors (i.e., Knouse Foods and Mott's). Despite grower's effort to reduce the importance of CM/OFM complex, the total number of rejected loads was about the same as during the 2008 season.

VA Call of the States Report

Horticulture
Virginia produced about 5.5 million bushels apple this year.

The weather was rainy and cloudy during fruit thinning period in May. Most growers thinned their apples well this year, but some may have over-thinned

Abundant rain was distributed evenly during the growing season. Apple fruit were bigger and softer, and fruit cracking in apples was not very serious this year because of the rain. On the other hand, bitter pit was more serious than on average, especially in ‘Golden Delicious’.

Hail caused serious damage in some orchards.

Apples ripened about a week earlier than normal and harvest season went well due to nice weather in September and October.

Peaches had good fruit size due to the rain and had a good price.

Entomology
OFM biofix on April 17, second latest date since 2000.
CM biofix on May 2, within range.
TABM biofix on May 20, 8 days later than 2^{nd} latest date since 2000.

Cool, wet conditions from bloom through about mid-June resulted in minimal mite problems reported in VA. Growers reported lower pressure from OFM and CM and generally only minor damage at harvest.

Many growers were concerned about residual activity of products during the spring due to rain.

Reports of generally increasing pressure from San Jose Scale, possibly due to reduced use of oil in the prebloom period.

Brown marmorated stink bug is established in VA, but not yet nearly as prevalent as in the panhandle of WV. We expect that issues from this pest will increase in coming years. There have been increasing reports of stink bug damage at harvest and of some growers applying pyrethroids as late as mid-September to manage this pest on late varieties.

Reports of some WAA outbreaks here and there in 2009. WAA populations generally higher in many orchards than has been seen in recent years, including at AHS-AREC, but generally not at “treatable” levels.

Pathology
Apple scab: 2009 was again an opportunity for success or failure of scab control programs. Early infection occurred in late March and a total of sixteen scab infection periods occurred in April and May. Scab lesions were first observed 30 Apr. Particularly challenging infection periods occurred: 14-16 Apr, 19-21 Apr, 3-5 May, 25-27 May, and 3-6 Jun. These had long wetting periods following heavy rainfall, which depleted most protective fungicide residue, requiring post-infection action for control.

Mildew: We had 33 dry weather days favorable for mildew infection from 30 Mar to 6 Jun. So, even in this “wet year”, about half of the days were favorable for the dry weather mildew fungus.

Fire Blight: *Maryblyt* predicted infection at our AREC only for 28 Apr, but four other days were “near-misses” that may have been infection periods elsewhere. Some later significant infection occurred on late bloom (8-9 May) on cultivars such as Rome, York and Nittany, resulting in scattered infection that continued to be a concern with spread by thunderstorms and hail injury on into the summer.

Sooty blotch and flyspeck: The cumulative wetting threshold of 250 hr for the presence of the sooty blotch and flyspeck fungi on unprotected fruit was reached 9 Jun, and by 1 Sep we had the third highest wetting hour total since 1994.

Stone fruits: Frequent May wetting periods were also favorable for development of peach scab, and later rains led to brown rot at harvest.

West Virginia State Report

<u>Horticulture (Steve Miller)</u>

1. Winter temps at or slightly below normal, with below normal precipitation. After an early bud break, cool temps in early April delayed development, but very high temps in late April advanced bloom rapidly. Several light frosts and one freeze during bloom. May brought cool temperatures, excessive rainfall, and extended cloudy conditions, making thinning decisions difficult. Ample rainfall through July. August to mid-October was very dry (< 2 inches rain), but have had 6 inches of rain during the past 4 weeks.

2. Peach crop down slightly (low temperatures), but apple crop about normal.

3. Dry conditions in late summer reduced apple size and contributed to above normal fruit drop on some cultivars.

4. Lack of cool nights in Aug. & Sept. reduced color development on Honeycrisp and Jonagold.

5. Poor response with ReTain, but ReTain + NAA provided excellent drop control and high quality fruit 4 weeks after normal harvest dates.

<u>Plant Pathology (Alan Biggs)</u>

1. 17 infection periods - late March through May; 21 infection periods – June to mid-Sept.

2. Abundant rainfall & cool temperatures favorable for early season apple scab and rust development.

3. Fire blight was severe in several orchards due to infections on late bloom and favorable conditions for shoot blight development.

4. Accumulation of sufficient wetting hours for sooty blotch and fly speck was on the earliest date seen in 5 years (275 hours on June 22). These diseases first observed on July 24 at 352 hrs of wetting.

5. Dry conditions in August & September resulted in only light to moderate amounts of summer diseases, but Necrotic Leaf Blotch on Golden Delicious was prominent in some blocks in mid to late August.

6. No significant disease outbreaks in peaches & nectarines, but some cherry growers experienced high levels of premature defoliation caused by cherry leaf spot.

Entomology (Henry Hogmire)

1. Rosy apple aphids were well controlled with early pink to petal fall neonicotinoids.

2. European red mites generally low through July, increased with warmer temperatures in August, but soon followed by deposition of overwintering eggs so most populations didn't require treatment.

3. Potato leafhoppers quite abundant, especially on younger trees.

4. Internal worms (CM, OFM) continue to be a significant problem, with CM the primary species responsible for fruit injury. Growers supplementing good insecticides with mating disruption continue to see population declines.

5. Leafroller populations continue to decline in most orchards.

6. Insect award of the year goes to Brown Marmorated Stink Bug. Big increase in orchards from last year. Significant damage in both peach and apple. Like Japanese Beetle clustered on peaches. Crawling out of picking sacs. Increased threat due to reproduction on fruit trees.

DEVELOPMENT AND VALIDATION OF A "REAL-TIME" APPLE IPM WEBSITE FOR NY

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Apple growers in the Eastern US have faced challenges in managing the complex of insects and diseases of apples using conventional pesticides during the last decade because of increasing pesticide regulatory restrictions, public concerns about food safety and environmental quality, and the development of resistance to older materials by key insect and disease pests. Growers are attempting to utilize newer reduced-risk pesticides, but they are more expensive and require more precise use patterns because of their different modes of action. In addition, many current IPM protocols were designed for older conventional materials. During the last several years, an interdisciplinary group of scientists at Cornell University has developed a web-based, Real Time Apple IPM Decision Support System that can deliver relevant, current information on weather data and pest populations to facilitate grower pest management decisions throughout the growing season. This system tracks seasonal development of key insect pests and diseases using Degree Day and Infection Risk Models. The models indicate pest status, pest management and sampling options, and are linked to an interactive system that helps growers choose appropriate materials when pesticides must be used.

Insect pest developmental stages are calculated from Degree Day (DD) accumulations at NEWA (NYS IPM's Network for Environment and Weather Applications) and NWS airport weather stations throughout the state (Fig. 1). The insect pests addressed by this website are: apple maggot, oriental fruit moth, codling moth, plum curculio, obliquebanded leafroller, and spotted tentiform leafminer.

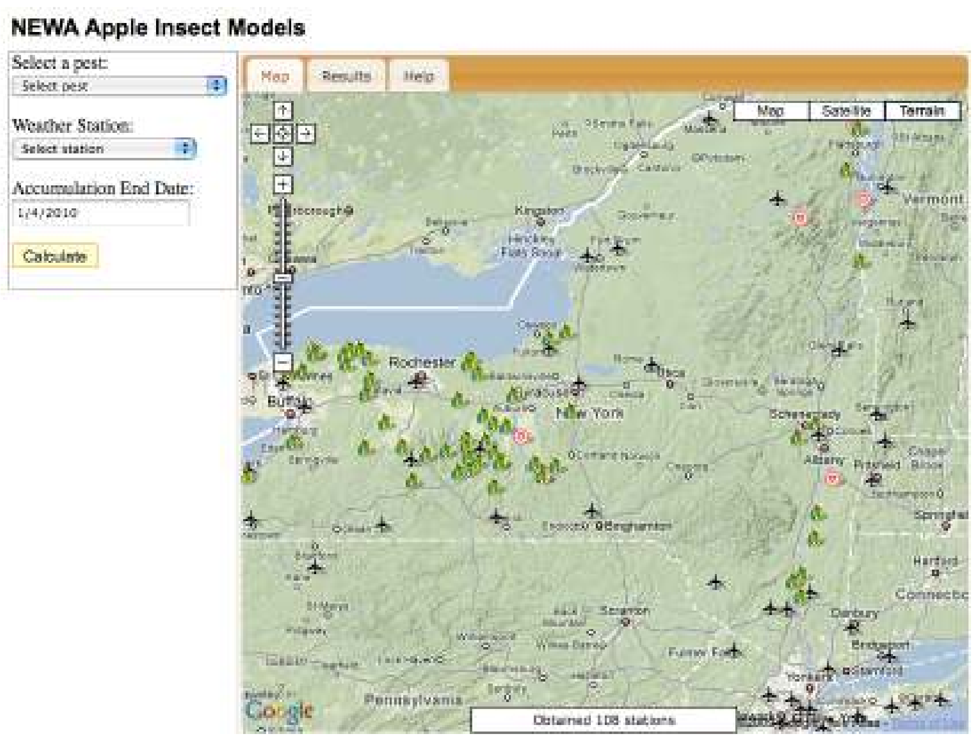
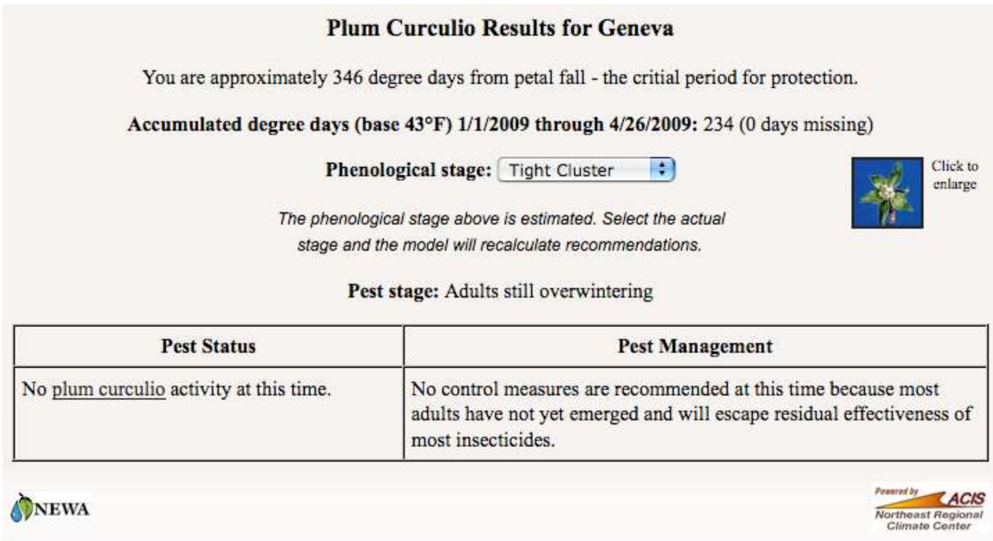


Fig. 1. Home screen for initial selection of pest and weather station of interest.
After the user selects a weather station and pest of interest, pest DD models and historical records are used to calculate: Tree Phenological Stage, Pest Stage(s), Pest Status, and Pest Management Information (Fig. 2).


Plum Curculio Results for Geneva

You are approximately 346 degree days from petal fall - the critial period for protection.

Accumulated degree days (base 43°F) 1/1/2009 through 4/26/2009: 234 (0 days missing)

Phenological stage: Tight Cluster

Click to enlarge

The phenological stage above is estimated. Select the actual stage and the model will recalculate recommendations.

Pest stage: Adults still overwintering

Pest Status	Pest Management
No plum curculio activity at this time.	No control measures are recommended at this time because most adults have not yet emerged and will escape residual effectiveness of most insecticides.

NEWA

Powered by ACIS Northeast Regional Climate Center

Fig. 2. Results page showing pest and crop developmental status and management information.

When a pesticide spray is recommended, a pesticide decision filter helps users pick an appropriate material to use (Fig. 3).

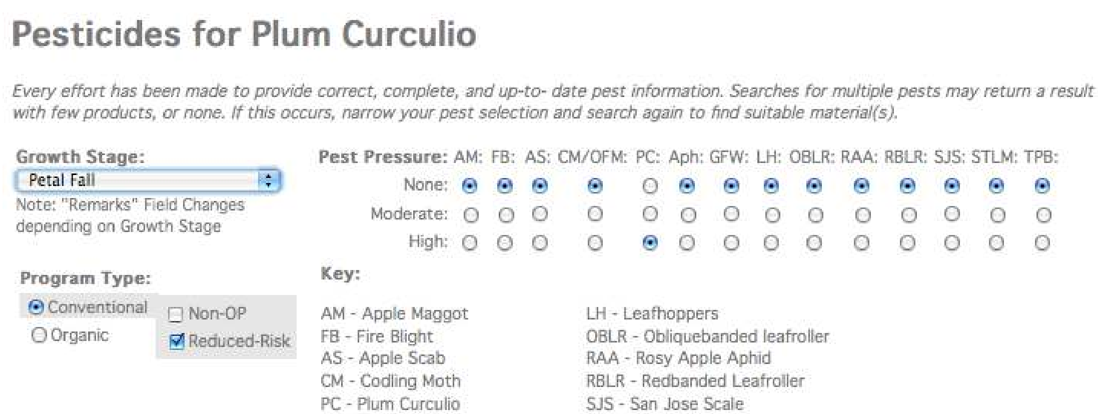


Fig. 3. Pesticide decision filter for selection of appropriate choice based on pest pressure, product efficacy, and management program elected.

Predictions provided by the website can be refined and adjusted to current insect activity by user-entered events obtained through field monitoring (such as biofix, first sustained flight of a pest species). The pesticide selection filter is based on Cornell University product efficacy ratings and the type of management program selected by the user (e.g., conventional, reduced-risk, non-organophosphate, organic). Hyperlinks on the results pages provide access to supplemental resources such as crop and pest biology and development information, sampling and monitoring methods, and pesticide profiles plus access to database of NYS labels for registered products.

During the 2009 growing season, the Apple IPM website was "beta-tested" by a group of 16 NY apple growers, along with their respective Cornell extension educators and private consultants located in Orleans, Wayne, Onondaga, Clinton, Saratoga, and Albany Counties. At each site, a planting of apples from 10-20 acres in size was monitored for crop and pest status throughout the season, and a suitable nearby weather station was designated for providing daily temperature data as a basis for crop and pest developmental predictions. Insect pests addressed by the website were: apple maggot (AM), oriental fruit moth (OFM), codling moth (CM), plum curculio (PC), obliquebanded leafroller (OBLR), and spotted tentiform leafminer (STLM).

DD information based on either historical records or user-entered biofix data included: the start, peak, or progress of the oviposition or egg hatch period (for CM, OBLR, OFM, and STLM); the start, peak or end of the pest's 1st, 2nd, etc., flight (for AM, CM, OBLR, OFM, and STLM) (Fig. 4); the first occurrence of adult or larval feeding, foliar or fruit damage, or mines (for OBLR and STLM). Insect monitoring traps were placed in all orchards and checked approximately once per week to monitor adult flights, and weekly fruit inspections were conducted starting in July to assess the incidence of any larval feeding damage to apples caused by leafrollers or internal feeding Lepidoptera such as codling moth or oriental fruit moth. All results of this insect monitoring were reported on a weekly basis to each respective grower and consultant for their use in determining appropriate management decisions in the blocks.

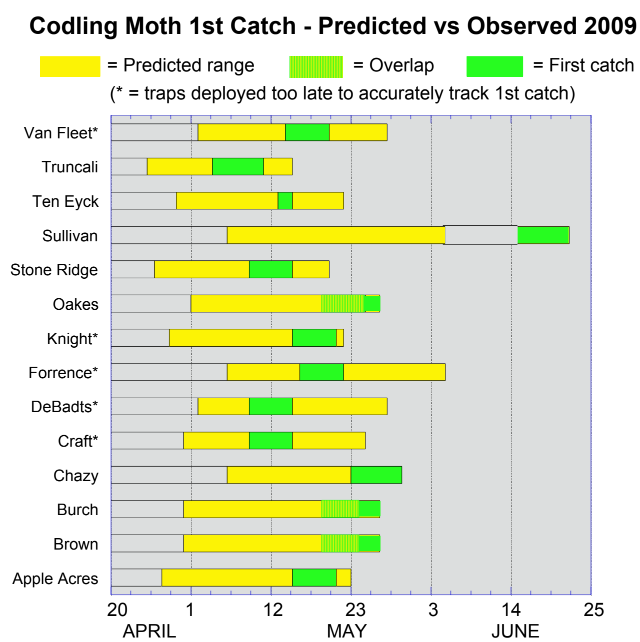


Fig. 4. Predicted vs. observed first trap capture of codling moth 1st generation adults.

We compared web predictions with population trends observed in the field for as many of the pest species as was possible, although not all populations of all species were large enough or distinct enough to make a practical assessment of the website's accuracy in all cases. In general, the main sources of error in the website predictions were:

- Traps set out too late; missed 1st flight; biofix wrong (STLM and OFM especially).
- Trap check interval too long to precisely identify trap catch trends; even 7-day period should be shortened for important events (dates near anticipated first or peak catches).
- Target populations too low to make good predictions of biological events.

- Model prediction (based on historical data) was simply not precise enough to be accurate every time (e.g., CM peak flight).
- Weather stations not numerous enough or close enough to individual sites to be representative of true DD conditions.

During the 2009 growing season, a field study was conducted to test two different IPM protocols integrating information obtained from the "Real Time" Apple IPM website in NY apple orchards. Tests were set up in 14 orchards in major NY apple production regions. Entomology department personnel monitored and sampled plots throughout the season. Growers applied pesticides based on monitoring results and web predictions of pest development. In the Fruit Monitoring Protocol, growers applied normal sprays for insect control until plum curculio (PC) activity was over. Starting in late June, 1000 apples were inspected on the tree weekly for damage from internal Lepidoptera (codling moth or oriental fruit moth) and obliquebanded leafroller (OBLR). Apple maggot (AM) traps were deployed in late July. Control sprays were recommended whenever treatment thresholds were reached (1 fruit damaged by either OBLR or internal leps; and an average AM capture of 5 AM/trap). In the Web-Optimized treatment Protocol, normal control sprays were also applied until PC activity was over. An initial summer spray was recommended based on web predictions of hatch of summer OBLR eggs and 1st generation internal lep eggs (using either Delegate or Altacor). A second spray was recommended based on web predictions of AM activity and 2nd generation internal lep egg hatch (alternating to whichever choice of Delegate or Altacor had not been used previously). Growers would have applied an average of 2.0 and 1.1 summer sprays, respectively, in the Web-Based and Fruit Monitoring plots if they had followed recommendations. Fewer sprays were recommended in these plots than have been previously applied in NY apple orchards under traditional IPM programs (2-3 Avg. sprays). Harvest insect damage was similar in both protocols (2.9%, Web-Based; 3.2%, Fruit Monitoring). Growers' spray records are being compared to assess the actual numbers of applications made to the orchards in this trial.

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Without Consent of Authors

WOOLLY APPLE APHID CONTROL

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Increases in woolly apple aphid (WAA), *Eriosoma lanigerum,* populations have been noted in some Pennsylvania apple orchards since the introduction of Delegate® (spinetoram) for codling moth (CM) control in 2008; even in orchards with known WAA resistant rootstocks. In addition, experiments in research and commercial apple orchards were conducted during 2008-9 to determine the efficacy of various insecticides for WAA control. Pre-bloom applications of chlorpyrifos were found to be very effective in giving seasonal control of WAA as were Movento® and diazinon when applied later in the season. Movento, however, failed to give mid-season control in one orchard with large trees on standard rootstocks. Control with imidacloprid (8 fl oz/acre) applied during the mid-season in 2008 was excellent, but mid-season applications of imidacloprid were ineffective in 2009 whether it was mixed with an adjuvant or not. Other neonicotinoid insecticides such as thiacloprid, acetamiprid and thiamethoxam were also ineffective in controlling this pest in 2009.

Fifteen grower orchards were monitored for WAA populations over a three year period (2007-9) as part of a USDA-RAMP grant. WAA populations were found to be significantly higher in orchards using Delegate for first generation CM control. Replicated 15-tree research plots and non-replicated five acre commercial blocks were also found to generally contain higher WAA populations when Delegate was used for first generation CM control. Evaluation of weekly colored pan trap samples from April through October in the RAMP orchards (over 7,000 samples from all three years) found lower numbers of the WAA parasitoid, *Aphelinus mali*, to be present in orchards treated with Delegate, despite higher populations of WAA.

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Measuring Success after 2-Year Large Scale Mating Disruption of CM in NY

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This material is based upon work supported by USDA/NIFA under Award Number 2007-49200-03888.

In 2007, fruit growers were struggling with control of codling moth (CM) and oriental fruit moth (OFM) detected in over 300 truckloads of apples from almost 80 growers at fruit receiving stations. In 2008, the number of truckloads of infested apples increased to almost 400 impacting over 110 growers. In 2008, 3 growers, who had over 5% fruit infestation and over 10% fruit damage by these pests in 2007, agreed to participate in a large scale project implementing mating disruption pheromones for control of these pests. This is the first large scale mating disruption project for CM in NY. The growers have completed the second season and the measures of success follow. This project is an educational project funded by the Northeast Center for Risk Management Education to help growers reduce the economic and environmental risk of codling moth and oriental fruit moth.

Methods:

In 2008, 3 participating growers chose the sprayable pheromones to apply with an airblast sprayer due to a lack of labor available on the farm in the spring. The growers actually purchased the pheromones registered for use in NY and were reimbursed at 40-50% of the cost for the 150 acres. Pheromones were to be applied at first flight and followed up with 2-3 per generation of flight until flight numbers were reduced to less than 5 moths per trap per week.

CM and OFM/LAW moth flight was monitored in trap stations set at 3-5 acre intervals around the 150 acres. Trap stations were also placed in nearby orchards to compare to undisrupted populations. We used Pherocon IIB traps and Trece OFM standard lures, hung 5 feet off the ground, and CM 10X lures hung in the tops of trees. Traps were checked weekly, and counts were reported to growers and illustrated on a kiosk by color coding to report the trap activity in the neighborhood.

Insecticides were applied based on efficacy for control of CM/OFM and timed based on the MSU model for the first generation, and followed up for the second generation based on high trap counts exceeding 5 moths per trap per week. The first generation was generally controlled at 1st and 2nd cover using Calypso. The second generation egg hatch in August was controlled using Delegate (newly registered in NY that year). Any flight activity between those periods was addressed using organophosphates since NY had limited insecticides registered for use against these pests.

Fruit damage assessments were made in July to evaluate control of the first generation, and followed up with harvest evaluations by picking fruit from trees, 50 apples from top and 50 from bottom from each of 5 trees scattered across the individual blocks of fruit by variety – over 18,000 apples.

In 2009, the growers chose the new technology with low labor input – Suterra Puffers for CM placed at 1 per acre with border spays of sprayable CM-F applied as needed. Trap monitoring and fruit inspections were done through the season. The CM lures were split across 3 different types: CM L2 (longlife standard lures), CM10X, and CM-DA Combo lures. Insecticides used included Calypso, Delegate and newly registered Altacor to address egg hatch after high trap numbers.

Measures of Success:

Trap counts:

Trap counts using sprayable pheromones were not zeroed most of the 2008 season due to 1) inconsistent saturation of the orchards with pheromone, 2) the tendency of growers to wait until they detect significant CM flight before they apply pheromone, 3) and the delay in waiting until an insecticide was scheduled. Growers also experienced rainfall removing the pheromone residue. The 2008 seasonal total number of moths caught per trap was 150 CM. Trap shut down in 2009 was improved compared to 2008. The comparable lure, CM 10X, caught only 11 moths for the seasonal per trap total compared to 150 the previous year – a 92% reduction. The non-mating disruption counts were reduced from 2008 levels by only 58%.

Insecticide use and cost:

Pheromones added $120 per acre and still required 5-6 insecticides the first season in this heavy pressure orchard. The insecticide choices in 2008 were changed from organophosphates (OPs) and pyrethroids used in 2007, to neonicotinoids and Delegate targeted at egg hatch. In 2008, growers spent nearly $300 managing CM and OFM.

In 2009, growers reduced insecticide applications to 3-4, reducing cost to $216-250 per acre, but not as low as hoped. This project has shown that new classes of insecticides are more expensive than older OP's and pyrethroids but more effective.

Fruit Damage Evaluation:

The overall damage at harvest in 2008 was 0.7% deep feeding, 1.8% sting damage just skin deep, and .3% worms in fruit compared to >12% damage in 2007. In 2009, there was essentially 0% deep feeding detected, 0.1% sting damage, and in all of the 18,000 apples, one worm was detected and identified as OFM (which was not under pheromone disruption). The non-mating disruption plots had approximately 1% deep and 1% sting damage. The pressure in 2009 was not as great as 2008 due to the cool, wet weather interfering with CM mating activity.

Economic Risk:

Partial Budget Analysis showed that mating disruption is an economically feasible solution for growers who divert 5-10% of fruit from juice grade to regular and premium grade apples o 50 acres of premium varieties at $12.5-13 per cwt. In this circumstance, the grower increased available cash to the operation in the range of $319-17,500. Mating disruption is economically feasible if:

- implemented in moderate to high pressure orchards that typically sustain 5-10% damage.

- used in orchards with moderate to high yield of 750-1200 bushels per acre.
- used in orchards with high value apples with a regular vs. premium price of $12.50-13.00 per cwt (100 lbs.).

This partial budget analysis predicts that if apple prices are less than $11 per cwt even in the first year to clean up the population, the high insecticide costs plus pheromone costs do not break even or result in more cash available. In subsequent seasons, this analysis method suggests that the benefits of improved fruit quality in the second and third season, the pheromone and insecticide costs must decrease in order to break even again. When growers are implementing mating disruption on a multi-year basis, the special sprays for CM can be applied as recommended for "low" pressure orchards, one spray per generation and if no damage is resulting, experience has shown that even certain pheromone application rates can be reduced on a case by case basis. An Excel Workbook was developed and will be available on the Risk Management Library website for growers to assess the economic risks and benefits of using mating disruption.

Although it does not appear to be economical in the second and third season after the population is reduced and controlled during the first season using pheromones and insecticides, the reduction in insecticide costs, possible reduction in pheromone costs, and the increased available cash from improved control the first season over the multiple year system improves the economic and environmental impact. Overall, using mating disruption in theory will result in less mating, fewer eggs, and fewer eggs hatching and causing the sting and deep damage. In insecticide programs only, stings will continue to be an issue, at least in fresh fruit, since most of the insecticides used at this time for CM do not impact on adults and must be ingested by taking a bite of fruit.

Summary:

This project has been successful in reducing trap catch signifying reduced moth activity, and in combination with effective insecticides and timing, has resulted in significantly reduced damage. The value is clear in cleaning up high pressure orchards that sustain 5-10% fruit damage.

It is difficult to measure the economic value of the grower's reputation for wormy apples, and how that might impact on his ability to maintain a market for fruit. It is also difficult to measure the management time in operating around worm-damaged apples at harvest to avoid fruit rejections or downgrading quality. Only time will tell if mating disruption pheromones will continue to compete for the pest management budget. Under high pest pressure, and with the potential of insecticide resistance to new insecticides, mating disruption is still a viable pest management tool.

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SPLAT-OrB: A NEW PHEROMONE FORMULATION FOR ORIENTAL BEETLE MATING DISRUPTION IN BLUEBERRIES

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Abstract

A study was conducted in commercial blueberry farms to evaluate SPLAT OrB, a new pheromone formulation for oriental beetle mating disruption. In 2008, SPLAT OrB was compared to plastic 'bubble' dispensers at 2.5 and 5 g of (*Z*)-7-tetradecen-2-one, the major sex pheromone component of oriental beetle, per ha. SPLAT OrB was deployed at 500 and 1000 point sources per ha, while plastic dispensers were deployed at 50 per ha. Pheromone trap captures were similar in plots treated with both pheromone formulations and significantly lower than untreated control plots treated. In addition, fewer females were found mated, fewer males were found in female-baited cages, and lower number of grubs was found in sentinel pots in all pheromone-disrupted plots, regardless of formulation, compared to untreated plots. These studies indicate that SPLAT OrB is as effective at disrupting mating in oriental beetles as plastic dispensers. SPLAT OrB may help lower labor costs once mechanical applications of SPLAT OrB are allowed in blueberries.

Few options are currently available for management of oriental beetle in blueberries. The insecticide imidaclopid is the only treatment available for grub control. Having a single control method not only raises resistance management issues, but also magnifies the constraints in using imidaclopid itself: imidaclopid is expensive, requires precise timing of application, it has limited efficacy against large late-instar grubs, is highly leachable, and may disrupt pollination and biological control. The total amount of imidacloprid allowed per acre is also limited. Since its other principal use in blueberries is for aphid control, growers may limit its overall use for oriental beetle, or may consequently not use any control for oriental beetles, even if needed. Chemical control methods do not target the adult stage because adults cause limited damage, the emergence period is long and during harvest, and they are difficult to target with insecticide applications due to their cryptic behavior. Therefore, an additional control is desperately needed. The most promising option is the use of *mating disruption*.

Previous studies evaluated the feasibility of microencapsulated sprayable formulations of (*Z*)-7-tetradecen-2-one, the major oriental beetle pheromone component (Polavarapu et al. 2002). Trap captures in blueberry plots treated with the pheromone formulation were reduced by over 90% compared to untreated controls. Because the oriental beetle pheromone is a ketone, its use in sprayable microencapsulated formulations is restricted in fruit crops. An alternative formulation is the use of point-source dispensers, which are exempt for tolerance restrictions. Lower trap captures, lower mating rates, and fewer grubs were found in blueberry plots containing 50-75 hand-applied plastic dispensers/ha with (*Z*)-7-tetradecen-2-one at 1 g active ingredient per dispenser compared to the untreated plots (Sciarappa et al. 2005). Following, we conducted studies in 2005-07 to determine the minimal effective rate of dispensers per ha (Rodriguez-Saona et al. 2009). Because of the relative high cost of active ingredient, our work focused on reduced rates of pheromone in bubble dispensers in order to make bubble dispensers an affordable alternative to imidacloprid sprays. One of the more costly aspects of hand-applied dispensers is the labor required to attach single dispensers on individual blueberry bushes. A new formulation of pheromone is available in an inert matrix that can be applied semi-mechanically in small dollops. Known as "Specialized Pheromone & Lure Application Technology" (SPLAT), the flowable quality of the matrix may allow for a more economical application procedure though a mechanized process.

In the present study, we tested the efficacy of SPLAT formulated pheromone (SPLAT OrB) for oriental beetle mating disruption. We evaluated pheromone rates of SPLAT OrB equivalent to those of plastic dispenser used by Rodriguez-Saona et al. (2009) and proven to provide reliable mating disruption in oriental beetle. A reasonable cost of the formulated SPLAT OrB, mechanically applied at higher point densities than hand-placed retrievable dispensers should reduce treatment costs. By testing a new pheromone formulation, we will provide blueberry growers with more than one option to disrupt mating in oriental beetle and accommodate their own personal needs and costs.

Materials and Methods

The study was conducted in three commercial blueberry farms in New Jersey. We evaluated the efficacy of ISCA Technologies, Inc. SPLAT OrB flowable pheromone formulation at two point-source densities (500 and 1000 per ha; Table 1), providing two doses (2.5 and 5 g per ha, respectively) of the major component (*Z*)-7-tetradecen-2-one for oriental beetle mating disruption. The efficacy of SPLAT OrB formulation was compared to hand-applied plastic dispensers (bubbles) (Table 1). In a previous study by the PI (Rodriguez-Saona et al. 2009), field treatments of plastic bubbles with pheromone at the rate of 50 bubbles per ha, providing a dose of 2.5 and 5g of the active ingredient per ha, proved efficacious in disrupting oriental beetle mating. We tested the SPLAT flowable formulation applied to wood stakes, thus allowing for the precise measurement and positioning of 0.5 g SPLAT OrB dollops (each dollop contained 5 mg of (*Z*)-7-tetradecen-2-one). Pheromone-treated stakes were placed at the base of a bush. All stakes and dispensers were removed from fields at the completion of the study. Treatments (5) were replicated in three different blueberry farms (1 farm = 1 replicate), and each treatment within farm was at least 1 ha. Pheromone treatments (point-sources) were applied in an evenly-spaced grid among blueberry bushes.

Data collection

Trap shut-down: In each plot, three Japanese beetle sex pheromone traps (Trécé, Salinas, CA) baited with 300 μg of oriental beetle sex pheromone were placed and monitored weekly to determine male populations. Traps were placed in 6 June, 2 weeks prior to placing dispensers to obtain number of beetles before treatment.

Mating Assessment: Mating rates in each plot were assessed by placing five screened cages, each containing a virgin female. Virgin females were obtained by previously collecting larvae from infested turf grass and rearing them to adults. Cages were designed to allow males entering but preventing males and females from exiting (Rodriguez-Saona et al. 2009). Cages were placed in plots for three nights and then retrieved to determine male presence and female mating status by placement in 30 ml rearing cups with moist sand and to permit egg laying. Cages were placed in plots three times over a 2-week period: at the end of June (20 and 24 June), and 1st week in July (1 July).

Grub density: The potential number of grubs per plot was assessed by placing a virgin female in each of five pots containing a 2- to 3-yr old blueberry plant (N = 75 virgin females). New females were placed weekly for a total of 4 weeks. Pots were located near the center of the plot. Females were tethered to the plant using a fishing line carefully tied to the elytra. Pots with tethered females were placed in the field at the end of June. Number of grubs in each pot was determined by destructive sampling.

Statistical Analyses. The experiment was designed as randomized complete block with five treatments (Table 1) replicated in three different farms, with farm as the block. Data on number of beetles in traps, percent of mated females, and number of grubs per plot were analyzed using ANOVA. If needed, data were log-transformed for number of beetles in traps. Data for percent mated females were arcsine square-root transformed. Means were separated using Tukey tests. To assess reduction in trap captures, disruption index (DI) was calculated using (C – T)/C x 100, where C = average beetle capture per trap in control plot, and T = average beetle captures per trap in treatment plot.

Results

Male oriental beetle captures among various treatment plots were not significantly different prior to placement of disrupters (F = 0.17, df = 4,10; P = 0.95) (Table 1). Post-treatment trap captures were significantly lower in plots treated with pheromone dispensers compared to trap captures in untreated control plots (F = 43.16; df = 4,30; P < 0.001) (Table 1; Figure 1). There was also an effect of farm on number of beetles captured (F = 12.51; df =2,30; P < 0.001); however, there was no treatment × farm effect (F = 1.17; df =8,30; P = 0.347). The disruption index ranged from 64 to 93% (Table 1).

Female recovery rate from cages was high (88%), and did not differ among treatments ((F = 0.83; df =4,14; P = 0.534). Fewer mated females were found in all pheromone-disrupted plots, regardless of formulation, compared to untreated control plots (F = 12.29; df =4,30; P < 0.001) (Figure 2A). There was no effect of time of deployment on percent of mated females (F =0.50; df =2,30; P =0.609) or treatment-by-deployment interaction (F =0.96; df =8,30 P =0.488). Also fewer males were found in cages in disrupted plots compared to cages in untreated control plots (F = 16.13; df = 4,30; P < 0.001) (Figure 2B). However, there was no effect of time of deployment on number of males per cage (F =0.11; df =2,30; P =0.892) or treatment-by-deployment interaction (F =0.72; df =8,30 P =0.675). Pheromone treatment also had a significant effect on the number of grubs per pot. Lower number of grubs were found in disrupted plots compared to control plots (F = 7.88; df = 4,60; P < 0.001) (Figure 2C). The number of grubs per pot did not vary among farms (F = 1.79; df =2,60; P = 0.176), and the effect of treatment did not vary among farms (no significant treatment × farm interaction; F =0.81; df =8,60; P =0.593).

Table 1. Pheromone rates, point source density, and results from 2008 oriental beetle mating disruption trial conducted in three commercial high
New Jersey.

Treatment Name	Pheromone Rate (mg)[1]	PS/ha[2]	AI/ha[3] (g)	Pre-Treatment[4]		Post-Treatment[4]						
						Farm 1		Farm 2		Farm 3		F
Control	----	----	----	60.3 ± 29.5	A	593.0 ± 64.8	A	696.7 ± 147.4	A	1973.3 ± 48.5	A	
Bubble High	100	50	5	84.3 ± 32.8	A	109.0 ± 15.3	B	90.3 ± 24.7	B	130.3 ± 6.2	B	
Bubble Low	50	50	2.5	101.7 ± 48.0	A	213.0 ± 51.7	B	141.7 ± 40.9	B	277.7 ± 49.4	C	
Splat High	5	1000	5	115.7 ± 70.7	A	121.7 ± 9.4	B	147.7 ± 52.9	B	164.3 ± 34.9	BC	
Splat Low	5	500	2.5	106.7 ± 71.2	A	180.7 ± 31.5	B	131.7 ± 11.3	B	320.0 ± 55.5	C	

[1] Amount of active ingredient ((*Z*)-7-tetradecen-2-one) per point source

[2] Number of point sources (PS) per hectar

[3] Total amount of active ingredient (AI) per hectar

[4] Means ± SE; Different letters within a column indicate significant differences between treatments ($P \leq 0.05$; Tukey test)

[5] DI = (C - T)/C × 100; Where C = average beetle captures per trap in control plot, T = average beetle captures per trap in treatment plot

Figure 1. Cumulative number of male oriental beetles in traps from mating disruption trials conducted in 2008 in three commercial blueberry farms in New Jersey

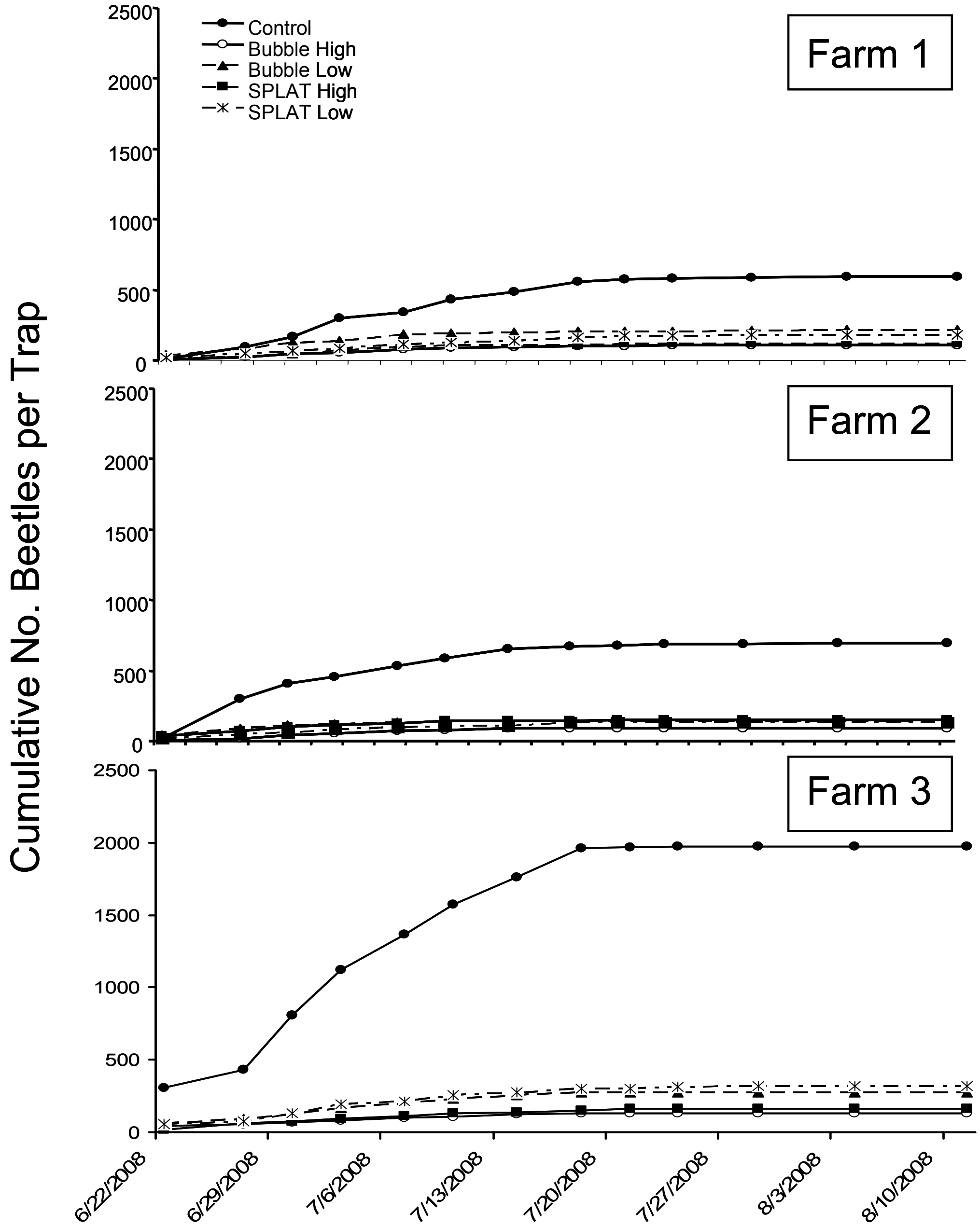
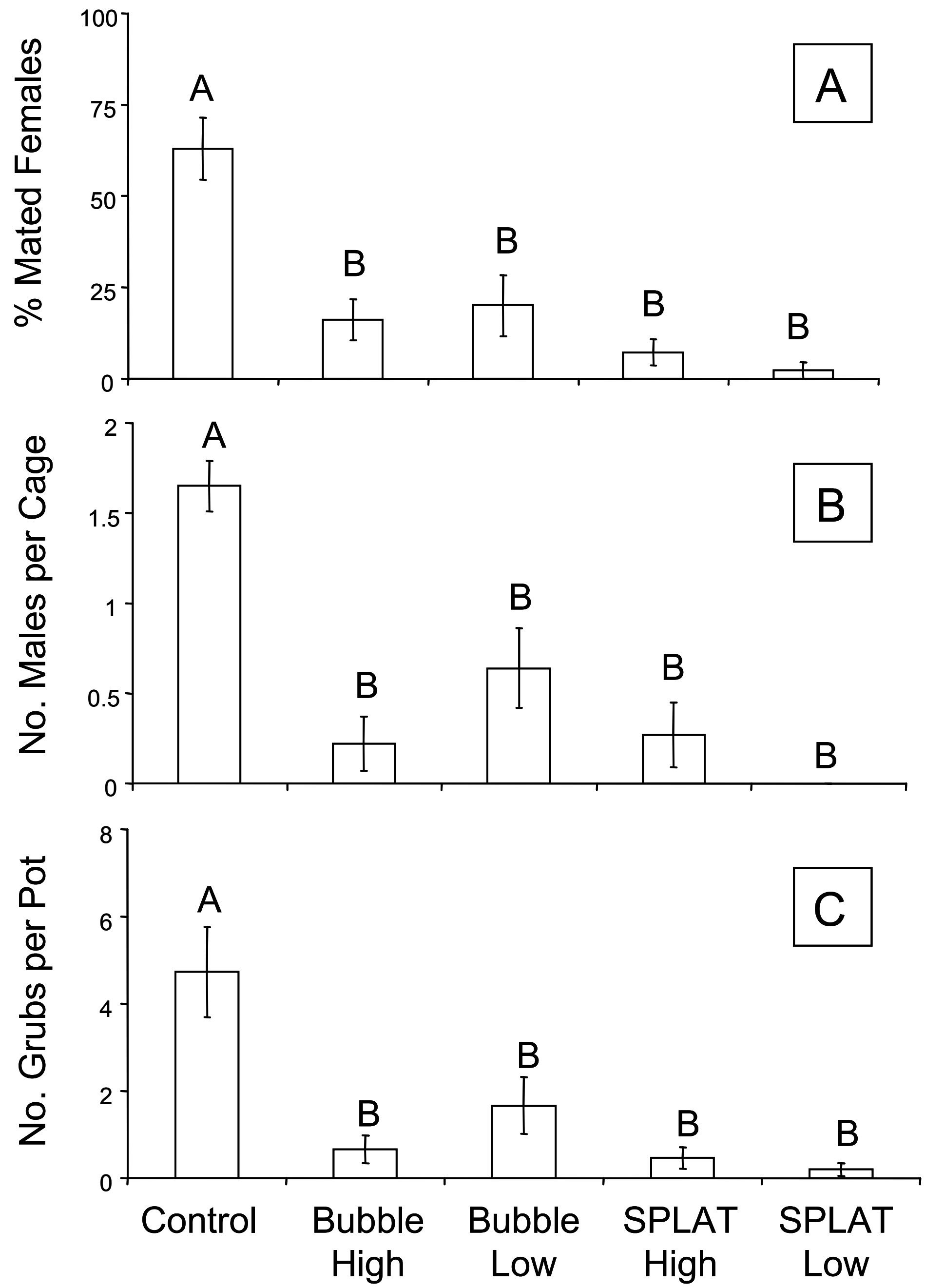


Figure 2. Percent of mated oriental beetle females (A), number of males in female-baited cages (B), and number of grubs (C) in control and pheromone-disrupted plots. Different letters indicate significant differences among treatments ($P \leq 0.05$; Tukey tests).



Conclusions

Our data indicate that both oriental beetle pheromone formulations, SPLAT OrB and plastic dispensers, provide effective oriental beetle mating disruption at rates of 2.5 and 5 g per ha in blueberries. Furthermore, this study shows that increasing the density of point sources from 50 to 500 per ha does not provide better mating disruption in oriental beetle. In fact, 50 dispensers per ha at a rate of 50 mg of (*Z*)-7-tetradecen-2-one per dispenser provided similar disruption of mating in oriental beetle as compared to 500 point sources of SPLAT OrB at a rate of 5 mg of pheromone per point source. Future work will develop devices to allow for mechanical application of SPLAT OrB, once this type of application is approved by EPA in fruit crops.

Acknowledgements

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GIS Source Data: Determining extent of forested area around Virginia vineyards

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I. Introduction

Vineyards throughout Virginia are surrounded by varying extents of forested habitat. Forested habitat in agricultural landscapes is found in the form of tree rows or hedgerows and areas of continuous forests. Naturally occurring in these forested communities are wild grapevines, which are particularly adapted to grow well in edge and disturbed environments. The abundance of wild grapevines in forested settings around vineyards increases the incidence of grape pests, specifically diseases and insects. Of particular interest is the grape berry moth that is a selective herbivore of grape, *Vitis* species, native to the eastern United States, and a major pest of cultivated grape in Virginia. Therefore, understanding the role of forested surroundings on the incidence of grape berry moth infestation in vineyards is pertinent.

By determining the amount of forested habitat within some proximity to a vineyard, researchers can evaluate the relationship of wild grape habitat to the incidence of grape berry moth infestation in cultivated grape. The objective of this study was to evaluate the difference in total forested area among various raster and vector data sources corresponding to area around vineyard blocks of interest. Sources of forested cover data included the 2001 National Land Cover Dataset, 1999-2000 Virginia Tree Cover data, 1999-2001 Virginia GAP data, and digitized polygon areas of tree cover delineated from 2002 Virginia Base Mapping Program Ortho-rectified aerial imagery.

II. Methods

The original raster data were obtained at a spatial resolution of 30 m, while aerial imagery (0.6 m resolution) was used to delineate forested polygon areas, which were then converted to raster data with 0.6, 10, and 30 m grid cell resolution. Raster conversion was done to contrast the digitized forested areas to data sources at similar and different scales. Source raster layers were reclassified to display areas that represented forested canopy cover. The classification codes designating forested areas of each data source were NLCD: 41-43, 91; Virginia Tree Cover: 1; and Virginia GAP: 2, 4, 5, 9, 64, 103-106, 111-113, 213-218. Up to a distance of 300 m from a vineyard area of interest, forested areas were digitized from aerial imagery for four vineyards with different extents and arrangements of surrounding canopy coverage. Only areas with continuous canopy cover greater than 5 m depth or length were digitized as forested canopy cover.

III. Results and Discussion

At a proximal distance of 200 m, Kentland Vineyard and Fincastle Vineyard had greater extents of continuous forest than Firefly Hill Vineyard or Naked Valley Vineyard, which were surrounded by more fragmented forested areas (Fig. 1; Tab. 2). Both 10 m grid and 30 m grid aerial raster images provided good approximation of 0.6 m raster images, although the 10 m raster was more consistent. Only 17% of the measurements of the 30 m aerial raster were more than 10% different from the 0.6 m aerial raster area, therefore I concluded that the 30 m aerial raster was a good approximation of the 0.6 m aerial raster. Important to note, in more than 80% of instances, the 30 m aerial was less than 10% different from the 0.6m aerial in contrast to less than 30% of instances for each of the alternative source data. In addition, there appeared to be an interaction between the abundance of forest at different search distances. At close search distances, results were variable while at 100 and 200 m distances, source data estimates more often approximated the 0.6 m aerial raster (Tab. 3).

Areas of greater forest fragmentation contributed to increased variability of forested area estimates. Kentland and Fincastle Vineyard were surrounded by more continuous patches of forest; therefore results were less variable at search distances that included larger patches of continuous forests (Tab. 4). This is in contrast to Firefly Hill Vineyard, which at the greatest search distance of 200 m, more fragmented area was included in the forest estimate. As a result, the RMSE of area estimates for Firefly Hill were greatest at the greater search distances (Tab. 4).

Initially this analysis was completed on four vineyards; however, more than 30 vineyards will be included in future analyses by developing a spatial model that will batch process basic steps. Some additional parameters that may assist with classification of forested extent include measures of shape index and edge perimeter. These two parameters may assist with discriminating between vineyard locations with continuous and fragmented forest surroundings. Nonetheless, efficient description and quantification forested habitat around a vineyard can aid in assessing the extent of potential wild grapevine habitat.

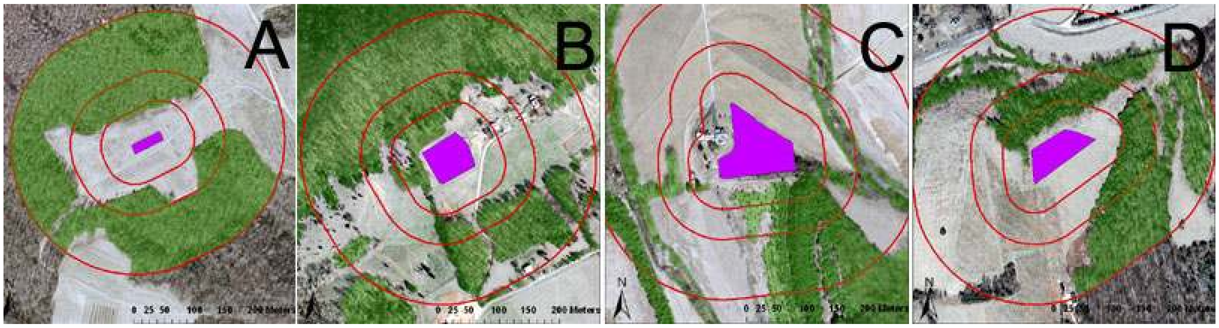

Figure 1. 2002 Ortho-rectified aerial imagery (0.6 m resolution) of vineyard locations used in study, including the vineyard at Kentland Farm (A), Fincastle Vineyard (B), Firefly Hill Vineyard (C), and Naked Valley Vineyard (D). All vineyards are shown at a scale of 1:3,255. Map area under green digitized as forest for area calculations at three search distances in red from a vineyard block (50, 100, 200 m).

Table 2. Evaluation of estimated forested area (hectares) for digitized aerial imagery at three search distances (50, 100, 200 m) from the perimeter of a vineyard block by converting polygon forested areas into three classes of raster grid resolution (0.6, 10, 30 m).

Search distance (m)		50			100			200		
Location	Vineyard area (Ha)	0.6m	10m	30m	0.6m	10m	30m	0.6m	10m	30m
Kentland Vineyard	0.08	0.09	0.10	0.09	1.68	1.70	2.07	9.62	9.61	10.71
Fincastle Vineyard	0.43	0.60	0.58	0.63	2.22	2.17	2.07	9.35	9.16	9.72
Firefly Hill Vineyard	0.91	0.48	0.51	0.45	1.65	1.62	1.80	5.16	5.25	4.86
Naked Valley Vineyard	0.45	0.47	0.53	0.72	2.23	2.27	2.25	6.66	6.78	6.66

Table 3. Evaluation of estimated forested area (hectares) for multiple raster data sources with 30 m spatial resolution at three search distances (50, 100, 200 m) from the perimeter of a vineyard block.

Search distance (m)		50				100				200			
Location	Vineyard area (Ha)	NLCD	DOF	GAP	Aerial	NLCD	DOF	GAP	Aerial	NLCD	DOF	GAP	Aerial
Kentland Vineyard	0.08	0.27	0.36	0.09	0.09	1.98	2.25	1.89	2.07	10.26	10.44	10.35	10.71
Fincastle Vineyard	0.43	0.95	0.90	0.72	0.63	2.36	2.16	2.07	2.07	8.43	9.00	9.99	9.72
Firefly Hill Vineyard	0.91	0.59	0.09	0.36	0.45	1.69	0.54	1.62	1.80	7.33	6.39	2.16	4.86
Naked Valley Vineyard	0.45	0.87	0.72	0.90	0.72	2.37	2.25	2.88	2.25	6.88	7.38	7.83	6.66

Table 4. Root mean square error (RMSE) in hectares across all 30 m raster data sources and vineyard locations, including an overall RMSE.

	Root Mean Square Error		
Source Buffer (m)	50	100	200
NLCD	0.37	0.33	1.40
DOF	0.33	0.74	1.66
GAP	0.33	0.50	3.28
Aerial	0.25	0.19	2.36
Kentland Vineyard	0.24	0.17	2.75
Fincastle Vineyard	0.41	0.26	1.70
Firefly Hill Vineyard	0.19	0.73	3.19
Naked Valley Vineyard	0.40	0.56	0.68
Overall	0.31	0.44	2.13

AN AUTOMATED SEX PHEROMONE TRAP FOR MONITORING ADULT CM AND OFM AND THE INFLUENCE OF TRAP COLOR ON MOTH AND NON-TARGET CAPTURES

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Insect monitoring can provide important information about the presence and density of specific populations of insects allowing for better timing and/or restriction of pesticide applications to reduce material and labor costs. Automation of insect trapping has the potential to further reduce labor costs by limiting the time and travel costs associated with this process. An automated, electronic sex pheromone prototype trap was designed and tested in the field in 2009 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.

Because color is known to affect trap selectivity, we performed studies to examine the effect of different colors of bucket style funnel traps (hereafter referred to as a 'bucket' trap) on both adult moth and non-target insect captures. While there are ways to use the electronic signal and the time of capture to limit false positive counts, we wanted to minimize the need for using those techniques by eliminating as many non-target catches as possible. Towards this end, five different trap combinations were tested for both CM and OFM in Biglerville, PA (Penn State University [PSU]), and for only CM in Quincy, WA (Washington State University [WSU]): two delta-type traps that were either orange or white (current standards), and three bucket style funnel traps that were painted orange, green, or white. At WSU, a third delta-type trap that was made of clear acetate was also tested. We tested the two trap types because delta traps are the current industry standard for monitoring both CM and OFM, but they are not suitable for housing the electronic components for the automated traps. Thus, we were comparing the moth trapping efficiency of the bucket traps and the delta traps. All traps in the color study were checked weekly, the number of moths was counted, and the number of non-target species was counted and categorized. An insecticidal strip (Vaportape® II) was placed in the bottom of all bucket traps to stun and kill the moths as they entered the funnel portion of the trap.

In addition to the color trap study, at both PSU and WSU we field tested 15 electronic prototype traps developed by engineers at Purdue University. The electronic traps were built using commercially available bucket traps and fitted with a micro-controller unit powered by 1.5V alkaline or NiMH rechargeable batteries. Four infrared (IR) emitters and four IR detectors lining the bucket trap funnel allowed for detection of insects passing through the funnel. Traps were also equipped with an internal clock that enabled users to set start and end operating times to reduce false positive counts from non-target insects and conserve battery power. The electronic trap prototypes were tested in the field with standard (control) bucket traps in order to compare moth capture rates. The electronic and standard CM bucket traps were modified by removing the circular top of the bucket trap and securing an orange plastic delta trap (no sticky liner) to the top of the bucket funnel. OFM traps were not modified in this manner until three weeks before the study ended. Codling moth traps at PSU and WSU were set to operate from 1700 hrs until 2200 hrs. Oriental fruit moth traps at PSU were set to operate from 1600 hrs until 2100 hrs and were later changed to operate from 1400 hrs until 2100 hrs. All CM and OFM traps were checked daily from mid-Aug. until mid-Sep., while OFM traps were checked daily until early Oct.

Data from the color trap study at WSU showed adult CM capture in orange bucket traps was similar to the number of moths captured in white or orange delta traps (Fig. 1). For non-target captures, the white bucket and white delta traps caught the most large non-target insects (e.g., bees, beetles, flies, etc.), while the orange bucket traps did not catch significantly more than the orange delta, which caught the least number of large non-target insects. At PSU, the orange bucket traps captured fewer CM adults than either the white or orange delta traps (approximately 25% capture of orange delta trap); however, the orange bucket trap captured numerically more moths than either the green or white bucket traps (Fig. 2A). For non-target captures, the white bucket and the white delta trap captured the greatest number of large non-target organisms, while the orange and green bucket and orange delta traps captured the fewest non-target organisms over the course of the study (Fig. 2B). For OFM, the green and orange buckets captured similar numbers of OFM adults, but their capture rate over the season was significantly lower than the white and orange delta traps (Fig. 3A). The capture rate of the green and orange buckets was approximately 80% lower than the respective delta traps. For non-target captures, there were no differences among any trap types and colors over the season, but the orange bucket and orange delta trap captured numerically the fewest large non-target organisms (Fig. 3B). Since the orange bucket trap captured a similar or greater number of CM and OFM adults than the other bucket colors and a lower number of non-target captures, the orange bucket was selected to house the prototype electronic components.

The electronic-equipped and non-electronic (standard) bucket traps were placed in a PSU orchard heavily infested with CM and OFM on 17 Aug. and the study continued until 18 Sep. for CM and 8 Oct. for OFM. A total of 420 moths were caught, 17 of which were CM and 403 were OFM. The standard traps captured about twice as many moths (CM and OFM combined) as the electronic traps (Fig. 4). Of the 17 CM adults captured, all were caught in standard traps. At WSU, a total of 18 CM adults were captured, 17 in the non-electronic traps and 1 in the electronic traps. A closer evaluation of the data showed that the one moth caught in the electronic traps occurred on a night when a battery fell out of the holder, so the results from PSU and WSU both showed that no CM were captured in functioning electronic traps. Ultrasonic waves produced by the clock mechanism inside the traps are suspected of deterring the moths, particularly CM, as they approach the trap. Other initial observations included the prototype electronic traps often recorded more events than the number of insects captured and less frequently captured insects that were not recorded as events. In addition, wind tunnel studies at WSU using clear acetate bucket traps showed that moths can fly up and down the funnel where the sensors are located in the electronic traps for up to 3 minutes before the insecticidal "kill" strip took effect. Even though the sensors were programmed to have a 10 second delay before a second event could be recorded, moths flying through the sensor path multiple times may also have contributed to falsely recorded events. The traps also occasionally produced a surge that was recorded as an event when the traps were initially activated. Since the electrical components were sensitive to electronic 'noise,' other falsely recorded events were likely due to low battery voltage and poor connections.

Based upon the data collected and observations made during this initial attempt to develop an automated, electronic monitoring trap for CM and OFM in 2009, a number of major changes to the design and functionality of this prototype trap will be made before the growing season in 2010.

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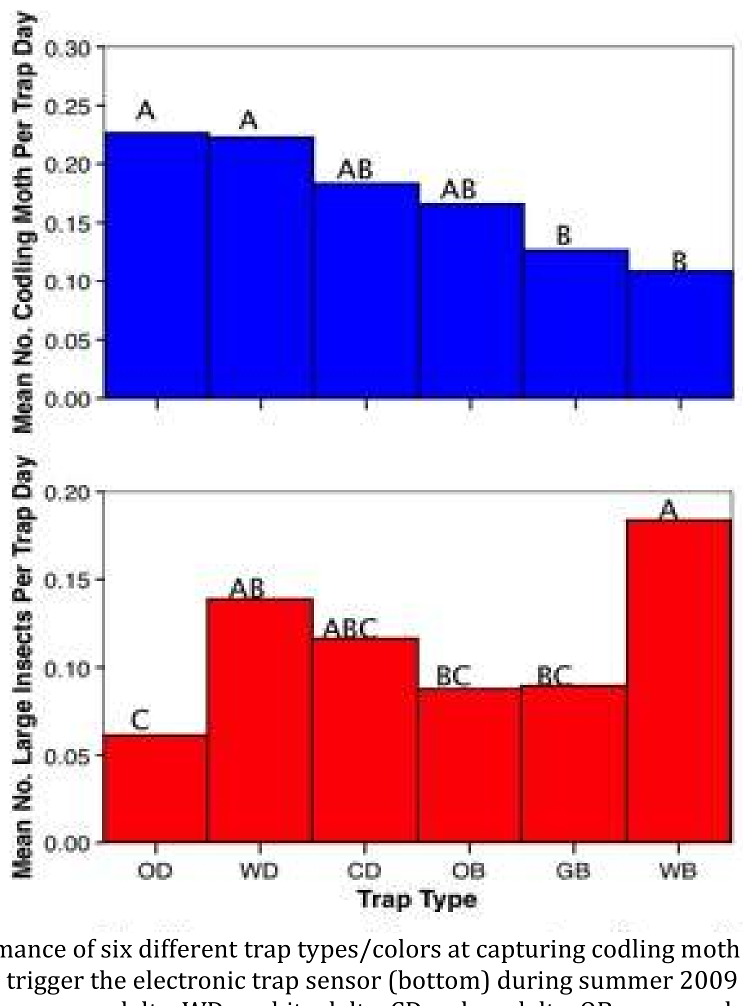


Fig. 1. Performance of six different trap types/colors at capturing codling moth (top) and non-target insects large enough to trigger the electronic trap sensor (bottom) during summer 2009 at a commercial orchard in Quincy, WA. OD = orange delta, WD = white delta, CD = clear delta, OB = orange bucket, GB = green bucket, WB = white bucket.

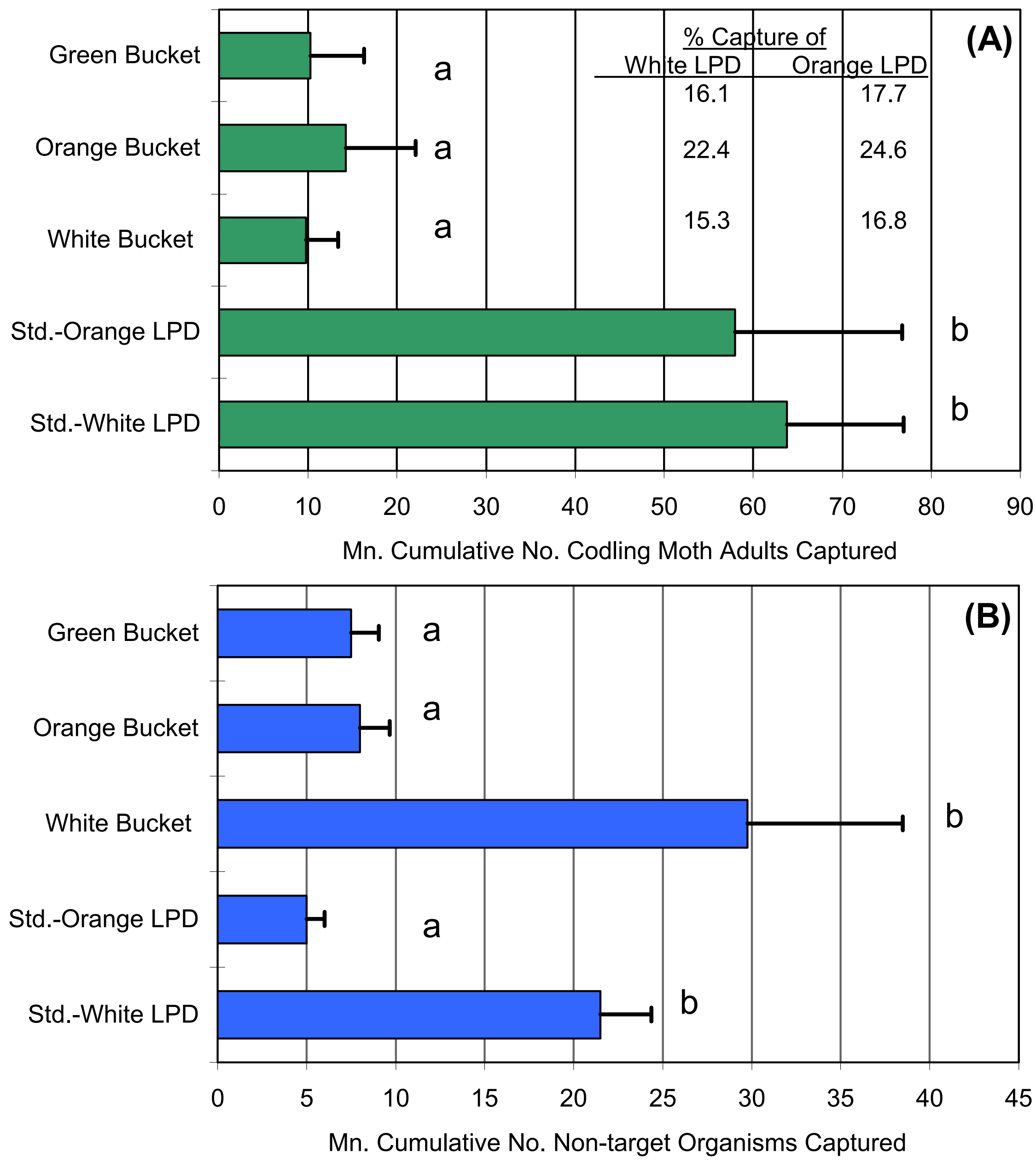
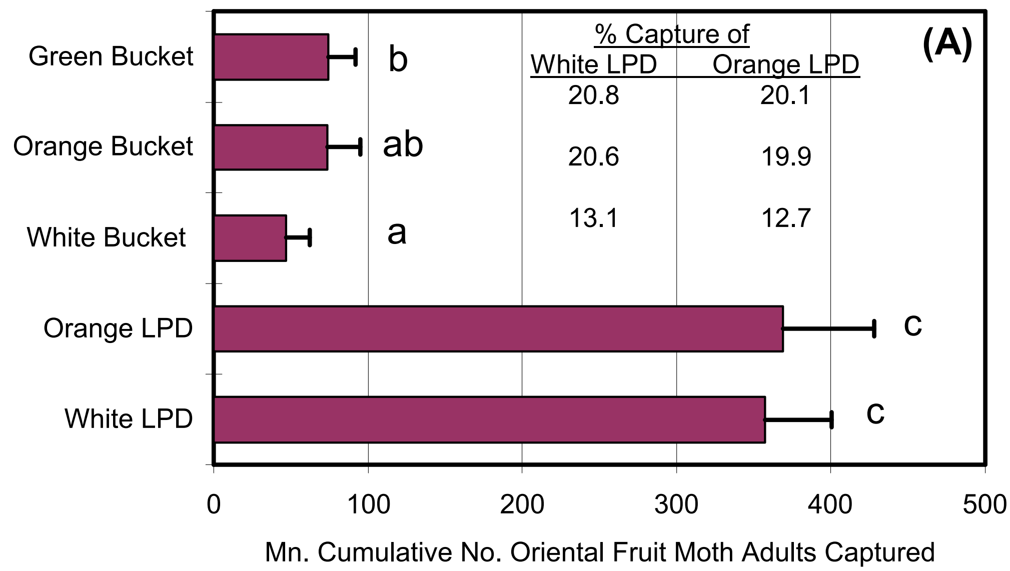


Fig. 2. Cumulative seasonal capture of adult codling moths (A) and of non-target insects (B) in three colors of "bucket" traps and two colors of standard Large Plastic Delta (LPD) traps in Pennsylvania apple orchards from 11 May to 8 Sep., 2009. The non-target insects consisted primarily of honeybees, flies, coccinellid beetles, true bugs, etc.



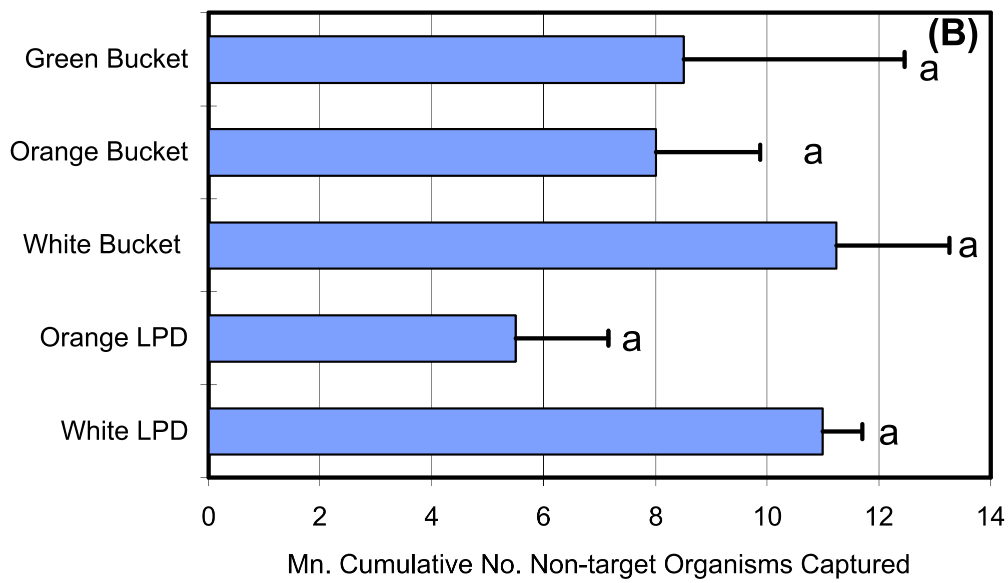


Fig. 3. Cumulative seasonal capture of adult oriental fruit moths (A) and non-target insects (B) in three colors of "bucket" traps and two colors of standard Large Plastic Delta (LPD) traps in Pennsylvania apple orchards from 11 May to 8 Sep., 2009. The non-target insects consisted primarily of honeybees, flies, coccinellid beetles, true bugs, etc.

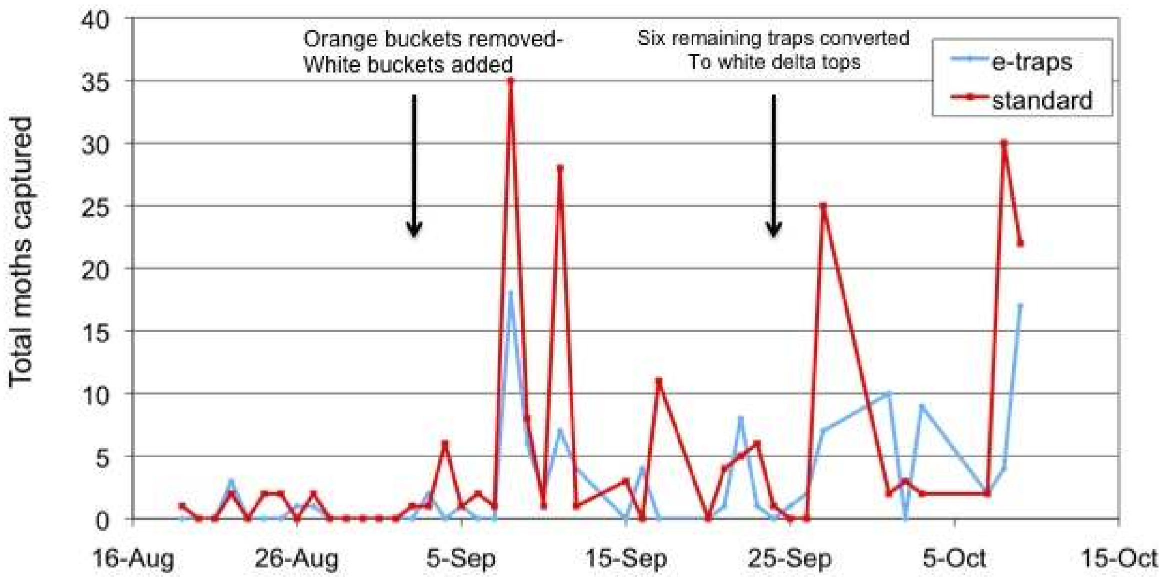


Fig. 4. Total moth captures (CM and OFM) in standard traps compared to electronic traps from 18 Aug. to 8 Oct. Codling moth traps were placed in the field on 17 Aug. and 26 Aug. for OFM. Trapping ended on 18 Sep. and 8 Oct. for CM and OFM, respectively.

Effects of Geranium Exposure on Japanese beetle (*Popillia japonica*) Feeding on Primocane-bearing Raspberries

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Introduction

Today raspberries are the third most popular fresh use berry in the United States (Stanton et al. 2007). The fruit contain soluble fiber, vitamins, and minerals and, like other fruits, contain their greatest nutritional value when fresh (Pritts and Handley 1989). However, harvesting an aesthetically pleasing fresh fruit is difficult due to the delicate fruit being damaged by insect pests, diseases, and natural decay (Shoemaker 1987). It is also important to use control methods providing a short pre-harvest interval to insure the berries do not decay before they can legally be harvested. Therefore, control strategies allowing a safe and optimal harvest should be tested.

In Virginia one of the most serious pests of raspberries is Japanese beetle, *Popillia japonica* Newman. This highly polyphagous beetle chews small holes in the fruit and skeletonizes the leaves of raspberries (Spangler and Agnello 1989, Demchak et al. 2006). The adults emerge from the soil during late June or early July and are present when the primocane-bearing varieties bear fruit in late July. Injury caused by the beetles not only makes fruit unmarketable, it makes the plants susceptible to diseases. A critical element in controlling Japanese beetle on brambles is the need for a short pre-harvest interval. Currently, most insecticides labeled for Japanese beetle control, such as Sevin, have longer pre-harvest intervals. Therefore, utilizing cultural control will put us one step closer to providing raspberry growers with an effective integrated control program for Japanese beetle.

A proposed method for the control of the Japanese beetle involves utilizing geranium toxicity. Zonal geraniums (*Pelargonium* x *hortorum*) have been reported to attract the Japanese beetle and paralyze them after feeding (Ballou 1929, Potter and Held 1999). The narcotic effect of geranium on Japanese beetles is greater when geraniums are exposed to sunlight and when the beetles feed on the flowers verses the foliage (Ballou 1929). After feeding on geranium beetles recover from their paralysis or die shortly after recovery. Beetles that survive still prefer to feed on geranium over other highly palatable foods despite the previous paralysis caused by the geranium (Potter and Held 1999). Beetles that are previously exposed and paralyzed by geraniums consume more plant material than beetles exposed to geraniums for the first time. This study examined whether the geranium's paralyzing capabilities can be used as a control method for Japanese beetle feeding on raspberries.

Materials and Methods

To test geraniums as a Japanese beetle control method on raspberries bioassays were conducted in a laboratory controlled setting. Japanese beetles were collected from exterior bucket traps baited with Tanglefoot® Japanese beetle bait and lure. Only live, active beetles were used in the experiments. 'Prelude' leaves were picked freshly from planted raspberry canes and the leaves' stems were wrapped with a moist cotton ball to keep the plant material alive. Red zonal geraniums (*Pelargonium* x *hortorum*) petals were also picked and the stems were wrapped with a moist cotton ball. All of the experiments took place within individual aerated plastic containers (16.3 x 17.8 x 9.7 cm). Resulting injury was measured from digital images using ImageJ (http://rsbweb.nih.gov/ij/download.html).

Bioassay 1: Exposure to Raspberry leaf vs. Exposure to Geranium petals

Individual Japanese beetles were placed into 15 containers that contained raspberry leaves and 15 separate containers that contained geranium petals. After 24 hours of exposure to either the raspberry leaves or the geranium petals, the beetles were moved into fresh containers that contained only raspberry leaves. The beetles were then allowed to feed on these leaves for 24 hours. After this time, digital images were taken of the leaves and the amount of injury was calculated.

Bioassay 2: Exposure to Raspberry leaf and Geranium petal vs. Raspberry leaf

Individual Japanese beetles were placed into 15 containers that contained raspberry leaves and geranium petals and 15 separate containers that contained only a raspberry leaf. After 24 hours of exposure digital images were taken of the raspberry leaves and the amount of injury was calculated.

Bioassay 3: Choice test, Presence on Raspberry leaf or Geranium petal

Two Japanese beetles were placed into 15 containers that contained raspberry leaves and geranium petals. After 24 and 48 hours, the location of the beetles was noted as on the raspberry leaf, on the geranium petal, or on neither.

Results and Discussion

Japanese beetles that were previously exposed to geraniums caused significantly less injury to raspberry leaves than the beetles that were previously exposed to raspberry leaves (Figure 1). There were numeric differences which show that previous feeding on geraniums did lessen the amount of injury. If the test's replications were increased or if the beetles were allowed to travel from geranium to raspberry the control may be greater.

When the beetles were allowed to feed on geranium petals and raspberry leaves versus raspberry leaves alone, the percent injury to the raspberry leaves was significantly reduced (Figure 2). Therefore, constant exposure to geranium significantly lessened the amount of defoliation. The findings of this test could be a result of there being more plant material for the beetles to feed on relative to the geranium actually controlling defoliation. Future tests should be conducted to see how close to each other the geraniums and raspberries would need to be in order to achieve Japanese beetle control.

When the beetles were allowed to choose between resting on raspberry leaves or geranium petals, the beetles preferred to be on the raspberry leaves (Figure 3). After 24 hours there were numerically more beetles present on raspberry leaves verses geranium petals; after 48 hours this difference became significant. Because the beetles prefer to be present on the raspberry leaves, more tests should be conducted to see if companion planting with geraniums would be an applicable control option. Also, the actual amount of geranium plant material that needs to be consumed by the beetles for control should be tested.

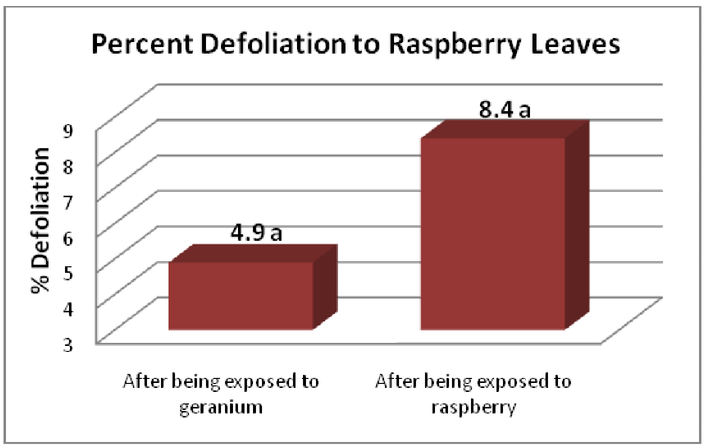

Figure 1. Percent defoliation of 'Prelude' raspberry leaves after 24 hours of Japanese beetles exposure that were previously exposed to either 'Prelude' raspberry leaves or Zonal geranium petals for 24 hours.

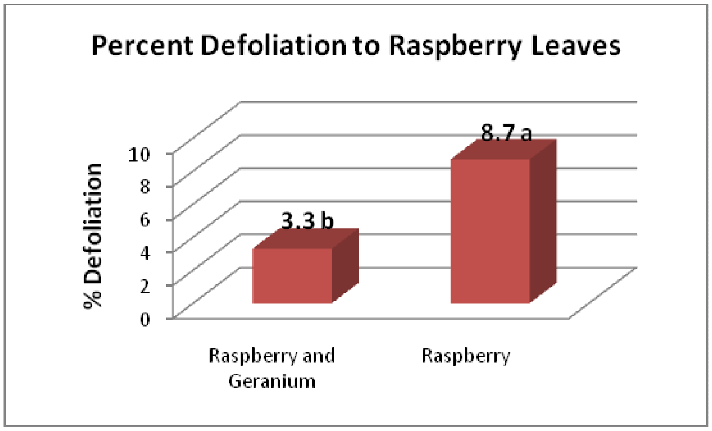

Figure 2. Percent defoliation of 'Prelude' raspberry leaves after 24 hours of Japanese beetles exposure. Japanese beetles were exposed to either raspberry leaves and geranium petals or raspberry leaves only.

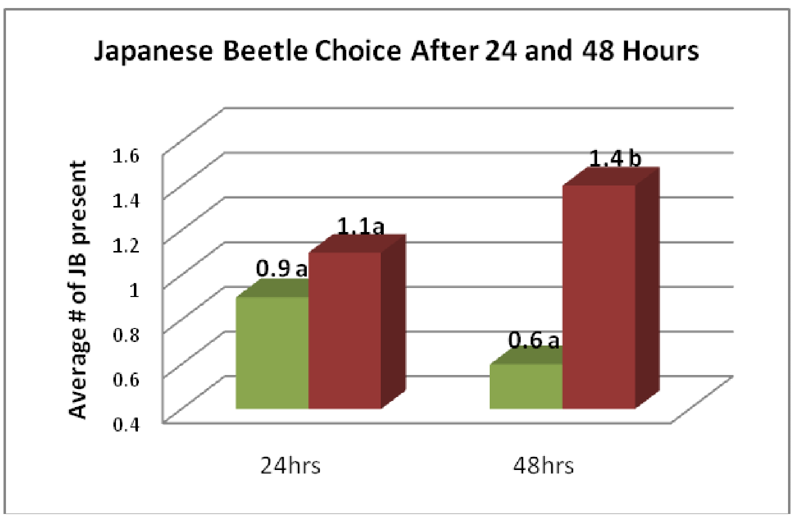

Figure 3. The average number of Japanese beetles present on 'Prelude' raspberry leaves or Zonal geranium petals after 24 or 48 hours.

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Stink bug (Hemiptera: Pentatomidae) Activity on Raspberries

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Introduction

Stink bugs can have up to five generations annually and are present during most crops' production seasons (McPherson and McPherson 2006). This pest family's impact on raspberry production is not completely clear; however, sucking injury from the insects has been observed on caneberries. Adults and nymphs pierce plant tissues to extract plant fluids. Also, the offensive odor that stink bugs produce has been known to make the berries distasteful (Ellis et al. 1991). Therefore, even if they do not physically damage the fruit they can still contaminate the harvest. Stink bug injury on different stages of buds and fruit needs to be documented so we can better understand their impact.

Methods:

Digital images and videos were taken in order to capture stink bug activity on raspberries.

Results and Discussion:

Stink bugs feed on the veins of raspberry leaves (Figure1 and Figure 2), on the sepal (Figure 3) and in between the drupelets of ripe and unripe berries (Figure 4, Figure 5, and Figure 6) of a raspberry plant. The resulting injury on the berries is in between the drupelets (Figure 7). Stink bugs defecate on the berries leaving a distasteful solution on the berries (Figure 8), which also makes the fruit undesirable. For a video of stink bug feeding, please visit: http://www.virginiafruit.ento.vt.edu/greensbyellowrasp.wmv

Figure 1. Brown stink bug feeding on a vein of a raspberry leaf.

Figure 2. Brown stink bug feeding on the underside of a raspberry leaf on the vein.

Figure 3. Brown stink bug feeding on the sepal of a raspberry plant.

Figure 4. Brown stink bug feeding in between the drupelets of an unripe red raspberry.

Figure 5. Brown stink bug feeding in between the drupelets of an unripe red raspberry.

Figure 6. Green stink bug feeding in between the drupelets of a 'Fall Gold' raspberry.

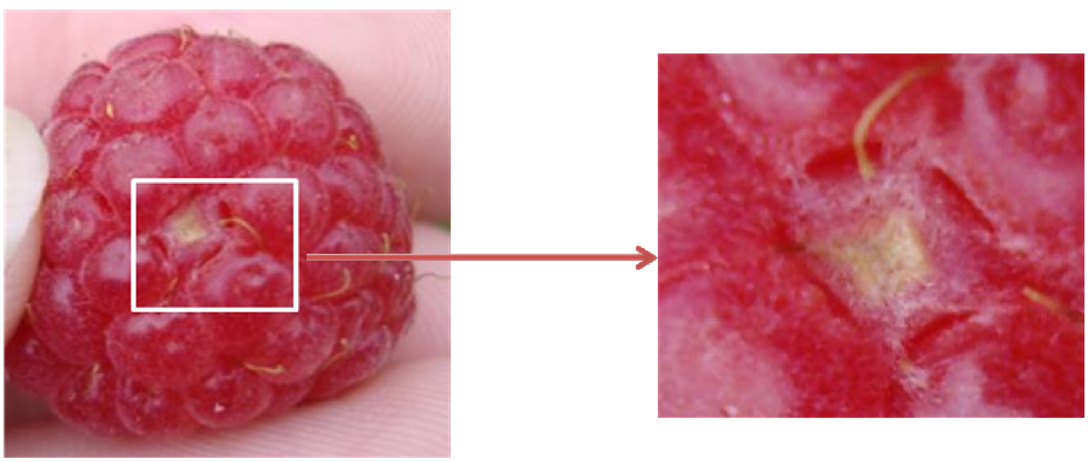

Figure 7. Enlarged image of stink bug damage on a red raspberry. Injury is seen as holes in between the drupelets and this caved-in drupelet.

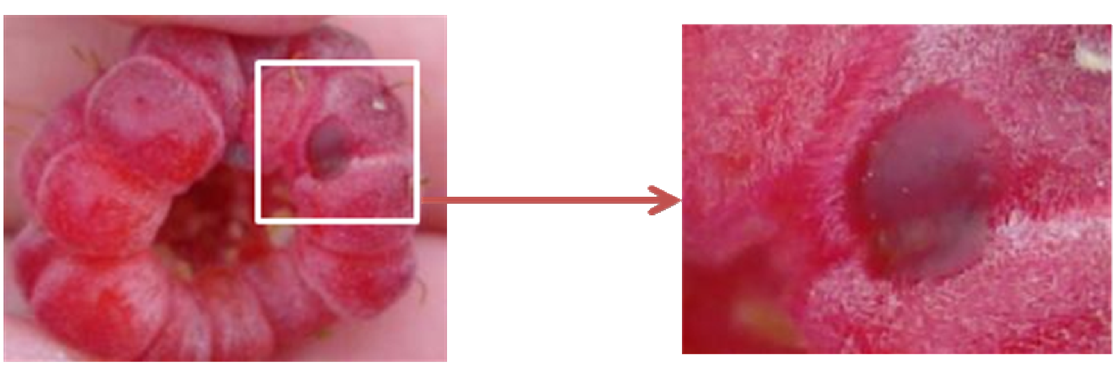

Figure 8. Enlarge image of stink bug excretions which is another resulting injury from stink bugs on raspberries.

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Control of grape root borer using mating disruption - 2009

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I. Introduction: Grape root borer, *Vitacea polistiformis* (Harris) (Lepidoptera: Sesiidae), is a pest of increasing significance in Virginia vineyards (Pfeiffer et al. 1990, Bergh et al. 2005). Control is difficult; there are several approaches available, but none are highly effective or practical. Lorsban applied as a barrier treatment is not highly effective throughout the protracted oviposition and adult emergence period. Soil mounding is often impractical, and is difficult to time to control the entire generation. The use of entomopathogenic nematodes has received some attention. *Heterorhabditis bacteriophora* was one of the most effective species against GRB in a study by Williams et al. (2002). A vineyard in Patrick County has a severe infestation of GRB, and mating disruption was attempted there, as well as a rescue treatment in which a nematode-laden drench was allowed to soak the root zone close to the crown of the vines.

II. Materials and Methods: In an earlier study (Pfeiffer et al. 2005), mating disruption research was carried out in a vineyard in Patrick County over three seasons. Ropes were placed on 17 Jul 2003, 6 Jul 2004, and 26 Jul 2005. Rope style dispensers were obtained from CBC America, containing a blend designed for mating disruption of the currant clearwing, *Synanthedon tipuliformis* Clerck (Isonet Z): (*E,Z*)-2,13-octadecadien-1-yl acetate (100) and (Z)-13-octadecadien-1-yl acetate (5) (Priesner et al. 1986). The GRB pheromone blend has been described as (E,Z)-2,13-ODDA (99), (Z,Z)-3,13-ODDA (1) (Snow et al. 1986). Ropes were applied to vineyard trellis posts at the rate of 494/ha (200/A). That study resulted in reduced incidence of grape root borer, and grower satisfaction with reduced vine mortality.

In the present study, research continued in Patrick County, with a shift in treatment blocks. Disruption was attempted in a new part of the vineyard; the control was the area used for disruption in the earlier study (Pfeiffer et al. 2005). Experimental plots were established in two additional vineyards, one in Orange County (northern Piedmont), and one in Northampton County (Eastern Shore (Delmarva Peninsula)). The new vineyards exhibited GRB infestations, with a heavy infestation found on the Eastern Shore. In addition to new research sites, the present study employed a placement rate of rope dispensers of 247/ha (100/A), in order to improve cost efficiency to growers. Treated areas were each ca 2 ha (5 A). Ropes were placed near the beginning of adult flight in 2007. Eclosing adults this year reflect the first disrupted generation. Pupal counts were made 30 Sep, 1 Oct in Patrick, Orange and Northampton counties, respectively.

III. Results:
Mating disruption provided effective control of GRB in this study using a reduced rate of pheromone dispensers. In the most heavily infested vineyard, exuviae were reduced by about 97%. In the moderately infested vineyard, the reduction was total. In Patrick County, there was no significant difference between the pheromone block and control, but

in this case the control had been treated with mating disruption for the three previous years.

Table 1. Grape root borer exuviae per 10-vine samples, with 10 samples taken per plot (100 vines).

Vineyard	Control	Mating Disruption
Patrick County	0.4	0.1 ns
Orange County	0.6	0.0 *
Northampton County	3.0	0.1 **

Data were transformed for analysis $[(x+0.5)^{0.5}]$. Single asterisk denotes significance at α=0.05; double asterisk denotes significance at α=0.01.

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FRUIT QUALITY AND SPRAY PROGRAMS IN NJ PEACH ORCHARDS

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Fruit IPM program post harvest data was reviewed and compared to recent pesticide programs now used in peach orchards. Each year we sample multiple varieties of peaches either as they are harvested or from bulk bins in storage, prior to being sorted. Each sample consists of 100 fruit from and individual block/variety and picking. Normally 3 samples (300 fruit) are examined for each sampling. We examined data from the past 19 years that included all peach growers in the NJ IPM program, and totaled 6,931 samples or 693,100 fruit over that time period.

Insect injury is summarized below. The survey data consists of varying numbers of samples from different farm sites with different varieties over the years, and was not statistically analyzed. The percent clean fruit did not seem to vary a great deal over the years (Table 1,2), but numerical trends are apparent for injury from tarnished plant bugs and stink bugs (Catfacing injury), plum curculio, and internal and external worms, or oriental fruit moth and tufted apple budmoth. The percent clean fruit fluctuated from a low of 82.93 in 2002 to a high of 91.39 in 2009 (Figure 1). The percent clean fruit is also a measure of disease incidence, which is not included here. From the years from 1999 through 2002 catfacing injury was the highest. Coincidently, these were the first few years after the removal of methyl parathion from peach use, and growers were trying to adjust with substitute products. Plum curculio injury appears with an increasing trend over the last few years since 2007 (Figure 2). We interpret this as a result of growers moving away from azinphos-methyl to reduced risk chemistries that are either not as effective, or growers being not accustomed to applying specific products for PC control. Tufted apple budmoth shows a decreasing trend since 2003, and oriental fruit moth has been rare over the last 3 years (Figure 3).

We also looked at grower insecticide use on 3 random farms from which we had data over the last 8-12 years. (Tables 3,4,5), and coded these growers by letter: D,G, and S. Several trends emerge. First, in terms of the number of applications made, defined as 1 spray with 1 material either alternate row middle or every middle, there is a general decrease in the use of organophosphate and carbamate materials. Secondly, there is an increase in the use of pyrethroids. While farms varied in size, each of tables 3-5 tracks the same farm size over multiple years, so an increase or decrease in the number of applications is a true measure of use. Examination of these same insecticide use records shows that some growers used from 14 to 15 consecutive pyrethroid applications. This emerging pattern is worrisome if only from a resistance management angle. Alternatives to multiple, consecutive applications and overuse of pyrethroids should be encouraged.

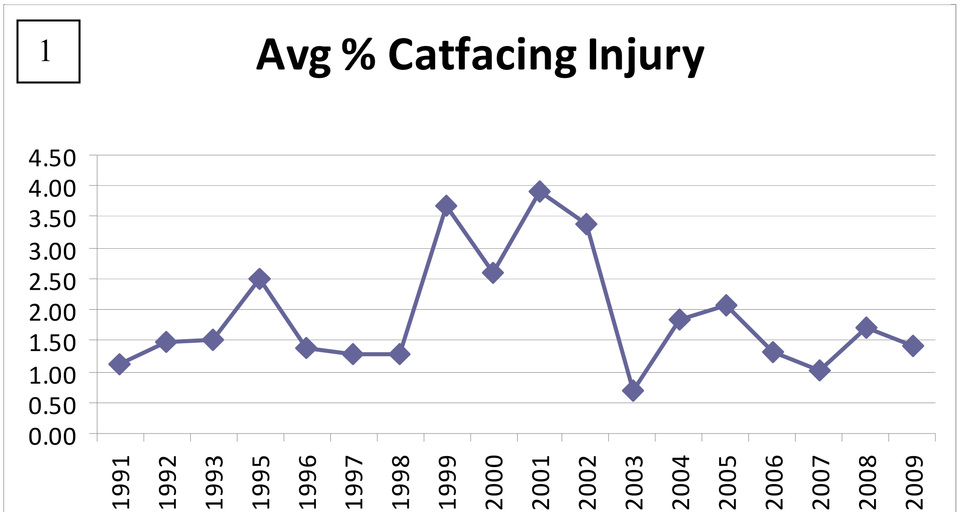
Table 1. Percent Insect Injury

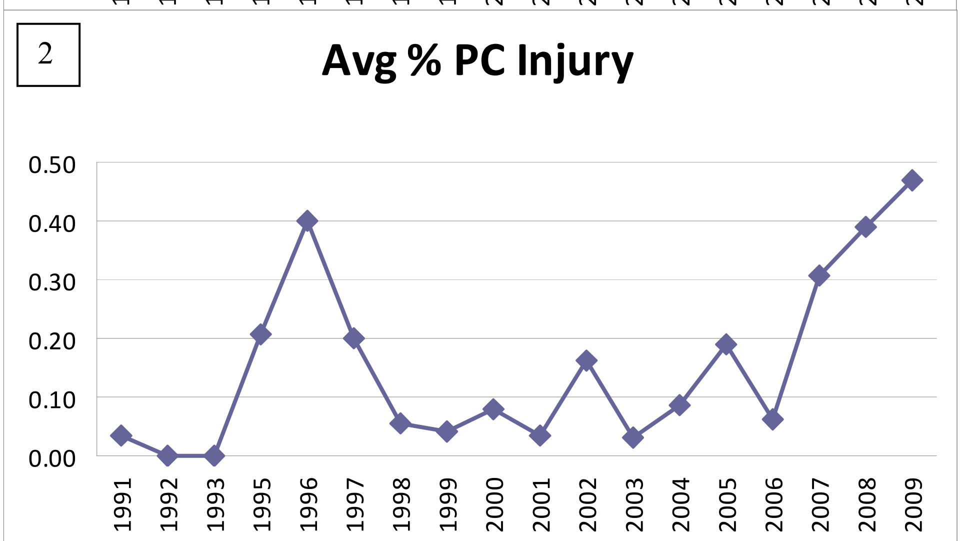
YEAR	CF	PC	OFM	JB	ET	LT	Clean
1991	1.11	0.03	0.18	0.03		0.00	81.28
1992	1.46	0.00	0.17	0.22		0.21	88.75
1993	1.51	0.00	0.29	0.25		0.15	86.30
1995	2.51	0.21	0.31	0.27			85.63
1996	1.39	0.40	0.15	0.26			90.54
1997	1.27	0.20	0.06	0.22			85.63
1998	1.27	0.05	0.24	0.36	0.50	1.96	85.67
1999	3.70	0.04	0.14	0.21	0.09	0.90	85.77
2000	2.61	0.08	0.18	0.13	0.06	0.16	88.77
2001	3.92	0.03	0.28	0.15	0.38	0.59	88.48
2002	3.39	0.16	0.24	0.10	0.67	2.02	82.93
2003	0.69	0.03	0.02	0.06	0.00	0.10	85.97
2004	1.84	0.09	0.02	0.20	0.10	0.56	89.46
2005	2.07	0.19	0.03	1.06	0.00	0.10	90.22
2006	1.31	0.06	0.22	0.53	0.02	0.28	86.68
2007	1.02	0.31	0.03	0.21	1.97	0.12	87.00
2008	1.72	0.39	0.05	0.38	0.00	0.57	84.15
2009	1.40	0.47	0.04	0.02	0.00	0.08	91.39
$\bar{X}$	2.17	0.15	0.15	0.26	0.26	0.70	86.92

Table 2. Percent Insect Injury

YEAR	TABM	OBLR	SJS	GPA	WPS	MINS	Clean
1991	1.72	0.00			0.00		81.28
1992	0.74	0.00			0.00		88.75
1993	1.38	0.00			0.00		86.30
1995	0.83	0.00	0.26		0.00		85.63
1996	0.42	0.00	0.00		0.00		90.54
1997	0.34	0.00	0.00		0.00		85.63
1998	0.78	0.00	0.11	0.31	0.00		85.67
1999	0.34	0.00	0.08	0.03	0.00		85.77
2000	0.46	0.00	0.45	0.04	0.00		88.77
2001	0.69	0.01	0.09	0.02	0.01	0.14	88.48
2002	0.76	0.01	1.03	0.04	0.00	0.19	82.93
2003	0.47	0.00	0.02	0.00	0.00	0.04	85.97
2004	0.07	0.00	0.31	0.00	0.00	0.06	89.46
2005	0.14	0.00	0.01	0.00	0.00	0.09	90.22
2006	0.04	0.00	0.44	0.01	0.00	0.00	86.68
2007	0.00	0.00	0.15	0.01	0.00	0.00	87.00
2008	0.01	0.00	0.00	0.00	0.00	0.00	84.15
2009	0.01	0.00	0.09	0.00	0.00	0.04	91.39
$\bar{X}$	0.46	0.00	0.23	0.06	0.00	0.08	86.92

Figures 1, 2, 3. Catfacing, Plum Curculio, and Oriental Fruit Moth & Tufted Apple Budmoth Injury.





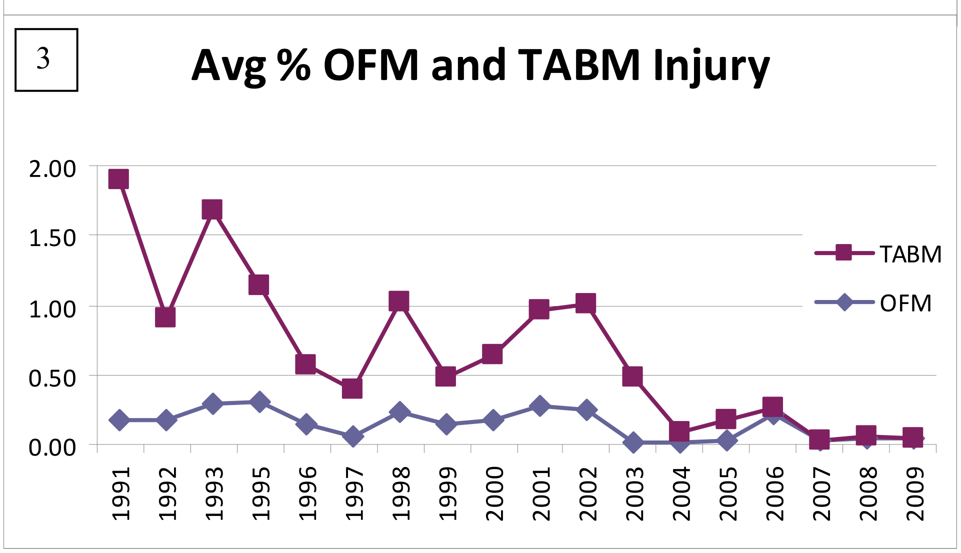


Table 3. Total Number of Farm Applications - Farm D										
			Year							
Chemical Type	**AI**	**Material**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Carbamate	carbaryl	Sevin 50W							5	
		Carbaryl 4L					14	4		
	methomyl	Lannate LV	142	49	26	25	4	10	30	2
Carbamate Total			142	49	26	25	18	14	35	2
Chlorinated-Hydrocarbon	endosulfan	Thionex 50W				51				
		Endosulfan 3EC	64							
Chlorinated-Hydrocarbon Total			64			51				
Naturalyte	spinosad	Spintor 2SC						9		
Naturalyte Total								9		
Neonicotinoid	thiamethoxam	Actara							86	
Neonicotinoid	imidacloprid	Provado 1.6F	16		91	8	80			53
Neonicotinoid Total			16		91	8	80		86	53
Organophosphate	azinphos-methyl	Guthion 50PVA	440	502	294	90	100			
	phosmet	Imidan 70 WP								47
	diazinon	Diazinon 50WP	20	43						
Organophosphate Total			460	545	294	90	100			47
Pyrethroid	esfenvalerate	Asana .66XL	141	179	313	486	602	550	308	69
	lambda-cyhalothrin	Warrior							175	393
	cyfluthrin	Part of Leverage								48
Pyrethroid Total			141	179	313	486	602	550	483	510
Pyrethroid+Neonicitinoid	cyflutrhrin+imidacloprid	Leverage 2.7								48

Table 4. Total Number of Farm Applications - Farm G														
			Year											
Chemical Type	**AI**	**Material**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Carbamate	carbaryl	Sevin 50W	1							16				
		Sevin 4F				5	6							
	methomyl	Lannate LV	80	3	63	24	8	21	13		4	11	1	
		Lannate 90SP	2	75	3	8	2	28	4		2	2		
Carbamate Total			83	78	66	37	16	49	17	16	6	13	1	
Chlorinated-Hydrocarbon	endosulfan	Endosulfan 50WP				45								
		Thiodan 50WP				9				60	2			
Chlorinated-Hydrocarbon Total						54				60	2			
Diacylhydrazine	methoxyfenozide	Intrepid 2F								4				
Diacylhydrazine Total										4				
Diamide+Neonicotinoid	Thiameth.+Chlor.	Voliam Flexi												19
Diamide+Neonicotinoid Total														19
Microbial	B. thuringiensis	Dipel					1							
Microbial Total							1							
Naturalyte	spinosad	Spintor 2SC					1	6	35	21	1	12	14	
Naturalyte Total							1	6	35	21	1	12	14	
Neonicotinoid	imidacloprid	Provado 1.6F			3		27		26		21		2	
	thiamethoxam	Actara									7		20	
Neonicotinoid Total					3		27		26		28		22	19
Organophosphate	azinphos-methyl	Guthion 50	20	225	95	83	127	230	154	56	8			
		Azinphos-methyl 50W	236											
	phosmet	Imidan 70 WP	6		50	8	137	96	75	46	182	111	109	77
	diazinon	Diazinon 50WP								9		20		
Organophosphate Total			262	225	145	91	264	326	229	111	190	131	109	77
Pyrethroid	esfenvalerate	Asana XL			46			15		43	54	67	120	65
	lambda-cyhalothrin	Warrior												66
Pyrethroid Total					46			15		43	54	67	120	131

Table 5. Total Number of Farm Applications - Farm S

			Year										
Chemical Type	**AI**	**Material**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2009**
Carbamate	carbaryl	Carbaryl 4L			28	33	25	20	30	20	33	10	6
		Sevin 80S	25	6									
	methomyl	Lannate 90SP	47	34	6		21	12				4	
	indoxacarb	Avaunt						1				3	2
Carbamate Total			72	40	34	33	46	32	30	20	33	14	8
Chlorinated-Hydrocarbon	endosulfan	Thionex 50W						3					
Chlorinated-Hydrocarbon Total								3					
Diacylhydrazine	methoxyfenozide	Intrepid 2F						17		1			
Diacylhydrazine Total								17		1			
Microbial	B. thuringiensis	Dipel		2									
Microbial Total				2									
Naturalyte	spinosad	Spintor 2SC			11	13	18	9	8	9	5	5	
Naturalyte Total					11	13	18	9	8	9	5	5	
Neonicotinoid	thiamethoxam	Actara									9		1
	imidacloprid	Provado 1.6F			34	21	50	5	30	11	26	28	20
Neonicotinoid Total					34	21	50	5	30	11	35	28	21
Organophosphate	azinphos-methyl	Guthion 50	3	287	1	197	165	112	97	77	56		
		Sniper 50	468		252								
		Sniper 2E			1								
		Guthion 2S				1							
	phosmet	Imidan 70W			119	124		72	4	13			74
	diazinon	Diazinon 50WP						16					
	chlorpyrifos	Lorsban 4E			34	33		32		56			1
Organophosphate Total			471	287	407	355	165	232	101	146	56		75
Pyrethroid	esfenvalerate	Asana XL	38			69	327	280	206	266	347	293	306
	cyfluthrin	Baythroid										6	
Pyrethroid Total			38			69	327	280	206	266	347	299	326
Pyretrhoid+neonicotinoid	cyfluthrin+imidaclopr	Leverage 2.7											20

SUCCESSES AND CHALLENGES WITH WHOLE FARM MATING DISRUPTION

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BACKGROUND

The decision process to choose the right insecticide to control pests in the orchard used to be relatively straightforward: apply one broad-spectrum compound and almost all pests in the orchard will be controlled. And then repeat; say once every ten to fourteen days. Today's grower faces a much more challenging process when tasked with controlling insect populations in the field. As the industry moves further away from broad-spectrum insecticides and relies more on complex, species-specific materials, the grower is now challenged with targeting a specific species with a specific product at a specific time during the season; and then repeat for the next pest. Choices are complicated, and timing is critical. Growers have little room for error since ultimately the grower is focused on producing clean, harvestable fruit at a cost that will turn a profit. Extensive research has been conducted to validate the efficacy of mating disruption as a method of insect control and more fruit growers are integrating mating disruption into pest management systems. Mating disruption is just one tool among many and understanding how it affects the production system in the orchard is a necessary step to take in order to maximize potential return.

The Whole Farm Mating Disruption (WFMD) program started as an effort to assist growers through the process of integrating mating disruption into their established pest control programs. The main objectives of the WFMD program were to provide/maintain effective control of codling moth *Cydia pomonella* (CM) and Oriental fruit moth *Grapholita molesta* (OFM) and potentially reduce the insecticide inputs in the orchards. In 2006 the WFMD program worked with one grower but in 2009 included twenty fruit orchards in eleven counties from across Pennsylvania. These twenty growers placed over 1,000 acres of apple and peach trees under mating disruption through the WFMD program. Orchard size varied from 6.5 acres to 118 acres and all growers marketed their produce through direct, retail markets such as road side stands or farmers markets.

The WFMD program was intended to be an educational, grower-run project so growers could become knowledgeable and experienced enough to run a mating disruption program independently. Each grower participant was given the same set of outlined instructions for the growing season and just as each grower operation was unique, each approach to the WFMD program was different as well. The WFMD program has gathered data for four consecutive seasons and observed/documented general trends and patterns common to the various experiences encountered with mating disruption.

MATERIALS AND METHODS

At the beginning of each season a meeting was held with each grower to discuss the upcoming growing season and the four primary focal areas of the WFMD program: choice and placement of mating disruption materials, specificity of implemented insect monitoring, other pests control options, and evaluation of results (i.e., fruit injury evaluations). Each area was discussed with each grower and a general seasonal plan was developed.

It was grower' responsibility to select, purchase, and place the mating disruption materials in the orchard although some cost-free MD materials were given to growers when available. During the 2009 growing season, the mating disruption products used by growers in apple blocks included: CheckMate CM/OFM Duel (Suterra LLC, Bend, OR.) placed at a rate of 150 per acre and Isomate CM/OFM TT (CBC America, Commack, NY) placed at rates of between 150 – 200 per acre. Mating disruption materials used by growers in peach blocks included: Disrupt OFM mats (Hercon Environmental, Emigsville, PA) placed at the rate 10 mats per acre, CheckMate OFM (Suterra LLC) placed at the rate of 100 per acre, and Isomate M-100 (CBC America) placed at a rate of 100 per acre.

Each growers was encouraged to monitor CM, OFM, tufted apple bud moth *Platynota idaeusalis* (TABM), obliquebanded leafroller *Choristoneura rosaceana* (OBLR), dogwood borer *Synanthedon scitula* (DWB), and apple maggot *Rhagoletis pomonella* (AM) with monitoring for all species being considered as a one set of traps. As orchards sizes varied, the number of monitoring trap sets also varied orchard by orchard, but each orchard was monitored by minimum of three sets of traps and maximum nine sets of traps. In apple blocks, white and orange large plastic delta (LPD) Pherocon VI pheromone traps (Trece, Inc. Adair, OK) were used to monitor CM, OFM, TABM, OBLR, and DWB. Codling moth was monitored using CM DAC lures from Trece Inc. Apple maggot was monitored using red sphere traps baited with ammonium carbonate as attractant (Great Lakes IPM, Inc. Vestabirg, MI). In peach blocks, pheromone traps were used to monitor OFM, TABM, OBLR, lesser peach tree borer *Synanthedon pictipes* (LPTB), and peach tree borer *Synanthedon exitiosa* (PTB). In every participating orchard, the grower assumed the responsibility for the monitoring practices but were asked to send their trap catches to the Project Coordinator at weekly intervals. The PSU Extension Tree Fruit Entomology staff sent periodic announcements via e-mail in spring and summer as timely reminders to change lures or place new insect monitoring traps.

During the season, fruit injury evaluations were conducted in most orchards. Evaluations were done twice during the season, once during mid-season in the summer and again at harvest. Although the number of evaluated fruit per orchard varied, at least 5 blocks and 4 x 100 half fruit (400 per block/cultivar) were evaluated in each orchard during the fruit evaluations.

It was left up to the grower to decide about the assortment and timing of necessary insecticide applications. Treatment decisions were based upon local pest populations determined by monitoring and fruit injury evaluations. The seasonal insecticide spray programs were gathered at the end of the season to assess what, if any, impact the mating disruption practices had on intensity of insecticide applications within each orchard.

RESULTS

This project goal was to provide a hands-on learning experience for each individual grower; therefore the general observations regarding the experiences within the WFMD program will be discussed citing specific examples only from some of involved orchards.

Orchard 1. Mating disruption dispensers Isomate CM/OFM TT and Isomate M-100 were placed May 18 on a 46-acre apple and peach orchard. Moth captures in pheromone traps in Grower 1 orchard indicated very low levels of monitored insect pest populations (Fig. 1). Pheromone traps did not detect neither CM nor OFM presence in the orchards but captured low numbers of TABM and OBLR during June and CM, TABM, OBLR, and AM were observed through August. Grower 1 applied five insecticide applications for the total of 3.5 complete insecticide applications (Table 1). No injured fruit was observed during fruit injury evaluations.

Orchard 2. The Isomate CM/OFM TT dispensers were placed April 30 on a 100 acre plus apple orchard while the Isomate M-100/Isomate Rosso dispensers were applied in late May (before start of the second OFM generation) in peach and cherry blocks. The captures of pests in monitoring traps indicated low, almost undetectable levels of insect pests populations (Fig. 2). Grower did not observe male moths of OFM or CM or AM flies in traps located in various fruit blocks thorough the season. Only sporadically, some OBLR moths were observed during the expected peak flights. Only the TABM population was at a higher level throughout the season. Grower 2 applied five spray applications for a total of 2.5 complete insecticide applications (Table 2). During fruit evaluations no internal feeder damage was detected but unfortunately the injury from plum curculio *Conotrachelus nenuphar* (PC) and stink bug complex did considerable damage to fruit and affected fruit quality at harvest (i.e., up to 3 percent of fruit injured by PC).

Orchard 3. The combination of Isomate CM/OFM TT/ and CheckMate CM/OFM Duels (apple), Checkmate OFM and Isomate M100 (stone fruit) dispensers were placed on April 29 (apple blocks) and late May (stone fruit blocks) on a 61-acre diversified orchard operation. Early in the season, monitoring traps were checked regularly but during mid and late summer checking of traps become less regular (Fig. 3). The collected data from pheromone traps indicated low populations of CM, OFM, and OBLR, and high population of TABM. Only two insecticide applications were made during the early part of the season and one additional in September for a total of 2.5 complete sprays for the entire season (Table 3). While the mid summer fruit evaluation did not detect any injured fruit, the fruit injury evaluations conducted in September discovered average of 1 percent of damaged fruit caused by larvae from the CM/OFM complex.

DISCUSSION

There are numbers of different ways a grower can approach monitoring, mating disruption, and insecticide applications, but it is only the full integration of these three areas that can provide the full benefits in perfect insect control in the orchards. Some growers check traps like clock-work and some check traps at random times throughout the season. Some growers despite placing mating disruption materials in their orchards still never skip a cover insecticide application. In this case the MD treatment is considered only as a second line of defense against CM and/or OFM. Other growers after placing MD materials never used insecticides against pest controlled by these products. Some growers to see first-hand the differences between mating disruption and no MD orchards have kept control blocks separate from their mating disruption blocks. Some growers took a year to first monitor pest populations in the orchard without mating disruption, to better understand what types of pests, the severity of populations, and in what locations pest populations reside.

Once growers are equipped with proper understanding of pest(s) situation within the orchard, they are able to better integrate mating disruption practices into their orchard operations. Having a basic understanding of insect and fruit injury identification is essential to identifying what problem pest exists in the orchard. Consistent, diligent monitoring is essential to stay in tune to changing insect pest populations in the orchard. If a grower decides to stop applying insecticides, then such a decision must be based on continuous, very vigilant monitoring of existing and potential pest populations in the orchard.

The majority of growers involved in our program followed the outlined instructions of the WFMD program. The mating disruption materials were placed in the field at a correct time and at the recommended rate. Growers also maintained a systematic/routine pest monitoring system in the orchard and sent the trap catch data to Penn State staff in a timely manner. For most of the time, based on information from monitoring tools, growers were able to decide by themselves about the need and relevance for insecticide applications. And as the final result the majority of the participating orchards had little to zero fruit injury during fruit injury evaluations.

The owner of the Orchard 1 is an example of a grower who was able to successfully incorporate the mating disruption practices into a pest management program. The information gained from monitoring traps was the base for applying insecticide treatments. The data collected from traps suggests that the current combination of pest control tools provide an effective method in controlling CM and OFM. The trap data also suggests that while populations of OBLR and TABM were present in the orchard, the grower was able to control those pests by selective treatments specifically targeted these species. While currently apple maggot is not a pest contributing to significant fruit injury, in Orchard 1 there was an existing AM population that could threaten the quality of the fruit in the future. By strict monitoring of AM, the grower was able to rapidly assess the possible threats by AM populations.

The owner of the orchard 2 is an example of the grower who does an excellent job in integrating mating disruption into a pest management program but experienced an unexpected change in the importance of the secondary pest populations. Due to applied mating disruption treatments this grower maintained excellent control of OFM and CM through the combined effort of mating disruption and insecticide applications, and also provided effective control of TABM and OBLR through proper applications of selective insecticides (Tab. 2 and Fig. 2). However, an unexpected increase in the populations of secondary pest populations presented itself in greater than before occurrence of fruit injured by PC and stink bug complex. Both PC and stink bug complex caused significant fruit damage to the extent the fruit was misshapen and deformed and resulted in economical loses at harvest.

Among farms participating in the WFMD program at least two additional farms located in different geographic regions across the state also experienced this type of severe PC and stink bug complex fruit injuries. The reduction in the number of insecticide applications combined with the choice of more selective compounds contributed likely to the increase in importance of PC and stink bug populations. Additionally, no effective methods were utilized for monitoring of this group of pests. And although PC and stink bugs are not traditionally considered the primary pests, they become a primary concern for the Grower 2.

Grower 3 did not fully follow through with the monitoring practices but continued to ‘blindly” trust the efficacy of mating disruption and in consequence continues to reduce the number of insecticide applications (Tab. 3 and Fig. 3). By stopping the monitoring practices in the middle of the season, the grower's understanding of dynamics of monitored pests became disconnected from existing pest populations in the orchard. The mating disruption treatment alone, especially in orchards with a relatively high CM/OFM pressure, usually is not able to provide a complete protection of fruit. The absence of needed supplemental insecticide treatments resulted in significant loss of fruit at harvest (i.e., about 1 percent fruit with live CM/OFM complex larvae). The situation in this orchard is a good example to demonstrate how a routine of a good pest monitoring could help in avoiding a problem at harvest. It needs to be emphasized that despite how well it appears things are in the orchard, future changes and shifts in pest populations are mostly unknown and the best way to accurately know what is going on in the orchard is to monitor.

Some growers may not be able to economically justify the inclusion of mating disruption into pest management practices. If a grower is selling directly to the consumer and is able to adjust the cost to consumer by marketing the product as grown with reduced insecticide output, then the cost of mating disruption may be worth the cost. But if the grower is unable to increase the return on the product, then the economic advantage may be in question. Each grower needs to assess individually whether mating disruption is a practice that makes sense for their individual operation. Also, specific orchards may not be conducive to establishing a mating disruption blanket across the orchard due to slope, crop diversification across orchard property, or small orchard acreage size or parcels. Insect control is only one piece of what a grower must address in order to run the full operation of the orchard. A straight forward outlined guide to the HOW of understanding the trap catches, a timeline telling WHEN to do something, and a comprehensive guide saying WHAT to be looking for what greatly help the grower efficiently manage this new style of pest control.

The WFMD program has been a loose outline yet structured program to provide guidance to growers when gaining experience how to implement mating disruption into their pest management plans. Focusing on monitoring, mating disruption, and insecticide applications has encouraged our growers to look at insect control from a new perspective. The education and experience the participating growers have received should lay a working foundation if they by themselves choose to continue to work with mating disruption in their orchards.

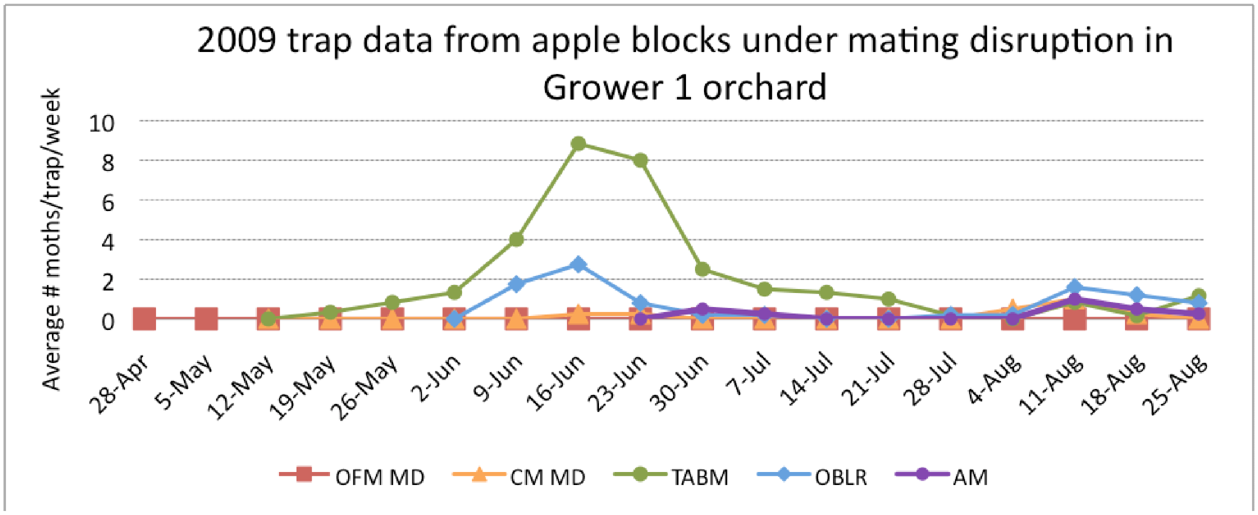

Figure 1. Insect pests flight activities in Grower 1 orchards. Average number of captured moths based on data from 5 sets of pheromone traps in apple blocks located in orchards with codling moth and oriental fruit moth mating disruption in 2009.

Table 1. The seasonal insecticides spray program in Orchard 1 during the 2009 season. All blocks were also treated with mating disruption materials to control codling moth and oriental fruit moth. ARM means insecticide applications applied as Alternate Row Middle sprays; C – as a complete sprays.

May 8	May 21	May 30	June 14	August 25
Assail 8 oz ARM	Assail 8 oz C	Guthion 1 lb ARM	Lannate 8 oz ARM	Delegate 5 oz C

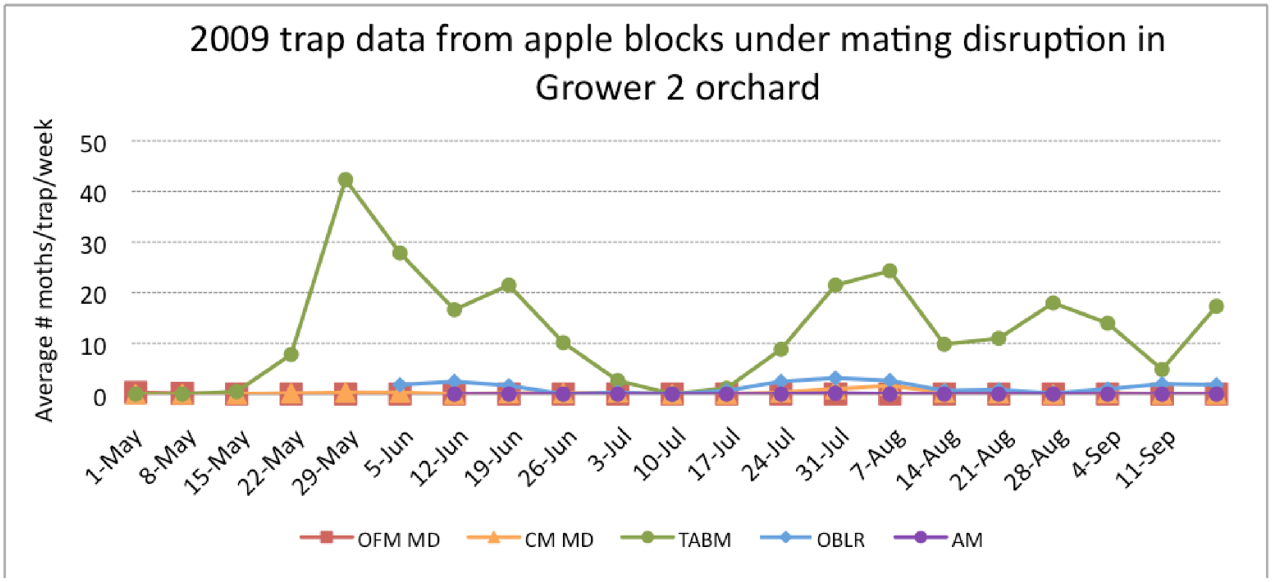

Figure 2. Insect pests flight activities in Grower 2 orchards. Average number of captured moths based on data from 7 sets of pheromone traps in apple blocks located in orchards with codling moth and oriental fruit moth mating disruption in 2009.

Table 2. The seasonal insecticides spray program in Orchard 2 during the 2009 season. All blocks were also treated with mating disruption materials to control codling moth and oriental fruit moth. All insecticide applications applied Alternate Row Middle sprays.

May 5	May 16	June 7	June 17	August 4
Assail 6 oz	Assail 6 oz	Delegate 4.5oz	Delegate 4.5oz	Altacor 2.5 oz

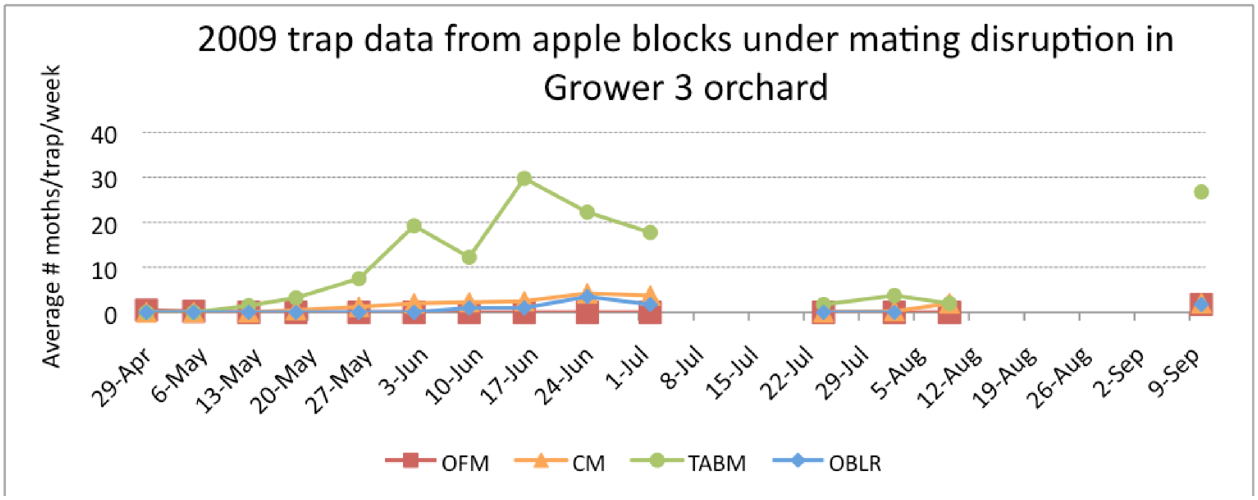

Figure 3. Insect pests flight activities in Grower 2 orchards. Average number of captured moths based on data from 6 sets of pheromone traps in apple blocks located in orchards with codling moth and oriental fruit moth mating disruption in 2009.

Table 3. The seasonal insecticides spray program in Orchard 3 during the 2009 season. All blocks were also treated with mating disruption materials to control codling moth and oriental fruit moth. ARM means insecticide applications applied as Alternate Row Middle sprays; C – as a complete sprays.

May 11	June 22	September 25
Agri-Mek 10 oz *plus* Imidan 2 lb C	Delegate 5 oz ARM	Delegate 6 oz C

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Without Consent of the Author

TESTING WEB-BASED APPLE IPM STRATEGIES

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The objective of this study was to develop and test apple IPM protocols that integrate information from the "Real Time" Tree Fruit IPM website in NY apple orchards. Tests were set up in 14 grower orchards in all major NY apple production regions. Two different IPM programs were tested in most orchards. Entomology department personnel monitored and sampled plots throughout the season. Growers applied pesticides based on monitoring results and IPM protocols.

In the Fruit Monitoring Protocol, growers applied normal sprays for insect control throughout plum curculio activity. Starting in late June, 1000 apples were monitored weekly for damage from internal lepidoptera (codling moth and oriental fruit moth) and the obliquebanded leafroller OBLR. Apple maggot (AM) red sticky traps with apple volatiles were deployed in late July. Control sprays were recommended whenever treatment thresholds were reached (1 apple damaged by either OBLR or Int Lep., or an average capture of 5 AM/trap).

In the Web-Optimized Treatment Protocol, growers applied normal insect control sprays throughout plum curculio activity. An initial summer spray was recommended based on web predictions of hatch of summer OBLR eggs and 2nd generation Int Lep eggs. A second spray was recommended based on web predictions of AM activity and 2nd generation Int. Lep. egg hatch.

Growers were allowed to choose their own pesticides for application in both of these programs, but we recommended that they use either Altacor or Delegate in both programs when sprays were necessary because these two chemicals provide excellent control of Int. Lep. and OBLR and are also active against AM. Growers were also told to rotate between these two materials in early and late sprays in order to manage resistance to these pests by using only one application of each material, which are in different chemical classes, so that pests were exposed to different modes of action during the season.

The "Classic Apple IPM Approach" for managing insect pests has traditionally been defined as not applying insecticides unless pest populations reach pre-determined threshold levels observed by sampling and monitoring orchards. This basic IPM format has been tested in NY apple orchards from the early 1970's until the present time and usually an average of 2-3 sprays during the summer after petal fall have been applied in monitored orchards. Although the Web-Optimized Treatment Protocol that was tested this year in 2009 may not fit the strict definition of the "Classic Apple IPM Approach" the level of recommended sprays, which would be 2/season, compares very favorably with results from standard IPM programs tested in NY orchards for many years. This Web-Based program has several potential advantages over standard IPM programs because it : 1) Reduces the need for IPM labor and expertise, 2) Eliminates some of growers' fear of not spraying in IPM programs, and 3) Could be more sustainable than sampling based programs because it would insure that insecticide residues were present in the orchard during estimated optimum activity periods of key insect pests such as Int. Lep. and OBLR. Theoretically, these residues could eliminate small populations of immigrating pests during these key times of pest activity. In contrast, IPM programs in which no summer control sprays are applied because pest thresholds were never reached have never been sustainable for more than 1-3 years, presumably because gradual immigration of small numbers of pests into relatively clean orchards eventually results in un-acceptable pest levels because of population increases in the absence of insecticide sprays.

Both treatment plots were monitored weekly throughout the season to provide research information by sampling 1000 apples, even though these results were used to determine the need and timing of sprays only in the Fruit Monitoring Protocol plots. Very few damaged apples were found in either of the treatments throughout the season, and most damaged apples observed were injured by the summer generation of OBLR rather than Int. Lep. (Fig. 1, Fig. 2)

Fig. 1. Damaged fruit observed during the summer in web-based plots in various grower orchards.

Numbers of damaged fruit/1000 sampled apples						
Date	**Jul 8**	**Jul 15**	**Jul 22**	**Aug 8**	**Aug 14**	**Aug 22**
AA	**0**	**0**	**0**	**0**	**0**	**0**
BR	**0**	**0**	**0**	**0**	**0**	**0**
BU	**0**	**0**	**0**	**0**	**0**	**0**
CZ	**0**	**0**	**0**	**0**	**0**	**0**
CR	**0**	**3**	**0**	**0**	**1**	**0**
DB	**0**	**0**	**0**	**0**	**1**	**0**
FR	**1**	**2**	**0**	**0**	**0**	**0**
FU	**0**	**0**	**0**	**0**	**0**	**0**
KN	**1.5**	**0**	**6**	**1**	**0**	**0**
OK	**0**	**0**	**0**	**0**	**0**	**0**
SU	**0**	**0**	**0**	**0**	**0**	**0**
VF	**0**	**0**	**0**	**0**	**0**	**0**

Fig. 2. . Damaged fruit observed during the summer in fruit monitoring plots in various grower orchards.

Numbers of damaged fruit/1000 sampled apples						
Date	**Jul 8**	**Jul 15**	**Jul 22**	**Aug 8**	**Aug 14**	**Aug 22**
AA	**0**	**0**	**0**	**0**	**0**	**0**
BR	**0**	**0**	**0**	**0**	**1**	**0**
BU	**0**	**0**	**0**	**0**	**0**	**0**
CZ	**0**	**0**	**0**	**0**	**0**	**0**
CR	**0**	**0**	**0**	**7**	**0**	**0**
DB	**0**	**0**	**2**	**0**	**0**	**0**
FR	**1**	**0**	**0**	**0**	**0**	**0**
FU	**0**	**0**	**0**	**0**	**0**	**0**
KN	**2**	**3**	**14**	**5**	**0**	**0**
OK	**0**	**0**	**0**	**0**	**0**	**0**
SL	**0**	**0**	**0**	**0**	**0**	**0**
SU	**0**	**0**	**0**	**0**	**0**	**0**
VF	**0**	**0**	**0**	**2**	**0**	**0**

AM pressure was quite high in all of the test orchards during July and August in 2009 and at least one spray would have been recommended in all of the orchards except the SL orchard (Fig. 3).

Fig. 3. AM catches in monitored orchards during 2009.

Cumulative Weekly Catch (Threshold= 15 flies)								
Date	**Jul 15**	**Jul 22**	**Jul 29**	**Aug 8**	**Aug 14**	**Aug 22**	**Aug 29**	**Sep 2**
AA		**6**	**14**	**23**	**44**	**53**	**59**	**65**
BR	**0**	**1**	**3**	**9**	**38**	**71**	**95**	**107**
BU	**1**	**2**	**8**	**23**	**36**	**63**	**117**	**132**
CZ	**2**	**9**	**9**	**49**	**62**	**93**	**114**	**128**
CR	**0**	**3**	**8**	**12**	**13**	**17**	**28**	**40**
DB	**1**	**3**	**9**	**37**	**63**	**69**	**79**	**90**
FR	**2**	**4**	**6**	**35**	**42**	**53**	**55**	
FU	**3**	**8**	**31**	**61**	**77**	**84**	**88**	**89**
KN	**12**	**30**	**54**	**64**	**84**	**107**		
OK	**6**	**7**	**8**	**11**	**17**	**23**	**28**	**33**
SL	**0**	**0**	**3**	**5**	**6**	**10**	**12**	**0**
SU	**2**	**7**	**7**	**23**	**44**	**86**	**99**	
VF	**0**	**3**	**25**	**53**	**159**	**259**	**267**	**285**

In the Web-Based plots growers strictly following the protocol would have applied an average of 2.0 sprays and in the Fruit Monitoring plots the growers would have applied an average of 1.1 sprays during the summer. Fruit damage was low and quite similar in both the Web-Based (2.9% Avg.) and Fruit Monitoring (3.2% Avg.) plots. Insecticide spray records are still being collected from participating growers, so it is currently not possible to determine how well growers followed the recommended protocols in all of the research plots. However, the initial results in both programs appeared to be promising and additional modification and testing of these different IPM protocols will continue during the next several seasons.

MONITORING INSECT PESTS IN BLUEBERRIES USING SPATIALLY-BASED METHODS

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Abstract

A complex of native and exotic insect pests attack highbush blueberries in the Northastern US. Without intensive management, contamination of harvested fruit by these insects results in rejected loads for exportation and lower market prices. We determined the distribution of pests in blueberry farms to better target insecticide applications using a large-scale monitoring approach combined with GIS and reduced-risk tactics in eight blueberry farms in 2009. Blueberry maggot (BBM), one of major pest of blueberry crop, distribution was significantly higher in farms surrounded by forest. Within farms BBM abundance was lower in fields with no forest border. A late season cultivar had higher BBM populations. Traps on border areas captured higher number of BBM indicating possible invasion from outside hosts. In certain cases, BBM were trapped inside the blueberry fields indicating the presence of resident populations. Site specific pest management practices may reduce the number of insecticide applications for BBM.

In the U.S., blueberries are grown mainly in ecologically and environmentally sensitive areas of porous soil with high water levels. In New Jersey, blueberries are grown in an ecologically important Pineland forest region, which serves as a fresh water source for 2.6 million people (NJDEP 2003). A complex of native and exotic insect species attacks highbush blueberries in this region. Due to its high value, zero tolerance of insect infestation for fresh fruit market, and a strict export protocol, contamination of harvested fruit by insects results in rejected loads and lower market prices. To protect fruit and plant injury, and to minimize the risk of crop rejection, organophosphate insecticides are key management tactics to control this diverse pest complex (Drummond 2006, Wise et al. 2006).

In recent years, integrated pest management (IPM) programs have been used in blueberry farms to protect fruit from direct feeding damage by insects. However, elimination or future phase-out plans of some key broad spectrum insecticides (organophosphates and carbamates) by the Food Quality Protection Act (FQPA) and high cost of newly available reduced-risk insecticides have limited pest management options for blueberry growers. An IPM program in individual blueberry fields can maintain high fruit quality and greatly reduce applications of conventional insecticides to control pest problem. This practice may, however, result in higher management costs per acre, while market price for blueberry is in decline, thus hindering the widespread adoption of IPM. An alternative is to develop IPM programs that use new reduced-risk insecticides applied across all of the managed fields within blueberry farms.

Results from a previous RAMP project revealed that blueberry pest abundance can vary by two orders of magnitude between fields on the same farm. If management programs incorporate spatial variability of pest abundance, insecticide use would be reduced dramatically, thus making ecologically-sound IPM programs more affordable. Geographic information systems (GIS) and spatially-based monitoring programs can complement the goals of IPM by enhancing precise insecticide applications over large areas. To achieve cost-effective implementation of IPM practices and reduce the environmental impact of blueberry production, a large-scale approach is needed that integrates spatially-based whole farm monitoring tactics with reduced-risk pest management practices. GIS-based field crop management programs have been developed for soil nutrition (Larisa et. al. 2005; Oudemans et. al. 2002; Bashford et. al. 1994; Schueller 1992), weed control (Gerhards et. al. 1997; Mortensen et al 1995; Johnson 1995), and pest management (Carrière et. al. 2006; Blom et al. 2002; Pozdnyakova et. al. 2002; Weisz et al. 1995, 1996). However, relatively little use has been made of this technology in high-value horticultural crops such as blueberries. In fact, most GIS work in high-value perennial fruit crops has been used for area-wide pest management programs to monitor pest distribution, rather than with-in farm mapping and real-time monitoring to affect daily pest management decisions among growers.

In this study, we combined GIS-based whole farm monitoring of a key blueberry insect pest, the blueberry maggot (BBM), with spatially-based management recommendations. The implications of this spatially-based IPM program was assessed by mapping BBM distribution across the fields and by measuring reduction of insecticide applications, active ingredient (a.i)/acre, and cost per acre.

Materials and methods:

A spatially-based whole farm integrated pest management program, referred as intensive crop management (ICM), was established in eight blueberry farms covering 1500 acres of blueberry fields in Burlington and Atlantic Counties in New Jersey. Farm size varied between 30 to 637 acres with three major blueberry cultivars: Duke, an early season cultivar; Bluecrop, a mid-season cultivar, and Elliott, a late season cultivar. Out of the eight farms, four ICM farms were paired with four farms having grower standard management programs (Standard). Such that, in the paired sites, one farm was under intensive monitoring program designated as "ICM" farm and the other was under standard monitoring program designated as "Standard" farm. We used paired farms for measuring the outcome (pesticide use pattern, a.i/acre, and cost/acre) of ICM and Standard programs. The other four unpaired growers were only under ICM.

Farms were selected based on three geo-spatial and landscape categories i.e. farms surrounded by (1) forest, (2) open fields or other crops, and (3) other blueberry farms (Table 1). Before the season started, farms were digitally mapped by individual fields with a Trimble hand held GPS device (*GeoXT* 2005 series) (Fig. 1). Trap layout for individual insect species were also mapped as point source data (Fig. 1). Digital maps were differentially corrected and exported to the desktop computer (GPS Pathfinder Office 3.10) for further spatial analysis. High resolution orthophotograph (image) for individual farms and surrounding areas were downloaded from the New Jersey Department of Environmental Protection (NJDEP) information warehouse (http://www.nj.gov/dep/gis). Geospatial data were analyzed by ArcGIS 9.0 software (Arc Editor version 9.3).

In 2009, four insect species: blueberry maggot (BBM), oriental beetle (OB), Cranberry fruitworm (CBFW), and sharp-nosed leafhopper (SNLH) were intensively monitored throughout the season. Adult BBM were monitored by using ammonium acetate baited yellow sticky traps. CBFW was monitored with pheromone-lured delta traps. OB was monitored using Japanese beetle traps, while SNLH adults were monitored with unbaited yellow sticky traps. In the ICM farms, BBM traps were placed at one trap per 2.5 acres irrespective of farm size (Fig. 1A). However, CBFW and SNLH traps were placed at one per 10 acres for a farm size higher than 50 acres. If the farm size was lower than 50 acres, we used one CBFW and SNLH trap for every 5 acres. Similarly, if the farm size was greater than 50 acres, we used one OB trap per 50 acres, otherwise, one OB trap was used for every 15 acres. Because most of insect pests move from the forest into blueberry fields, one third of the total traps were placed at the border of the farms, while the rest of the traps were placed inside the farms; thus, farms with longer peripheral line especially smaller farms had higher number of traps in border areas compared to the number of traps inside the fields. Farms under standard monitoring programs had fewer numbers of traps (approximately one tenth of the ICM farms). BBM traps were changed every 15 days. CBFW and OB pheromone lures were not changed during the season but the sticky bottoms were changed periodically. SNLH traps were also changed as needed.

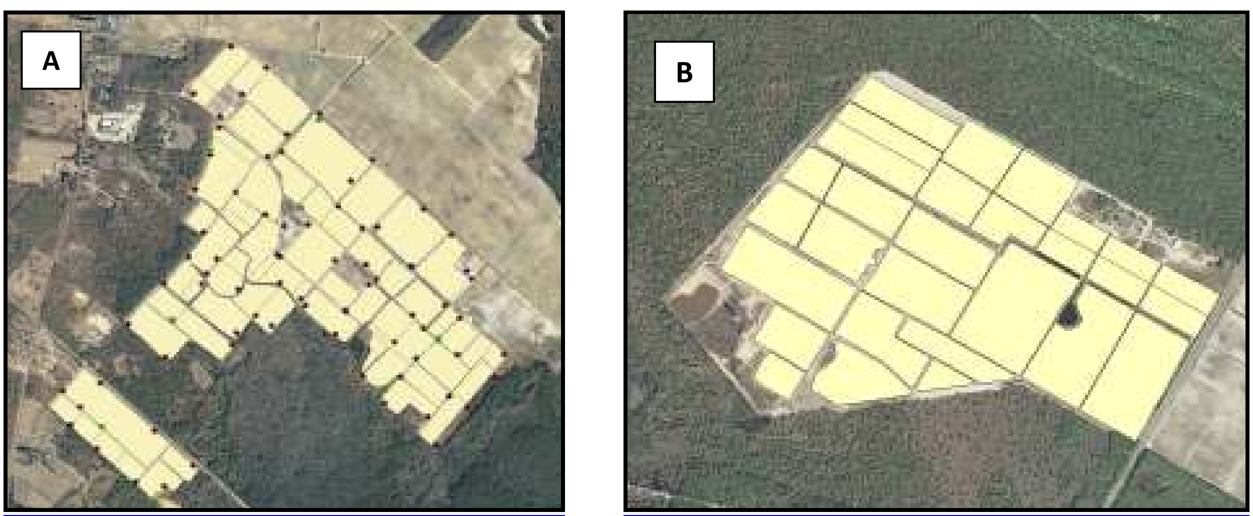

Figure 1: Showed the trap layout in an Intensive monitoring farm (A), and in a Standard monitoring farm (B). Each dot represents spatial location of a trap.

BBM traps were monitored twice a week starting the first week of June until the second week of September. CBFW traps were monitored weekly from the first week of May until the first week of July. SNLH was monitored from the first week of June to the first week of October. OB traps were checked from the second week of June to mid-August. Data on number of insects captured in each traps were entered in Excel. Number of adult captures per trap per week was calculated. Traps were categorized by “border” and “inside” based on the position described in the previous section and a one-way ANOVA was used to analyze whether there are differences in the average number of insect captures per trap between trap positions. Weekly number of captures was also plotted against time of captures to identify temporal distribution of adult emergence. Because the data are yet to be analyzed, the result and discussion sections focus only on BBM distribution within farms. We will present the results for other pest species (CBFW, OB, and SNLH) in future proceedings.

Results and Discussions:

Overall BBM populations varied among farms depending on landscape categories. Among the eight growers, farms surrounded by forest had higher number of BBM populations than farms with no forest boundaries (Table 1).

Table 1: Acreage, landscape, number of traps, and average number BBM captures in eight blueberry farms in 2009.

Name of the Farms	Acreage		Landscape categories†	# of BBM traps in ICM farm	# of BBM captured/ trap/season		F Value	P- value
	ICM	Std			Border	Inside		
MB	205.03	144.54	Mixed	69	1.03	1.0	1.25	0.29
DR	135.27	117.94	Blueberry farm	66	0.71	0.43	1.18	0.28
HS	38.44	25.03	Blueberry farm	15	0.83	0.33	0.35	0.56
JW	44.24	32.07	Forest	17	7.5	1.33	5.37	0.03*
ABC	616.4	X	Forest	176	8.18	7.56	0.01	0.90
AM	44.6	X	Forest	18	12.4	1.5	13.97	0.002*
R&S	156.62	X	Forest	55	2.31	0.88	4.63	0.03*
BH	29.16	X	Forest	11	2.83	0.33	10.32	0.009*

†Landscape categories are based on farms surrounded by forest, open areas or other crops, and other blueberry farms. * = number of BBM captures is significantly different between border and inside traps.

Among the farms with forest boundaries, traps near the forest captured significantly higher number of BBM than traps placed inside blueberry fields (Table 1; Fig. 2). In farms R&S (Fig. 2A), JW (Fig. 2B), AM (Fig. 2C), and BH (Fig. 2D), where more than 80% of the farm is surrounded by forest, total number of BBM captures/trap/season were significantly higher in border traps than inside traps (P = 0.03, 0.03, 0.002, and 0.009 for farms R&S, JW, AM, and BH, respectively).

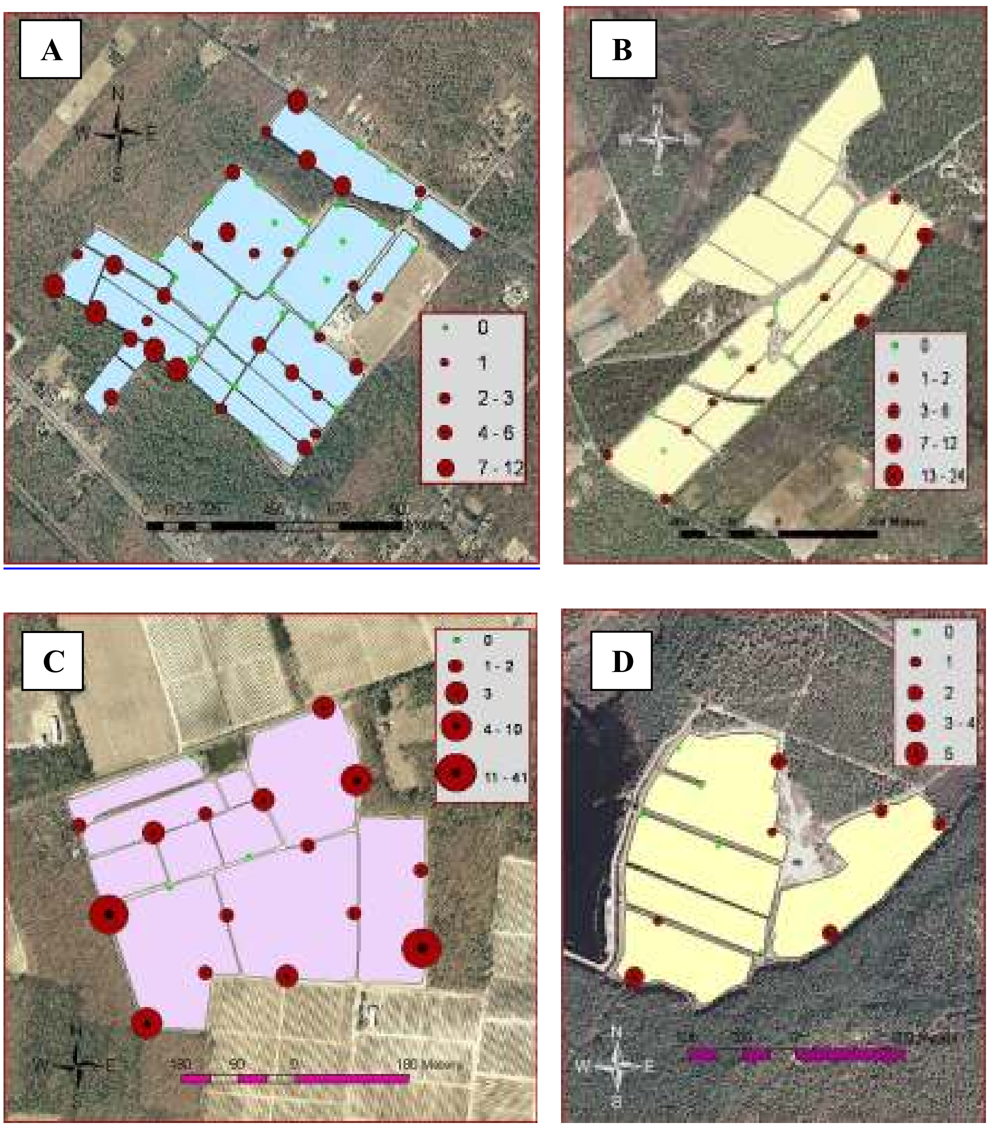

Figure 2: Geospatial locations and seasonal blueberry maggot distribution in farms surrounded by forest; R&S (A), JW (B), AM (C), and BH (D) in 2009. Large dark circles showing the spatial position of traps with higher blueberry maggot catches.

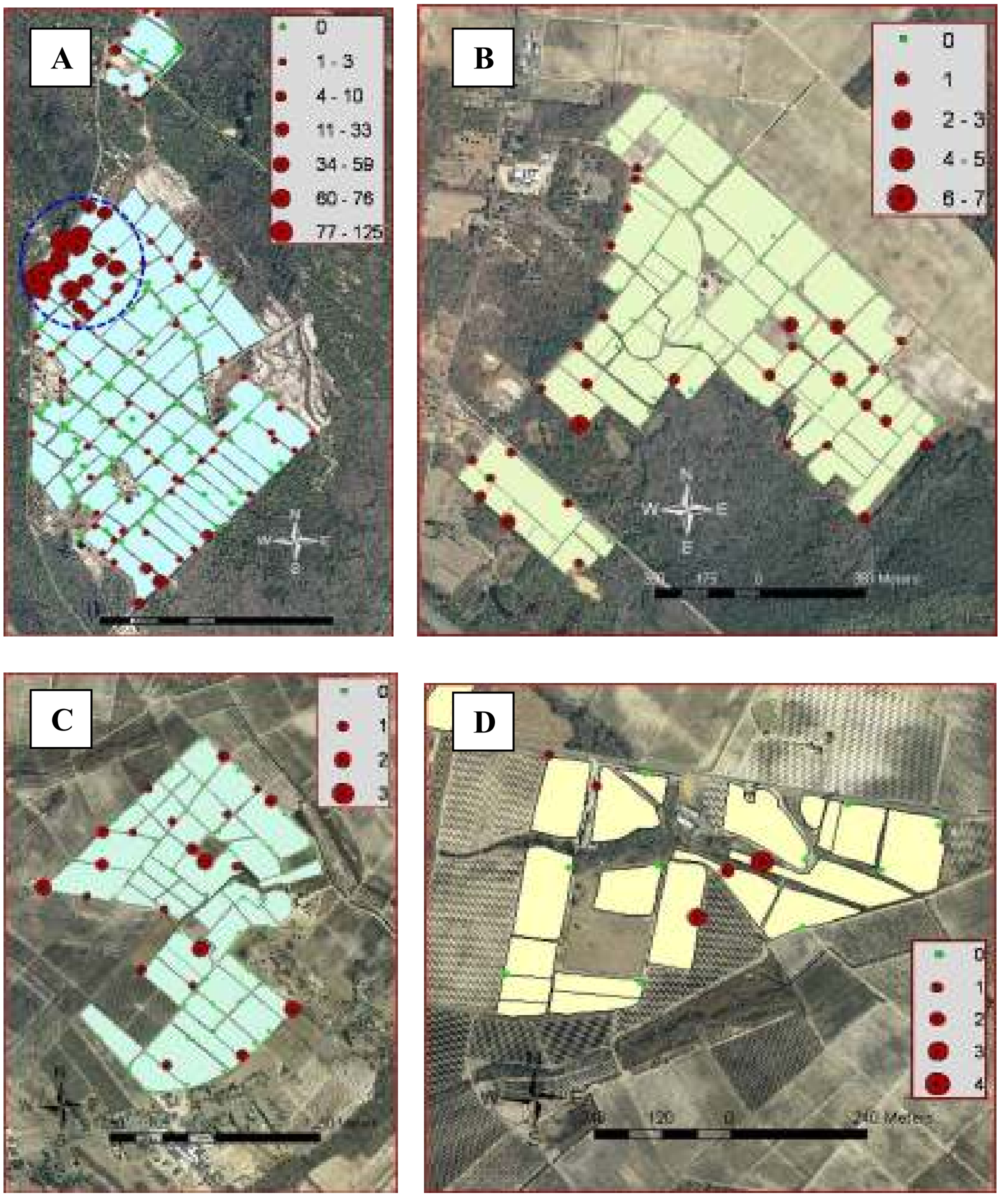

Figure 3: Geospatial locations and seasonal blueberry maggot distribution in farms: ABC, with late cultivar (A): MB, with mixed landscape (B); and DR and HS, with farms surrounded by other blueberry farms (C and D). Large dark circles showing the spatial position of traps with higher blueberry maggot catches.

Overall farms surrounded by mixed landscape (i.e. forest, vegetables, and open fields) had lower number of BBM populations than farms with forest boundaries (Table 1). However, in a mixed landscape farm, BBM population distribution was biased near the fields with forest than the fields with other crops or open fields (Fig. 3B). Farms surrounded by other blueberry farms had very low numbers of BBM compared to the farms with forest and mixed landscape boundaries (Fig. 3C-D). In these farms (DR and HS), no significant differences were found in number of BBM captures between traps in border versus inside fields (P = 0.28 and 0.56 for DR and HS, respectively).

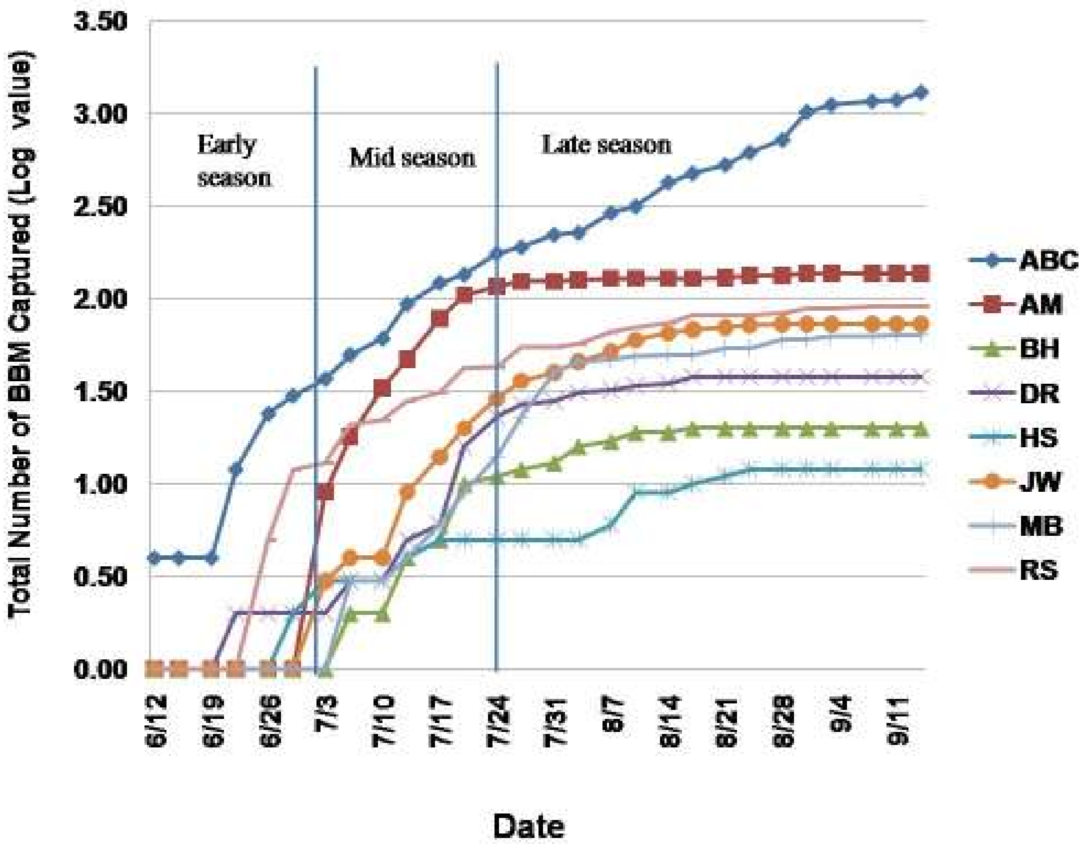

Figure 4. Log value of the cumulative number of blueberry maggot (BBM) captured in baited traps at eight ICM farms during 2009 blueberry growing season. BBM traps were set at the same rate of one trap per 2.5 acres in all farms.

In all but one farm (ABC; Figs. 3A & 4), captures of adult BBM was substantially lower in the early season. During mid season, number of BBM captures sharply increased in farms with forest border compared to farms with no forest border or bordering other crops (Fig. 4). During late season, BBM captures decreased in most farms except for ABC farm where BBM captures continued to increase. Although high number of trap captures was observed in ABC farm in the late season, these were confined to a small area of the farm where only Elliott (late season cultivar) are grown (Fig. 3A). When excluding this late emergence BBM population from the analysis, we found a significant difference (P = 0.02) between border and inside trap captures with higher BBM captures in the border traps prior to the late season (Fig. 3A).

Conclusions:

Results from the first year of this project indicate that captures of adult BBM were significantly higher in farms surrounded by forest. Farms with no forest border had lower maggot populations. A late season cultivar had higher BBM than the early and mid season cultivars. These data indicate possible invasion of BBM from outside host plants, i.e. wild blueberry and huckleberry hosts in the forest understory. In certain cases, BBM adults were trapped inside blueberry fields indicating the presence of resident populations. Current results suggest that BBM monitoring should be biased towards the forest. With a better knowledge of pest distribution within farms, blueberry growers are more likely to follow site specific reduced-risk management practices to control BBM. In the next years of study, we will further investigate the economic outcome of these spatially-based IPM management strategies.

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Performance of Energy Absorbing Materials for Passive Bulk Bin Filling

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Abstract

To increase efficiency and allow mechanization of apple harvest, a device is needed to fill bulk bins in the field without causing damage to the fruit. Three experiments were conducted to determine materials and designs suitable for constructing a passive bin filling device. Two concepts for achieving the desired functionality of such a device are (1) grates of granular materials that absorb energy while still allowing fruit to pass through them, and (2) mats of energy absorbing foams. These mats could be used in combination with a grate and would cover any hard materials within the device. In Experiment I, six configurations of energy absorbing grates were tested by dropping apples through them onto a layer of stationary apples. The performance of these grates was evaluated with respect to bruise width, depth, and volume; each configuration proved capable of significantly reducing the chance of bruising. In Experiment II, three different foams were evaluated by dropping apples from various heights onto small samples covering a piece of wood. Bruising was negligible until the threshold height of just under 1 meter (39 inches). The final experiment was a performance analysis for two prototype bin filling systems. The experiment indicated that fruit drop height should be maintained near two inches and that fruit singulation from picking to bin filling yielded the highest amount of bruise free fruit.

Introduction

Labor saving technologies such as full mechanization of harvest or less radical harvest assist technology could greatly increase the efficiency of apple harvest. One major obstacle to any technology for improving efficiency is the need to collect the fruit in a bulk container after it has been removed from the tree without causing significant damage. The standard method of fruit harvest involves having harvest employees fill a picking bag with fruit. Once the bag is full, they carefully empty their bags into a bulk bin. There is potential for substantial economic and ergonomic improvements if picking bags can be removed from the harvest process, and allow for a more continuous process.

The problem lies in the physiology of an apple. Apples are much more fragile and sensitive to bruising under fast loading (Baugher, 2006). If an apple is allowed to fall freely rather than delicately lowered into a bin, it will have a considerable amount of kinetic energy when it either hits the bottom of the bin or other apples. This kinetic energy must be absorbed by something. Without any additional materials present, this energy will be absorbed during a very short period of time in a relatively small area by either the falling apple itself, or the apples already in the bin. If materials are present during the fall that can absorb this energy before the fruit reach the bottom of the bin, bruising can be prevented.

The objective of this study was to determine if a device employing an energy absorbing material, or combination of such materials, could be designed to absorb enough energy of harvested fruit dropped onto it to prevent bruising when the apple struck a layer of apples on a hard surface below it. Construction of a successful prototype would support the possible future development of a passive bin filling device for use in orchards. This device would ideally be used in combination with other harvest assist technology, primarily a harvest platform (Baugher et al., 2009). One system that was modeled, presented in Figure 1, is a granular absorption medium apple distributor design. In this system, the kinetic energy of the fallings is absorbed by cubes (or other shapes) of energy absorbing foam or elastic cords resting on top of or suspended from a grating. The second system that was modeled is a pneumatic self-adjusting design shown in Figure 2. The principle behind the design is to alternate the inflation of two or more sets of cylinders. The cylinders themselves absorb the energy of the dropping apples by keeping the air pressure in the cylinders to a minimum. With these devices, ladders and picking bags could be eliminated all together from the apple harvest, allowing workers to pick continuously from the beginning to the end of a row.

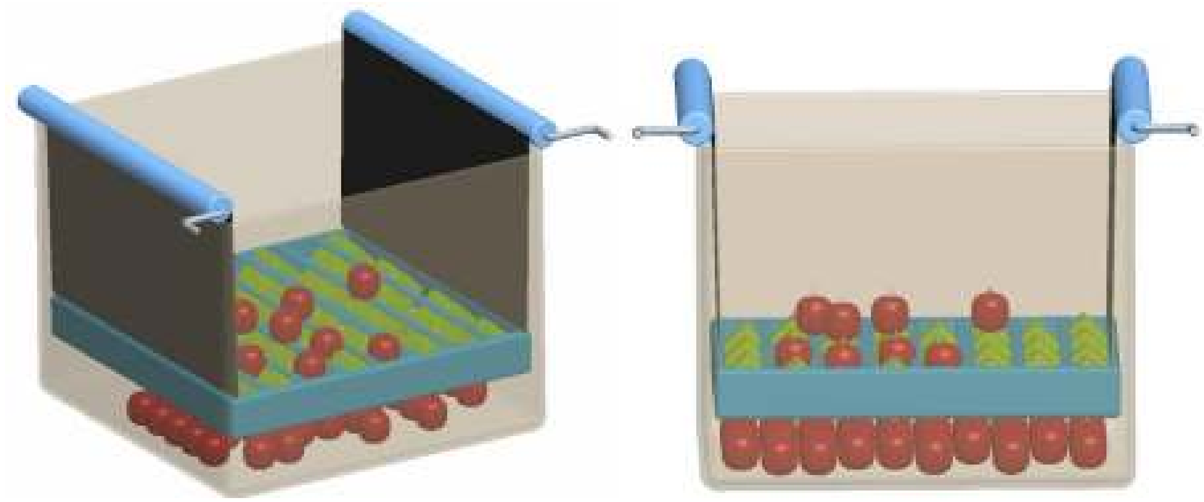

Figure 1. Conceptual model of a granular absorption medium apple distributor design.

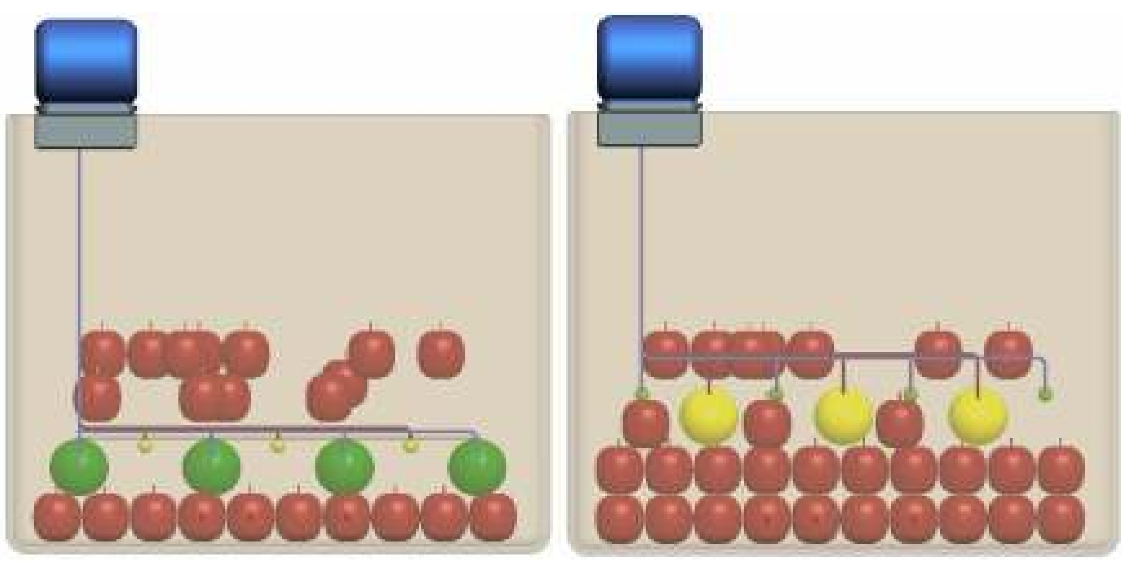

Figure 2. Conceptual model of a pneumatic self-adjusting apple distributor.

Materials and Methods

Experiment I: Energy Absorbing Grates

We tested six configurations of energy absorbing grates consisting of variations of three different materials for their ability to passively handle apples without causing damage. The experiment included four replications of six configurations. In each replication eight apples [of 2 ¾ to 3 inch size) passed through that particular configuration. Trials were conducted with Delicious, a variety with low susceptibility to bruising, and Golden Delicious, a variety with high susceptibility to bruising.

We designed an apparatus that allowed the apples to free fall in a semi-random direction onto the uppermost layer of energy absorbing material. Each type of material was arranged in a two-foot square wooden frame. Fastened to a similar frame was a padded ramp at a 15° incline. This ramp (Figure 3) was tapered with padded dividers at one end, which directed the apples in each replicate in a random direction. A rack (Figure 4) allowed the square frames to be inserted at any one of four positions with the ramp on top. The separation between the positions was 13 cm (5 in). The racks were placed every 13 cm from the bottom of the bin so that the materials could be arranged in different configurations. For each experiment, the bottommost frame was on the lowest rack and just above the bottom layer of apples, while the ramp was one rack above the uppermost material.

The three energy absorbing materials were 6.3 cm (2.5 in) diameter hard foam balls strung on elastic (rubber) bands, 7.6 cm (3 in) diameter soft foam balls strung on rubber bands, and rubber bands alone. The rubber bands were stock materials ordinarily used for training apple trees. The foam balls were purchased from toy departments.

The six configurations were as follows: one layer of 48 hard foam balls (Figure 5), one layer of 36 soft foam balls (Figure 6), one layer of each type of ball, two layers of rubber bands (Figure 7), one layer of each type of ball with one layer of rubber bands, and one layer of each type of ball with two layers of rubber bands. In the bottom of the testing apparatus was a single layer of apples onto which the test apples fell after passing through the energy absorbing materials. A control value for bruising was determined by allowing the apples to fall onto the layer of apples without any of the energy absorbing materials present.

Figure 3. Padded ramp with one replicate of apples.

The apples were inspected for previous damage, and any bruises were circled with a permanent marker to distinguish them from bruises resulting from the experiment. The apples were left at room temperature for approximately one hour before the experiment. For each of the four replicates, eight apples were placed in the ramp and allowed to drop all at once. If any apples stopped, the frames were shaken slightly until the apples passed to the bottom. The apples then sat at room temperature overnight until they were inspected for bruising. The skin over the damaged area was peeled back and the bruise diameter was measured. The apples were then cut through the bruise and the bruise depth measured. Levels of downgrading due to bruising were determined based on USDA Grades and Standards (Table 1).

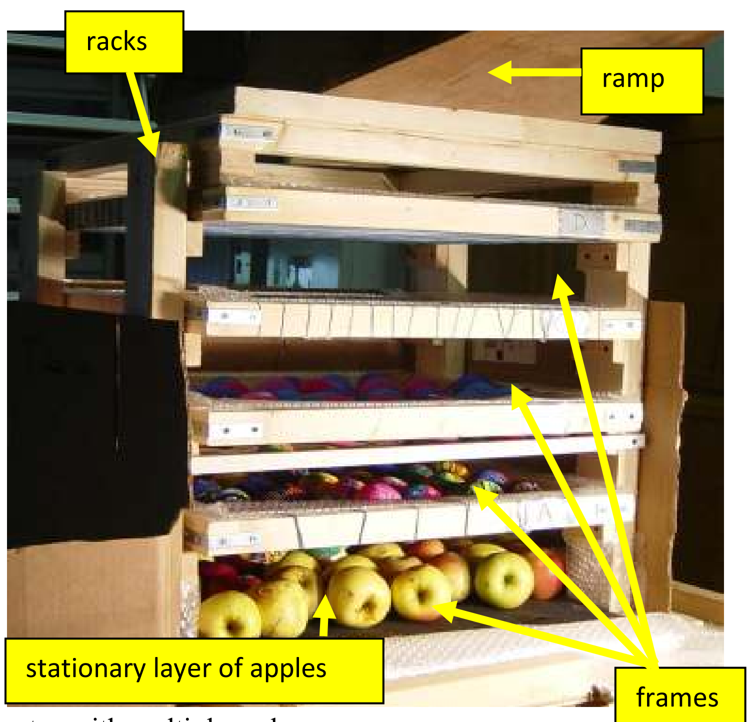

Figure 4. Testing apparatus with multiple racks.

Figure 5. Hard foam balls.

Figure 6. Soft foam balls.

Figure 7. Rubber bands.

Experiment II: Energy Absorbing Foams

Three different types of foams were subjected to a bruise threshold test (Hyde et al., 2003) to determine the ability of each to absorb energy and therefore prevent bruising. Rome and Fuji varieties were used for this experiment. The three types of foam were PORON® brand foams donated by the Rogers Corporation.

Foam Type	Thickness
resilient	12.7 mm (1/2 in)
energy absorbing	10.8 mm (~7/16 in)
combination	19.0 (3/4 in)

Apples were dropped from heights of 15 cm (6 in), 30 cm (12 in), 40 cm (15 in), 60 cm (25 in), 100 cm (39 in), and 160 cm (63 in) onto each type of foam using the same ramp apparatus as before (Figure 8). Apples were also dropped from each height onto a pine board to determine a control value for comparison. These apples were allowed to sit overnight at room temperature. The skin over each bruise was peeled back and the bruise diameter measured. The apples were cut through the bruise and the bruise depth measured.

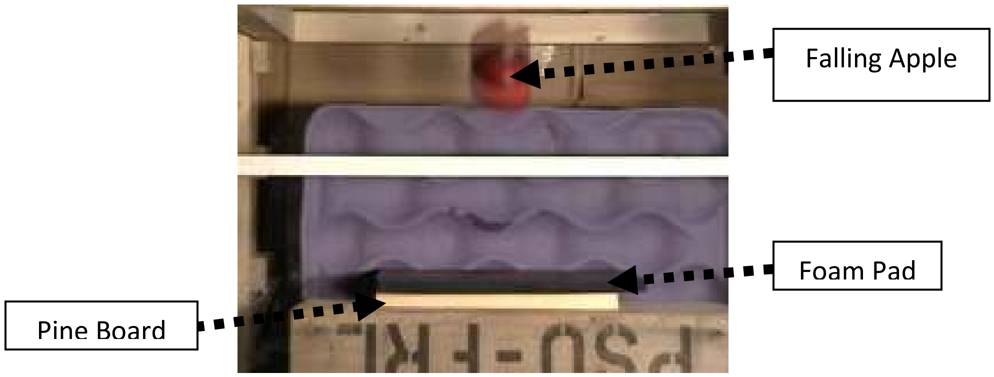

Figure 8. Bruise threshold test for PORON® foams.

Experiment III – Full Scale Bin Filler Prototypes

Two full scale bin filler prototypes were tested in Experiment III. The first bin filler design was an energy absorbing grate (Figure 9) constructed from nylon bungee cords with a foam base pad. The second system was a pneumatic self-adjusting bin filler design (Figure 10) constructed with inflatable bladders. The study included four replications of three drop height configurations—2.5, 5, and 10 cm (1, 2, and 4 in), respectively. In each replication eight apples (of 2 ¾ to 3 inch size) passed through each particular bin filler configuration. Trials were conducted with Golden Delicious, a variety with high susceptibility to bruising. The testing apparatus was designed to allow the apples to free fall in a semi-random direction onto the uppermost layer of energy absorbing material. Additionally, one incomplete layer of red apples was placed on the bottom of the bin allowing room for the test apples to distribute. The test apples were placed on a padded ramp at a 15° incline with padded dividers to prevent bruising prior to departure from the ramp.

The energy absorbing grate bin filler contained two layers of nylon bungee cords 9 mm (3.6 in) in diameter configured approximately at a spacing of 3.75 cm (1.5 in). The drop height between the two layers of bungee cords was 7.5 cm (3 in) and the drop height to the foam mat was 9 cm (3.5 in).

The pneumatic self-adjusting bin filler contained two layers of 10 cm (4 in) plastic inflated bladders. The pressure in the upper bladder layer was slightly lower than the pressure in the bottom bladder layer. This enabled the system to absorb the largest amount of energy without causing apples to bounce upon impact.

A control value for bruising was determined by allowing the apples to fall onto the incomplete layer of apples without any of the energy absorbing materials present. For the singulated trials, each apple was released individually from the ramp to completely isolate any initial bruising from apple collisions between the end of the ramp and the bin filler.

The apples were inspected for previous damage, and any bruises were circled with a permanent marker to distinguish them from bruises resulting from the experiment. The apples were left at room temperature for approximately one hour before the experiment. For each of the four replicates, eight apples were placed in the ramp and allowed to drop all at once. The apples remained at room temperature overnight until they were inspected for bruising. The skin over the damaged area was peeled back and the bruise diameter was measured. Then the apples were cut through the bruise to measure the bruise depth. Levels of downgrading due to bruising were determined based on USDA Grades and Standards (Table 1).

Table 1. Classification of bruise damage, based on USDA Grades and Standards.

Class	USDA fresh market standard	Bruise specifications
1	"Extra Fancy"	No bruising
2	"Extra Fancy"	Bruise diameter ≤ 3.2 mm (1/8 in)
3	"Extra Fancy"	Bruise diameter 3.2 mm (1/8 in) to 6.4 mm (¼ in)
4	"Extra Fancy"	Bruise diameter 6.4mm (¼ in) to 12.7 mm (½ in) or area of several bruises ≤ 127 mm^2
5	"Fancy"	Bruise diameter 12.7 mm (½ in) to 19 mm (3/4 in)
6	Downgraded	Bruises larger than the tolerances in "Fancy"
7	Downgraded	Cuts or punctures of any size

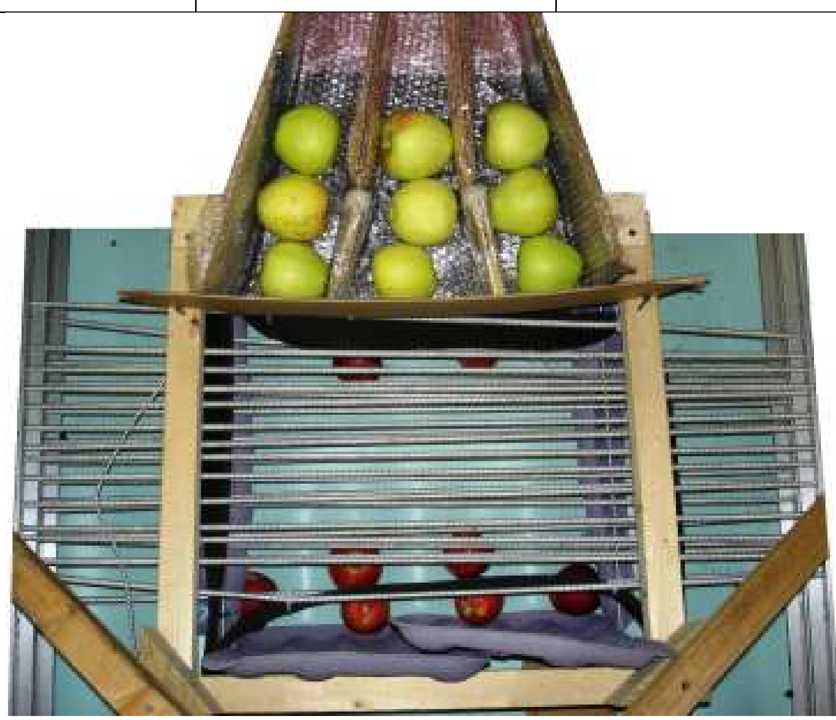

Figure 9. Top view of the energy absorbing grate bin filler.

Figure 10. Pneumatic self-adjusting bin filler with test ramp.

Statistical Analyses

All data were subjected to analysis of variance. Mean separations were conducted using Fisher's protected least significant difference test at $P \leq 0.05$.

Results and Discussion

The results of Experiment I, including the percentage of downgraded fruit, mean bruise width, and mean bruise volume are found in Table 2. All material combinations showed the ability to significantly reduce bruising. However, only the treatments that included rubber bands had 100% Extra Fancy grade fruit. The data suggest that the elasticity of a rubber band is capable of absorbing the energy of falling fruit. In each case, either a foam material fastened to rubber bands, or the bands themselves gripped the apples long enough for the rubber bands to stretch out around them. The rubber bands allowed the fruit to pass through one layer, and they immediately snapped back to their original positions before additional fruit fell.

The results of Experiment II are shown in Figure 9. When a single fruit was dropped onto a wood surface bruising occurred at a drop height as low as 15 cm (38 in). The three foams tested caused no significant bruising until 100 cm (254 in). One foam, which was both resilient and energy absorbent, caused no significant bruising even from our highest drop height of 160 cm (5 ft 3 in). This is noteworthy, as most surfaces, even those used in packing houses, will cause bruising at heights considerably lower than these.

Bruise measurements and corresponding levels of downgraded fruit for all testing configurations in Experiment III are presented in Table 3 and Figure 12. The trend lines for all trials demonstrated that as drop height increases bruise volume increases nearly linearly. The energy absorbing grate reduced bruise volume at all heights compared to the control, which was not surprising based on Experiment I results. The pneumatic bin filler did not perform as well as the grate since the fruit passed more slowly through the air filled bladders, allowing more opportunities for fruit-to-fruit contact. An important finding (Figure

13) was that performance increases significantly when fruit are singulated prior to entering the bin filler. The optimal bin filling configuration was a singulated fruit transfer system with a drop height of no more than 5 cm (2 in).

Future Research

The scope of our harvesting research was to design a dry bin filling system that was capable of handling apples within an acceptable level of bruising, and two passive concepts were identified. The three experiments described in this paper helped our project team develop a greater insight into the required design requirements to ultimately develop an in-field bin filling system. In addition, we quantified the significance of maintaining fruit singulation throughout the entire harvesting process from picking to transport to bin filling. Our future efforts will focus on integrating an apple transport system with a bin filler design, so that fruit are singulated upon picking all the way to the bin. This strategy should result in a harvesting system that will improve a fruit harvest worker's productivity without sacrificing fruit damage.

Acknowledgements

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Table 2. Effects of energy absorbing grates on apple bruising and USDA fresh market grade (percentages based on % of total apples tested).

Treatment	Downgraded to Fancy Grade (%)	Downgraded to No. 1 or Utility Grade (%)	Bruise width (mm)	Bruise volume (mm^3)
Hard foam balls	3	0	1.1 b[z]	10.7 b
Soft foam balls	3	0	2.1 b	12.4 b
1 layer each ball type	3	0	1.0 b	19.2 b
2 layers rubber bands	0	0	1.3 b	8.2 b
2 layers balls + 1 layer bands	0	0	0.6 b	3.6 b
2 layers balls + 2 layers bands	0	0	1.6 b	43.9 b
Control	28	3	7.1 a	195.1 a

[z] Means, within columns, followed by dissimilar letters are significantly different according to Fisher's protected least significant difference, $P \leq 0.05$.

Table 3. Effects of full scale bin filler prototypes on apple bruising and USDA fresh market grade (percentages based on % of total apples tested).

Treatment	Downgraded to Fancy Grade (%)	Downgraded to No. 1 or Utility Grade (%)	Bruise width (mm)	Bruise volume (mm^3)
Energy absorbing grate prototype – 2.5 cm drop	0	0	1.3 d	10.5 de
Energy absorbing grate prototype – 5 cm drop	3	3	2.7 cd	22.5 cde
Energy absorbing grate prototype – 10 cm drop	0	9	5.6 abc	62.8 cde
Pneumatic prototype – 2.5 cm drop	6	6	5.1 bc	57.8 cde
Pneumatic prototype – 5 cm drop	9	13	6.0 abc	115.9 bc
Pneumatic prototype – 10 cm drop	18	13	6.6 ab	182.7 b
Energy absorbing grate/singulated – 2.5 cm drop	0	0	0.0 d	0.0 e
Energy absorbing grate/singulated – 5 cm drop	0	0	0.3 d	4.6 e

Energy absorbing grate/singulated – 10 cm drop	9	0	1.2 d	11.5 de
Pneumatic prototype/singulated – 2.5 cm drop	0	0	0.2 d	0.7 e
Pneumatic prototype/singulated – 5 cm drop	3	0	0.6 d	2.4 de
Pneumatic prototype/singulated – 10 cm drop	6	0	0.9 d	5.9 de
Control – 2.5 cm drop	13	6	5.5 abc	111.1 bcd
Control – 5 cm drop	24	13	8.7 ab	187.7 b
Control – 10 cm drop	34	19	9.0 a	289.6 a

[z] Means, within columns, followed by dissimilar letters are significantly different according to Fisher's protected least significant difference, P ≤ 0.05.

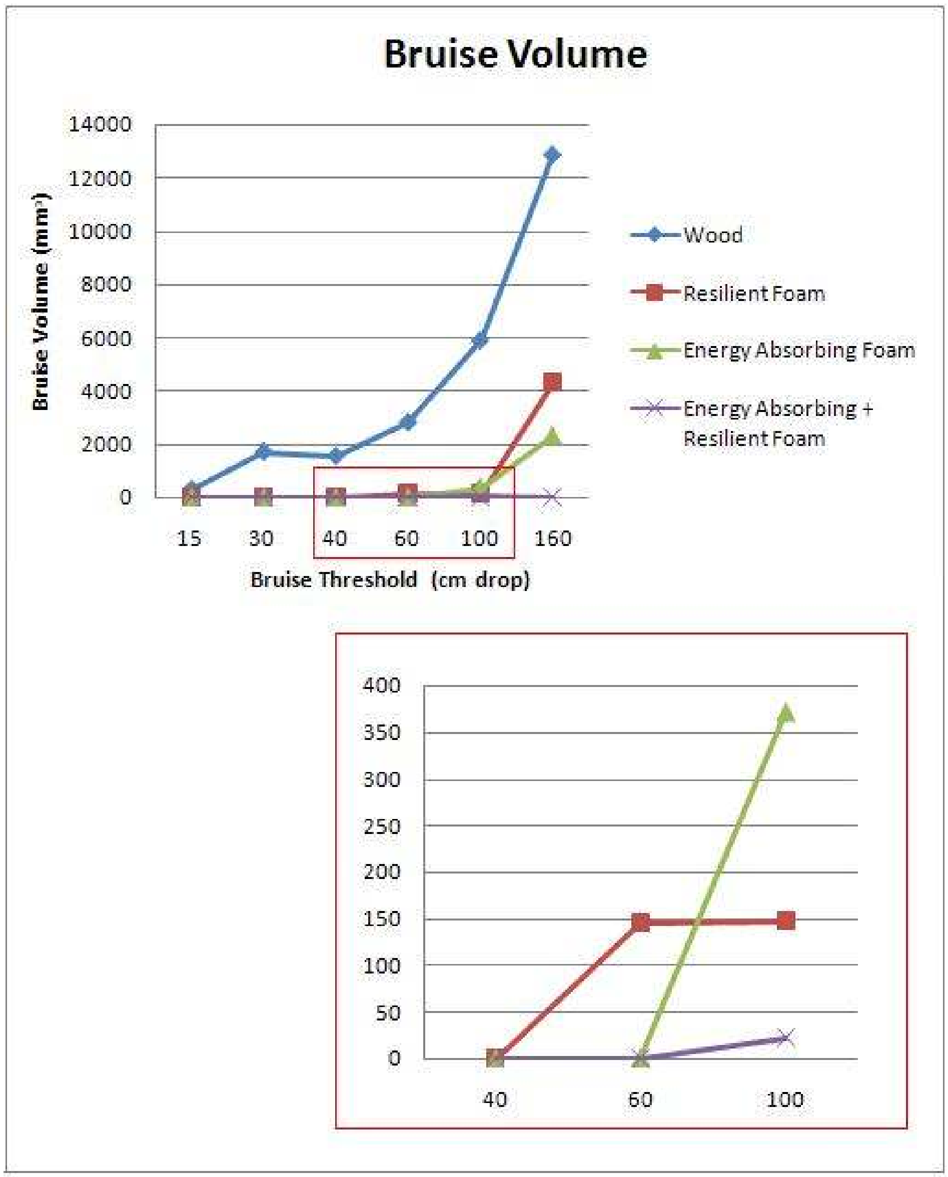

Figure 11. Effects of dense foam materials on bruise volume for all drop heights, compared to a pine board control.

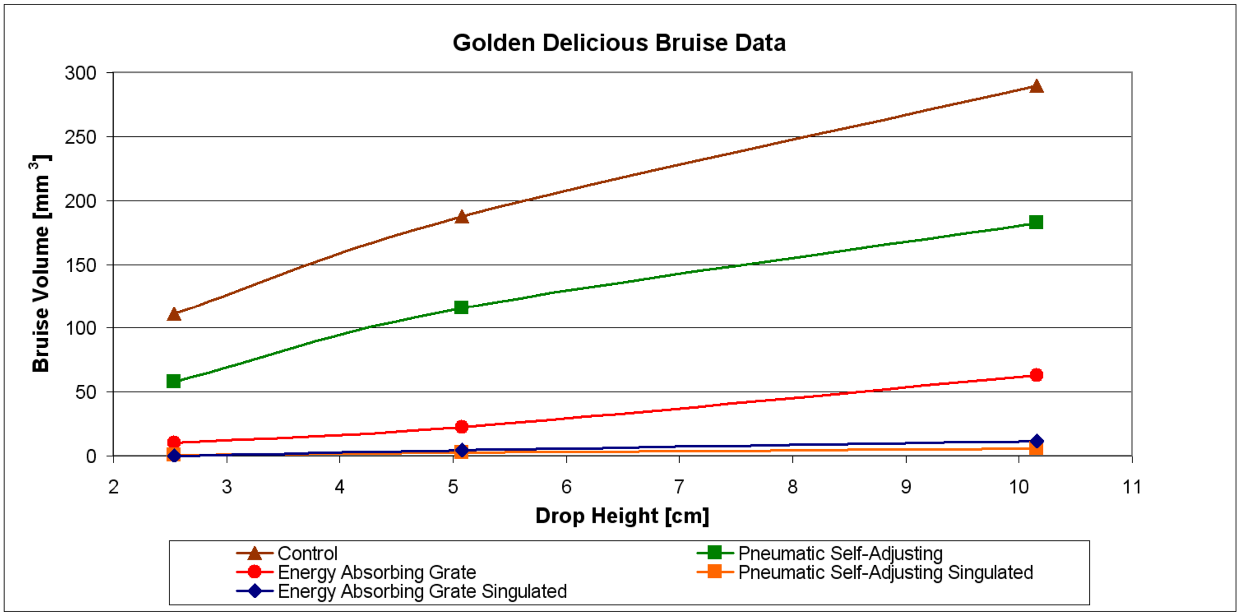

Figure 12. Trend lines comparing the performance of two full-scale bin filling prototypes across three drop heights.

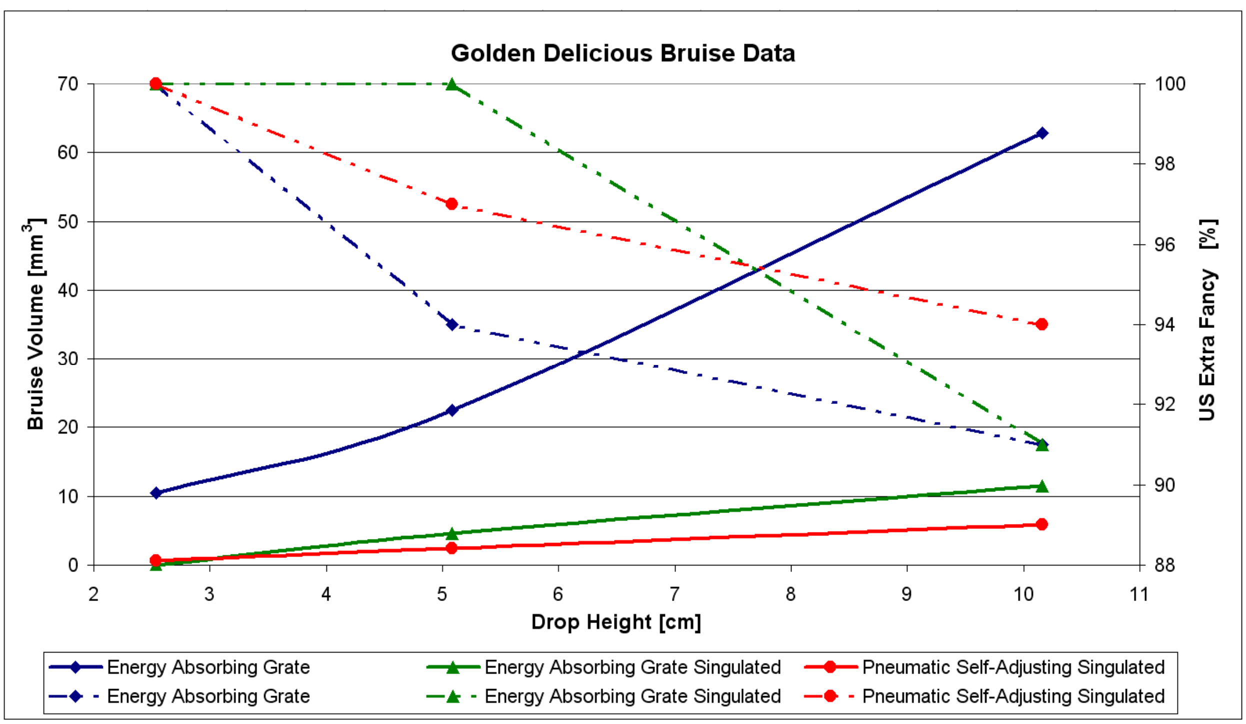

Figure 13. Bruise volume trend lines for the three best bin filling configurations with respective effects on USDA grades.

Developing Management Strategies to Optimize

The Uses of a Mobile High Tunnel System

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Over the past ten years the use of high tunnels by direct market producers has grown considerably in the mid-Atlantic region. These tunnels are being used to provide season extension, improve crop quality, and as an important tool for pest management. Although standard high tunnels are not permanent structures they are constructed with posts that are driven into the ground making them difficult and time consuming to move to accommodate multiple crops in one season. Producers have, for many years, been interested in a tunnel that could be easily and quickly moved to facilitate rotations, allow for easier soil renovation, and to optimize timing of the protective cover. Significant challenges presented by a mobile high tunnel include: mechanism of movement, site accessibility, and weight, as well as overall stability during movement and once secured over the crop. These factors have contributed to the fact that commercial availability of a mobile high tunnel system has been extremely limited until very recently.

This report will address the site selection and preparation, construction, fabrication, and establishment of plantings in a high tunnel system called *Rolling Thunder* which is manufactured by Rimol Greenhouse Systems. This system has been constructed at the University of Maryland's Western Maryland Research and Education Center in Keedysville, Maryland. The system consists of an 18'x 48' tunnel with rollup sides for ventilation on a 150' long track. Each post is mounted on a grooved wheel at the base allowing the structure to roll on the track. The tunnel will be moved three times a year along the track to cover a different crop. The site has water supplied by a frost free hydrant for irrigation. There is no electricity or source of supplemental heat. Crops to be grown include Annual strawberries for the early spring, heirloom tomatoes for the summer, and primocane bearing red raspberries for the fall. These crops were selected due to the profit potential observed by direct market producers in the mid-Atlantic. As the work progresses other crops will be examined. Since this work is intended for the direct market grower there will undoubtedly be many crops that will have the potential to fit into the mobile system based on the needs of the farmers' markets and CSA's.

This ongoing work will examine the functionality and practicality as well as the profitability of the mobile system. As an example growers have voiced concerns regarding the strength of this tunnel in wind. This question can at least be partially answered as the tunnel in Keedysville withstood winds in excess of 50 miles per hour in mid October 2009. Observations of this nature and of the production data will contribute to the further development of this system and will be documented to allow producers an opportunity to develop realistic expectations of this type of structure before making the investment.

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Without Consent of the Author

PERFORMANCE OF GOLDEN DELICIOUS ON 18 ROOTSTOCKS IN PENNSYLVANIA

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A plethora of apple rootstocks have been released in the last few years. Many are coming from eastern European countries and were not readily available before. Countries such as the Czech Republic, Germany (formerly East Germany) and Russia have released several new rootstocks. The rootstocks from the Czech Republic are designated the J-TE series; J = jablon (apple) and TE = Těchobuzice, the location of the research center. The rootstocks from Germany are designated PiAU from **Pi**llnitz with **AU** = apfel-unterlage (apple rootstock). Rootstocks from Russia were named in honor of the original breeder pomologists V.J. Budagovsky located at the Michurinsk College of Agriculture. Currently the most widely used rootstock from this series is B.9. Japan has released a series of rootstocks designated JM. These rootstocks are reportedly smaller than M.9 propagate by hardwood cuttings; some have resistance to apple crown rot and most are resistant to wooly apple aphids. The regional research project, NC-140 has for years evaluated new rootstock releases in a cooperative replicated manner. The results are typically published at the end of the 5th (Marini et al., 2009) and 10th growing season. The purpose of this report is to present an interim report of one such planting using Golden Delicious on 18 different rootstocks planted at the Horticulture Research Farm at Rock Springs in central Pennsylvania.

Materials & Methods

As part of the NC-140 Regional Research Project Golden Delicious (Gibson) was grafted on the 18 rootstocks listed in Table 1 and planted in the spring of 2003. The spacing was 3.5m x 5.5m with a single wire at 8 ft with conduit at each tree. The trees were trained as a vertical axe. There were 6 to 8 trees each in four blocks with two tree of each rootstock per block. Data collected yearly included trunk circumference which was converted to trunk cross sectional area (TCSA cm^2). Flower clusters were counted in 2004 and 2005 but removed shortly after fruit set in 2004. In subsequent years bloom was evaluated by rating the bloom density on a 0 to 5 scale with 0 = no bloom, 3 = full crop and 5 = snowball bloom. Beginning in 2005 yields per tree (kg) and number of fruit per tree were measured at harvest. Efficiency (gm/cm^2 of TCSA) was calculated as was crop load (# fruit/cm^2 of TCSA). Average fruit weight (g) was calculated from taking the total yield per tree and dividing by the number of fruit. Cumulative yield was calculated by taking total yield over all the years (2005 – 2007). Cumulative efficiency was calculated by taking total yield from 2005 – 2006 and dividing by TCSA in 2006.

Results

In 2004 trees on B.62-396 had the greatest number of flowers per tree. In 2005 trees on G.935 and CG.6210 had the greatest number of flowers (Table 2). Flower density was greatest on J-TE-G. In 2005 G.935 had the greatest number of flowers and flower density although neither was significantly better than B.62-396. In both years JM.2 had the lowest number of flowers. In 2006 through 2008 the highest bloom rating varied by rootstock (data not shown), however, JM.2 consistently had the lowest bloom rating all three years, contradicting the supposedly higher flowering capability as outlined by Wertheim (1998).

Tree height and spread was measured at the end of the 5th leaf in 2007. Trees on J-TE-G were the shortest and had the narrowest spread (Table 3). Trees on PiAU 56-83 were the tallest and had the greatest spread although they were not significantly larger than trees on JM.2, JM.8, or PiAU 51-4. At the end of 2008 tree size as measured by TCSA was greatest for JM.2 and the least for J-TE-G. Trees that had similar TCSA's to JM.2 were PiAU 51-4 and PiAU 56-83. Trees with similar TCSA's to J-TE-G were B.62-396, B.9, G.16, G.41, G.935 and M.9T337. Trees that were similar to JM.2 in height, spread and TCSA are larger than M.26 and would not be considered dwarfing.

Trees on PiAU 51-4 produced the greatest cumulative number of fruit and total yield during the first four producing seasons (2005 – 2008) but not significantly more so than eight other rootstocks (Table 4). Trees on J-TE-G produced the lowest number of cumulative fruit and cumulative yield but had the highest cumulative efficiency. Trees on JM.2 had relatively low numbers of fruit, low yields and were the least efficient. There were no differences in average fruit weight as influenced by rootstock. Cumulative efficiency was greatest for trees on J-TE-G but not significantly better than ten other rootstocks. JM.2 had the lowest efficiency

Conclusions

The study will be continued until 2012 so the results presented here should be considered preliminary. However at this point, Geneva 41 and Geneva 935 have performed adequately in comparison to M.9T337. Geneva 16 has also performed adequately, but we are concerned in noticing a tendency for the foliage to look off color in the early fall and it may indicate a compatibility problem with this rootstock. B.62-396 has performed well and should be further tested. In other trials in Europe B.62-396 was rated better than B.9 because it was easier to propagate (Bites & Lepsis, 2004). In comparison of size, B.62-396 was significantly smaller than M.26 and similar although slightly larger than several clones of M.9 (Czynczyk et al., 2001) CG.6210, although larger than we would like, has been very productive and precocious. Since this planting is supported we do not know for certain if this rootstock could be free standing. The

Pilnitz rootstocks in this trial are too vigorous although they have produced large yields. JM.2 and JM.8 in this trial are too large and unproductive, especially JM.2 which was significantly larger than M.26. J-TE-G produced the smallest tree and may be too small at lower tree densities. A report from Germany (Stehr, 2007) indicated that J-TE-G is similar to M.27 in size and approximately 40% smaller than M.9, However, in the same report J-TE-H is reported to be slightly larger than M.9 (about 15%). PiAU 56-83 is 90% larger than M.9. Clearly there is much confusion over the size of many of these rootstocks.

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Table 1. Golden Delicious apple trees on eighteen rootstocks planted in 2003 at the Horticulture Research Farm at Rock Springs, Pa.

B.62-396	B.9	Cepiland
CG.6210	G.41	G.16
G.935	JM.1	JM.2
JM.7	JM.8	J-TE-G
J-TE-H	M.26	M.9T337
PiAU 51-11	PiAU 51-4	PiAU 56-83

Table 2. Total number of flower clusters and flowering density of Golden Delicious apple trees on different rootstocks in the second and third year after planting.

	2004		2005	
Rootstock	Tot. # Clusters	Clust./TCSA, #/cm^2	Tot. # Clusters	Clust./TCSA, #/cm^2
B.62-396	17.1 b	2.1 ab	184.3 bcde	22.3 def
B.9	2.9 ab	0.7 a	79.7 ab	19.9 cde
Cepiland	1.5 a	0.3 a	136.8 abcde	18.3 cde
CG.6210	0.9 a	0.1 a	227.1 de	22.0 def
G.16	5.9 ab	0.8 a	199.3 cde	25.8 ef
G.41	4.0 ab	0.8 a	138.9 abcde	22.6 def
G.935	0.6 a	0.1 a	231.5 e	32.0 f
JM.1	9.8 ab	1.3 ab	145.2 abcde	17.0 bcde
JM.2	0.0 a	0.0 a	53.6 a	5.5 a
JM.7	11.0 ab	1.2 ab	162.7 abcde	18.6 cde
JM.8	0.0 a	0.0 a	105.0 abc	12.5 abcd
J-TE-G	14.5 ab	3.0 b	114.9 abc	23.3 def
J-TE-H	11.0 ab	1.3 ab	196.8 cde	24.8 ef
M.26	3.9 ab	0.7 a	97.8 abc	16.4 bcde
M.9T337	0.4 a	0.1 a	122.1 abcd	23.5 ef
PiAu 51-11	0.6 a	0.1 a	114.9 abc	16.0 abcde
PiAu 51-4	3.1 ab	0.3 a	126.4 abcde	10.9 abc
PiAu 56-83	0.3 a	0.0 a	67.8 a	6.3 ab
P-Value	0.0002	0.0002	0.0001	0.0001

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

Table 3. Tree height and spread (cm) of Golden Delicious apple trees on different rootstocks at the end of 2007 (5th leaf) and trunk cross sectional area at the end of 2008 (6th leaf).

	2007		
Rootstock	Tree Height, cm.	Tree Spread, cm.	08 Fall TCSA, cm^2
B.62-396	299 abc	245 abc	30.0 abc
B.9	283 ab	227 ab	20.2 ab
Cepiland	321 bcd	261 bc	37.4 bc
CG.6210	322 bcd	267 bcd	44.3 cd
G.16	283 ab	247 abc	30.1 abc
G.41	282 ab	220 ab	24.2 abc
G.935	296 ab	251 abc	29.5 abc
JM.1	322 bcd	242 abc	38.4 bcd
JM.2	381 de	271 bcd	86.6 f
JM.7	328 bcd	261 bc	39.1 bcd
JM.8	368 cde	272 bcd	59.4 de
J-TE-G	244 a	208 a	16.9 a
J-TE-H	313 bc	258 abc	37.0 bc
M.26	344 bcde	258 abc	41.2 cd
M.9T337	319 bcd	244 abc	32.2 abc
PiAu 51-11	322 bcd	241 abc	43.7 cd
PiAu 51-4	383 de	289 cd	76.5 ef
PiAu 56-83	404 e	320 d	80.2 ef
P-Value	0.0001	0.0001	0.0001

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

Table 4. Cumulative total number of fruit, total yield per tree, average fruit weight and cumulative efficiency of Golden Delicious on different rootstocks at the end of the 6th leaf (2008).

Rootstock	05-08 Tot. # Fruit		05-08 Tot. Yield, kg		05-08 Avg. Frt wt, g		05-08 Eff., kg/cm^2	
B.62-396	463	abcd	81.68	abc	173	a	2.74	ef
B.9	313	ab	53.10	a	169	a	2.69	ef
Cepiland	457	abcd	80.81	abc	176	a	2.15	bcdef
CG.6210	597	cd	104.94	bc	176	a	2.42	cdef
G.16	465	bcd	76.22	ab	166	a	2.54	def
G.41	371	ab	62.96	a	171	a	2.67	ef
G.935	476	bcd	80.12	ab	168	a	2.71	ef
JM.1	389	abc	66.31	ab	166	a	1.74	abcde
JM.2	379	ab	67.99	ab	169	a	0.79	a
JM.7	459	abcd	79.03	ab	175	a	2.02	bcdef
JM.8	455	abcd	80.51	abc	170	a	1.52	abc
J-TE-G	274	a	47.10	a	175	a	2.85	f
J-TE-H	380	ab	70.99	ab	182	a	2.05	bcdef
M.26	384	ab	67.57	ab	173	a	1.69	abcd
M.9T337	395	abc	70.21	ab	177	a	2.23	bcdef
PiAu 51-11	361	ab	66.44	ab	180	a	1.54	abc
PiAu 51-4	666	d	120.05	c	173	a	1.58	abc
PiAu 56-83	592	cd	106.12	bc	171	a	1.32	ab
P-Value	0.0001		0.0001		0.1898		0.0001	

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

RESULTS OF THREE APPLE CULTIVARS GROWN IN FOUR TRAINING SYSTEMS

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In recent years the apple industry has seen a dramatic change in production systems. Not too long ago the most common training production system was a free standing central leader system. As the availability of labor has declined and costs have gone up more growers are looking to try to reduce tree size to increase efficiency of labor. This has been coupled with the increasing use of dwarfing rootstocks in the M.9 size class. The central leader system, also known as "spread and head", was predicated on the need to spread branches and head them as well as the central leader to stiffen them up and increase branching. The constant heading reduced flowering and delayed production. With costs of production increasing constantly, fruit growers need plantings to come into production sooner. New training systems have dramatically reduced the use of heading cuts and therefore increased early yields. The purpose of this study was to look at three different apple cultivars that have slightly different growth habits and see if different training systems were influenced by cultivar growth habit.

Materials & Methods

A planting of Ginger Gold, Crimson Gala and Fuji (BC#2) all on M.9 NAKB T337 was established at the Horticulture Research Farm at Rock Springs, PA in 1997. Ginger Gold growth habit is typified as acrotonic or tip bearing like. Normally Gala is not considered to have a basitonic growth habit (spur type); but this particular strain has a spurrier type habit than most Gala strains. Fuji was chosen to represent a growth habit that is in between the previous two growth patterns.

Four training systems were chosen to represent new training systems that were just being developed. The first new system was the vertical or French Axe (A) supported by a single wire at 8 ft (2.4 m) to which a conduit was attached; the second system was a modified version of a slender spindle (SS) patterned after the system developed in The Netherlands (Wertheim, 1978). The third system utilized was one that was developed at Penn State, the Low Trellis (T) Hedgerow System (Tukey, 1983). All these systems were planted at a spacing of 6 ft x 12 ft (1.8 m x 3.7 m) or 605 trees per acre (1495 trees/ha). The last training system utilized was a V-Axe, where trees were planted 3 ft (0.9 m) in the row and every other tree was alternately leaned at a 60^{o} angle to the east and the next one to the west, with between row spacing of 16 ft (4.9 m) resulting in a tree density of 908 trees per acre (2,244 trees/ha.). The individual trees were then trained following vertical axe methods

The design of the planting was a randomized complete block with six replications (blocks). Tree training systems were randomly assigned as rows within the block and then five trees of each cultivar were randomly assigned within the row. Smallest trees were assigned to the T system to insure limbs were low to the ground.

Trunk circumference was measured each fall 1997 through 2006 and converted to trunk cross sectional area (TCSA). TCSA was not determined after the 2006 growing season. Once the trees began fruiting, in 1999, yield and number of fruit were collected from the 5 tree sub plots up to and including 2006 (10th leaf). There after yield and fruit number were collected from the middle tree of each 5 tree subplot. Crop load and efficiency was determined by dividing the number of fruit and the yield per tree by average TCSA for that 5 tree section. Tree height and spread were measured at the end of the 10th growing season. The VA was removed at the end of the 11th growing season (2007) due to problems with poor quality fruit and low fruit set in the bottom of the canopy; hence there is no yield data after 2007 for that system. An ANOVA was run on all data and when the P value was significant, a Tukey-Kramer mean separation was run.

Results

Beginning in 1999 and each year through 2007 there were several factors measured that had significant cultivar x system interactions (Table 1). Not all the same factors had significant interactions each year. The least amount of interactions occurred in 2005, which was also the year much of the crop was reduced due to a spring frost event. Both average number of fruit per tree and yield per hectare had significant cultivar x system interactions in six out of nine years.

Tree size as measured by TCSA at the end of the 10th growing season showed a cultivar x system interaction (Table 1). Within cultivars the largest Ginger Gold trees were in the S and A systems while there was no difference between the VA and T systems. Within the cultivar Gala the largest trees were in the A system but were not significantly larger than the SS system. With Fuji, the largest trees were in the SS and the T systems with trees in VA and A being significantly smaller. Within training systems Fuji had a significantly higher TCSA than the other two cultivars for all systems except the A system where there was no difference by cultivar. For Ginger Gold and Gala the tallest trees were in the A system. The shortest trees for all cultivars were in the T system. Spindle trees were consistently taller than the trellis trees. The spindle was difficult to maintain at low heights as the soil was too vigorous. Tukey (1989) indicated at this same site M.9 can be more vigorous than is desirable due to the cultivar x soil vigor combination.

The T system was the narrowest as it was summer pruned each year according to recommendations (Table 2). At harvest because the T was so narrow it was often possible to harvest most of the fruit from both sides of the tree wall without going to the other side of the canopy wall. The VA tended to be the widest due to the angle at which the trees were spread. The S and A were intermediate in row width for all cultivars. There were no differences by cultivars within a given training system in tree width.

Cumulative number of fruit per tree for all three cultivars was highest on trees trained to the A system (Table 4). For Gala and Fuji the lowest cumulative number of fruit per tree was on the VA system; whereas, with Ginger Gold the lowest was on the trellis. Within any one system, Gala tended to have the highest number of fruit. Within a cultivar cumulative yield per tree (kg) was also highest for all three cultivars on the A system and tended to be lowest in the VA except for Ginger Gold. Between cultivars cumulative yield in the S and T was significantly higher for Fuji with no differences for VA or A. Through 2007 cumulative yield per tree (kg) was highest for Ginger Gold and Gala in the Axe system (Table 4). Cumulative yield per tree for Fuji was also the highest for the A system but it was not significantly higher than yield per tree for the Spindle; and the S, A and T systems all had significantly higher yields per tree than the VA. Within a training system Fuji outperformed Ginger Gold and Gala in per tree yield in the S and T systems. There was no difference within the VA or A system between cultivars.

Cumulative yield efficiency for 1999 - 2006 (kg/cm^2 TCSA) for Ginger Gold was highest for the VA but not significantly higher than the Axe. For Gala the lowest cumulative efficiency per tree were trees trained to the Spindle and was similar to those trained to the VA and T. The highest cumulative efficiency per tree for Fuji was for trees trained to the Axe and significantly better than the other three systems suggesting that Fuji may best suited to an Axe training system. Between cultivars within a system Fuji performed the worst in the V-Axe and similar to Gala. This may be related to the late maturity of the cultivar and the less time the tree has to recover after fruit harvest and killing frosts. All three cultivars performed equally as well in the Spindle and Axe systems. Gala performed best in the Trellis system. This may have been due to the more basitonic growth habit and therefore better light exposure on spur leaves aided by the yearly summer pruning

Cumulative yield per unit of land (kg/ha) for Ginger Gold was highest for the VA but similar to the A system (Table 5). Gala yields for the VA and A systems were highest and similar to each other and better than yields of either S or T systems. Yields for Fuji were significantly better in the A system than in the T system. While cumulative yield per unit of land (kg/ha) appeared to be related to tree density with the V-Axe having the highest yield in the early years this advantage dissipated in later years. Although in all three cultivars the Axe had similar yields per hectare.

Summary

After the first two years there was a significant cultivar x training systems interaction for many factors. Fuji trees were the largest as measured by TCSA and the most productive cultivar doing well on all the training systems. Due to higher number of trees per unit of land the VA tended to yield more fruit per unit of land; but the A system yield more fruit per tree. In five out of ten years Gala trained to an A systems had higher yields than the other systems. Fuji trained to the VA system had the lowest yields in five of ten years. This phenomena could be related to poorer light levels in the more dense lower portion of the canopy and the denser nature of the growth habit being more like a type 3 growth habit. Ginger Gold yield per tree was only affected by training system in three out of ten years indicating that Ginger Gold was adaptable to all the systems.

Appreciation is expressed to the State Horticultural Association of Pennsylvania's Endowment Fund for funding this project.

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Table 1. Significant interaction of cultivar by system for yearly measured parameters. by year

Year	TCSA	#Fruit/ Tree	Yield/tree (kg)	Yield/Ha	Efficiency	Crop Load	Bloom rating
1999		X			X	X	
2000	X		X				
2001		X	X		X	X	X
2002		X	X	X	X	X	X
2003		X	X	X	X		X
2004	X		X	X	X	X	
2005	X			X			
2006	X	X		X			X
2007		X	X	X			

Table 2. Trunk cross sectional are of three apple cultivars in four training systems at the end of the 10th leaf at Rock Springs, PA

2006 Trunk Cross-sectional Area, cm^2				
	Ginger Gold	Gala	Fuji	
V-Axe	33.3 a	36.1 a	45.0 a	
Spindle	47.1 b	47.8 bc	63.9 b	
Axe	47.7 b	50.6 c	55.2 a	
Trellis	38.5 a	39.0 ab	61.3 b	
P - Value	0.0001	0.0007	0.0011	
	V-Axe	Spindle	Axe	Trellis
Ginger Gold	33.3 a	47.1 a	47.7 a	38.5 a
Gala	36.1 a	47.8 a	50.6 a	39.0 a
Fuji	45.0 b	63.9 b	55.2 a	61.3 b
P - Value	0.0013	0.0011	0.1128	0.0001

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

Table 3. Tree height and spread of three apple cultivars trained to four different training systems at the end of their 10th leaf planted at Rock Springs, PA.

2006 Tree Height, cm.				
	Ginger Gold	Gala	Fuji	
V-Axe	361 b	354 b	304 b	
Spindle	362 b	363 b	337 b	
Axe	415 c	433 c	345 b	
Trellis	203 a	202 a	200 a	
P - Value	0.0001	0.0001	0.0001	
	V Axe	Spindle	Axe	Trellis
Ginger Gold	361 b	362 ab	415 b	203 a
Gala	354 b	363 b	433 b	202 a
Fuji	304 a	337 a	345 a	200 a
P - Value	0.0021	0.0326	0.0001	0.5129
2006 Tree Row Width, cm.				
	Ginger Gold	Gala	Fuji	
V-Axe	468 c	447 c	443 c	
Spindle	226 b	212 b	224 b	
Axe	206 b	199 b	215 b	
Trellis	115 a	104 a	113 a	
P - Value	0.0001	0.0001	0.0001	
	V-Axe	Spindle	Axe	Trellis
Ginger Gold	468 a	226 a	206 a	115 a
Gala	447 a	212 a	199 a	104 a
Fuji	443 a	224 a	215 a	113 a
P - Value	0.1267	0.2218	0.3232	0.0693

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

Table 4. Cumulative number of fruit per tree and yield per tree as influenced by cultivar and training system from 1999 to 2007.

Cumulative # Fruit per Tree, 1999-2007				
	Ginger Gold	Gala	Fuji	
V-Axe	815 a	1085 a	835 a	
Spindle	847 ab	1221 a	1195 bc	
Axe	1049 b	1482 b	1282 c	
Trellis	779 a	1127 a	1033 b	
P - Value	0.0105	0.0004	0.0001	
	V-Axe	Spindle	Axe	Trellis
Ginger Gold	815 a	847 a	1049 a	779 a
Gala	1085 b	1221 b	1482 b	1127 b
Fuji	835 a	1195 b	1282 ab	1033 b
P - Value	0.0005	0.0001	0.0021	0.0003
Cumulative Yield per Tree, kg., 1999-2007				
	Ginger Gold	Gala	Fuji	
V-Axe	133.11 a	127.24 a	130.86 a	
Spindle	144.29 a	147.98 a	197.00 bc	
Axe	177.01 b	180.26 b	205.45 c	
Trellis	130.33 a	134.03 a	168.95 b	
P - Value	0.0020	0.0001	0.0001	
	V-Axe	Spindle	Axe	Trellis
Ginger Gold	133.11 a	144.29 a	177.01 a	130.33 a
Gala	127.24 a	147.98 a	180.26 a	134.03 a
Fuji	130.86 a	197.00 b	205.45 a	168.95 b
P - Value	0.6886	0.0001	0.1049	0.0001

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

Table 5. Cumulative efficiency (kg/cm^2 TCSA) per tree of Ginger Gold, Gala and Fuji grown under four different training systems for 1999 - 2006

Cumulative Efficiency per Tree, kg/cm^2, 1999-2006				
	Ginger Gold	Gala	Fuji	
V-Axe	2.92 b	2.46 ab	2.14 a	
Spindle	2.20 a	2.00 a	2.28 a	
Axe	2.66 ab	2.56 b	2.78 b	
Trellis	2.32 a	2.39 ab	2.08 a	
P - Value	0.0026	0.0272	0.0008	
	V-Axe	Spindle	Axe	Trellis
Ginger Gold	2.92 b	2.20 a	2.66 a	2.32 ab
Gala	2.46 ab	2.00 a	2.56 a	2.39 b
Fuji	2.14 a	2.28 a	2.78 a	2.08 a
P - Value	0.0042	0.2686	0.2020	0.0151

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

Table 6. Cumulative yield 1999 - 2007 per hectare (kg/ha) of Ginger Gold, Gala, and Fuji on four training systems

Cumulative Yield per Hectare, kg., 1999-2007				
	Ginger Gold	Gala	Fuji	
V Axe	298,323 c	285,166 b	293,286 ab	
Spindle	215,708 ab	221,223 a	294,506 ab	
Axe	264,623 bc	269,487 b	307,135 b	
Trellis	194,840 a	200,373 a	252,569 a	
P - Value	0.0004	0.0001	0.0182	
	V Axe	Spindle	Axe	Trellis
Ginger Gold	298,323 a	215,708 a	264,623 a	194,840 a
Gala	285,166 a	221,223 a	269,487 a	200,373 a
Fuji	293,286 a	294,506 b	307,135 a	252,569 b
P - Value	0.6886	0.0001	0.1049	0.0001

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

UPDATE ON INNOVATIVE TECHNOLOGIES FOR THINNING OF FRUIT

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Introduction

Hand thinning of tree fruit is a labor-intensive and tedious process. Reducing the labor requirement through mechanization would help reduce labor costs, decrease the need for short-term labor scheduling during the bloom season, and improve profitability. This project, with support from several funding sources*, is investigating methods to mechanize fruit thinning tasks. Peaches have been the target fruit during the first couple of years' work on this project. With grower and industry cooperation, the project has already clearly demonstrated that mechanized peach thinning is viable (Baugher et al., 2009). One particular thinning unit (Darwin string thinner) is now available for commercial purchase and use. However, further refinements and developments are being investigated, including automated positioning of the string thinner, design changes in a prototype drum shaker, and design of a selective thinning unit.

Objectives

The fruit thinning project has five primary objectives:

1) Integrate mechanization and tree canopy architecture by investigating training modifications to make flowers or fruit more visible/accessible and new methods of targeting optimum level of crop load adjustment at various stages of bloom/fruit development.
2) Further develop and modify two prototype non-selective fruit thinning devices to improve prototype efficacy, commercialization potential, and the opportunity for immediate adoption by an industry that is actively seeking engineering solutions for the near term.
3) Develop and integrate electronic and mechanical technologies for higher precision and selective thinning.
4) Provide technology transfer by pilot testing prototype units from Objectives 2 and 3 in orchards with commercial growers, and work with industry towards commercialization of thinning units.
5) Evaluate sociological implications and economic impact of implementation of mechanized fruit thinning devices by comparing traditional approaches with new mechanized approaches developed and tested in previous objectives.

* Funding sources include USDA, State Horticultural Association of Pennsylvania, Washington Tree Fruit Research Commission, California Canning Peach Association, Pennsylvania Department of Agriculture, and The South Carolina Peach Council.

Work progressed on all five objectives during the first year. Results have been obtained from objectives 1, 2, 4, and 5 and are summarized in this report.

Thinning units

The non-selective thinners are designed to quickly and efficiently thin trees without discrimination between blossoms or fruit. These units will randomly remove blooms or small fruit but can be adjusted to change removal rates. The selective thinner will identify specific blossoms and then remove them.

Darwin String Thinner

The Darwin string thinner is manufactured by Fruit-Tec in Germany and removes blossoms only. There are now three models, the 250, 300, and the newer PT-250. The 250 and 300 are 2.5 m (8 ft) and 3.0 m (10 ft) long vertical thinners (Figure 1) that can be adjusted in height and angle to remove blossoms from perpendicular V and other similar architectures in peaches. The string arrangements, spindle rpm, and forward tractor speed help determine the removal rates of the unit (Schupp, et al. 2008). The PT-250 is a 2.5 m (8 ft) long thinner that can adjust to either the vertical or horizontal positions (Figure 2). This versatile thinner can be adjusted in height and angle to remove blossoms in both perpendicular V and open vase architectures.

Figure 1. Darwin 300 vertical string thinner.

Figure 2. Darwin PT-250 horizontal string thinner.

USDA Drum Shaker

The drum shaker (Figure 3) is based on a design from the USDA Appalachian Fruit Research Station in Kearneysville, WV, and was originally developed to harvest oranges. The modified version used for peach thinning is based on a blackberry harvest design. This unit was tested on both blossom and small fruit stages. The drum shaker is a prototype and is currently not commercially available.

Figure 3. USDA drum shaker.

Selective Thinning Unit

Selective thinning requires a higher level of technology because each blossom has to be identified and then an “end effector” component has to be properly positioned to remove the blossom. This requires the use of imaging and robotics. The advantage of such a unit is that the remaining blossoms and/or small fruit would be ideally spaced for maximum growth and quality.

Results to Date

The Darwin string thinner was tested extensively in commercial peach orchards during the bloom season of 2009. Test sites included orchards in Pennsylvania, South Carolina, Washington State, and California. The drum shaker was tested during bloom and early fruit stages during Spring and Summer of 2009 in Pennsylvania and West Virginia. Highlights of the Pennsylvania results are presented here.

Several parameters were tested for the Darwin thinner, including bloom stage, spindle rpm, string configurations, and pruning methods. The results are shown as “net economic impact”, which is the cost benefit beyond hand thinning alone and includes machine cost, follow-up hand thinning time, and fruit size distribution. Prices for various fruit sizes are based on data obtained from the *USDA Agricultural Marketing Service Report, Appalachian District.*

Results from the Darwin tests show that the unit provides similar crop load results to hand thinning and in some cases increases fruit size. In almost all cases, the economic gain is positive compared to hand thinning controls. Bloom trial results for Pennsylvania are shown in Figure 4. These results are shown for Sugar Giant and Arctic Sweet cultivars. The economic returns range from $50/ac to $417/ac. Pruning modification results show returns for two cultivars (John Boy and White Lady) ranging from -26/ac to $595/ac (Figure 5).

The drum shaker was also tested in Pennsylvania orchards, by itself and in combination with the Darwin. The economic returns ranged from $147/ac to $309/ac for John Boy (Figure 6).

Almost all trials showed positive economic gains in 2009. In 2008, when there was a much higher crop load in Pennsylvania peach orchards, the gains ranged from $250-$554/ac for bloom stage trials, $242-$1164/ac for pruning trials, and -$34 to $606/ac for drum shaker trials (Baugher et al, 2009). Results from other regions participating in the project showed similar values.

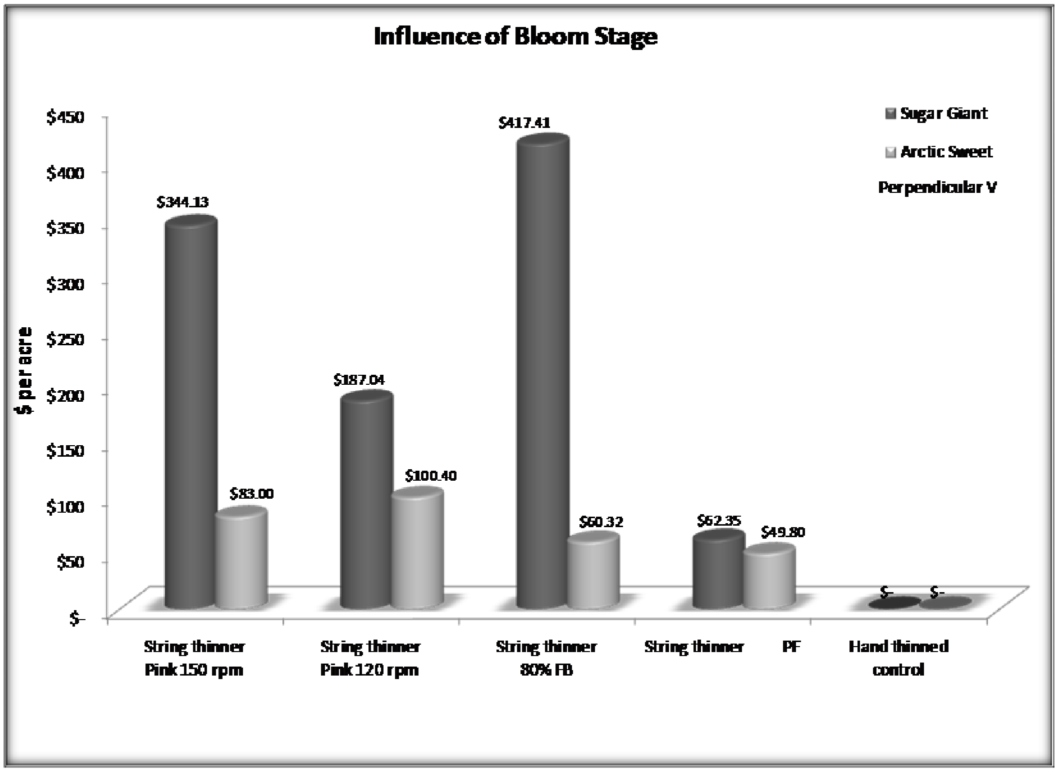

Figure 4. Economic return of Darwin string thinner utilization based on bloom stage.

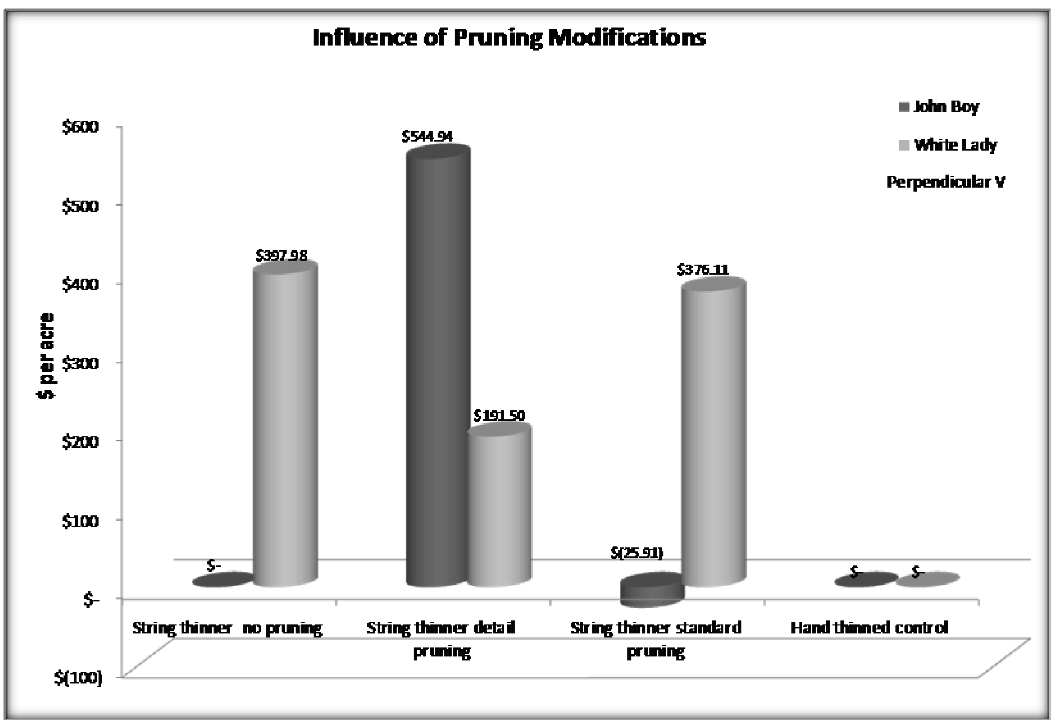

Figure 5. Economic return of Darwin string thinner utilization based on pruning.

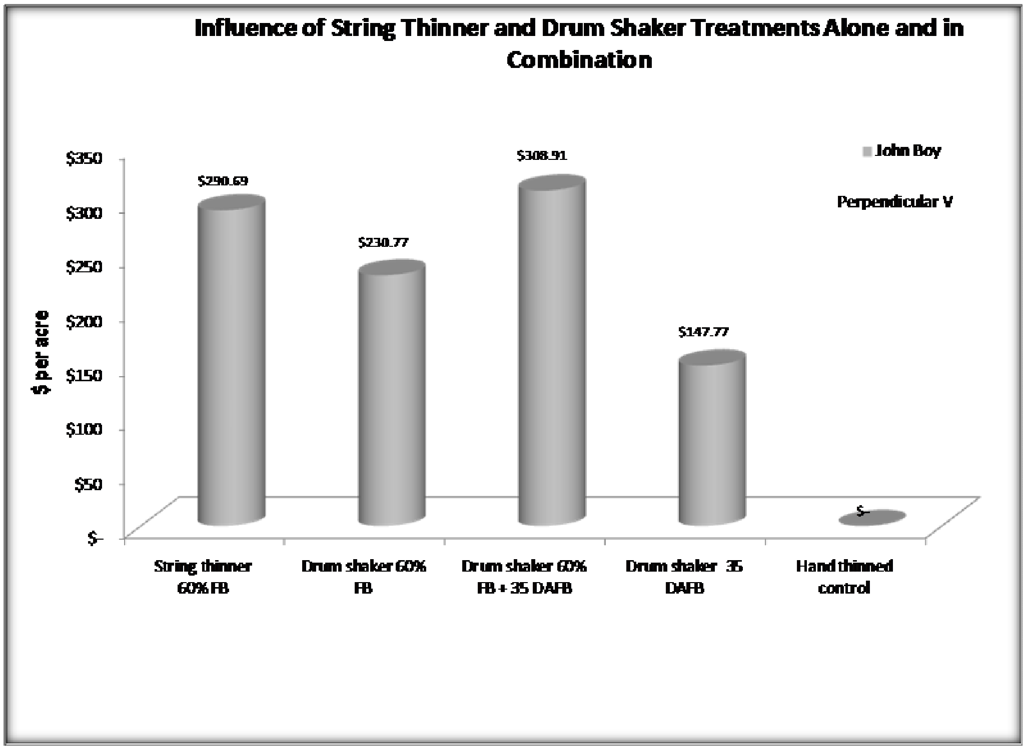

Figure 6. Economic return of drum shaker alone and in combination with string thinner.

Development of conceptual designs began for the selective thinner. Several methods to remove the blossoms have been tested, including water jets, air jets, and laser. However, the team has determined that the most practical removal method would be a direct contact mechanical device, such as a mechanism that gently grips the branch and rubs off the appropriate blossoms, or one with a spinning brush or paddle that rubs off the blossom. Two project teams are working on the image analysis to determine the location of branches and blossoms, as well as finding distances from the unit to the branch. These are being tested in both lab and orchard settings.

Continuing Activities

Testing of the string thinner and the drum shaker will continue through the 2010 growing season. Modifications to both units are being made. Sensors and controls will be added to the Darwin thinner to allow automatic positioning of the spindle, which will reduce driver fatigue and potentially increase the speed of thinning. Stability analysis is being performed on the Darwin, particularly when it is in the horizontal position, to determine what counterweights should be added to ensure that tip-over does not occur. Alternative materials will be investigated for the drum shaker rods to eliminate bark damage.

Development of the selective thinning unit is still in the early stages. Prototype designs for the components of the unit, including image analysis, controls, robotic arm selection, and blossom removal mechanism, are being investigated and tested. Within the next two years, these components will be integrated into a single unit and the selective thinner will be demonstrated.

Investigations into the economic and sociological aspects of the mechanization of thinning will also continue. Cost viability of the selective thinner needs to be determined. Barriers to adoption of the mechanized thinning approaches will be further explored.

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Not for Citation or Publication
Without Consent of the Author

ABSCISIC ACID, ETHYLENE, AND POLYGALACTURONASE ARE INVOLVED IN YOUNG FRUIT ABSCISSION INDUCED BY NAA AND SHADING IN ‘GOLDEN DELICIOUS’ APPLES

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Fruit thinning is very important to the success of the apple industry because thinning can improve fruit size and quality, which means a good price on the market. Thinning can also maintain tree structure and more importantly, it can increase return bloom, which guarantees a sustainable business for the growers.

Fruit thinning is usually conducted by chemical thinners but chemical thinning results are inconsistent because we still have an incomplete understanding of the modes of action of the chemical thinners, and we do not know very clearly about how other environmental factors affect the ultimate thinning responses. Some researchers think that chemical thinners thin apples by reducing carbohydrates available to young fruits. Others propose that chemical thinners enhance the fruit abscission through increased ethylene production. Also ABA plays important roles in plant responses to various environmental stresses that may lead to abscission.

The objective of this study was to determine the expression patterns of genes responsible for biosynthesis of ethylene and ABA and cell wall degradation in the young apple fruit abscission caused by fruit thinner and shading. In the 2006 experiment, we chose ‘Golden Delicious’ apple trees on M.27 rootstock. Treatments included a non-treated control, NAA sprayed at 15 $mg \cdot L^{-1}$ and 92% polypropylene shade for 5 consecutive days. We treated the trees when fruit size was about 11 mm in diameter. After treatment, we tagged limbs and counted fruit for each treatment. We measured fruit ethylene production and studied the expression of certain groups of genes in the fruit abscission zone (FAZ) and the fruit cortex (FC), using real-time quantitative PCR.

Fig. 1 shows a time course of the fruit abscission rate and the total fruit abscission. The fruit abscission rate gradually increased and peaked around 15 days after treatment. Both the fruit thinner NAA and shading effectively increased the fruit abscission. As for the total fruit abscission, NAA-treated trees had much more fruit drop than the control, and shading caused almost 100% fruit drop. The ethylene production in young fruit is shown in Fig. 2. Fruit ethylene production was significantly increased by NAA and by shading from day 1 through day 5 and the NAA effect seemed to be more significant than shading. Fig. 3 shows the expression of genes encoding enzymes involved in ethylene biosynthesis. In both the FAZ and the FC, NAA enhanced the expression of ACC synthase genes *5A* and *5B* especially at an early stage after treatment, while shading significantly increased the expression of these two genes only in the FAZ but not quite as much in the FC. Both NAA and shading increased the expression of ACC oxidase gene which is *ACO1* in the FAZ and the FC. The expression of gene encoding enzymes involved in ethylene perception is shown in Fig. 4. The expression of these ethylene receptor genes (*MdETR1a*, *MdETR1b* and *MdERS1*) was up-regulated by shading in the FAZ and the FC. NAA had little effect on *MdETR1a* expression but enhanced the expression of *MdETR1b* and *MdERS1* in both tissues. *MdNECD1* has been reported as a key gene in ABA biosynthesis and *MdPG2*, which encodes polygalacturonase, is associated with cell wall degradation. In Fig. 5, the expression of both genes was obviously increased by NAA and shading in the FAZ and the FC.

We also got confirmative data from a 2007 experiment in 'Red Delicious' apples. We applied AVG, the inhibitor of ethylene biosynthesis, before NAA treatment, and found that AVG could reduce the young fruit ethylene production and the fruit abscission caused by NAA (Fig. 6). In Fig. 7, it was shown that on day 4 after treatment, in the FAZ, these genes that are responsible for ethylene synthesis, perception and cell wall degradation were largely induced by NAA, and AVG reduced NAA-enhanced expression of these genes.

To sum up, NAA and shading increased the young fruit abscission through increased ethylene production of young fruit. In the FAZ and the FC, NAA and shading enhanced the expression of ACC synthase and oxidase genes (*MdACS5A*, *MdACS5B* and *MdACO1*), most ethylene receptor genes (*MdETR1ab* and *MdERS1*), and ABA synthetic gene (*MdNCED1*) and cell wall hydrolysis gene (*MdPG2*). On the other hand, AVG could reduce the young fruit abscission caused by NAA by reducing ethylene production of young fruit caused by NAA. In the FAZ, AVG could reduce NAA-induced expression of *MdACS5A, MdACS5B*, *MdACO1*, *MdETR1a*, *MdERS1* and *MdPG2*. Therefore, we conclude that ethylene and ABA are involved in the young apple fruit abscission caused by NAA and shading. Certain genes related to ABA biosynthesis, ethylene biosynthesis, perception and cell wall degradation are responsible for fruit thinning in 'Golden Delicious' apples. In addition, NAA and shading may share a certain pathway during the fruit abscission process, which may need further investigation.

Acknowledgments

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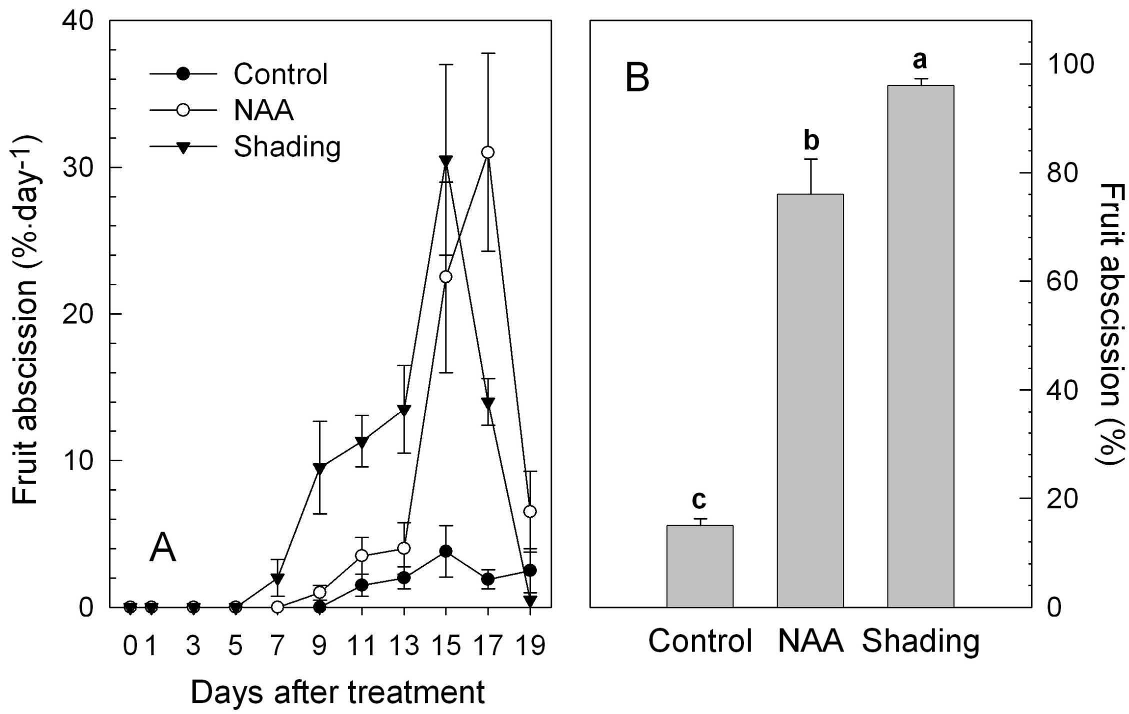

Fig.1 Effect of NAA and shading on fruit abscission rate (A) and total fruit abscission (B) in 'Golden Delicious' apples in 2006. Data are means ± SE (n=4).

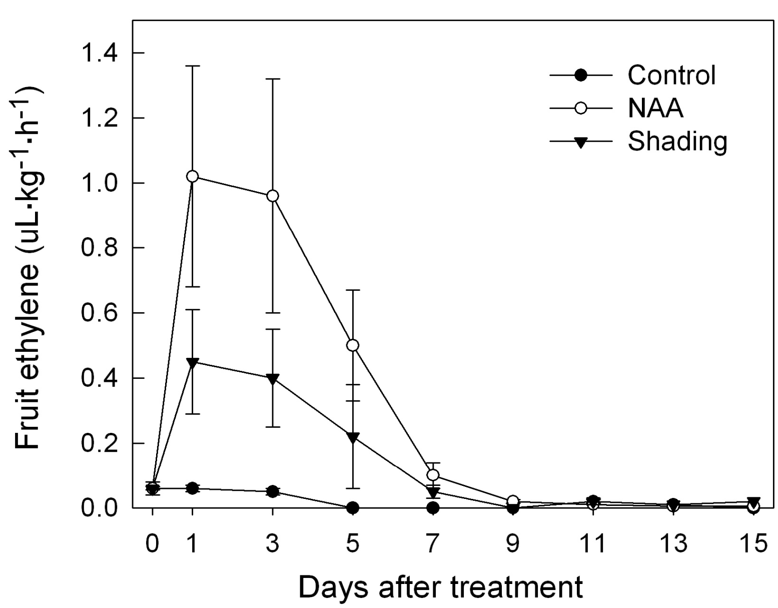

Fig.2 Effect of NAA and shading on fruit ethylene production in 'Golden Delicious' apples in 2006. Data are means ± SE (n=3).

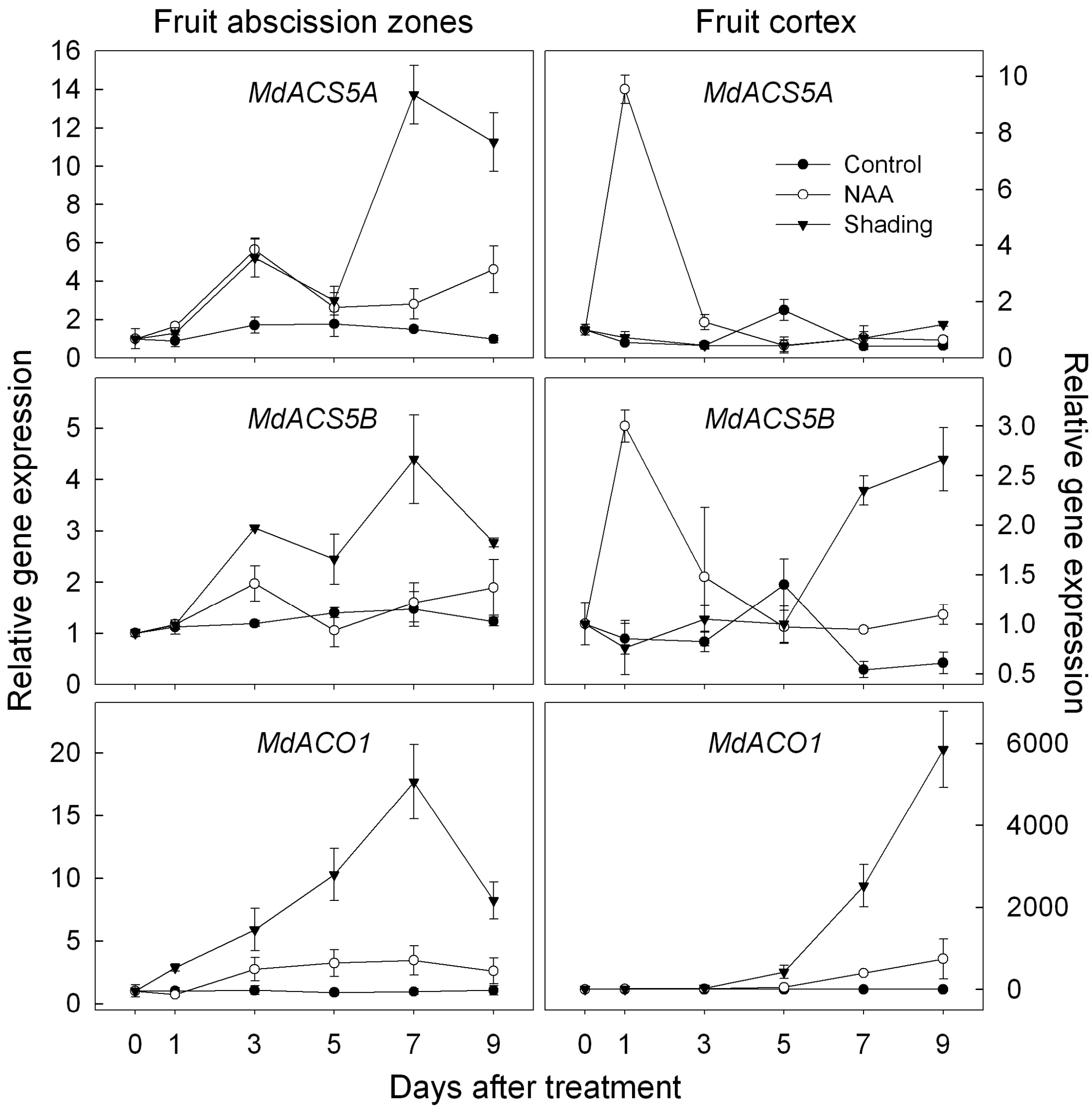

Fig.3 Effect of NAA and shading on the expression of genes encoding enzymes involved in ethylene biosynthesis. Data are means ± SE (n=3).

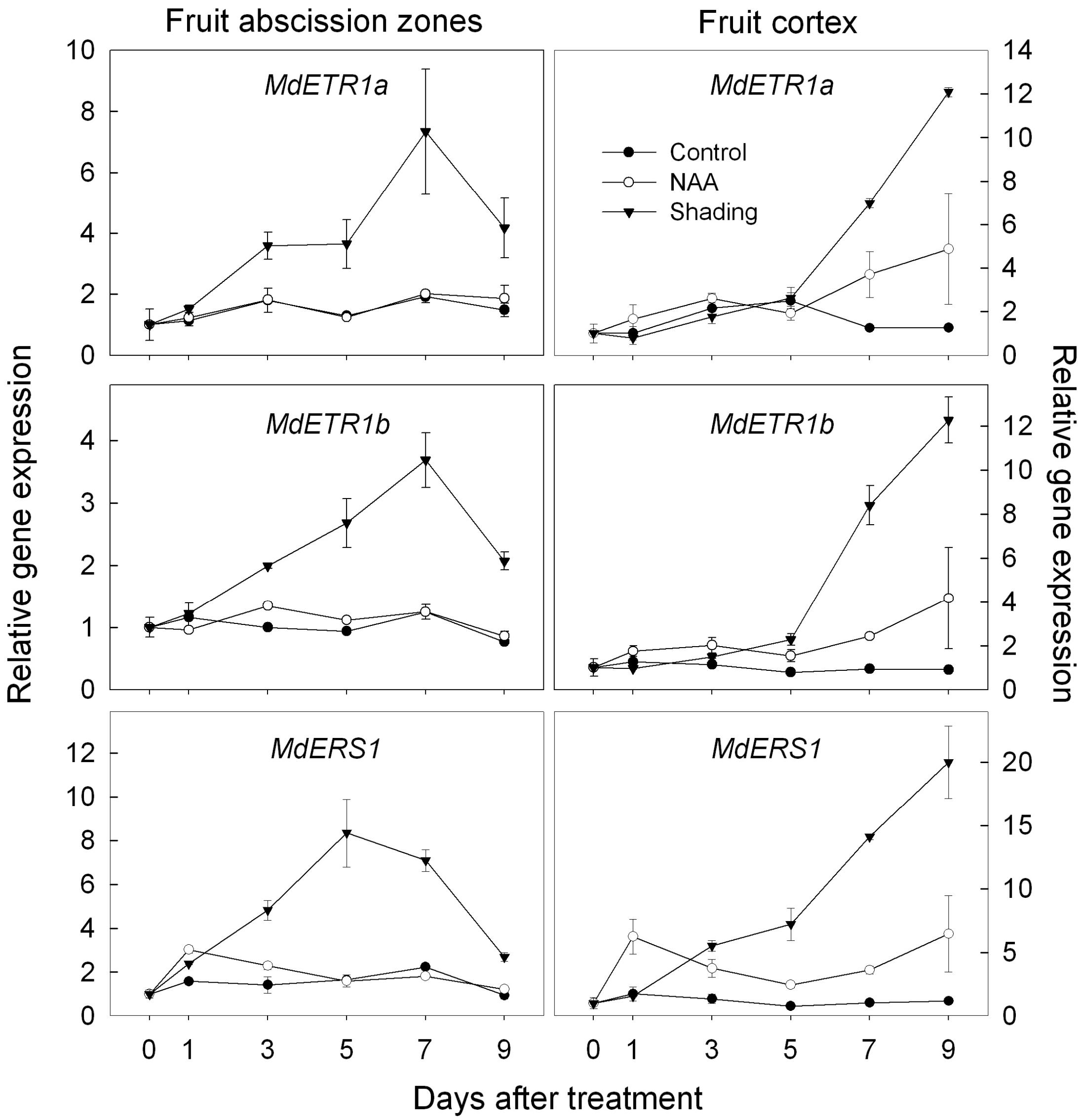

Fig.4 Effect of NAA and shading on the expression of genes encoding enzymes involved in ethylene perception. Data are means ± SE (n=3).

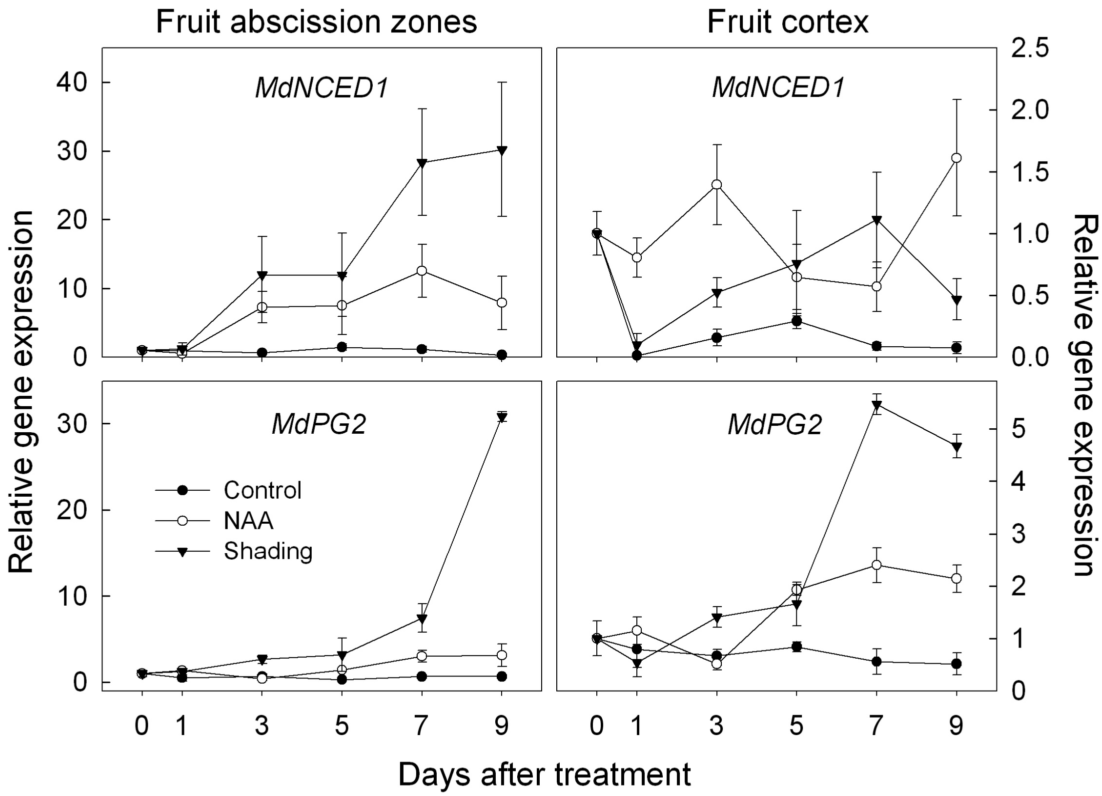

Fig.5 Effect of NAA and shading on the expression of genes encoding enzymes involved in ABA biosynthesis and cell wall degradation. Data are means ± SE (n=3).

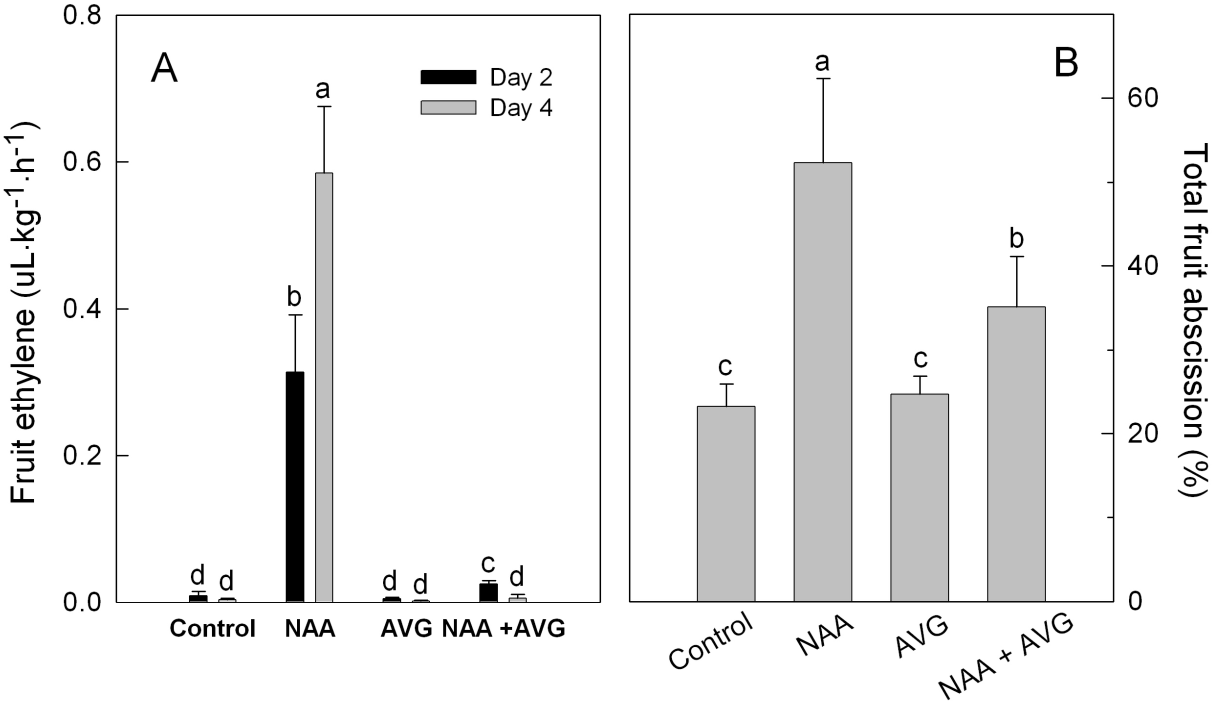

Fig.6 Effect of NAA and AVG on fruit ethylene production (A) and total fruit abscission (B) in 'Red Delicious' apples in 2007. Data are means ± SE (n=4).

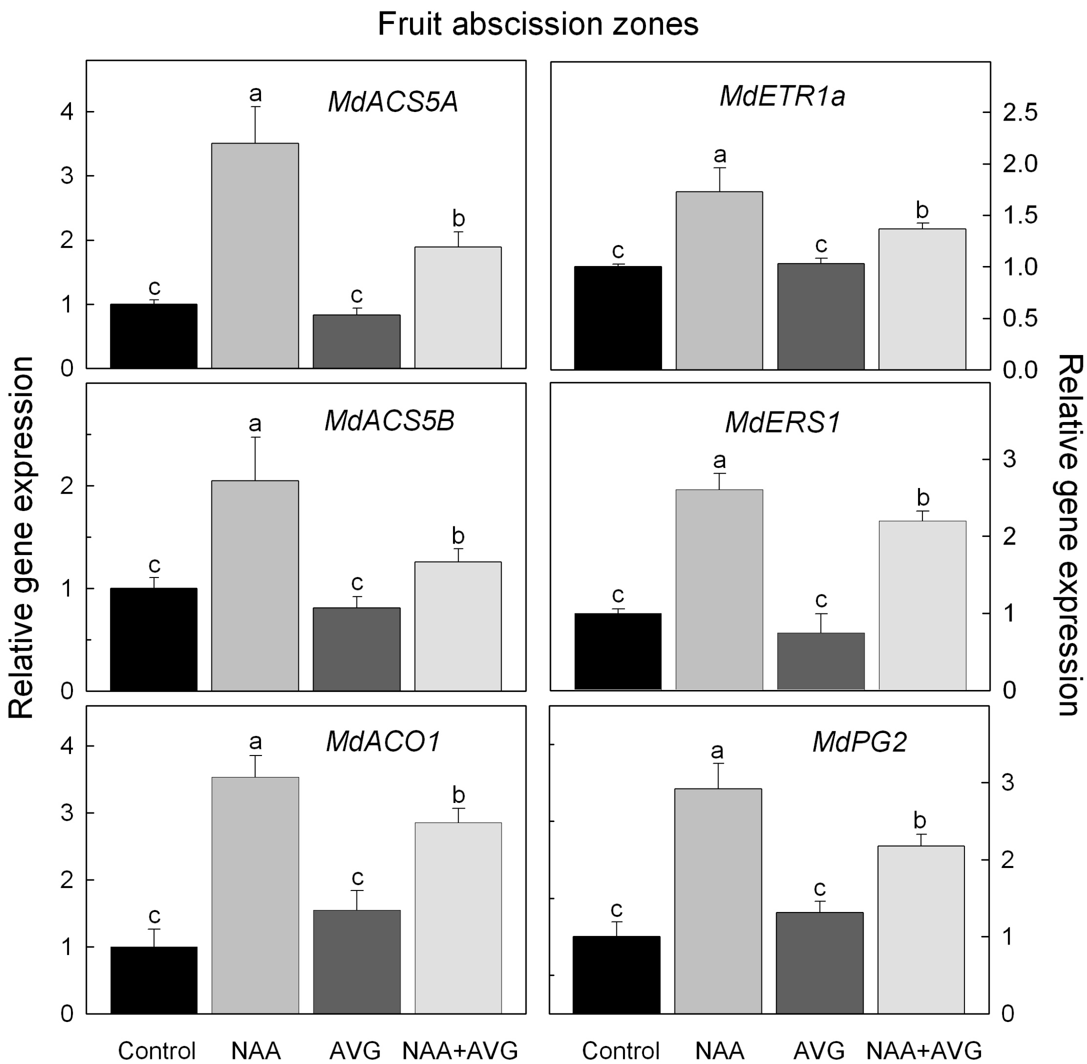

Fig.7 Effect of NAA and AVG on the expression of genes encoding enzymes involved in ethylene and cell wall degradation in 'Red Delicious' apples in 2007. Data are means ± SE (n=3).

Return bloom in 'Stayman' apple with NAA and/or ethephon: 2007 through 2009

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Following a season in which apple trees produce a full crop, many cultivars fail to produce enough bloom the next year for an adequate crop. Obtaining good return bloom is a problem for many apple growers. Plant growth regulators (PGRs) are recommended to enhance return bloom in apple. This study examines the effect of multiple sprays of two PGRs, 1-naphthalenacetic acid (NAA) and/or (2-chloroethyl)phosphonic acid (ethephon), applied during the growing season on return bloom in the 'Stayman' apple cultivar. Treatments were applied dilute with a handgun sprayer beginning in 2007 and repeated in 2008 and 2009. In addition to a hand-thinned and a non-thinned control, treatments included: a chemically thinned (CT) only spray (NAA in 2007 and carbaryl + oil in 2008 and 2009); four bi-weekly NAA sprays at 5 ppm beginning 6 weeks after full bloom (WAFB) ("Summer NAA"); four weekly NAA sprays at 5 ppm beginning 4 weeks before harvest ("Pre-harvest NAA"); four bi-weekly ethephon sprays at 150 ppm beginning 6 WAFB (Ethephon); and a combined treatment of summer NAA and ethephon. All NAA and ethephon treated trees received the CT spray at the commercial recommended fruit size stage. Ethephon and summer NAA + ethephon applied in 2007 increased return bloom compared to the control and CT only treatments in 2008. Ethephon alone applied in 2008 increased return bloom in 2009 compared to the non-thinned control ($p = 0.0219$) and the hand thinned control ($p = 0.0210$) (SAS PROC

MIXED @ 5%). Summer or pre-harvest NAA treatments increased return bloom slightly in 2008 and 2009, but the difference was not significant from the control treatments. None of the treatments affected pre-harvest fruit drop. Pre-harvest NAA advanced fruit maturity (based on starch index rating) in all three years and ethephon advanced maturity in 2008 and 2009 compared to the non-thinned and hand thinned controls. Additional data are needed to determine if ethephon provides an economic benefit from the enhanced return bloom.

Eugenol bloom thinner on peach

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Peaches must be thinned to obtain annual crops of marketable size fruit. Traditionally, peach thinning has been accomplished by hand in the absence of reliable chemical thinners. Peach thinning is a labor intensive, expensive cultural practice. Previous studies in our lab have demonstrated that eugenol, an essential oil, at rates ranging between 2% and 8% (v/v), will thin peach trees at bloom time. The current study examined the effect of eugenol applied at five rates (0, 0.5, 1, 2, and 3% v/v) on mature 'John Boy' peach trees at the 90 to 100% full bloom stage. All sprays were applied with an airblast sprayer in full dilute water carrier volume based on the calculated tree-row-volume. Response to eugenol was rate dependent. Eugenol at 1, 2, and 3% significantly reduced total fruit numbers (r^2 = 0.698) and crop load (r^2 = 0.626) [fruit/cm^2 trunk cross-sectional area (TCSA)]. A 1% eugenol spray reduced fruit number per tree by 52% compared to the non-thinned (0% eugenol) control trees. Fruit diameter was increased on trees bloom thinned at the 1, 2, and 3% rate of eugenol. At the 2% and 3% rate, eugenol reduced fruit numbers by 91% and 94% respectively, thus nearly defruiting the trees. A frost on the morning of spray application reduced the overall crop load on all trees. A crop load of 2.26 fruit/cm^2 TCSA on the control trees was about four-fold less than normally expected on the trees used in this study. Fruit on control trees averaged 7.85 cm diameter, well above marketable peach fruit size, and was not different from the mean fruit diameter for all other treatments. Because of the reduced crop load resulting from frost damage, gross returns (based on prevailing market prices and fruit size distribution) minus thinning costs were greater for control trees than for trees sprayed with 1, 2, or 3% eugenol. The current trial confirms the effectiveness of eugenol as a bloom thinner and further illustrates the potential problem growers could face in applying a bloom thinner to peach trees before the threat of frost has passed.

WEED SUPPRESSION BY GRASSES FOR ORCHARD FLOOR MANAGEMENT

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Fruit trees in orchards of the mid-Atlantic region are often planted in vegetation-free rows alternating with grass travel alleys. The tree rows can be maintained vegetation-free by herbicides or tillage but soil degradation or tree injury can result from these practices. Grasses that suppress weeds but minimally compete with fruit trees may be an alternative to herbicide and tillage for tree rows. This research was conducted in the greenhouse and field to determine grasses that suppress weeds without competing with fruit trees. Five grasses (rough stalk bluegrass, *Poa trivialis*; Chewings red fescue, *Festuca rubra*; creeping red fescue, *Festuca rubra*; Fawn tall fescue, *Festuca arundinaceae*; and perennial ryegrass, *Lolium perenne*) were tested. In pot trials using different seeding rates in the greenhouse creeping red fescue competed most effectively while rough stalk bluegrass competed least effectively with three weeds (dame's rocket, *Hesperis matronalis*; cornflower, *Centaurea cyanus*; and Chicory, *Cichorium intybus*). However, as grass seeding rates decreased competitiveness with weeds was similar between Chewings red fescue, creeping red fescue, Fawn tall fescue, and perennial ryegrass. Similar results were obtained over a 3-year field experiment; rough stalk bluegrass competed least effectively with weeds but the other four grasses provided similar weed suppression – generally providing as much weed suppression as traditional herbicides. None of the candidate grasses significantly reduced yields of 10-year-old apple (*Malus xdomestica* Borkh.) and peach (*Prunus persica* L. (Batch) trees. Grass and mowing warrants further study as part of an orchard floor management system.

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EFFECTS OF TIMING AND CONCENTRATION OF AVG AND NAA ALONE OR IN COMBINATION ON PREHARVEST FRUIT DROP AND EXTENSION OF HARVEST SEASON IN ‘DELICIOUS’ APPLES

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The problem of preharvest fruit drop, which occurs before fruit develop optimum color and maturity, usually causes a serious economic loss. On the other hand, picking fruit before adequate maturity may lead to poor storability and poor fresh and processed fruit quality.

Our previous research indicated that naphthaleneacetic acid (NAA), a synthetic auxin, aminoethoxyvinylglycine (AVG), an inhibitor of ethylene biosynthesis, and 1-methylcyclopropene (1-MCP), an inhibitor of ethylene action, can reduce preharvest drop of apples. In addition, NAA usually accelerates fruit ethylene production, the expression of *MdPG1* gene and fruit softening. AVG can delay fruit ripening but its effect in reducing preharvest fruit drop is inconsistent, especially in dry and warm years. Another problem is that AVG is very expensive (about $240 per pouch per acre). In previous studies, we also found that the combination of AVG and NAA is more effective than either alone in delaying preharvest fruit drop by synergetically suppressing expression of *MdPG2* in fruit abscission zones, and the combined treatment could overcome the side effect of fruit softening caused by NAA.

The objective of this study was to determine the timing and concentration of AVG and NAA in combination on preharvest fruit drop in ‘Delicious’ apples. In 2009, we chose 12-year-old ‘Delicious’ apple trees on Mark rootstock and treatments included AVG at 31.25, 46.875, 62.5, and 125 $mg \cdot L^{-1}$; NAA at 10 $mg \cdot L^{-1}$ and sprayable 1-MCP at 80 and160 $mg \cdot L^{-1}$ with various combinations. We treated the trees 4 and 2 weeks before harvest (WBH).

The following tables (Table 1-7) show the effects of preharvest applications of sprayable 1-MCP, AVG and NAA on fruit drop, fruit firmness, fruit weight, color, starch, soluble solids and the occurrence of water core disease.

In conclusion, the combination of NAA and AVG or 1-MCP are more effective than NAA, AVG or 1-MCP alone in delaying preharvest fruit drop while maintaining fruit quality. In order to reduce the production cost and preharvest fruit drop, maintain the fruit quality, extend the harvest season, and increase the growers’ profits, AVG in the combination of NAA + AVG should be used based on the tree row volume (TRV) instead of one pouch per 100 gallon per acre. NAA at 10 $mg \cdot L^{-1}$ + AVG at 31.25 or

46.875 mg·L^{-1} can be applied 2 WBH to reduce preharvest fruit drop and extend the harvest window.

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Table 1. Effect of preharvest applications of sprayable 1-MCP, AVG and NAA on fruit drop of 'Bisbee Delicious'/Mark apples (2009)[Y]

TRT	WBH	Conc. (ppm)	Cumulative fruit drop (%) 9/7	9/16	9/21	9/29	10/5	10/13	10/19
Control	-	-	0 a	5.1 a [Z]	34.8 a	69.8 a	86.4 a	92.3 a	94.4 a
AVG	4	125	0 a	0 b	0 b	2.1 bc	5.3 cd	10.5 cd	17.6 cde
AVG	4	62.5	0 a	0.5 b	2.5 b	6.6 bc	22.3 b	34.8 b	51.3 b
NAA	2	10	0 a	0.5 b	1.2 b	4.3 bc	13.1 bcd	28.3 b	42.7 b
AVG + NAA	4 2	125 10	0 a	0 b	0.9 b	1.4 bc	3.3 cd	5.0 cd	15.2 cde
AVG + NAA	4 4 & 2	125 10	0 a	0 b	0 b	0 c	1.3 d	2.6 d	5.5 e
AVG + NAA	2 2	125 10	0 a	0 b	0 b	0.4 bc	2.5 d	5.2 cd	10.2 de
AVG + NAA	2 2	62.5 10	0 a	0 b	1.3 b	1.8 bc	3.4 cd	11.2 c	20.9 cd
AVG + NAA	2 2	46.875 10	0 a	0 b	1.8 b	2.6 bc	4.9 cd	12.2 cd	22.5 cd
AVG + NAA	2 2	31.25 10	0 a	0.3 b	1.9 b	2.7 bc	6.5 cd	11.0 c	27.1 c
1-MCP	2	160	0 a	0 b	2.0 b	6.6 b	14.9 bc	26.6 b	45.4 b
1-MCP + NAA	2 2	80 10	0 a	0 b	0.8 b	1.4 bc	3.6 cd	8.0 cd	18.4 cde

[Y]Anticipated harvest date was September 21, 2009.
[Z] Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

Table 2. Effect of preharvest applications of sprayable 1-MCP, AVG and NAA on fruit firmness of 'Bisbee Delicious'/Mark apples (2009)[Y]

TRT	WBH	Conc.(ppm)	Fruit firmness (lb) 8/25	9/10	9/21	10/6	10/21
Control	-	-	18.2	16.4	14.8 c [Z]	13.3 c	11.6 e
AVG	4	125	-	-	15.4 b	15.4 a	14.3 abc
AVG	4	62.5	-	-	15.4 b	14.9 ab	14.0 abc
NAA	2	10	-	-	15.5 b	12.1 d	9.4 f
AVG + NAA	4 2	125 10	-	-	15.6 ab	15.3 ab	14.8 a
AVG + NAA	4 4 & 2	125 10	-	-	16.1 a	15.6 a	13.9 bc
AVG + NAA	2 2	125 10	-	-	15.6 ab	15.2 ab	14.6 ab
AVG + NAA	2 2	62.5 10	-	-	15.6 ab	15.0 ab	13.7 bc
AVG + NAA	2 2	46.875 10	-	-	15.7 ab	14.4 ab	12.5 d
AVG + NAA	2 2	31.25 10	-	-	15.8 ab	14.2 ab	12.0 de
1-MCP	2	160	-	-	15.5 b	15.2 ab	14.5 ab
1-MCP + NAA	2 2	80 10	-	-	15.4 b	14.6 ab	13.5 c

[Y]Anticipated harvest date was September 21, 2009.
[Z] Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

Table 3. Effect of preharvest applications of sprayable 1-MCP, AVG and NAA on fruit weight of 'Bisbee Delicious'/Mark apples (2009)[Y]

TRT	WBH	Conc.(ppm)	Date when fruit weight (g) was determined				
			8/25	9/10	9/21	10/6	10/21
Control	-	-	185.3	209.8	228.7 a [Z]	233.7 a	272.1 a
AVG	4	125	-	-	209.6 ab	220.6 ab	256.8 ab
AVG	4	62.5	-	-	193.4 b	217.1 ab	241.8 bc
NAA	2	10	-	-	204.9 b	206.5 ab	256.0 ab
AVG + NAA	4 2	125 10	-	-	193.8 b	217.8 ab	245.0 abc
AVG + NAA	4 4 & 2	125 10	-	-	195.1 b	194.4 b	250.8 abc
AVG + NAA	2 2	125 10	-	-	200.5 b	217.2 ab	236.4 bc
AVG + NAA	2 2	62.5 10	-	-	204.8 b	198.1 b	222.3 c
AVG + NAA	2 2	46.875 10	-	-	196.5 b	209.4 ab	249.4 abc
AVG + NAA	2 2	31.25 10	-	-	200.2 b	228.1 a	250.2 abc
1-MCP	2	160	-	-	207.4 b	213.8 ab	249.9 abc
1-MCP + NAA	2 2	80 10	-	-	204.0 b	229.6 a	245.5 abc

[Y]Anticipated harvest date was September 21, 2009.
[Z] Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

Table 4. Effect of preharvest applications of sprayable 1-MCP, AVG and NAA on red color of 'Bisbee Delicious'/Mark apples (2009)[Y]

TRT	WBH	Conc.(ppm)	Red color (%)				
			8/25	9/10	9/21	10/6	10/21
Control	-	-	60.8	89.8	95.1 ab [Z]	95.0 b	97.9 ab
AVG	4	125	-	-	96.1 ab	97.5 ab	98.1 a
AVG	4	62.5	-	-	95.7 ab	98.5 a	98.5 a
NAA	2	10	-	-	97.4 a	97.4 ab	98.1 ab
AVG + NAA	4 2	125 10	-	-	94.3 ab	96.3 ab	96.3 bc
AVG + NAA	4 4 & 2	125 10	-	-	93.0 b	97.4 ab	98.0 ab
AVG + NAA	2 2	125 10	-	-	96.1 ab	98.4 a	97.5 abc
AVG + NAA	2 2	62.5 10	-	-	96.3 ab	96.7 ab	98.3 a
AVG + NAA	2 2	46.875 10	-	-	95.6 ab	97.3 b	98.0 ab
AVG + NAA	2 2	31.25 10	-	-	94.0 ab	95.9 ab	96.1 c
1-MCP	2	160	-	-	95.1 ab	97.3 ab	98.1 ab
1-MCP + NAA	2 2	80 10	-	-	94.2 ab	97.2 ab	98.0 ab

[Y]Anticipated harvest date was September 21, 2009.
[Z] Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

Table 5. Effect of preharvest applications of sprayable 1-MCP, AVG and NAA on starch of 'Bisbee Delicious'/Mark apples (2009)[Y]

TRT	WBH	Conc.(ppm)	Starch (0-8)				
			8/25	9/10	9/21	10/6	10/21
Control	-	-	1.3	4.7	6.6 a [Z]	7.4 ab	7.9 a
AVG	4	125	-	-	5.1 cde	7.0 bcd	7.5 cd
AVG	4	62.5	-	-	5.4 bcd	7.1 bcd	7.6 bc
NAA	2	10	-	-	6.4 a	7.8 a	8.0 a
AVG + NAA	4 2	125 10	-	-	5.0 cde	6.9 d	7.5 cd
AVG + NAA	4 4 & 2	125 10	-	-	4.3 e	6.9 d	7.6 cd
AVG + NAA	2 2	125 10	-	-	5.4 bcd	7.0 bcd	7.4 d
AVG + NAA	2 2	62.5 10	-	-	5.4 bcd	7.1 bcd	7.7 cd
AVG + NAA	2 2	46.875 10	-	-	5.8 abc	7.3 bc	7.8 ab
AVG + NAA	2 2	31.25 10	-	-	6.1 ab	7.2 bcd	8.0 a
1-MCP	2	160	-	-	4.7 de	6.8 d	7.1 e
1-MCP + NAA	2 2	80 10	-	-	5.4 bcd	6.8 d	7.5 cd

[Y]Anticipated harvest date was September 21, 2009.
[Z] Mean separation within columns by Duncan's multiple range test, *P* = 0.05.

Table 6. Effect of preharvest applications of sprayable 1-MCP, AVG and NAA on soluble solids of 'Bisbee Delicious'/Mark apples (2009)[Y]

TRT	WBH	Conc.(ppm)	Soluble solids				
			8/25	9/10	9/21	10/6	10/21
Control	-	-	9.6	12.2	13.6 a [Z]	15.2 a	15.5 a
AVG	4	125	-	-	11.7 b	14.4 ab	14.8 ab
AVG	4	62.5	-	-	12.4 ab	14.5 ab	15.1 ab
NAA	2	10	-	-	13.5 a	14.6 ab	15.4 a
AVG + NAA	4 2	125 10	-	-	11.8 b	13.7 b	14.3 bc
AVG + NAA	4 4 & 2	125 10	-	-	12.1 b	14.2 b	14.9 ab
AVG + NAA	2 2	125 10	-	-	12.8 ab	14.5 ab	14.9 ab
AVG + NAA	2 2	62.5 10	-	-	12.2 b	14.1 b	14.8 ab
AVG + NAA	2 2	46.875 10	-	-	11.9 b	14.3 ab	12.5 d
AVG + NAA	2 2	31.25 10	-	-	12.5 ab	14.6 ab	12.0 d
1-MCP	2	160	-	-	12.1 b	14.1 b	14.5 ab
1-MCP + NAA	2 2	80 10	-	-	12.1 b	14.1 b	13.5 c

[Y]Anticipated harvest date was September 21, 2009.
[Z] Mean separation within columns by Duncan's multiple range test, *P* = 0.05.

Table 7. Effect of preharvest applications of sprayable 1-MCP, AVG and NAA on water core of 'Bisbee Delicious'/Mark apples (2009)[Y]

TRT	WBH	Conc.(ppm)	Water core (%)				
			8/25	9/10	9/21	10/6	10/21
Control	-	-	0	0	87.5 a [Z]	95.0 ab	87.5 b
AVG	4	125	-	-	0 c	65.0 cd	97.5 ab
AVG	4	62.5	-	-	20.0 bc	97.5 a	95.0 ab
NAA	2	10	-	-	85.0 a	95.0 ab	100.0 a
AVG + NAA	4 2	125 10	-	-	0 c	67.5 bcd	92.5 ab
AVG + NAA	4 4 & 2	125 10	-	-	0 c	55.0 d	95.0 ab
AVG + NAA	2 2	125 10	-	-	15.0 c	82.5 abcd	90.0 ab
AVG + NAA	2 2	62.5 10	-	-	47.5 b	75.0 abcd	100.0 a
AVG + NAA	2 2	46.875 10	-	-	17.5 bc	90.0 abc	97.5 ab
AVG + NAA	2 2	31.25 10	-	-	12.5 c	90.0 abc	100.0 a
1-MCP	2	160	-	-	17.5 bc	72.5 abcd	95.0 ab
1-MCP + NAA	2 2	80 10	-	-	20.0 bc	72.5 abcd	97.5 ab

[Y]Anticipated harvest date was September 21, 2009.
[Z] Mean separation within columns by Duncan's multiple range test, *P* = 0.05.

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FIRE BLIGHT OF APPLES AND PEARS: EPIDEMIOLOGICAL CONCEPTS COMPRISING THE MARYBLYT FORECASTING PROGRAM

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Symptoms of fire blight were first described over 200 years ago and, until 1919, when it was reported from New Zealand, the disease was limited exclusively to North America (10). It now occurs in at least 43 countries worldwide (5, 8). Throughout most of its history, the disease has been frequently described as "characteristically erratic and unpredictable". Young orchards with no history of the disease could suffer severe tree losses in a single season, while other, more established orchards seemed to escape infection even though the disease may have been common the previous year. The destructiveness of fire blight and the highly sporadic nature of damaging epidemics have encouraged growers to adopt intensive management practices that depend heavily on the use of protective antibiotic sprays applied at frequent intervals every year. This approach, although generally adequate, seldom affords complete control, sometimes fails, and often seems excessive given the amount of disease that subsequently develops in comparable untreated orchards.

Many aspects of fire blight have been described since its discovery. More recently, some of the specific requirements governing the infection process, and how these affect the progress of epidemics, have been described. Maryblyt (11, 14, 15) was an early attempt to integrate much of what was known about the disease in apples and pears into a comprehensive model. The primary focus has been to construct a program that fruit growers can use as an aid in making decisions for controlling fire blight in apple and pear orchards. Because of its accuracy, Maryblyt has also found use in research, teaching and extension programs.

Multiple phases of fire blight

Fire blight epidemics develop in several phases, each of which can be identified by a distinctive set of symptoms. Recognizing these phases and understanding how each develops is important for assessing risks and for making decisions on the most appropriate control measures needed. There are at least five distinct kinds of infections associated with fire blight, not all of which occur every year or with equal intensity. The Maryblyt program predicts four of these: blossom, canker, shoot and trauma blight. A fifth type, rootstock blight, has only recently been characterized and the bases for its prediction are not yet fully understood.

Understanding the factors that contribute to blossom infections. Blossom blight symptoms result from direct infections of open flowers with intact petals. Early symptoms develop as a darkening of the flower base or petiole, which may be accompanied by tiny droplets of ooze. The infected petiole soon wilts and the pathogen invades the spur and other flowers in the cluster. In some cases, damage is limited to the fruiting spur, but the pathogen often continues to invade and kill a portion of the supporting limb or branch. Since blossom infections are usually the earliest to develop and occur in large numbers over a wide area, they are a major source of secondary inoculum that can fuel later epidemics of shoot blight. Several research articles have been published that provide data to validate the blossom blight component of Maryblyt (5, 7, 9, 19).

The incidence of blossom blight is one of the most sporadic aspects of fire blight epidemics. The Maryblyt model was built on the assumption that there is an abundance of inoculum and that, for a blossom infection event to occur, four strict conditions must be met in sequence. These conditions and the required sequence are: *i*) flowers must be open with stigmas and petals intact (stigmas exposed for colonization, flowers in petal fall are resistant); *ii*) accumulation of at least 198 degree hours (DH) > 65°F (110 DH> 18.3°C) within the last 80 degree days (DD) >40°F (44.4 DD >4.4°C) for apples or within the last 120 DD > 40°F for pears (defines the epiphytic infection potential for the oldest open (and, hence, most colonized) flower in the orchard); *iii*) a wetting event occurring as dew or ≥ 0.01 inch (0.25 mm) of rain, or ≥0.10 inch (2.5 mm) of rain the previous day (allows movement of bacteria from colonized stigmas to the nectarthodes); and, *iv*) an average daily temperature of ≥ 60°F (15.6°C) (this may influence the rate at which the bacteria migrate into the nectarthodes as well as the multiplication of bacteria needed to establish infections).

When all four of these minimum requirements are met in the sequence shown, infections occur and the first early symptoms of blossom blight can be expected to appear with the accumulation of an additional 103 DD>55°F (57 DD>12.7°C). In real time, this interval can vary from 5 to 30 (or more) days depending upon the prevailing temperatures. The occurrence of blossom blight symptoms a month after bloom is not at all unusual and seems especially true in cooler temperate climates. Since infections initiated in response to a single rain or dew event can occur within minutes, it is also characteristic for most symptoms to develop simultaneously. This may be one reason why symptoms appear suddenly rather than gradually and show about the same degree of wilt or necrosis when they first appear. As the epidemic progresses, however, the severity of individual infections varies due to inoculum density, multiple infection cycles and the physiological status of the tissues involved.

When the orchard conditions are less than these minimum requirements, few or no symptoms occur and no significant epidemic develops. However, the degree to which any one or more of these thresholds is exceeded provides a subjective basis for estimating the severity of any given blossom infection event. Thus, many open flowers pose a greater risk than few or no open flowers (i.e., more infection sites); an EIP of 200-300 poses a greater risk (i.e., more flowers colonized) than a marginal EIP of 100; thorough wetting by heavy dew or prolonged rain is more important than intermittent showers; and, average temperatures > 60°F are likely to support more infections. While the greatest proportion of open (=susceptible) flowers occurs at full bloom, the risk period for damage to fruiting spurs is much longer. This is because single flower infections usually destroy the supporting spur. Thus, the period between 20% bloom and 80% petal fall, when there is at least one colonized but uninfected blossom per spur, represents an extended period of high risk.

Bloom that continues over an extended period, typically beyond the normal bloom period and referred to as “rat-tail” bloom, also results in an extended period of high risk, especially for cultivars with this inherent trait, such as Pink Lady. Temperatures are usually much warmer during this period and the risk of fire blight is usually high during this period. Not all flowers in the orchard open (=susceptible) or begin petal fall (=resistant) at the same time. Because all of the flowers open on any one day have not been equally exposed for colonization by the bacteria they are not all equally subject to infection. Only those flowers that have been open long enough for colonization are likely to become infected. This helps explain the often erratic differences in the number of infections that occur with different cultivars in the same orchard. The proportion of open flowers colonized by *E. amylovora* as a function of cumulative degree hours > 65°F (18.3°C) was adapted from research on pears in California (20) and shows the rate at which open flowers are colonized by the pathogen as a function of cumulative DH> 65°F (18.3°C). A similar relationship seems true for apples (15).

While the estimates for spur loss based on proportion of open blossoms are useful for estimating maximum risk, they should not be used when deciding whether a particular infection event is severe enough to justify treatment. On the contrary, treatment decisions for blossom blight should be based strictly on whether an infection event is expected or has occurred, not on how severe it might be. This is because even a few early blossom infections provide many new sources of bacteria throughout the orchard to fuel a later epidemic of shoot blight.

Cool weather has a negative effect on the epiphytic infection potential, EIP. The rate at which flower buds open slows and the rate that bacteria colonize flowers is reduced. Also, at temperatures above 40°F (4.4°C) some already colonized, but uninfected, flowers will continue to mature and become resistant as they enter the petal fall stage.

A 3-day cool period during bloom can reduce the risks for blossom blight significantly. For this reason, the Maryblyt program reduces the risk for infection due to cool weather by making incremental reductions in the cumulative DH total. For one and two consecutive days with no temperature above 64°F (17.8°C), the total DH accumulation is reduced first by one-third and then by one-half, respectively, and to zero for a third consecutive cool day or in response to any one day with a freezing temperature greater than 24°F (-4.4 °C). Once the DH total exceeds 400 (EIP=200), however, no negative adjustments are made. If the temperature falls below 24°F (-4.4 °C), 90% of the blossoms will be killed and the EIP automatically resets to zero, even if the DH has exceeded 400; this is a new rule in v. 7.0.

A wetting event during bloom provides a means for the bacteria colonizing the stigmas to move down into the nectrarthodes at the base of the flower where infections take place (18). The presence of a continuous film of water between the stigma and the nectary may allow substances in the nectar to establish a chemical gradient, which the bacteria can detect and follow into the infection sites (2). From a risk standpoint, therefore, heavy dew may contribute to more infections than a small rain shower because of the thoroughness of the wetting that occurs in a greater number of flowers. This may explain why blossom blight occurs more frequently and more severely in low areas of the orchard where heavy dew is common.

Note, too, that when all other conditions for flower infection exist, simply spraying the trees with water is enough to trigger the development of blossom blight. On this basis, it appears that infections can be initiated within minutes and that high volume, water-based fungicide sprays for other diseases and overhead irrigation should be avoided during bloom. We have no evidence to indicate a similar risk occurs with low volume sprays (e.g., approx. 100 gallons per acre or 1,000 liters per hectare).

When cankers overwinter. Canker blight symptoms develop as the result of renewed activity by the pathogen at the margins of overwintering cankers established during the previous season. Unlike other phases of the disease, canker blight occurs regularly every year in areas where the disease is established (15). The earliest symptom of canker blight is the appearance of a narrow, water soaked zone in the healthy bark tissue bordering active cankers. This can be seen by cutting through the bark across the canker margin. Within a few days after this, brownish streaks can be seen in the inner bark tissue. The bacteria then invade nearby vegetative shoots internally, causing them to wilt and die. Such shoots, especially water sprouts, are often mistaken for symptoms of early shoot blight.

This event (CMS in Maryblyt) can be predicted quite reliably with the accumulation of at least 196 DD > 55°F (109 DD> 12.7°C) after green tip (usually about petal fall $\pm$ one week) (15). Typical canker blight symptoms (CBS) that result from the internal invasion of nearby vegetative shoots by the bacteria follow CMS with the accumulation of an additional103 DD>55°F (57 DD> 12.7°C).

When blossom blight is severe, canker blight symptoms can be easily overlooked. Also, when compared to the large amount of inoculum available from infected blossom clusters, such late canker activity probably adds little to the overall risks for shoot blight. However, when blossom blight does not occur or is very light, these active cankers represent a primary source of inoculum for the shoot blight phase (12). Thus, orchards must be monitored closely when canker blight symptoms are expected (about 300 DD > 55°F or 167 DD > 12.7°C after green tip). Prompt removal of these active cankers before extensive necrosis develops should help delay the appearance of shoot blight. This seems especially true in orchards that are isolated from other sources of inoculum.

Epidemic progression into shoot blight. Shoot blight symptoms result from direct infections of vegetative shoot tips. From this initial site of infection, the bacteria then invade and kill the entire shoot and, often, a portion of the supporting branch. The earliest symptom of shoot blight is tip wilt, which causes the tip to curve downward like a shepherd's crook. For shoot blight to occur, there must first be a local source of inoculum. This is available from tissues showing symptoms of either blossom or canker blight (15). Since wind and insects can disperse the pathogen from other orchards and wild trees, the primary inoculum sources need not be within the orchard being monitored. As with blossom blight, early dispersal of the pathogen and its colonization of foliar surfaces or substomatal areas prior to infection occurs seems likely with the shoot blight phase of fire blight epidemics.

The exact mechanism and the amount of inoculum needed for shoot tip infections is not known, but insects with sucking or piercing mouthparts seem to be associated in many locations. Our observations suggest that bacterial colonies may develop independently on leaf surfaces or substomatal areas, having arrived there via rain, wind or by casual insect visits. Actual inoculation then occurs later when various insects with sucking mouthparts arrive and begin probing any of the top three shoot tip leaves in search of a suitable feeding site. In a fewer number of cases, the bacteria may be transmitted to a healthy shoot tip by an insect that has fed previously on other tissues containing the pathogen, but not yet showing symptoms.

The insects that are most important in contributing to shoot blight epidemics will, undoubtedly, vary from site to site and from region to region. In Maryland, and many other parts of the U.S., early shoot blight symptoms are most closely associated with the activity of winged adults of the white apple leafhopper. These are first available about 675 DD>40°F (375 DD>4.4°C) after green tip. In areas where the white apple leafhopper does not occur, the accuracy of shoot blight predictions should be improved by changing the vector availability threshold for a more appropriate vector. Later in the season, and where white apple leafhoppers are not present, suitable insect vectors may include different species of leafhoppers and other insect species. Clarke, et al. (6) recently published information from Pennsylvania indicating that the green apple aphid is not an effective vector for the fire blight bacterium. An important role for potato leafhoppers has been proposed by Pfeiffer et al. (13). The feeding habits of potato leafhopper seem particularly suited to creating wounds in tender tissues that could become infected if inoculum was present and environmental conditions were suitable.

Shoot blight forecasts using Maryblyt are limited to only the first early shoot blight symptoms and are based on the assumption that insect vectors are present. These early symptoms usually develop with the accumulation of 103 DD>55°F (57 DD > 12.7°C) after the first appearance of either blossom or canker blight symptoms in the immediate area when: *i*) the average daily temperature is 60°F (15.6°C) or above, and *ii*) suitable insect vector populations are present. Rain and wind help distribute the bacteria but they do not appear to be required for shoot blight to occur. Thus, in dry seasons, new shoot infections often appear limited to sites fairly close to earlier blossom or canker infections. In years with more frequent rainfall during the period of active shoot growth, the incidence of shoot blight is more widespread (i.e., leaf populations of the pathogen are also more widespread) (3). In either case, whether infections occur seems to depend on the overall availability of an epiphytic (=surface) inoculum and the presence and activity of insects with sucking mouthparts.

The appearance of the first shoot blight symptoms in isolated orchards with no history of fire blight may be later than that predicted by Maryblyt and is attributed to the late arrival of the pathogen from some distant source or late developing populations of insects with sucking mouthparts. This latter factor can also be influenced by insecticide treatments by the grower. In either case the number of shoot blight infections should be small; if they are numerous and widely dispersed, however, then look for another vector. After the first appearance of shoot blight, infections are incited more or less in a clustered pattern near the original infections, with occasional random occurrences (depending on epiphytic populations of bacteria, insect activity on shoot tips, and severity of windblown rain events) until vegetative growth is complete (3). Maryblyt does not attempt to predict these later shoot tip infections.

Trauma events and disease "explosion." Trauma blight symptoms develop on many different tissues and are associated with infections following injuries caused by late frosts (≤28°F, -2.2°C), hailstorms or high winds that damage the foliage. These injuries appear to breach defense mechanisms that normally confer resistance to fire blight in mature tissues of susceptible cultivars and in generally resistant cultivars like Red Delicious (17). Similar effects may occur when cuts are made to remove infected branches during the growing season, which often result in the formation of small cankers on the branch stubs (17). Such cankers may provide additional inoculum for continuing fire blight epidemics in subsequent years.

The actual risks for loss vary with the severity of the injurious event and the epiphytic population of the bacteria present when it occurs. Trauma blight incidents can be expected any time after early bloom when the EIP reaches 100, but are generally more severe when the EIP exceeds 200-250. While free water on the surfaces of leaves is likely during a late frost event or with hail, infections do occur in the absence of rain under high wind conditions that tatter the foliage or damage blossom clusters. Even here, however, if rain accompanies the high wind or follows it closely, the incidence and severity of damage is likely to be much greater.

Tree mortality on susceptible rootstocks. Rootstock blight occurs when bacteria from blossom or shoot infections (including trauma situations) move systemically into the rootstock and initiate a localized canker that girdles and kills the tree. It is especially prevalent with apple cultivars on highly susceptible M-26, M-9 and Mark (Mac 39) rootstocks and C-6 interstems (16, 17). It occurs most frequently when fire blight susceptible scion cultivars on these rootstocks become infected (blossom, shoot or trauma blight), but it can occur with resistant cultivars following a trauma blight incident (e.g., Delicious on M-26 rootstock). The loss of > 30% of the trees in an orchard with susceptible scions on M-26 rootstocks within 5 to 7 years after planting is not unusual. While resistant scions like Delicious on these rootstocks are generally more durable, high tree losses can still occur following incidents of hail or high wind (i.e., trauma blight).

Putting it all together - monitoring and predicting fire blight. Maryblyt integrates the use of three cumulative heat unit "clocks" to indirectly monitor the development of the host, pathogen populations, insect vector availability and symptom development. The age of apple and pear flowers and the appearance of insect vectors (15), for example, can be monitored with reasonable accuracy using cumulative DD> 40 °F (4.4°C). Cumulative DH> 65 °F (18.3 °C) is used in Maryblyt to establish the epiphytic infection potential (EIP) for assessing infection risks (14). The EIP is based on data relating cumulative heat units and blossom colonization by the bacteria (19), but it really encompasses much more (availability of open flowers, bee activity, etc.). Thus, an EIP of "zero" does not mean that all bacteria are dead, but only that the risk for infection is low. Once infection occurs, symptom development is predicted using cumulative DD > 55°F (12.7°C).

The degree days accrued in one day can be estimated by subtracting the base, or minimum threshold temperature from the daily average temperature. This approach was used successfully in earlier Maryblyt versions, but sometimes led to prediction errors in some climates, especially where there were wide differences between the daily minimum and maximum temperatures (e.g., the semi-arid US Pacific Northwest). Version 4.2 introduced the use of a mathematical sine wave function with a 90°F (32°C) maximum and various minimum temperature thresholds for DD and DH determinations that reduced some of this variability (1). That approach is continued in Version 7, but with additional user-determined choices for sine wave method (single or double) and the option to adjust the parameters of all the thresholds.

Practical use of the software involves the user creating a data file for a particular location, and if desired, individual orchard blocks within that location. The crop, apple or pear, can be selected at this time, and there is no longer any need to enter AG or PG to initialize the model. Required inputs include maximum and minimum temperatures, use of phenological indicators (only three are of critical importance), and indications of wetting (rainfall amount or presence of dew or fog). For phenological bud stage indicators, D (dormant) or ST (silver tip) can be entered early but do not affect the program. Three entries are required for the program to function: *i*) GT (green tip) is when 50% of the buds show green tissue (this is a biofix to begin predictions), *ii*) B or B1 (first bloom) is when the first flower opens in the orchard, and *iii*) petal fall (PF) when the last open flower in the orchard is gone (stops blossom blight predictions). Any other entries in the phenology column are for notation only and do not affect the program. During bloom, the first character in this column must remain as B.

Graphical presentation of data and the program's output may be appealing to some users. Maryblyt v. 7 has the ability to toggle the graphical display, along with many options for choosing which data to show. Prediction mode is useful for determining the effect on fire blight risk of forecasted weather scenarios, and then using the information to make informed management decisions. Generally, begin data entry for Maryblyt just before green tip is expected and do not stop entering daily weather data until the prediction of early shoot blight symptoms (SBS), or until the last trauma blight symptom (TBS) if a trauma event occurred. During the early season, before bloom, data can be entered every few days or weekly; once bloom is about to start and when forecasts predict that an infection event or symptom appearance is near, data entries (and decisions) should be made daily.

Summary. Fire blight is a complex disease that can develop in a variety of distinct phases during the course of a season, not all of which occur every year or with the same intensity. Blossom blight is usually the first phase to develop and is most destructive in bearing orchards. Canker blight symptoms generally begin during late bloom, but may not be clearly visible on young shoots near canker sites until 1-2 weeks after petal fall. Tissues showing either blossom or canker blight symptoms provide a source of inoculum for the subsequent development of shoot blight. Shoot blight is often most destructive in non-bearing orchards where rapid vegetative growth is encouraged, but it also can result in much damage to major scaffold limbs in bearing orchards. Trauma blight is an unusual phase of fire blight where infections occur through injuries caused by severe weather events and can affect mature tissues that might otherwise exhibit resistance. Each phase develops in response to different conditions and can appear alone or in combination in any given orchard or season. Any incidence of blossom, shoot or trauma blight symptoms can lead to the loss of entire trees due to the subsequent development of rootstock cankers where susceptible rootstocks are used. Because the pathogen multiplies rapidly and is dispersed widely well before infection events occur, major epidemics can develop quickly even where the incidence of the disease has been low. Thus, once fire blight is known to occur in an area, good control is possible only through rigorous monitoring and an aggressive management program. For additional information and to download Maryblyt, visit http://www.caf.wvu.edu/kearneysville/Maryblyt/index.html.

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RELATIVE SUSCEPTIBILITY OF SELECTED APPLE CULTIVARS TO CEDAR APPLE RUST, QUINCE RUST, POWDERY MILDEW, AND APPLE SCAB

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Susceptibility ranking of various apple cultivars to diseases often depends on observations at single locations made by plant pathologists, plant breeders, growers and nursery personnel in the field. Several researchers have observed differences among apple cultivars to apple rusts, powdery mildew and apple scab, although there have been few new reports during the past decade. In 1994, a regional project was initiated to examine the performance of new apple cultivars in replicated trials under a wide range of climatic and edaphic conditions. The project (NE-183), entitled "Multidisciplinary Evaluation of New Apple Cultivars" (currently NECC-1009 "Multidisciplinary Evaluation of New Tree Fruit Cultivars"), began with 26 cooperators in 18 states and two Canadian provinces. A primary objective of the NE-183 project was to evaluate horticultural qualities and pest and pathogen susceptibility of new apple cultivars, strains, and advanced selections with commercial potential and to determine the limitations and positive attributes of these cultivars. This paper presents a brief synopsis of recent reports on the relative susceptibility of new apple cultivars and selections to rusts, powdery mildew, and apple scab pathogens.

Materials and Methods. Two groups of cultivars and selections (hereafter referred to as cultivars) were established at multiple locations in 1995 (23 entries) and 1999 (22 entries). Golden Delicious was the standard in both groups since it performs well across a wide variety of climates. Single tree plots were replicated five times in a randomized complete block design. Planting groups from which data were collected were located near Asheville, NC (1999), Winchester, VA (1995 and 1999), Kearneysville, WV (1995), Highland, NY (1995 and 1999), Amherst, MA (1999), and New Haven, CT (1995).

1995 group. All 23 cultivars were propagated by Adams County Nursery, Aspers, PA, on M.9 NAKB 337 rootstock in 1993. Pioneer McIntosh served as additional standard cultivar with known susceptibility to apple scab. Trees were planted in 1995 at 2-m in-row spacing with spacing between rows varying by location. Drive middles were planted with Kentucky-31 fescue (*Festuca arundinacea*), and a weed-free strip (1 m in 1995; 2 m in the remaining years) was maintained in the tree row with herbicides applied at recommended rates. Trees were headed at planting time and individually staked. Minimal pruning and training was done to allow assessment of natural tree structure, and to allow expression of natural flowering and fruit set tendencies. All flowers or young fruit were removed the first year by hand or by chemical means followed by hand thinning. Fertilizer application, pest management, and orchard floor management were subsequently done according to recommended local standards and based on leaf analyses. Recorded weather data included daily maximum and minimum temperatures, wetting periods, and precipitation during the growing season. Trees were allowed to fruit in their third leaf, 1997, and in subsequent years. Insecticides were applied from 1996 through 2000, as were fixed copper and/or streptomycin to manage fire blight.

1999 group. All 22 cultivars were budded in 1997 at Wafler Nursery in Walcott, NY, on M.9 NAKB 337 rootstock. Subsequent orchard establishment, horticultural management, experimental design, and weather monitoring were as described above.

Moderate to high pathogen inoculum levels were encouraged and minimal spray schedules were applied to maintain tree growth and prevent severe defoliation. In NY and VA, a protectant fungicide (primarily captan 50W, 1 lb per 100 gal dilute) was applied at a reduced rate three times in May or early June to suppress scab. No fungicide was applied in WV or CT. Disease inoculum was naturally abundant at most locations; however, cedar apple rust inoculum was introduced on cedar galls in VA.

Results and Discussion. Cedar apple rust. *1995 Group. Leaves.* Across all cultivars and locations, mean disease incidence ranged from 0% (Golden Supreme, Gala Supreme, and Enterprise) in NC to 45.2% for Creston in CT (Table 1). Mean disease incidence of the standard Golden Delicious ranged from 17.1% in WV to 33.2% in CT. Incidence of cedar apple rust on leaves varied significantly among cultivars, but did not vary by location. The cultivar x location interaction was not significant. Creston, Shizuka, GoldRush, Braeburn, and Cameo were generally the most susceptible; whereas, Golden Supreme, Gala Supreme, NY 75414-1, and Enterprise generally exhibited the lowest incidences of leaf rust (Table 1).

1995 Group. Fruit. Across all cultivars and locations, mean disease incidence ranged from 0% for many cultivars in both VA and NY to 6.4% for Yataka in VA and 5.3% for GoldRush in NY (Table 1). For the standard Golden Delicious, mean disease incidence ranged from 0.8% in VA to 0.2% in NY. Incidence of cedar apple rust on fruit did not vary among cultivars or locations, and the cultivar x location interaction was not significant. Incidence of cedar apple rust on leaves was not correlated with incidence on fruit.

1999 Group. Leaves. Across all cultivars and locations, mean disease incidence ranged from 0% for Sundance, Runkel, NY 79507-19, and NY 79507-49 in VA to 44.7% for Pinova in NY (Table 2). For the standard Golden Delicious, mean disease incidence ranged from 15.6% in VA to 39.2% in NY. Incidence of cedar apple rust on leaves varied among cultivars, locations, and for cultivar x location. CQR10T17, Scarlet O'Hara, Crimson Crisp, Chinook, and Princess were very susceptible at both sites; whereas, Zestar, Sundance, NY 65707-19, NY 79507-72, and NY 79507-49 generally exhibited the lowest incidences of leaf rust (the latter four are also scab resistant) (Table 2). The incidence of leaf rust on Pinova (44.7%) and NJ 109 (36.3%) was higher relative to other cultivars in NY when compared with VA (8.3 and 6.2%, respectively).

1999 Group. Fruit. Across all cultivars and locations, mean disease incidence on fruit ranged from 0% for many cultivars in both VA and NY to 25.9% for CQR10T17 in NY (Table 2). Disease incidence was generally low in VA; with the highest incidence also observed on CQR10T17 (5.5%). Disease incidence was 0% at both locations for Rogers McIntosh, Sundance, NY 79507-49, and NY 79507-72 (the latter three are scab resistant). For the standard Golden Delicious, mean disease incidence ranged from 5.0% in VA to 9.6% in NY. Incidence of cedar apple rust on fruit varied among cultivars but not among locations; the cultivar x location interaction was not significant. Incidence of cedar apple rust on leaves was not correlated with incidence of cedar apple rust on fruit.

Quince rust. *1995 Group.* Across all cultivars and locations, mean disease incidence on fruit ranged from 0% for Pioneer Mac in NY to 56.0% for Fortune in VA (Table 3). Quince rust incidence was much lower in NY than VA. For the standard Golden Delicious, mean disease incidence ranged from 24.0% in VA to 3.6% in NY. Incidence of quince rust on fruit varied among cultivars and locations, and the cultivar x location interaction was significant. Fortune and Cameo were generally the most susceptible in VA; whereas, Suncrisp, Shizuka, and Golden Supreme were the most susceptible in NY.

1999 Group. Across all cultivars and locations, mean disease incidence on fruit ranged from 0% for several cultivars in VA to 46.0 and 46.5% for Zestar and NJ 109, respectively, in NY (Table 3). Quince rust incidence was numerically lower in VA than NY – the opposite of the 1995 group. For the standard Golden Delicious, mean disease incidence ranged from 6.0% in VA to 28.2% in NY. The cultivar x location interaction term was not significant in this analysis, nor were the cultivar and location main effects. The cultivars Crimson Crisp, Princess, and NJ 109 were ranked highest for disease at both locations; whereas, the cultivars Runkel and Sundance were ranked lowest.

Resistance to cedar apple rust and quince rust not related. *1995 Group.* No significant relationships were observed for the incidences of these two diseases from data sets from VA (2001) and NY (1998, 1999, and 2003). Likewise, in the 1999 group, no significant relationships were observed for the incidences of these two diseases from data sets from VA (2002 and 2004) and NY (2001 and 2002).

Powdery mildew. Although powdery mildew data were collected at all locations in all years, for the purposes of determining relative susceptibility, only data sets that showed ≥10% leaf infection incidence on at least one cultivar at that location were included in the analysis (see table footnotes). In the 1995 cultivar group, across all cultivars and locations, mean disease incidence ranged from 1.6% for Gala Supreme in West Virginia to 51.9% for the cultivar Ginger Gold in Virginia (Table 4). For the standard, Golden Delicious, mean disease incidence ranged from 4.0% in West Virginia to 30.7% in Virginia. Incidence of powdery mildew on leaves varied significantly among cultivars and locations. The cultivar x location interaction was significant. When data from West Virginia were excluded from the analysis, the location and cultivar x location effects were not significant. Ginger Gold was the most susceptible cultivar, followed by Suncrisp, GoldRush, Creston, and Braeburn. The cultivars and selection Gala Supreme, NY 75414-1, and Enterprise generally exhibited the lowest incidences of powdery mildew (Table 4).

In the 1999 cultivar group, across all cultivars and locations, mean disease incidence ranged from 10.7% for the cultivar September Wonder in Virginia to 48.6% for the selection CQR10T17 in New York (Table 5). For the standard, Golden Delicious, mean disease incidence ranged from 22.2% in Virginia to 42.1% in New York. Incidence of powdery mildew on leaves varied significantly among cultivars and cultivar x location. The location main effect was not significant. The greater susceptibility of Roger's McIntosh, Pinova, NY 79507-49 and NY 79507-72 in Virginia when compared to New York accounted for a large part of the cultivar x location interaction. The cultivars and selections CQR10T17, Crimson Crisp, Delblush, and Sundance were the most susceptible. The cultivars and selections Zestar!, NY 65707-19, Hampshire, and September Wonder were the least susceptible to powdery mildew (Table 3).

Leaf area affected with mildew in Virginia ranged from 2.1% for the selection NY 65707-19 to 22.5% for the selection CQR10T17 (Table 5). Differences among cultivars and selections were significant. Percentage of fruit with powdery mildew russet symptoms in Virginia ranged from 0% for Cripps Pink, Chinook, NJ 109, Ambrosia, and Zestar! to 39.9% for the cultivar Pinova (Table 5). Percent leaf area affected by mildew was significantly and positively related to mildew incidence. Neither incidence nor leaf area affected were related to fruit symptoms.

Apple scab. In the 1995 group, across all cultivars and locations, mean disease incidence on leaves ranged from 0% for several cultivars (Pristine, Enterprise, and GoldRush) at several locations to 48.1% for the cultivar Orin in NY (Table 6). For the standard, Pioneer McIntosh, mean disease incidence ranged from 22.6% in VA to 46.4% in NY. Incidence of scab on leaves varied significantly among cultivars, but did not vary by location. The cultivar x location interaction was not significant. The cultivars Ginger Gold, Orin, and Cameo were generally the most susceptible; whereas, the scab resistant cultivars GoldRush, Enterprise, Pristine and NY 75414-1 generally exhibited the lowest incidences of leaf scab (Table 6). Cultivars without the V_f gene for scab resistance that had relatively low leaf scab incidence included Gala Supreme and Sansa. Honeycrisp also exhibited relatively low leaf scab incidence in VA and NC, but reached 19.1 and 10.8% mean leaf infection incidence in NY and WV, respectively.

For fruit in the 1995 group, across all cultivars and locations, mean disease incidence ranged from 0% for many cultivars in WV, VA and NY to 50.9% for the cultivar Yataka in WV (Table 7). For the apple scab susceptible standard, Pioneer McIntosh, mean disease incidence ranged from 18.5% in VA to 73.8% in WV. Incidence of apple scab on fruit varied significantly among cultivars, but not among locations. The cultivar x location interaction was not significant. The cultivars Fuji, Cameo, Shizuka, and Yataka were the most susceptible to apple scab fruit infections, whereas the cultivars GoldRush, Enterprise, Pristine, NY 75414-1, and Honeycrisp exhibited the least fruit scab (the first four cultivars listed are scab-resistant).

In the 1999 group, across all cultivars and locations, mean disease incidence on leaves ranged from 0% for several cultivars and selections in MI and VA to 95.0% for the cultivar Silken in MI (Table 8). For the standard, Rogers McIntosh, mean disease incidence ranged from 30.2% in NY to 96.4% in MI. Incidence of apple scab on leaves varied among cultivars, but not among locations. The cultivar x location interaction was not significant. The cultivars Cripps Pink, Silken, Delblush, Chinook, and Hampshire were the most susceptible; whereas, the cultivars Princess, Sundance, Scarlet O'Hara, Crimson Crisp, CQR10T17, NY 65707-19, NY 79507-72, and NY 79507-49 generally exhibited the lowest incidences of leaf scab (usually near 0%; the latter eight are all scab resistant, Table 8).

For fruit in the 1999 group, across all cultivars and locations, mean disease incidence ranged from 0% for many cultivars in MI, VA and NY to 97.4% for NJ 90 in MI (Table 9). The standard cultivar, Rogers McIntosh, exhibited a range of 49.3 to 96.3% fruit infection in VA and MI, respectively. Incidence of apple scab on fruit varied among cultivars but did not vary among locations; the cultivar x location interaction was not significant. The cultivars Cripps Pink, Ambrosia, Silken, and NJ 90 were the most susceptible to fruit scab; whereas, the cultivars Princess, Scarlet O'Hara, Sundance, Crimson Crisp, CQR10T17, NY 65707-19, NY 79507-72, and NY 79507-49 generally exhibited no fruit scab (the latter eight are scab-resistant, Table 9).

Most apple producers decide which apple cultivars to grow based on predictions and/or perceptions of future profitability. Relative susceptibility to insects or pathogens does not usually influence cultivar selection. However, organic producers sometimes choose to avoid highly susceptible cultivars and we suspect that using disease-resistant cultivars will become a standard procedure for organic apple production in humid climates because managing scab, rust, and mildew with sulfur and liquid lime sulfur is expensive, time-consuming, unreliable, and negatively impacts productivity. Even apart from organic production, cultivars that are highly susceptible to certain pests or diseases may need extra applications of pesticides each year, and the costs associated with those extra fungicide applications should be considered prior to planting highly susceptible cultivars. For example, Ginger Gold may require one or two additional mildew sprays per year when compared to less susceptible cultivars such as McIntosh; whereas, McIntosh may require more sprays to control apple scab. Knowing what to expect from new cultivars can help in planning pest control strategies for orchards that contain these cultivars.

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Table 1. Cedar apple rust leaf and fruit infection of 23 apple cultivars planted in 1995 at five locations.

	Percent leaves [v]					Percent fruit [w]	
Cultivar [x]	NC	VA	WV	NY	CT	VA	NY
Creston	33 ab [z]	27 a	32 a	23 b	45 a	0	1
GoldRush [y]	35 a	23 abc	26 abc	22 b	44 ab	0	5
Shizuka	29 abc	25 ab	28 ab	26 a	36 abc	0	1
Cameo	19 d-g	21 cd	22 bcd	16 cd	35 bc	2	1
Golden Delicious	22 c-f	22 bcd	17 def	18 c	33 cd	1	0
Braeburn	27 bcd	23 abc	21 cd	14 def	33 cd	1	1
Ginger Gold	19 d-g	23 a-d	19 de	15 c-f	31 cde	1	1
Arlet	24 cde	16 e	19 de	15 cde	29 c-f	1	0
Pristine [y]	18 d-g	17 e	16 def	12 d-g	25 d-h	0	0
Senshu	14 ghi	19 de	8 gh	12 efg	23 e-i	1	1
Fuji Red Sport #2	8 hij	11 f	13 efg	10 gh	26 c-g	2	0
Yataka	17 efg	7 g	11 fg	9 gh	27 c-g	6	0
Honeycrisp	30 abc	10 fg	11 fg	7 h	21 f-j	0	0
Orin	20 d-g	7 g	11 fg	11 fg	20 f-j	0	0
Sunrise	27 a-d	0 h	7 ghi	0 i	15 i-m	0	0
Suncrisp	7 hij	0 h	2 hi	2 i	18 g-k	1	0
Golden Supreme	0 j	0 h	1 hi	0 i	16 h-l	0	0
Pioneer Mac	5 j	0 h	3 hi	0 i	11 j-m	0	0
Fortune	15 fgh	0 h	3 hi	1 i	7 lm	1	0
Sansa	6 ij	0 h	1 i	3 i	8 lm	1	0
Enterprise [y]	0 j	0 h	1 i	1 i	10 klm	0	0
NY 75414-1 [y]	1 j	0 h	1 hi	0 i	9 klm	0	0
Gala Supreme	0 j	0 h	3 hi	0 i	6 m	0	0

[v] Means from 1998 (NC); 1997 and 1998 (VA); 1995, 1996, and 1997 (WV); 1995, 1996, 1997, and 2004 (NY); and 1996, 1997, and 1998 (CT).

[w] Means from 2001 (VA); and 1997, 1998, 1999, 2003, and 2004 (NY).

[x] Order of apple cultivars (most susceptible to least susceptible) based on the mean ranks for percent leaves across all locations.

[y] Cultivars or selections with genetic resistance to the apple scab pathogen, *Venturia inaequalis*.

[z] Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

Table 2. Cedar apple rust leaf and fruit infection of 22 apple cultivars planted in 1999 at two locations.

	Percent leaves [u]		Percent fruit [v]	
Cultivar or selection [w]	VA	NY	VA	NY
CQR10T17 [x]	26 a [y]	38 b	6 a	26 a
Scarlet O'Hara (Co-op 25) [x]	20 b	43 a	4 abc	21 b
Chinook (BC 8S-27-51)	16 c	43 a	0 d	11 ef
Princess (CQR12T50) [x]	15 c	44 a	5 abc	19 bcd
Pinova	8 d	45 a	0 d	10 ef
Crimson Crisp (Co-op 39) [x]	20 b	36 bc	2 bcd	19 bcd
Golden Delicious	16 c	39 b	5 ab	10 f
Ambrosia	15 c	39 b	2 bcd	15 de
Pink Lady	14 c	NA [z]	NA	NA
NJ 109	6 de	36 bc	0 d	16 cd
BC 8S-26-50	5 e	36 bc	2 cd	19 bcd
September Wonder (Jubilee Fuji)	1 f	33 c	0d	8 fg
Rogers McIntosh	0 f	15 de	0 d	0 h
Hampshire	0 f	16 de	0 d	2 h
Delblush	NA	13 ef	NA	4 gh
Runkel	0 f	17 d	0 d	3 h
NJ 90	0 f	10 f	0 d	3 h
Zestar! ® (Minnewashta)	0 f	3 h	1 d	1 h
Sundance (Co-op 29) [x]	0 f	4 gh	0 d	0 h
NY 65707-19 [x]	0 f	7 g	0 d	1 h
NY 79507-72 [x]	0.0 f	4 gh	0 d	0 h
NY 79507-49 [x]	0 f	2 h	0 d	0 h

[u] Means from 2000 - 2004 (VA) and 2000, 2001, 2002, and 2004 (NY).

[v] Means from 2002 and 2004 (VA); and 2001, 2002, and 2004 (NY).

[w] Order of apple cultivars (most susceptible to least susceptible) based on the mean ranks for percent leaves across all locations.

[x] Cultivars with genetic resistance to the apple scab pathogen, *Venturia inaequalis*.

[y] Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

[z] NA = cultivar not available.

Table 3. Quince rust fruit infection of 23 and 22 apple cultivars planted in 1995 and 1999 at two locations.

	Percent fruit [v]				
	1995 Group		1999 Group		
Cultivar [w]	VA	NY	Cultivar	VA	NY
Shizuka	30 bcd [y]	4 ab	Crimson Crisp (Co-op 39) [x]	19	41
Cameo	40 ab	3 a-g	Princess (CQR12T50) [y]	6	39
Golden Supreme	26 b-f	4 abc	NJ 109	5	47
Senshu	28 b-e	3 a-f	September Wonder (Jubilee	NA [z]	35
Fuji Red Sport #2	34 bc	2 b-h	Zestar!® (Minnewashta)	1	46
Golden Delicious	24 b-g	4 a-d	CQR10T17 [x]	18	27
Braeburn	25 b-f	3 a-e	Ambrosia	11	28
Sansa	27 b-f	3 a-g	BC 8S-26-50	4	36
Creston	36 bc	2 b-h	Delblush	NA	33
Fortune	56 a	1 d-h	NJ 90	3	34
GoldRush [x]	23 b-g	4 a-d	Pinova	13	22
Suncrisp	11 e-h	5 a	Golden Delicious	6	28
Yataka	20 c-g	3 a-f	NY 79507-72 [x]	0	38
Gala Supreme	28 b-e	1 e-h	Scarlet O'Hara (Co-op 25) [x]	6	25
Arlet	20 c-g	2 c-h	NY 79507-49 [x]	6	27
Enterprise [x]	24 b-g	0 gh	NY 65707-19 [x]	7	21
Sunrise	14 d-h	2 b-h	Cripps Pink	2	NA
Orin	7 gh	2 b-h	Rogers McIntosh	0	31
Honeycrisp	15 d-h	1 e-h	Chinook (BC 8S-27-51)	0	28
Pristine [x]	1 h	2 a-h	Runkel	0	16
Pioneer Mac	14 d-h	0 h	Sundance (Co-op 29) [x]	0	7
NY 75414-1 [x]	13 d-h	0 e-h	Hampshire	NA	18
Ginger Gold (least)	10 fgh	1 fgh			

[v] Means from 2000 (VA) and 1999 (NY) for the 1995 group. Means from 2002, 2003, and 2004 (VA) and 2001, 2002, and 2003 (NY) for the 1999 group.

[w] The order of apple cultivars is from most susceptible to least susceptible, based on the mean ranks across all locations.

[x] Cultivars with genetic resistance to the apple scab pathogen, *Venturia inaequalis*.

[y] Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

[z] NA = cultivar not available.

Table 4. Percent leaves with powdery mildew infection from 23 apple cultivars, from the 1995 group at three locations.

	Disease ratings by plot location		
Cultivar or selection [x]	New York	Virginia	West Virginia
Ginger Gold (most)	43.9 a [y]	51.9 a	6.0 b-e
Suncrisp	22.5 c	36.4 b	5.3 b-f
GoldRush[z]	29.9 b	28.1 cde	9.4 a
Creston	19.4 cd	30.3 cd	7.5 abc
Braeburn	17.2 de	30.3 cd	7.8 ab
Shizuka	23.0 c	30.3 cd	4.0 d-h
Pioneer Mac	15.1 def	33.0 bc	4.6 c-h
Orin	17.1 de	29.3 cd	4.8 b-g
Golden Delicious	15.7 def	30.7 cd	4.0 d-h
Honeycrisp	14.4 ef	28.6 cd	4.2 d-h
Cameo	14.6 ef	26.6 c-f	4.1 d-h
Sunrise	13.0 e-h	17.2 hij	3.6 e-h
Arlet	9.5 g-j	22.3 fgh	5.3 b-f
Sansa	11.6 f-i	15.2 j	6.7 a-e
Golden Supreme	13.8 efg	22.7 fgh	2.4 fgh
Fortune	11.8 fgh	25.7 d-g	2.1 gh
Yataka	3.3 l	18.6 hij	2.5 fgh
Fuji Red Sport #2	5.4 jkl	19.2 hij	2.7 fgh
Senshu	7.0 i-l	21.0 hij	1.8 gh
Pristine [z]	8.2 h-k	16.0 ij	2.0 gh
Enterprise [z]	5.3 jkl	13.6 jk	2.8 fgh
NY 75414-1 [z]	5.8 jkl	8.3 k	2.4 fgh
Gala Supreme (least)	3.0 l	8.8 k	1.6 h

[x] The order of apple cultivars is from most susceptible to least susceptible, based on the mean ranks of % leaves infected across locations.

[y] Means within columns represent observations from 1995 – 1998, inclusive, for NY, VA, and WV,. Different letters denote significant differences according to the Waller Duncan k-ratio t test ($p = 0.05$).

[z] Indicates cultivars or selections with genetic resistance to the apple scab pathogen, *Venturia inaequalis*.

Table 5. Percent leaves, percent leaf area, and percent fruit injury following powdery mildew infection on 22 apple cultivars, from the 1999 group at two locations.

Cultivar or selection [w]	Disease ratings by plot location			
	New York	Virginia		
	% leaves	% leaves	% leaf area	% fruit
CQR10T17[x] (most)	48.6 a[y]	31.4 ab	22.5 a	0.27 g
Crimson Crisp (Co-op 39) [x]	46.4 a	30.4 ab	21.3 a	27.8 b
Delblush	45.2 a	NA	NA	NA
Sundance (Co-op 29) [x]	33.6 bc	33.3 a	21.3 a	3.6 fg
Cripps Pink	NA[z]	27.2 bc	12.3 bc	NA
Golden Delicious	42.1 ab	22.2 c-f	5.2 efg	1.5 g
Pinova	26.4 c-f	29.7 abc	11.7 bcd	39.9 a
Chinook (BC 8S-27-51)	43.1 ab	20.2 fg	9.1 b-e	0.0 g
NJ 90	30.9 cd	21.5 d-g	7.6 c-g	13.0 de
Runkel	25.8 c-f	24.9 bcd	9.7 b-e	1.7 fg
Rogers McIntosh	18.9 fg	30.6 ab	14.2 b	3.1 fg
Scarlet O'Hara (Co-op 25) [x]	29.4 cde	19.5 g	6.3 d-g	21.7 bc
NY 79507-49 [x]	19.1 fg	22.3 cde	7.3 d-g	17.6 cd
BC 8S-26-50	30.3 cde	18.3 g	5.7 efg	8.4 ef
NJ 109	19.4 fg	20.7 efg	4.8 efg	0.0 g
Princess (CQR12T50) [x]	20.7 efg	18.7 g	3.6 fg	1.2 g
Ambrosia	23.9 def	13.0 hi	3.2 fg	0.0 g
NY 65707-19 [x]	22.7 d-g	13.1 hi	2.1 g	27.0 b
NY 79507-72 [x]	17.8 fg	20.0 g	4.9 efg	0.98 g
Hampshire	18.9 fg	17.6 gh	8.4 b-e	NA
Zestar!® (MN 1824)	16.9 fg	12.1 i	3.4 fg	0.0 g
September Wonder (least)	13.5 g	10.7 i	5.5 efg	NA

[w] The order of apple cultivars is from most susceptible to least susceptible, based on the mean ranks of % leaves infected across locations.

[x] Indicates genotypes with genetic resistance to the apple scab pathogen, *Venturia inaequalis*.

[y] Means within columns represent observations from 1999 – 2004, inclusive, from VA; and 2000 and 2004 from NY. Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

[z] NA = cultivar not available.

Table 6. Percent leaves with apple scab infection from 23 apple cultivars, from the 1995 NE-183 group at four locations.

	Plot location			
Cultivar or selection [x]	New York	North Carolina	Virginia	West Virginia
Ginger Gold (most)	34.1 bc	26.4 bc	33.3 a	30.5 a
Orin	48.1 a	27.6 ab	24.3 d	26.1 ab
Pioneer Mac	46.4 a	38.3 a	22.6 de	24.5 bc
Cameo	33.3 bcd	21.7 b-e	30.0 ab	25.9 ab
Shizuka	33.2 bcd	21.4 b-e	28.4 bc	24.6 bc
Sunrise	35.1 bc	20.7 b-e	22.0 de	26.3 ab
Yataka	31.4 cde	17.6 b-f	27.8 bc	30.5 a
Braeburn	39.0 b	15.1 def	18.3 f	23.6 bc
Fuji Red Sport #2	29.2 c-f	13.8 ef	25.4 dc	25.7 ab
Suncrisp	33.1 bcd	15.8 c-f	22.4 de	22.0 bc
Golden Delicious	32.0 cde	18.4 b-e	19.9 ef	15.1 de
Golden Supreme	20.7 ghi	25.4 bcd	17.8 f	20.8 bc
Arlet	29.3 c-f	19.4 b-e	12.2 g	14.0 ef
Senshu	22.6 fgh	13.8 ef	22.6 de	20.1 cd
Creston	27.1 d-g	11.2 ef	8.3 h	12.9 ef
Fortune	26.3 efg	6.6 fg	1.5 i	9.0 fg
Honeycrisp	19.1 hi	0.0 g	0.6 i	10.8 ef
Sansa	15.5 i	0.0 g	0.0 i	5.0 gh
Gala Supreme (least)	8.8 j	0.0 g	0.2 i	4.0 gh
NY 75414-1 [y]	3.1 jk	0.0 g	0.4 i	0.0 h
GoldRush [y]	1.3 k	0.0 g	0.1 i	0.0 h
Enterprise [y]	1.2 k	0.0 g	0.0 i	0.0 h
Pristine [y] (least)	0.3 k	0.0 g	0.0 i	0.0 h

[x] The order of apple cultivars is from most susceptible to least susceptible, based on the mean ranks across all locations. Data are from 1997 and 1998 (New York), 1998 (North Carolina), 1996 – 1998 (Virginia), and 1996 - 1998 (West Virginia).

[y] Indicates cultivars with genetic resistance to the apple scab pathogen, *Venturia inaequalis*. Scab reported for these cultivars was not verified and might represent mis-identification of lesions in the field.

[z] Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

Table 7. Percent fruit with apple scab infection from 23 apple cultivars, from the 1995 NE-183 group at three locations.

	Plot location		
Cultivar or selection [x]	New York	Virginia	West Virginia
Fuji Red Sport #2 (most)	32.4 ab [z]	41.3 a	28.2 cde
Pioneer Mac	35.6 a	18.5 g	73.8 a
Cameo	29.7 bc	35.0 bc	18.5 d-g
Shizuka	23.7 ef	38.3 ab	26.9 c-f
Yataka	23.6 ef	24.3 e	50.9 b
Golden Supreme	9.9 h	35.1 bc	37.9 bc
Orin	27.4 cd	23.3 ef	26.7 c-f
Senshu	26.1 de	33.6 c	15.6 e-h
Sunrise	23.2 ef	19.0 fg	33.2 c
Ginger Gold	15.8 g	29.0 d	31.1 cd
Arlet	28.5 cd	24.3 e	14.0 fgh
Fortune	30.3 bc	10.8 h	15.7 e-h
Braeburn	22.9 ef	15.5 g	17.0 efg
Creston	28.2 cd	4.7 i	7.7 ghi
Suncrisp	25.1 de	1.2 ij	2.5 hi
Golden Delicious	16.9 g	18.0 g	7.4 ghi
Sansa	8.7 h	0.0 j	14.3 fgh
Gala Supreme	21.5 f	1.0 ij	2.1 hi
GoldRush [y]	2.5 i	0.0 j	0.0 i
Honeycrisp	1.0 i	0.0 j	0.0 i.
Enterprise [y]	0.4 i	0.0 j	0.0 i
Pristine [y]	0.0 i	0.0 j	0.0 i
NY 75414-1 [y] (least)	0.0 i	0.0 j	0.0 i

[x] The order of apple cultivars is from most susceptible to least susceptible, based on the mean ranks across all locations. Data are from 1997 and 1998 (West Virginia), 1997, 1998, 1999, 2003, and 2004 (New York), and 1997 – 2001 (Virginia).

[y] Indicates cultivars with genetic resistance to the apple scab pathogen, *Venturia inaequalis*. Scab reported for these cultivars was not verified and might represent mis-identification of lesions in the field.

[z] Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

Table 8. Percent leaves with apple scab infection from 24 apple cultivars, from the 1999 NE-183 group at three locations.

	Plot location		
Cultivar or selection [w]	Mich.	New York	Virginia
Cripps Pink (most)	NA [y]	NA	80.3 a
Silken	95.0 ab [z]	NA	NA
Rogers McIntosh	96.4 a	30.2 a	48.9 d
Delblush	92.5 abc	23.8 c	NA
Chinook (BC 8S-27-51)	88.9 a-e	24.6 bc	68.2 b
Hampshire	81.8 ef	27.9 ab	71.4 b
NJ 90	91.6 a-d	24.2 c	48.4 d
Ambrosia	84.3 cde	23.3 c	68.4 b
Zestar! ® (Minnewashta)	87.0 b-e	17.4 d	67.9 b
September Wonder (Jubilee Fuji)	83.7 de	14.2 de	58.4 c
Autumn Gold	74.4 f	NA	NA
Golden Delicious	73.5 fg	11.1 ef	37.8 e
Runkel	65.1 gh	7.3 g	44.6 d
Pinova	73.9 f	8.6 fg	19.6 f
NJ 109	58.4 h	3.2 h	23.8 f
BC 8S-26-50	43.7 i	1.7 h	24.9 f
NY 79507-72 [x]	0.0 j	1.2 h	0.9 g
NY 65707-19 [x]	0.0 j	0.3 h	0.0 g
Princess (CQR12T50) [x]	0.0 j	0.2 h	0.3 g
Sundance (Co-op 29) [x]	0.0 j	0.0 h	0.1 g
CQR10T17 [x]	0.0 j	0.1 h	0.1 g
Scarlet O'Hara (Co-op 25) [x]	NA	0.1 h	0.1 g
NY 79507-49 [x]	0.0 j	0.1 h	0.0 g
Crimson Crisp (Co-op 39) [x] (least)	0.0 j	0.1 h	0.0 g

[w] The order of apple cultivars is from most susceptible to least susceptible, based on the mean ranks across all locations. Data are from 2003 and 2004 (Michigan), 1999, 2000, and 2002 (New York), and 2000, 2002, 2003, and 2004 (Virginia).

[x] Indicates cultivars with genetic resistance to the apple scab pathogen, *Venturia inaequalis*. Scab reported for these cultivars was not verified and may represent mis-identification of lesions in the field.

[y] NA = cultivar not available.

[z] Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

Table 9. Percent fruit with apple scab infection from 24 apple cultivars, from the 1999 NE-183 group at three locations.

	Plot location		
Cultivar or selection [w]	Mich.	New York	Virginia
Cripps Pink (most)	NA[y]	NA	76.5 b
Ambrosia	93.0 ab [z]	34.2 c	84.5 a
Silken	85.8 abc	NA	NA
Rogers McIntosh	96.3 a	56.4 a	49.3 ef
NJ 90	97.4 a	48.2 ab	46.3 f
Hampshire	78.8 cd	38.8 bc	NA
Chinook (BC 8S-27-51)	80.9 bc	29.7 c	55.0 d
September Wonder (Jubilee Fuji)	78.8 cd	13.4 de	NA
Zestar! ® (Minnewashta)	73.7 cd	6.4 def	67.6 c
Delblush	78.0 cd	8.3 def	NA
Autumn Gold	76.9 cd	NA	NA
Golden Delicious	67.4 d	1.0 ef	67.3 c
Runkel	49.5 e	14.8 d	44.6 f
BC 8S-26-50	42.8 e	8.0 def	58.8 d
Pinova	46.2 e	2.9 def	53.6 de
NJ 109	44.9 e	1.6 def	49.6 ef
CQR10T17 [x]	0.0 f	0.2 ef	0.0 g
NY 79507-72 [x]	0.0 f	0.0 f	0.0 g
Princess (CQR12T50) [x]	0.0 f	0.0 f	0.0 g
NY 65707-19 [x]	0.0 f	0.0 f	0.0 g
Scarlet O'Hara (Co-op 25) [x]	NA	0.0 f	0.0 g
Sundance (Co-op 29) [x]	0.0 f	0.0 f	0.0 g
NY 79507-49 [x]	0.0 f	0.0 f	0.0 g
Crimson Crisp (Co-op 39) [x] (least)	0.0 f	0.0 f	0.0 g

[w] The order of apple cultivars is from most susceptible to least susceptible, based on the mean ranks across all locations. Data are from 2003 and 2004 (Michigan), 2002 (New York), and 2002, 2003, and 2004 (Virginia).

[x] Indicates cultivars with genetic resistance to the apple scab pathogen, *Venturia inaequalis*. Scab reported for these cultivars was not verified and might represent mis-identification of lesions in the field.

[y] NA = cultivar not available.

[z] Letters denote the differences among means according to the Waller Duncan k-ratio t test ($p = 0.05$).

EVALUATION OF PRUNING TECHNIQUES AND BACTERICIDES FOR MANAGING BACTERIAL CANKER OF SWEET CHERRY

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The efficacy of pruning technique and copper sprays to protect pruning wounds from bacterial canker infection on sweet cherry cv Hedelfingen was examined in two field experiments: uninoculated and inoculated. In both, copper was applied before and after pruning in spring (Cuprofix Disperss in 2006 and COCS in 2008) and individual branches were shielded from copper by wrapping with plastic. The uninoculated experiment, consisted of trees trained to a Vertical Axis system, in 3 replicate blocks, 15 trees/block. On each tree, two (3- to 5-cm diam) branches were pruned to leave 15-cm-long stubs, one copper-treated, the other shielded. The inoculated experiment consisted of 16 trees trained to a Vogel system on which the fate of inoculations with copper-sensitive *Psuedomonas syringae* pv. *syringae* (Pss) on stub and flush cuts was compared, one each copper-treated or shielded. Isolations to recover Pss from inoculated pruning cuts were made 2 and 4 weeks post-inoculation. Bacterial canker symptom development was assessed periodically during the growing season.

In both years, copper provided only nominal control of bacterial infections in pruning cuts. The extent of canker on inoculated stubs treated with copper was, on average 3 cm less in 2006 and 2 cm less in 2008 (Fig 1 A and B). Flush cuts were as likely to become infected as stub cuts. Discoloration progressed somewhat less from flush cuts than from stub cuts, whether treated with copper or not. However, stub-cut-infections did not progress into scaffolds or trunks. Pruning stubs may effectively contain bacterial canker infections in a dead end that is walled-off by the tree. Pss was re-isolated from all inoculated stub and flush cuts. Only one of the Pss isolates was resistant to copper, indicating this is not a contributing factor in lack of control. We have a physical collection of 420 bacterial isolates and have begun sequencing the genome of one of the Pss isolates from NY sweet cherry.

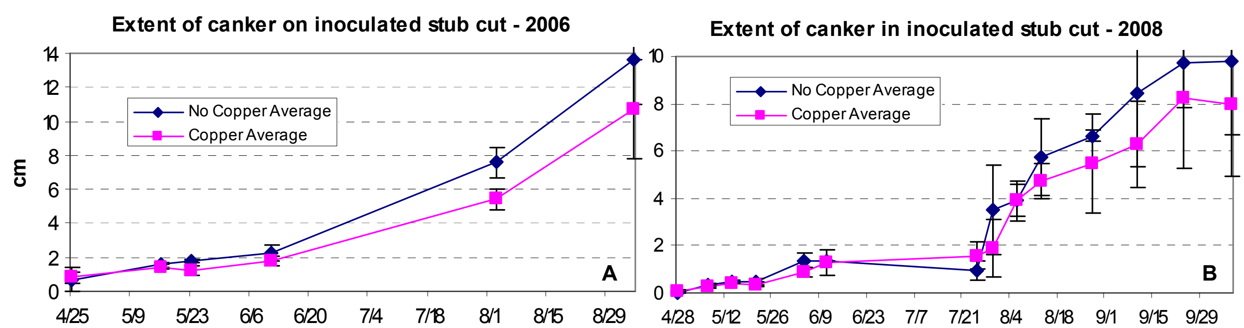

Figure 1. Progression of sunken bark on pruning stubs inoculated with *Psuedomonas syringae* pv. *syringae* that were sprayed before and after pruning (Copper) or shielded from spray (No Copper). Measurements (cm) were taken on the dates shown (X axis). A. 2006. B. 2008.

Laboratory experiments with green cherry fruit were conducted to determine post-infection and pre-infection activity of Kocide 2000 (standard), Regalia, Flameout, Oxidate, Serenade, BCYP, Kasumin, Kasumin + Captan, Prophyt, Pentra Bark, Prophyt + Pentra Bark, Urea, Kasumin + Pentra Bark, and Flameout + Pentra Bark against Pss. Results from eradicant tests (Tables 1 and 2) and protectant tests (Tables 3 and 4) suggest that Flameout may have promise as a material to replace or augment the use of copper in managing this disease. Kasumin had eradicant activity, but not protectant activity against infection.

Tables 1 and 2. Eradicant tests in a green cherry fruit assay using labeled rates of treatment products applied after wound-inoculation with $1x10^8$ cfu of Pss. The diameter (mm) of the resulting lesion was measured after 48 hours. Means of four replicate experiments are shown in each table. Means followed by the same letter do not significantly differ (P=.05, Tukey's HSD).

Eradicant Treatment	Diam 48 hr	% control
Uninoculated	1.1 c	-
Inoculated	3.1 a	-
Flameout	1.4 bc	54.5
Kasumin + Captan	2.3 abc	26.3
Kasumin	2.3 abc	25.3
Prophyt	2.6 ab	15.2
Kocide 2000	3.0 a	2.0
Pentra Bark	3.1 a	0.0
Oxidate	3.1 a	0.0
Regalia	3.2 a	0.0
Prophyt + Pentra Bark	3.2 a	0.0
BCYP	3.3 a	0.0
Serenade	3.3 a	0.0

Eradicant Treatment	Diam 48 hr	% control
Uninoculated	1.0 d	-
Inoculated	3.9 a	-
Flameout + Pentra Bark	1.9 cd	51.3
Flameout	2.2 bcd	44.4
Kocide 2000	2.7 abc	31.7
Kasumin + Pentra Bark	2.8 abc	29.4
Kasumin + Captan	2.9 abc	27.0
BCYP	3.2 abc	19.8
Serenade	3.4 ab	13.5
Prophyt + Pentra Bark	3.4 ab	13.5
Kasumin	3.4 ab	13.5
Regalia	3.5 ab	10.3
Oxidate	3.6 ab	7.9
Prophyt	3.8 a	4.8
Pentra Bark	3.8 a	3.2
Urea	4.0 a	0.0

Tables 3 and 4. Protectant tests in a green cherry fruit assay using labeled rates of treatment products applied before wound-inoculation with $1x10^8$ cfu of Pss. The diameter (mm) of the resulting lesion was measured after 48 hours. Means of four replicate experiments are shown in each table. Means followed by the same letter do not significantly differ (P=.05, Tukey's HSD).

Protectant Treatment	Diam 48 hr	% control
Uninoculated	1.1 c	-
Inoculated	3.1 ab	-
Flameout	2.6 b	17.2
BCYP	2.7 b	14.1
Oxidate	2.8 ab	10.1
Kasumin + Captan	2.8 ab	9.1
Kocide 2000	2.8 ab	9.1
Regalia	2.9 ab	7.1
Pentra Bark	3.0 ab	4.0
Kasumin	3.1 ab	1.0
Prophyt	3.1 ab	0.0
Serenade	3.3 ab	0.0
Prophyt + Pentra Bark	3.7 a	0.0

Protectant Treatment	Diam 48 hr	% control
Uninoculated	1.1 d	-
Inoculated	3.9 abc	-
Flameout + Pentra Bark	2.3 cd	40.7
Flameout	2.7 bcd	32.5
Kocide 2000	2.8 bcd	30.2
Kasumin + Pentra Bark	3.3 abc	17.5
BCYP	3.6 abc	7.9
Kasumin	3.7 abc	7.1
Prophyt + Pentra Bark	3.9 abc	0.8
Prophyt	4.0 abc	0.0
Kasumin + Captan	4.0 ab	0.0
Serenade	4.0 ab	0.0
Urea	4.0 ab	0.0
Pentra Bark	4.1 ab	0.0
Oxidate	4.2 ab	0.0
Regalia	4.5 a	0.0

Current field experiments (2009 and 2010) are exploring different pruning times (March, April, May, and post-harvest) and the effect of copper, phosphite or no treatments applied twice in fall and twice in spring for managing canker infections. Preliminary results from these experiments conducted in Geneva and Highland, NY will be reported.

APPLE SCAB FUNGICIDE RESISTANCE IN THE NORTHEASTERN UNITED STATES: PREVALENCE AND PRACTICAL RESISTANCE

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The apple scab pathogen, *Venturia inaequalis*, threatens apple sustainability in the temperate production regions of the northeastern US. In the absence of durable host resistance in commercially desirable cultivars, producers make considerable fungicide applications to avoid losses to apple scab (7). Apple scab is managed with as many 12 applications of fungicides per season (5,6). Site-specific fungicide chemistries such as the Demethylation inhibititors (DMI) and Quinone outside inhibititors (QoI) are some of the safest and most effective fungicides for use against apple diseases. However, due of their single site mode of action, these highly effective fungicides are prone to resistance development.

DMI resistance in *V. inaequalis* populations in the northeastern US was first confirmed at the turn of the century (3,4), but it wasn't until 2004 that widespread fungicide resistance testing was established. Based the 2007-2009 testing effort, it is evident that DMI resistance is widespread throughout the region. Indeed, very few orchards in the region would be considered "sensitive" to DMI fungicides (Fig. 1A). Moreover, the level of DMI resistance exhibited by most orchards is such that one could expect failures using commercially formulated products in less than optimal situations. Such situations would include curative mode applications, alternate row middle applications, application with extended intervals, and applications to highly susceptible cultivars.

The recent registration of DMI chemistries with higher intrinsic activity against apple scab has raised questions as to the ability of resulting fungicide products to break practical resistance. This concept is defined as the point at which a pathogen population is sufficiently resistant to a fungicide chemistry as to result in a failure of the commercially formulated product under appropriate use practices. Field trials were conducted in 2008 and 2009 in orchards with SI practical resistance to look at the potential of newly introduced DMI chemistries on several cultivars. Trial results indicate that fungicide products containing difenoconazole, fenbuconzaole, and flutriafol have the ability to overcome practical resistance only on certain cultivars (Fig. 2). Practical resistance to DMI fungicides seems to be cultivar dependent, and is likely due to the interplay between fungicide mode of action and cultivar susceptibility.

In 2007, the first qualitative QoI resistant orchard population was detected in NY (1), and in 2008 there were more instances of QoI resistant populations. In these populations the qualitative resistance genotype was only represented in a small proportion of the population sample, while the majority of population resistance appeared to be due to the quantitative resistance component (2) (Fig. 1B). In 2009, few orchards tested resistant to QoIs, but only a few isolates from theses orchards had the qualitative resistant genotype. However, the majority of the isolates from these orchards did display a strong quantitative resistance phenotype. Since the proportion of population members with the qualitative resistance is low, chemistry rotations in fungicide programs may have slowed selection in the Northeastern US. Moreover, the introduction of newer SI chemistries, with the potential to break practical resistance, may continue to retard the selection of qualitative resistance to QoIs.

FIGURES

Figure 1.

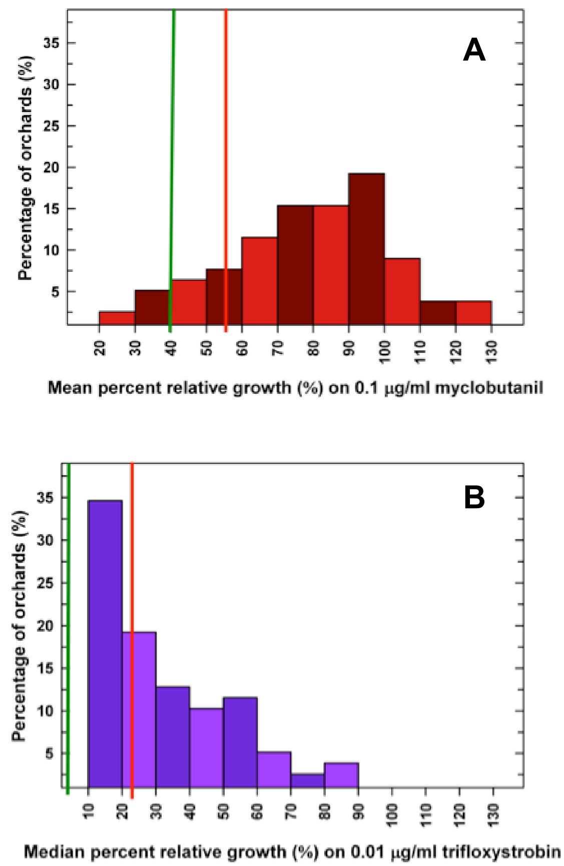

Figure 1. Fungicide sensitivity distributions of for myclobutanil (**A**) and trifloxystrobin (**B**) from orchard populations in the Northeastern United states surveyed from 2007-2009. Values represent means (**A**) or medians (**B**) and standard errors of individual orchard populations with > 27 isolates per population. The horizontal green and red lines indicate means from a collection of orchards that are ‘baseline’ or have ‘practical resistance’, respectively.

Figure 2.

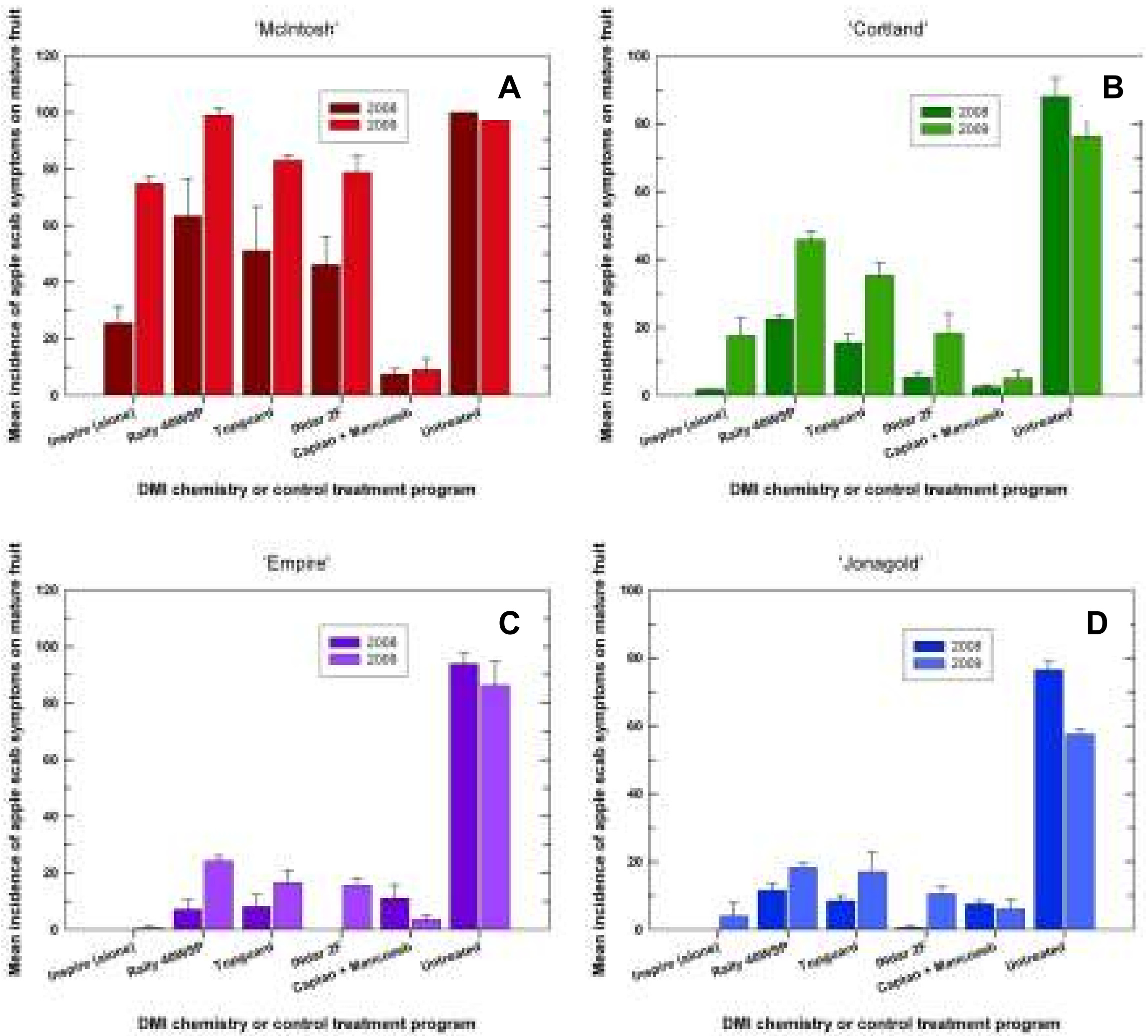

Figure 2. Performance of DMI fungicide chemistries in mixed cultivar orchards with similarly DMI-resistant populations. Cultivars evaluated included: **A**) 'McIntosh', **B**) 'Cortland', **C**) 'Empire', and **D**) 'Jonagold'. Values represent means and standard errors of harvest scab incidence of four replicate single-tree plots with 10 samples of 5 five apples per tree. Dark and light colored bars represent trial results from 2008 and 2009 respectively.

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EVALUATION OF FUNGICIDE PROGRAMS FOR APPLE SCAB & POWDERY MILDEW

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Apple scab and powdery mildew are widespread and considered to be the most devastating diseases affecting commercial apple production in Pennsylvania. Without adequate control, they greatly reduce marketable yield by causing extensive damage to fruit and the increased need for synthetic fungicide application in orchards. A trial was conducted at the Penn State Fruit Research and Extension Center research orchards to evaluate the performance of various fungicide programs and schedules for control of scab and powdery mildew on mature 'Rome Beauty', 'Red Delicious', and 'Stayman' apple trees on dwarf/Malling 26 rootstock. The test was conducted in a randomized complete block design with four replications. Treatments were applied dilute to both sides of trees with a boom sprayer at 400 psi, which delivered 100 gal/A. Early season spray dates and respective growth stages were as follows: 9 Apr (1/2" GT), 16 Apr (TC), 24 Apr (Pink Bloom), 5 May (Bloom), 13 May (Petal fall), and 21 May (1C), 1 Jun (2C). Maintenance sprays (mostly Captan/Topsin) for summer diseases were applied from 12 Jun (2C) to 29 Jul (7C) to all the treatments with a boom sprayer. A maintenance program for insects was applied to all the treatments with an airblast sprayer at 100 gal/A at 400 psi. Weather data was recorded with electronic monitoring systems (Campbell Scientific and Spectrum Weather Systems) and scab infection periods calculated using a modified Mill apple scab infection model. Rainfall for April, May, June, July and Aug was 4.4 in., 6.9 in., 4.42 in., 4.98 in., and 2.75 in., respectively. Several scab infection periods occurred during the primary period 16 Mar to 15 Jun. There were 6 moderate scab infection events that occurred over 11 days that included 1-4 continuous days of wetting and 9 severe infection events occurring over 33 days that ranged from 2-5 continuous days of wetting. The first apple scab lesions on 'Red Delicious' spur leaves were observed on 4 May from the severe infection period on 13 Apr. Overall, apple scab pressure was very high and powdery mildew pressure was moderate in the test site. Incidence of scab was recorded by observing all leaves on 19 May, 22 Jun, and 17 Aug on 25 shoots. Incidence of scab on fruit was determined on 17 Aug on 25 fruit. Data were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Fisher's Protected LSD Tests ($P \leq 0.05$).

Scab incidence on nontreated 'Rome Beauty' shoot leaves on 19 May, 22 Jun, and 17 Aug was 93, 100, and 98%, respectively. Scab incidence on 'Red Delicious' shoot leaves on 19 May, 22 Jun, and 17 Aug was 72, 99, and 100%, respectively. Scab incidence on 'Stayman' shoot leaves on 19 May, 22 Jun, and 17 Aug was 85, 100, and 100%, respectively. Early incidence of scab (19 May) on treated 'Rome Beauty', 'Red Delicious', and 'Stayman' shoot leaves ranged from 1-31%, 0-28% and 1-28%, respectively, with all the treatments being similar to each other and different from the nontreated control. All treatments on 22 Jun assessment, except the Topguard only program (Trt. 3) provided significant scab control on shoots compared to the nontreated shoots. Topguard with Dithane (Trt. 4) and Topguard with Captan (Trt. 5) gave comparable control on scab with the other programs. Overall, Inspire + Dithane program (Trt. 2) and Luna Sensation (Trt. 6) followed by Topguard + Captan (Trt. 3), Dithane with Indar (Trt. 9), Rally + Dithane (Trt. 10), Dithane + Captan/GWN-4617 + Dithane (Trt. 11) significantly reduced the level of scab on shoots on all 3 cultivars. Luna Sensation provided the best scab control on fruit on both 'Rome Beauty' and 'Stayman', while Inspire Super program had the best fruit scab control on 'Red Delicious'. By 22 Jun, powdery mildew incidence and severity on nontreated 'Rome Beauty', 'Red Delicious', and 'Stayman' shoot leaves was 54% and 19%, 21% and 64% and 7% and 67%, respectively. Topguard alone (Trt. 3), Topguard + Dithane (Trt. 4), Luna Sensation (Trt. 6) and GWN-4617/GWN-4616 + Dithane (Trt. 12) schedules significantly provided the best powdery mildew control. No treatments caused phytotoxicity to leaves or fruit.

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We wish to thank Penn State Fruit Research and Extension Center Technical Service for treatment applications and maintenance of the orchards.

Table 1. Scab incidence on 'Rome Beauty' apple.

		% Scab incidence			
	Application	Shoots[y]			Fruit[x]
Trmt. and Rate/100 GPA	Timing[z]	19 May	22 Jun	17 Aug	17 Aug
1. Untreated Ck		93.0 f[w]	100.0 f	98.0 c	86.0 efg
2. Inspire Super 12.0 oz +					
Dithane 75DF 3.0 lb.............	½"GT,TC,P,B,PF,1C	4.0 abc	7.0 a	92.0 bc	40.0 abc
3. Topguard 13.0 fl oz................	1/2"GT-1C…………	31.0 d	90.0 def	94.0 bc	95.0 fg
4. Topguard 13.0 fl oz +					
Dithane 75DF 3.0 lb……….	1/2"GT-1C…………	10.0 c	50.0 bc	94.0 bc	45.0 abc
5. Topguard 13.0 fl oz +					
Captan 80WG 2.5 lb……….	1/2"GT-1C…………	9.0 bc	8.0 c	87.0 bc	73.0 def
6. Scala 10.0 oz	½' GT				
Luna Sensation 4.0 oz……….	TC-P,B,PF,1C……....	6.0 abc	50.0 bc	79.0 ab	32.0 ab
7. Scala 10.0 oz	½" GT				
Flint 2.0 oz…………………..	TC-P,B,PF,1C……....	5.0 abc	65.0 cde	98.0 c	83.0 efg
8. Syllit FL 24.0 oz	½" GT,TC				
Dithane 75DF 3.0 lb +					
Indar 2F 8.0 fl oz +					
LI-700 4.0 oz	P,B,PF				
Captan 80WG 4.0 lb	1C…………………..	6.0 abc	63.0 cd	99.0 c	64.0 cde
9. Dithane 75DF 3.0 lb	½" GT-TC				
Dithane 75DF 3.0 lb +					
Indar 2F 8.0 fl oz +					
LI-700 4.0 fl oz	P,B,PF				
Captan 80WG 4.0 lb...............	1C…………………..	5.0 abc	55.0 c	97.0 c	36.0 ab
10. Rally 40W 5.0 oz +					
Dithane 75DF 3.0 lb……….	½" GT-1C…………	1.0 ab	61.1 cd	90.0 bc	53.0 bcd
11. Dithane 75DF 3.0 lb +					

Captan 80WG 3.0 lb	½” GT				
GWN-4617 3.4 oz +					
Dithane 75DF 6.0 lb +					
LI 700 4.0 oz………………	TC-1C………………	4.0 abc	21.0 ab	98.0 c	50.0 bcd
12. Dithane 75DF 3.0 lb +					
Captan 80WG 3.0 lb	½” GT				
GWN-4617 3.4 oz +					
Dithane 75DF 6.0 lb rot. +					
LI 700 4.0 oz	TC,PF,2C				
GWN-4616 10.0 oz +					
Dithane 75DF 3.0 lb……….	B,1C………………..	5.0 abc	52.0 c	100.0 c	71.0 def

z Timing: 1 = (1/2” GT) 4/9; 2 = (TC) 4/16; 3 = (Pink Bloom) 4/24; 4 = (Bloom) 5/5; 5 = (Petal fall) 5/13; 6 = (1C) 5/21; 7 = (2C) 6/1; 8 = (3C) 6/12; 9 = (4C) 6/23; 10 = (5C) 7/1; 11 = (6C) 7/14; 12 = (7C) 7/29.

y 25 shoots/tree-replicate

x 25 fruit/tree-replicate

w Means marked with the same letter(s) within columns are not significantly different, Fisher’s Protected LSD, P $\leq$ 0.05

Table 2. Scab incidence on ‘‘Red Delicious’ apple.

		% Scab incidence			
	Application	Shoots[y]			Fruit[x]
Trmt. and Rate/100 GPA	Timing[z]	19 May	22 Jun	17 Aug	17 Aug
1. Untreated Ck		72.0 d[w]	99.0 l	100.0 h	88.0 h
2. Inspire Super 12.0 oz +					
Dithane 75DF 3.0 lb............	½”GT,TC,P,B,PF,1C	0.0 a	6.0 ab	47.0 ab	6.0 abc
3. Topguard 13.0 fl oz................	1/2”GT-1C…………	28.0 c	94.0 jkl	97.0 gh	78.0 gh
4. Topguard 13.0 fl oz +					
Dithane 75DF 3.0 lb……….	1/2”GT-1C…………	14.0 b	47.0 c-g	81.0 e-h	19.0 a-e
5. Topguard 13.0 fl oz +					
Captan 80WG 2.5 lb……….	1/2”GT-1C…………	3.0 ab	32.0 bcd	58.0 bcd	11.0 a-d

6. Scala 10.0 oz	½' GT				
Luna Sensation 4.0 oz……….	TC-P,B,PF,1C……....	3.0 ab	24.0 abc	51.0 bc	12.0 a-d
7. Scala 10.0 oz	½" GT				
Flint 2.0 oz…………………..	TC-P,B,PF,1C……....	2.0 ab	71.0 g-k	85.0 fgh	61.0 a-d
8. Syllit FL 24.0 oz	½" GT,TC				
Dithane 75DF 3.0 lb +					
Indar 2F 8.0 fl oz +					
LI-700 4.0 oz	P,B,PF				
Captan 80WG 4.0 lb	1C…………………..	5.0 ab	47.0 c-g	73.0 def	23.0 a-e
9. Dithane 75DF 3.0 lb	½" GT-TC				
Dithane 75DF 3.0 lb +					
Indar 2F 8.0 fl oz +					
LI-700 4.0 fl oz	P,B,PF				
Captan 80WG 4.0 lb..............	1C…………………..	4.0 ab	37.0 cde	69.0 c-f	32.0 de
10. Rally 40W 5.0 oz +					
Dithane 75DF 3.0 lb……….	½" GT-1C…………	1.0 ab	67.0 f-j	77.0 d-g	32.0 de
11. Dithane 75DF 3.0 lb +					
Captan 80WG 3.0 lb	½" GT				
GWN-4617 3.4 oz +					
Dithane 75DF 6.0 lb +					
LI 700 4.0 oz………………	TC-1C………………	5.0 ab	64.0 e-i	80.0 e-h	27.0 b-e
12. Dithane 75DF 3.0 lb +					
Captan 80WG 3.0 lb	½" GT				
GWN-4617 3.4 oz +					
Dithane 75DF 6.0 lb rot. +					
LI 700 4.0 oz	TC,PF,2C				
GWN-4616 10.0 oz +					
Dithane 75DF 3.0 lb……….	B,1C………………..	8.0 ab	63.0 e-i	84.0 e-h	10.0 a-d

[z] Timing: 1 = (1/2" GT) 4/9; 2 = (TC) 4/16; 3 = (Pink Bloom) 4/24; 4 = (Bloom) 5/5; 5 = (Petal fall) 5/13; 6 = (1C) 5/21; 7 = (2C) 6/1; 8 = (3C) 6/12; 9 = (4C) 6/23; 10 = (5C) 7/1; 11 = (6C) 7/14; 12 = (7C) 7/29.

[y] 25 shoots/tree-replicate

[x] 25 fruit/tree-replicate

[w] Means marked with the same letter(s) within columns are not significantly different, Fisher's Protected LSD, $P \leq 0.05$

Table 3. Scab incidence on 'Stayman' apple.

Trmt. and Rate/100 GPA	Application Timing[z]	% Scab incidence: Shoots[y] 19 May	Shoots[y] 22 Jun	Shoots[y] 17 Aug	Fruit[x] 17 Aug
1. Untreated Ck		85.0 e[w]	100.0 g	100.0 h	87.0 hi
2. Inspire Super 12.0 oz +					
Dithane 75DF 3.0 lb………	½"GT,TC,P,B,PF,1C	4.0 ab	6.7 b	29.0 ab	21.0 a-d
3. Topguard 13.0 fl oz…………	1/2"GT-1C…………	28.0 d	86.0 fg	85.0 fgh	75.0 gh
4. Topguard 13.0 fl oz +					
Dithane 75DF 3.0 lb……….	1/2"GT-1C………….	22.0 cd	37.0 bcd	88.0 fgh	39.0 c-f
5. Topguard 13.0 fl oz +					
Captan 80WG 2.5 lb……….	1/2"GT-1C…………	8.0 ab	20.0 abc	57.0 cde	19.0 a-d
6. Scala 10.0 oz	½' GT				
Luna Sensation 4.0 oz……….	TC-P,B,PF,1C……...	1.0 a	27.0 abc	51.0 a-d	10.0 a
7. Scala 10.0 oz	½" GT				
Flint 2.0 oz…………………	TC-P,B,PF,1C……...	6.0 ab	63.0 def	75.0 d-h	35.0 b
8. Syllit FL 24.0 oz	½" GT,TC				
Dithane 75DF 3.0 lb +					
Indar 2F 8.0 fl oz +					
LI-700 4.0 oz	P,B,PF				
Captan 80WG 4.0 lb	1C………………….	8.0 ab	61.0 def	77.0 d-h	40.0 c-f
9. Dithane 75DF 3.0 lb	½" GT-TC				
Dithane 75DF 3.0 lb +					
Indar 2F 8.0 fl oz +					
LI-700 4.0 fl oz	P,B,PF				
Captan 80WG 4.0 lb..............	1C………………….	5.0 ab	44.0 cd	73.0 d-h	25.0 a-d
10. Rally 40W 5.0 oz +					
Dithane 75DF 3.0 lb……….	½" GT-1C…………	8.0 ab	41.0 cd	77.0 d-h	27.0 a-d
11. Dithane 75DF 3.0 lb +					
Captan 80WG 3.0 lb	½" GT				
GWN-4617 3.4 oz +		2.0 abc	31.0 bc	56.0 b-e	43.0 def

Dithane 75DF 6.0 lb +					
LI 700 4.0 oz………………	TC-1C………………				
12. Dithane 75DF 3.0 lb +					
Captan 80WG 3.0 lb	½” GT				
GWN-4617 3.4 oz +					
Dithane 75DF 6.0 lb rot. +					
LI 700 4.0 oz	TC,PF,2C				
GWN-4616 10.0 oz +					
Dithane 75DF 3.0 lb……….	B,1C……………….				
		11.0 abc	41.0 cd	77.0 d-h	36.0 b-e

z Timing: 1 = (1/2” GT) 4/9; 2 = (TC) 4/16; 3 = (Pink Bloom) 4/24; 4 = (Bloom) 5/5; 5 = (Petal fall) 5/13; 6 = (1C) 5/21; 7 = (2C) 6/1; 8 = (3C) 6/12; 9 = (4C) 6/23; 10 = (5C) 7/1; 11 = (6C) 7/14; 12 = (7C) 7/29.

y 25 shoots/tree-replicate

x 25 fruit/tree-replicate

w Means marked with the same letter(s) within columns are not significantly different, Fisher’s Protected LSD, $P \leq 0.05$

Table 4. Incidence and severity of powdery mildew on R. Beauty, R. Delicious, and G. Delicious.

		% P. mildew incidence[y] (Shoots)			% P. mildew severity[x] (Shoots)		
	Application	22 Jun			22 Jun		
Trmt. and Rate/100 GPA	Timing[z]	Rome	R Del	Stayman	Rome	R Del	Stayman
1. Untreated Ck		54.0 e [w]	21.0 ab	7.0 ab	19.2 abc	63.7 h	67.3 h
2. Inspire Super 12.0 oz +							
Dithane 75DF 3.0 lb.......	½”GT,TC,P,B,PF,1C	33.0 cd	13.0 ab	16.0 abc	11.6 ab	1.2 ab	0.9 ab
3. Topguard 13.0 fl oz...........	1/2”GT-1C…………	0.0 a	4.0 ab	0.0 a	0.0 a	47.5 g	34.7 fg
4. Topguard 13.0 fl oz +							
Dithane 75DF 3.0 lb…...	1/2”GT-1C…………	0.0 a	3.0 ab	2.0 a	0.0 a	13.9 a-e	11.2 a-d
5. Topguard 13.0 fl oz +							
Captan 80WG 2.5 lb…...	1/2”GT-1C…………	36.0 cd	9.0 ab	13.3 abc	17.4 abc	8.8 a-d	5.5 abc
6. Scala 10.0 oz	½’ GT						
Luna Sensation 4.0 oz…..	TC-P,B,PF,1C……...	0.0 a	0.0 a	4.0 a	0.0 a	6.5 abc	7.8 a-d
7. Scala 10.0 oz	½” GT	23.0 bc	0.0 a	11.0 abc	8.4 ab	24.1 ef	21.0 def

Flint 2.0 oz……………..	TC-P,B,PF,1C……...						
8. Syllit FL 24.0 oz	½" GT,TC						
Dithane 75DF 3.0 lb +							
Indar 2F 8.0 fl oz +							
LI-700 4.0 oz	P,B,PF						
Captan 80WG 4.0 lb	1C…………………..	36.0 cd	12.0 ab	27.0 abc	19.2 abc	15.4 b-e	21.2 def
9. Dithane 75DF 3.0 lb	½" GT-TC						
Dithane 75DF 3.0 lb +							
Indar 2F 8.0 fl oz +							
LI-700 4.0 fl oz	P,B,PF						
Captan 80WG 4.0 lb.........	1C…………………..	37.0 cd	24.0 ab	40.0 cd	15.2 ab	11.7 a-e	17.3 cde
10. Rally 40W 5.0 oz +							
Dithane 75DF 3.0 lb…..	½" GT-1C………….	26.0 bc	12.0 ab	28.0 abc	17.5 abc	20.7 e-f	13.4 a-d
11. Dithane 75DF 3.0 lb +							
Captan 80WG 3.0 lb	½" GT						
GWN-4617 3.4 oz +							
Dithane 75DF 6.0 lb +							
LI 700 4.0 oz……	TC-1C………………	28.0 bc	7.0 ab	11.0 abc	14.9 ab	21.3 def	11.7 a-d
12. Dithane 75DF 3.0 lb +							
Captan 80WG 3.0 lb	½" GT						
GWN-4617 3.4 oz +							
Dithane 75DF 6.0 lb rot. +							
LI 700 4.0 oz	TC,PF,2C						
GWN-4616 10.0 oz +							
Dithane 75DF 3.0 lb…..	B,1C………………..	11.0 ab	7.0 ab	1.0 a	3.9 a	22.5 def	13.4 a-e

[z] Timing: 1 = (1/2" GT) 4/9; 2 = (TC) 4/16; 3 = (Pink Bloom) 4/24; 4 = (Bloom) 5/5; 5 = (Petal fall) 5/13;
6 = (1C) 5/21; 7 = (2C) 6/1; 8 = (3C) 6/12; 9 = (4C) 6/23; 10 = (5C) 7/1; 11 = (6C) 7/14; 12 = (7C) 7/29.

[y] 25 shoots/tree-replicate

[x] 25 fruit/tree-replicate

[w] Means marked with the same letter(s) within columns are not significantly different, Fisher's Protected LSD, $P \leq 0.05$

REDUCED FUNGICIDE RESISTANCE RISK AND ORGANIC ALTERNATIVE PROGRAMS FOR APPLE DISEASES, 2009

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Various programs designed to reduce the risk of fungicide resistance (Trts. 2-7 different schedules using combinations of sulfur, lime sulfur, captan, mancozeb, and copper) compared with two conventional programs containing Rally (Trt. 7) or Inspire Super (Trt. 8) were evaluated for season-long control of apple scab, powdery mildew, and cedar apple rust. The tests were conducted at the Penn State Fruit Research and Extension Center University Drive research orchards on mature 'Golden Delicious', and 'Red Delicious' trees on M.26 rootstock. Treatments were arranged in a randomized complete block design with four replications. Treatments were applied dilute to both sides of the trees with a boom sprayer at 400 psi, which delivered 100 gal/A. Treatment applications were made on 7 to 15-day intervals from 10 Apr (1/2" green) to 31 Jul (7C). A maintenance program for insects was also applied to all the treatments with an airblast sprayer. Weather data was recorded with electronic monitoring systems (Campbell Scientific and Spectrum Weather Systems) and scab infection periods calculated using a modified Mill apple scab infection model. Rainfall for April, May, June, July, and Aug was 4.4 in., 6.9 in., 4.42 in., 4.98 in., and 2.75 in., respectively. Apple scab pressure was severely high due to adequate wetting periods from the beginning of the growing season. Several scab infection periods occurred during the primary period 16 Mar to 15 Jun. There were 6 moderate scab infection events that occurred over 11 days and included 1-4 continuous days of wetting and 9 severe infection events occurring over 33 days that ranged from 2-5 continuous days of wetting. Disease incidence on 'Golden Delicious' and 'Red Delicious' spur and shoot leaves and fruit was recorded by observing all leaves on 25 spur clusters and shoots and fruit per tree (4 replicates/treatment) on 18 May, 8 Jun, and 21 Jul. Data obtained was analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Fisher's Protected LSD Test ($P \leqq 0.05$).

The incidence of scab on nontreated ‘Golden Delicious' spur leaves and shoot leaves was 52, 98, and 100% on 18 May, 8 Jun and 21 Jul, respectively (Table 1). Scab incidence on nontreated ‘Golden Delicious’ fruit was 100% on 21 Jul. Scab incidence on nontreated ‘Red Delicious’ spur leaves (18 May), shoot leaves (8 Jun and 21 Jul) and fruit (21 Jul) was 50, 72, 100 and 100%, respectively (Table 2). From 18 May to 8 Jun, scab on treated spur and shoot leaves increased from 0-66% on ‘R. Delicious’ and from 0-68% on ‘G. Delicious’. On 21 Jul, scab on treated shoot leaves and fruit ranged from 41-85% and 2-31% on ‘R. Delicious’ and 43-49% and 2-29% on ‘G. Delicious’ with treatments being similar to each other and significantly different from the nontreated control. Overall, the conventional program with Inspire Super, Penncozeb/Captan, Topsin program (Trt. 8) showed the best control on scab compared with the conventional Rally, Penncozeb/Captan, Topsin program (Trt. 7). Reduced-risk programs with Manzate, Captan, MicroSulf/MicroSulf, Captan (Trt. 6) and Penncozeb, MicroSulf/MicroSulf, Kocide, Lime Sulfur (Trt. 4) had comparable scab control with Inspire Super, Penncozeb/Captan, Topsin program (Trt. 8). Most of the reduced risk programs provided comparable results to the conventional Rally, Penncozeb program in suppressing scab on spur leaves, shoots, and fruit. From 18 May to 8 Jun, powdery mildew incidence on nontreated ‘G. Delicious’ and ‘Red Delicious’ shoots was 3-8.6% and 1-26 %, respectively. On 21 Jul, cedar apple rust on nontreated ‘G. Delicious’ and ‘Red Delicious’ shoots was 1 and 38%, respectively. All treatments reduced the level of powdery mildew compared to the nontreated control (Table 3). All treatments except Trt. 2 and 3 (with MicroSulf early) significantly reduced the incidence of cedar apple rust on ‘Golden Delicious’ shoots. No treatments caused phytotoxicity to leaves or fruit.

ACKNOWLEDGEMENTS

We wish to thank SHAP for financial support and Penn State Fruit Research and Extension Center Technical Service for treatment applications and maintenance of the orchards.

Table 1. Efficacy of alternative programs for scab on 'Golden Delicious' apple

		% Scab incidence				
		Spur				Sev.
	Application	Leaves[y]	Shoots[x]		Fruit[w]	Fruit
Trmt. and Rate/100 GPA	timing[z]	18 May	8 Jun	21 Jul	21 Jul	21 Jul
1. Untreated Ck ……………		52.0 cd[v]	98.6 f	100.0 f	100.0 a	95.0 e
2. MicroSulf WP 10.0 lb	1 ½" GT-1C					
Captan 80WG 3.0 lb +						
MicroSulf WP 3.0 lb	2C-5C					
Captan 80WG 3.5 lb +						
Topsin M 70WP 1.0 lb..	6C-7C…………..	2.0 a	42.1 bc	89.0 f	13.0 b	3.5 a
3. MicroSulf WP 10.0 lb	½" GT-TC					
Penncozeb 75DF 3.0 lb +						
Captan 80WG 3.0 lb +						
MicroSulf WG 3.0 lb	B-1C					
MicroSulf WP 6.0 lb	2C-4C					
Kocide 3000 8.0 oz +						
Hydrated lime 1.0 lb	5C-6C					
Lime Sulfur (LS) 1% 1.0 gal	7C………………	3.0 a	68.6 de	78.0 de	15.0 b	4.5 a
4. Penncozeb 75DF 3.0 lb +						
MicroSulf WP 3.0 lb	½" GT-1C					
MicroSulf WP 6.0 lb	2C-4C					
Kocide 3000 4.0 oz rot w.						
LS 1% 1.0 gal………………	5C-7C…………..	5.0 a	61.0 bcd	52.9 bcd	16.0 b	4.3 a
5. MicroSulf WP 10.0 lb	½" GT-TC					
Penncozeb 75DF 3.0 lb +						
MicroSulf WP 3.0 lb	B,PF-1C					
MicroSulf WP 6.0 lb	2C-5C					
Kocide 3000 4.0 oz +						
MicroSulf WP 6.0 lb……..	6C-7C…………..	1.0 a	47.1 cd	67.0 cd	29.0 bc	9.5 a
6. Manzate Pro-Stick 3.0 lb +						
Captan 80WG 3.0 lb +						
MicroSulf WP 3.0 lb	½" GT-1C					
MicroSulf WP 6.0 lb	2C-5C	0.0 a	21.4 ab	34.0 a	13.0 b	3.3 a

Captan 80WDG 3.5 lb	6C-7C					
T-Methyl E-Ag 70WP 1.0 lb.	6C-7C…………..					
Conventional Prog. Ck 1						
7. Rally 40W 5.0 oz +						
Penncozeb 75DF 3.0lb	½” GT-1C					
Captan 80WG 3.5 lb	2C-4C					
Captan 80WG 2.0 lb +						
Topsin M 70WP 1.0 lb	5C-7C…………..	2.7 a	33.6 abc	53.0 bc	13.0 b	3.3 a
Conventional Prog. Ck 2						
8. Inspire Super 12.0 oz +						
Penncozeb 75DF 3.0 lb	GT,TC,P,B,PF,1C					
Captan 80WG 3.5 lb	2C-4C					
Captan 80WG 2.0 lb +						
Topsin M 70WP 1.0 lb…..	5C-7C…………...	0.0 a	0.0 a	42.5 ab	2.0 a	0.0 a

[z] Timing: 1 = ½” GT (4/10); 2 = TC (4/18); 3 = Pink bloom (4/27); 4 = bloom (5/8); 5 = Petal fall (5/15); 6 = 1C (5/22); 7 = 2C (6/3); 8 = 3C (6/15); 9 = 4C (6/24); 10 = 5C (7/8); 11 = 6C (7/20); 12 = 7C (7/31)

[y] 25 spur-leaf cluster/tree-replicate

[x] 25 shoots/tree-replicate

[w] 25 fruit/tree-replicate

[v] Means marked with the same letter(s) within columns are not significantly different, Fisher’s Protected LSD Test, P ≤.05.

Table 2. Efficacy of alternative programs for scab on ‘Red Delicious’ apple

		% Scab incidence				
		Spur				% Sev.
	Application	Leaves[y]	Shoots[x]		Fruit[w]	Fruit
Trmt. and Rate/100 GPA	Timing[z]	18 May	8 Jun	21 Jul	21 Jul	21 Jul
1. Untreated Ck ………………		50.0 b[v]	72.1 d-h	100.0 g	100.0 f	98.3 f
2. MicroSulf WP 10.0 lb	1 ½” GT-1C					
Captan 80WG3.0 lb +						
MicroSulf WP 3.0 lb	2C-5C					
Captan 80WG 3.5 lb +						
Topsin M 70WP 1.0 lb…	6C-7C…………..	2.0 a	43.6 bcd	85.0 efg	31.0 bc	9.3 ab
3. MicroSulf WP 10.0 lb	½” GT-TC					
Penncozeb 75DF 3.0 lb +						
Captan 80WG 3.0 lb +		1.0 a	56.4 c-f	78.0 deg	22.0 ab	7.3 ab

MicroSulf WG 3.0 lb	B-1C					
MicroSulf WP 6.0 lb	2C-4C					
Kocide 3000 8.0 oz +						
Hydrated lime 1.0 lb	5C-6C					
Lime Sulfur (LS) 1% 1.0 gal	7C………………					
4. Penncozeb 75DF 3.0 lb +						
MicroSulf WP 3.0 lb	½" GT-1C					
MicroSulf WP 6.0 lb	2C-4C					
Kocide 3000 4.0 oz rot w.						
LS 1% 1.0 gal………………	5C-7C…………..	0.0 a	51.4 b-e	62.0 bcd	23.0 ab	6.0 ab
5. MicroSulf WP 10.0 lb	½" GT-TC					
Penncozeb 75DF 3.0 lb +						
MicroSulf WP 3.0 lb	B,PF-1C					
MicroSulf WP 6.0 lb	2C-5C					
Kocide 3000 4.0 oz +						
MicroSulf WP 6.0 lb……..	6C-7C…………..	6.7 a	65.7 c-h	46.0 ab	12.0 ab	3.3 ab
6. Manzate Pro-Stick 3.0 lb +						
Captan 80WDG 3.0 lb +						
MicroSulf WP 3.0 lb	½" GT-1C					
MicroSulf WP 6.0 lb	2C-5C					
Captan 80WDG 3.5 lb	6C-7C					
T-Methyl E-Ag 70WP 1.0 lb.	6C-7C…………..	0.0 a	22.9 ab	51.0 abc	17.0 ab	1.3 ab
Conventional Prog. Ck 1						
7. Rally 40W 5.0 oz +						
Penncozeb 75DF 3.0lb	½" GT-1C					
Captan 80WG 3.5 lb	2C-4C					
Captan 80WG 2.0 lb +						
Topsin M 70WP 1.0 lb..	5C-7C…………..	0.0 a	42.9 bcd	67.0 cde	22.0 ab	6.0 ab
Conventional Prog. Ck 2						
8. Inspire Super 12.0 oz +						
Penncozeb 75DF 3.0 lb	GT,TC,P,B,PF,1C					
Captan 80WDG 3.5 lb	2C-4C					
Captan 80WG 2.0 lb +						
Topsin M 70WP 1.0 lb…..	5C-7C…………...	0.0 a	4.3 a	41.0 a	2.0 a	0.5 a

[z] Timing: 1 = ½" GT (4/10); 2 = TC (4/18); 3 = Pink bloom (4/27); 4 = bloom (5/8); 5 = Petal fall (5/15); 6 = 1C (5/22); 7 = 2C (6/3); 8 = 3C (6/15); 9 = 4C (6/24); 10 = 5C (7/8); 11 = 6C (7/20); 12 = 7C (7/31)

[y] 25 spur-leaf cluster/tree-replicate

[x] 25 shoots/tree-replicate

[w] 25 fruit/tree-replicate

[v] Means marked with the same letter(s) within columns are not significantly different, Fisher's Protected LSD Test≤0.05

Table 2. Efficacy of alternative programs for powdery mildew on apple

		Red Delicious[y]			Golden Delicious[y]		
	Application	% P. mildew		Rust	% P. mildew		Rust
Trmt. and Rate/100 GPA	timing[z]	18 May	8 Jun	21 Jul	18 May	8 Jun	21 Jul
1. Untreated Ck ………………		1.0 ab[x]	25.7 b	1.0 ab	3.0 a	8.6 ab	38.0 c
2. MicroSulf WP 10.0 lb	1 ½" GT-1C						
Captan 80WG 3.0 lb +							
MicroSulf WP 3.0 lb	2C-5C						
Captan 80WG 3.5 lb +							
Topsin M 70WP 1.0 lb…	6C-7C…………..	0.0 a	1.4 a	0.0 a	1.0 a	0.0 a	16.0 ab
3. MicroSulf WP 10.0 lb	½" GT-TC						
Penncozeb 75DF 3.0 lb +							
Captan 80WG 3.0 lb +							
MicroSulf WG 3.0 lb	B-1C						
MicroSulf WP 6.0 lb	2C-4C						
Kocide 3000 8.0 oz +							
Hydrated lime 1.0 lb	5C-6C						
Lime Sulfur (LS) 1% 1.0 gal	7C………………	0.0 a	0.7 a	3.0 ab	0.0 a	0.0 a	11.0 ab
4. Penncozeb 75DF 3.0 lb +							
MicroSulf WP 3.0 lb	½" GT-1C						
MicroSulf WP 6.0 lb	2C-4C						
Kocide 3000 4.0 oz rot.							
LS 1% 1.0 gal………	5C-7C…………..	3.0 bc	0.0 a	2.0 ab	0.0 a	0.0 a	0.0 a
5. MicroSulf WP 10.0 lb	½" GT-TC						
Penncozeb 75DF 3.0 lb +							
MicroSulf WP 3.0 lb	B,PF-1C						
MicroSulf WP 6.0 lb	2C-5C						
Kocide 3000 4.0 oz +							
MicroSulf WP 6.0 lb……..	6C-7C…………..	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

6. Manzate Pro-Stick 3.0 lb +							
Captan 80WDG 3.0 lb							
MicroSulf WP 3.0 lb +	½" GT-1C						
MicroSulf WP 6.0 lb	2C-5C						
Captan 80WDG 3.5 lb	6C-7C						
T-Methyl E-Ag 70WP 1.0 lb.	6C-7C…………..	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Conventional Prog. Ck 1							
7. Rally 40W 5.0 oz +							
Penncozeb 75DF 3.0lb	½" GT-1C						
Captan 80WG 3.5 lb	2C-4C						
Captan 80WG 2.0 lb +							
Topsin M 70WP 1.0 lb..	5C-7C…………..	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Conventional Prog. Ck 2							
8. Inspire Super 12.0 oz +							
Penncozeb 75DF 3.0 lb	GT,TC,P,B,PF,1C						
Captan 80WDG 3.5 lb	2C-4C						
Captan 80WG 2.0 lb +							
Topsin M 70WP 1.0 lb…..	5C-7C…………...	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

[z] Timing: 1 = ½" GT (4/10); 2 = TC (4/18); 3 = Pink bloom (4/27); 4 = bloom (5/8); 5 = Petal fall (5/15); 6 = 1C (5/22); 7 = 2C (6/3); 8 = 3C (6/15); 9 = 4C (6/24); 10 = 5C (7/8); 11 = 6C (7/20); 12 = 7C (7/31)

[y] 25 shoots/tree-replicate

[x] Means marked with the same letter(s) within columns are not significantly different, Fisher's Protected LSD Test, $P < 0.05$.

PREHARVEST CONTROL OF BROWN ROT AND RHIZOPUS ROT ON PEACH AND NECTARINE, 20009

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Brown rot and Rhizopus rot are major diseases of all commercially grown stone fruit and can cause major crop losses in peaches and nectarines. Favorable weather conditions can lead to fruit infections causing entire crop loss on the tree or in storage. Improved disease management strategies and effective fungicides have reduced disease losses. This project evaluated seven synthetic (Trts. 2-8) and two organic alternative (Trts. 9-10) programs for control of brown rot and Rhizopus rots in a mature 'Loring' and 'Redskin' peach and 'SunGlo' nectarine orchard located at a Penn State Fruit Research & Extension Center in Arendtsville. Treatments were applied with a boom sprayer (100 gal/A spray volume at 400 psi) on each side of the tree. One bloom application (B) was made on 22 Apr. Preharvest (PH) and harvest applications (H) were made on 22 Jul (PH for 'SunGlo'), 7 Aug (H for 'SunGlo', PH for 'Loring'), 17 Aug (H for 'Loring', PH for 'Redskin'), and 2 Sep (H for 'Redskin'). Four replications of each treatment were applied to a randomized complete block design, with each plot consisting of a tree each of 'Loring' and 'Redskin' peach and 'SunGlo' nectarine. Maintenance sprays for other diseases and insects were applied to all treatments from petal fall through the cover sprays with an airblast sprayer (100 gal/A spray volume at 400 psi). There was no blossom blight observed after bloom. At maturity, 50 fruits were harvested from each plot for assessments. Fruits were harvested on 7 Aug ('SunGlo'), 17 Aug ('Loring') and 2 Sep ('Redskin') and placed on fiber produce trays and incubated in a temperature controlled room at 70^{o} F. Brown rot and Rhizopus rot were assessed at 1, 4, and 8 days after harvest incubation (DAH). Data obtained was analyzed by analysis of variance with appropriate transformations and significance between means was determined by the Fisher's Protected LSD ($P \leq 0.05$).

Weather conditions were favorable for brown rot development on fruit. At harvest or 1 day after harvest (1 DAH), 4 DAH, and 8 DAH, all fungicide treatments significantly reduced the incidence of brown on nectarine 'SunGlo'. Tilt followed by Pristine, both rates of Inspire XT, Indar, LEM SC, and

Inspire Super showed significant control on brown rot. On ‘Redskin’ peach, only the synthetic programs significantly reduced brown rot from 1 DAI to 8 DAI with Pristine followed by Indar, LEM SC, Tilt, Inspire XT, and Inspire Super. Brown rot on ‘Loring’ was significantly reduced by Inspire Super, Inspire XT, Tilt, and organic Microthiol programs from 1 DAH to 4 DAH. After 8 days postharvest of incubation, only Indar significantly reduced the level of brown rot on ‘Loring’ peach. Rhizopus rot levels were negligible at harvest and increased to 8, 32, and 41% at 8 DAH on ‘RedSkin’, ‘SunGlo’ and ‘Loring’, respectively. Only Tilt, Pristine, LEM 17 and organic copper Nordox significantly control Rhizopus rots at 4-8 DAH on ‘SunGlo’ nectarine. None of the treatments significantly control Rhizopus rot on ‘Loring’ and ‘Redskin’. Phytotoxicity in the form of leaf chlorosis and shot hole like symptoms was observed in Nordox copper treated trees.

ACKNOWLEDGEMENTS

We wish to thank Penn State Fruit Research and Extension Center Technical Service for treatment applications and maintenance of the orchards.

Table 1. Incidence of brown rot and Rhizopus rot on ‘Loring’ peach

		Disease incidence (% infected fruit)*					
		Brown rot			Rhizopus rot		
Treatment and Rate/100 GPA	Timing[z]	1 DAH[y]	4 DAH[y]	8 DAH[y]	1 DAH[y]	4 DAH[y]	8 DAH[y]
1. Nontreated control	....	5.5 b[x]	66.5 b	99.5 c	0.0 a	31.5 ab	40.5 a
2. Inspire Super 10.0 fl oz………..	1 BLM,1PH,1H	1.5 a	51.5 a	99.5 c	0.0 a	35.0 ab	49.5 abc
3. Inspire XT 5.0 fl oz……………	1 BLM,1PH,1H	0.0 a	47.0 a	99.0 c	0.5 ab	30.0 a	44.5 ab
4. Inspire XT 7.0 fl oz……………	1 BLM,1PH,1H	3.0 a	66.0 b	100.0 c	1.0 b	51.0 c	60.0 de
5. Tilt 4.0 fl oz……………………	1 BLM,1PH,1H	3.5 ab	50.5 a	96.0 ab	0.0 a	34.0 ab	45.5 ab
6. Pristine 12.5 oz………………...	1 BLM,1PH,1H	3.5 ab	66.5 b	99.5 c	0.5 ab	36.5 ab	54.0 b-e
7. Indar 2F 6.0 fl oz + LI700 4.0 fl oz........................	1 BLM,1PH,1H	1.0 a	45.0 a	95.0 a	0.0 a	32.5 ab	51.5 bcd
8. LEM 17SC 24.0 fl oz…………	1 BLM,1PH,1H	3.5 ab	67.5 b	98.5 c	0.5 ab	40.0 b	50.5 bcd
9. Org. Prog./Microthiol 5.0 lbs….	1 BLM,1PH,1H	3.5 ab	51.5 a	98.0 bc	0.0 a	34.5 ab	56.0 cde
10. Org. Prog./Nordox 0.5-1.0 lb + Hydrated lime 1.0lb …………	1 BLM,1PH,1H	18.5 c	74.0 b	100.0 c	0.0 a	38.0 ab	61.5 e

z BLM = Bloom, PH = 12-14 days Preharvest, H = Harvest
y DAH= Days after harvest
x Means in the same column marked with he same letter(s) are not significantly different, Fisher’s Protected LSD.

Table 2. Incidence of brown rot and Rhizopus rot on 'Redskin' peach

Treatment and Rate/100 GPA	Timing^z	Disease incidence (% infected fruit)* Brown rot 1 DAH^y	Brown rot 4 DAH^y	Brown rot 8 DAH^y	Rhizopus rot 1 DAH^y	Rhizopus rot 4 DAH^y	Rhizopus rot 8 DAH^y
1. Nontreated control	....	63.0 e	93.5 e	96.0 d	2.0 a-d	8.0 b	8.0 abc
2. Inspire Super 10.0 fl oz………..	1 BLM,1PH,1H	25.0 d	70.5 d	82.5 c	4.5 d	8.5 b	11.5 c
3. Inspire XT 5.0 fl oz……………	1 BLM,1PH,1H	10.0 bc	58.0 c	78.5 c	0.5 ab	5.5 ab	6.0 ab
4. Inspire XT 7.0 fl oz……………	1 BLM,1PH,1H	10.5 c	57.0 c	80.0 c	0.5 ab	6.0 ab	6.5 bc
5. Tilt 4.0 fl oz……………………	1 BLM,1PH,1H	10.1 bc	56.1 c	75.3 c	0.0 a	8.0 b	7.6 abc
6. Pristine 12.5 oz………………...	1 BLM,1PH,1H	3.5 ab	26.6 a	48.7 a	1.5 abc	3.0 a	3.5 a
7. Indar 2F 6.0 fl oz + LI700 4.0 fl oz.........................	1 BLM,1PH,1H	3.0 a	30.0 a	53.0 a	1.5 abc	3.0 a	4.5 a
8. LEM 17SC 24.0 fl oz…………	1 BLM,1PH,1H	3.5 ab	42.0 b	63.0 b	0.0 a	6.5 ab	10.5 bc
9. Org. Prog./Microthiol 5.0 lbs…	1 BLM,1PH,1H	62.5 e	97.0 e	97.0 d	4.0 cd	8.5 b	8.5abc
10. Org. Prog./Nordox 0.5-1.0 lb + Hydrated lime 1.0lb …………	1 BLM,1PH,1H	58.0 e	90.5 e	94.5 d	3.0 bcd	5.0 ab	5.0 a

z BLM = Bloom, PH = 12-14 days Preharvest, H = Harvest
y DAH = Days after harvest
x Means in the same column marked with he same letter(s) are not significantly different, Fisher's Protected LSD.

Table 3. Incidence of brown rot and Rhizopus rot on 'SunGlo' nectarine

Treatment and Rate/100 GPA	Timing^z	Disease incidence (% infected fruit)* Brown rot 1 DAH^y	Brown rot 4 DAH^y	Brown rot 8 DAH^y	Rhizopus rot 1 DAH^y	Rhizopus rot 4 DAH^y	Rhizopus rot 8 DAH^y
1. Nontreated control	....	39.5 d^x	84.5 g	99.0 g	0.0 a	10.5 b	32.0 c
2. Inspire Super 10.0 fl oz………..	1 BLM,1PH,1H	7.0 b	27.5 de	68.0 de	0.0 a	13.0 b	41.0 d
3. Inspire XT 5.0 fl oz……………	1 BLM,1PH,1H	1.5 a	16.0 bc	60.5 cd	0.0 a	5.0 a	32.0 c
4. Inspire XT 7.0 fl oz……………	1 BLM,1PH,1H	2.5 ab	14.5 bc	54.0 bc	0.0 a	4.0 a	31.5 c
5. Tilt 4.0 fl oz……………………	1 BLM,1PH,1H	1.5 a	11.0 ab	42.0 a	0.0 a	2.0 a	13.5 a
6. Pristine 12.5 oz………………...	1 BLM,1PH,1H	1.0 a	6.0 a	50.0 ab	0.0 a	2.5 a	12.5 a
7. Indar 2F 6.0 fl oz + LI700 4.0 fl oz.........................	1 BLM,1PH,1H	3.0 ab	21.0 cd	62.5 cde	0.0 a	4.5 a	25.5 bc
8. LEM 17SC 24.0 fl oz…………	1 BLM,1PH,1H	1.5 a	18.0 bc	70.0 ef	0.0 a	4.5 a	20.5 ab
9. Org. Prog./Microthiol 5.0 lbs…	1 BLM,1PH,1H	3.5 ab	29.0 e	78.0 f	0.0 a	12.0 b	32.0 c
10. Org. Prog./Nordox 0.5-1.0 lb + Hydrated lime 1.0lb …………	1 BLM,1PH,1H	28.0 c	46.5 f	62.0 cde	1.0 b	3.0 a	13.5 a

z BLM = Bloom, PH = 12-14 days Preharvest, H = Harvest
y DAH = Days after harvest
x Means in the same column marked with he same letter(s) are not significantly different, Fisher's Protected LSD.

EFFECT OF CULTURAL AND CHEMICAL METHODS ON CLUSTER ARECHITECTURE AND BUNCH ROT OF GRAPES

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Bunch rot of wine grapes is a perennial disease management challenge in Pennsylvania. The disease can involve a number of fungi and bacteria, most notably the fungal pathogen, *Botrytis cinerea.* In wet harvest seasons, a sour bunch rot complex can develop that may include fungi like *Penicillium* spp., *Aspergillus* spp., *Rhizopus* spp., and others as well as various types of bacteria. Grape bunch rots tend to be most difficult to control in varieties that produce compact bunches such as *Vitis vinifera* 'Chardonnay', 'Pinot Noir', and 'Riesling'. Research has described the relationship between cluster compactness and bunch rot development on grapes in the East and methods that reduce cluster compactness can reduce susceptibility to bunch rots (Zitter and Wilcox, Hed et al.). Reductions in cluster compactness may also improve chemical fungicide coverage by allowing for better penetration into the cluster. This is especially critical during ripening, when clusters are most susceptible to rots.

Cluster zone leaf removal exposes fruit to better aeration and sunlight and reduces the development of harvest rots in eastern vineyards (Zoecklein et al., Hed and Travis). This practice is generally applied sometime after fruit set. However, research has indicated that leaf removal applied at the beginning of bloom (trace bloom), starves inflorescences for photosynthate and reduces the number of flowers setting fruit. This reduces cluster compactness and predisposition to harvest rots and may further improve control of bunch rots and sour rots (Howell and Clearwater).

Applications of gibberellic acid (GA) have reduced cluster compactness and bunch rots on 'Vignoles', 'Pinot gris', and 'Chardonnay' in eastern vineyards (Feree et al., Hed and Travis). However, the effects of GA, negative and positive, depend on variety, rate, and timing, and require clarification. In recent Penn State trials, GA applications effectively reduced sour rot and *Botrytis* on 'Chardonnay' and 'Vignoles', while replacing two *Botrytis* specific fungicide applications. This is important for at least two reasons: there are no reliable chemical controls for sour rots (which can be more devastating to wine quality than *Botrytis*), and reduced reliance on pesticides will delay the development of resistance to *Botrytis* specific fungicides.

Lastly, bloom applications of prohexadione calcium were shown to reduce bunch rots of wine grapes in trials conducted in Ontario and Germany (Dr. Wendy McFadden, personal communication; Dr. Daniel Molitor, personal communication) This report briefly summarizes the results of several field trials in Pennsylvania over the past 3 years. The objectives were to determine the effects of leaf removal and gibberellic acid (trial 1) and prohexadione calcium (trial 2) on bunch rot control, cluster compactness, and yield of wines grapes. Experiments were also conducted to determine the effects of cluster compactness on fungicide spray coverage. Trial 1 and spray coverage experiments were conducted at the Lake Erie Regional Grape Research and Extension Center in North East, PA. Trial 2 was conducted at the Lake Erie Regional Grape

Research and Extension Center and the Penn State Fruit Research & Extension Center in Biglerville PA.

Trial 1: Evaluation of leaf removal, gibberellic acid and fungicides for control of Botrytis bunch rot of Chardonnay grapes, 2007-2009. Over 3 years, treatments were applied to twelve-vine plots in a 0.4 ha vineyard of mature *Vitis vinifera* 'Chardonnay' vines trained to a four cane kniffen system. Treatments were arranged in a randomized complete block design with 4 replications. *Botrytis*-specific fungicides (cyprodinil (Vangard 75 WG) and fenhexamid (Elevate 50 WDG)) and gibberellic acid (ProGibb) were applied with a Friend covered-boom plot sprayer at 100 psi and 100 gallons/A. Leaf removal (2-4 leaves per shoot removed from the cluster zone) was performed by hand or by Gallagher leaf blower (mechanical). All other diseases were controlled with a standard fungicide program. The incidence (percent infected) and severity (percent area infected) of Botrytis bunch rot were determined just before harvest from 50 clusters per plot. Cluster effects were determined from 16 clusters per plot. Overall yield was determined from all clusters per plot. Data were analyzed using analysis of variance and mean separation was determined by Fisher's Protected LSD test. Ten treatments were arranged as follows:

1. Unsprayed (no gibberellic acid (GA), no leaf removal (LR), no *Botrytis* fungicides)
2. Core fungicide program - 2 *Botrytis* fungicides (at pre-closure and veraison), no GA, no LR
3-4. Core fungicide program amended with a single GA application at bloom (5 or 10 ppm).
5-9. Core fungicide program amended with hand LR (trace bloom, 2-3 weeks post bloom, or veraison) or mechanical LR (2-3 weeks post bloom or veraison).
10. Full fungicide program: core fungicide program amended with 2 additional *Botrytis* fungicides (bloom and pre-harvest), no GA, no LR amendment.

<u>Results:</u> *Botrytis* was responsible for nearly all harvest bunch rot in all three years. Two *Botrytis* fungicide applications (core program) significantly reduced bunch rots in all years when compared to the unsprayed check. Two additional fungicide applications to the core program numerically improved bunch rot control over the core program alone, but the improvement was never statistically significant in any year. In 2007 (a dry season), rot pressure was relatively low and amendments to the two fungicide core program did not significantly improve *Botrytis* control over the core program alone. In 2008, bloom GA application at 5 ppm, and LR at trace bloom (by hand) or 2-3 weeks post bloom (mechanical) significantly improved *Botrytis* control when compared to 2 fungicides (core program) alone. In 2009, only LR at trace bloom significantly improved *Botrytis* control when compared to the core program alone. In general, bunch rot reductions increased the earlier leaf removal was performed; trace bloom leaf removal was the most effective amendment to the core fungicide program, allowing for the reduction of 2 fungicide applications from a full fungicide program (four fungicides) without sacrificing bunch rot control.

<u>Effects on cluster architecture:</u> All amendments to the core fungicide program numerically reduced berries per cluster (fruit set) and berries per cm of the rachis (compactness), but most reductions were minimal. Trace bloom leaf removal generated the greatest reductions in fruit set (by 24 %) and compactness (23 %) when compared to the core fungicide program.

Effects on yield: Most amendments to the core program had little or no negative effect on yield per vine or cluster weight. The one exception was trace bloom leaf removal, which generated reductions in average yield per vine and cluster weight of 24 and 15 %, respectively, when compared to the core fungicide program. An assessment of clusters per shoot in 2009 revealed that, after 3 years of treatment to the same vines, none of the amendments reduced bud fruitfulness when compared to the core fungicide program.

Trial 1. Severity* of Botrytis (% area of cluster rotted) on Chardonnay grape, over 3 years

Treatment and rate/A	2007	2008	2009
Unsprayed Check	3.40 b**	14.70 c**	8.84 e**
Core (2 *Botrytis* fungicide program)	1.23 a	5.28 b	3.54 bcd
Core + ProGibb 4% (5 ppm)	0.57 a	2.42 a	3.75 cd
Core + ProGibb 4% (10 ppm)	0.57 a	3.39 ab	2.61 abc
Core + hand LR (trace bloom)	0.22 a	1.45 a	1.03 a
Core + hand LR (2-3 wks post-bloom)	0.31 a	2.75 ab	2.10 abc
Core + hand LR (veraison)	0.75 a	3.54 ab	4.34 cd
Core + mech. LR (2-3 wks post-bloom)	0.75 a	2.01 a	3.16 abc
Core + mech. LR (veraison)	0.96 a	2.99 ab	5.82 d
Core + 2 *Botrytis* fungicides	1.21 a	3.77 ab	1.16 ab

*Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables.
**Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD ($P \leq 0.05$).

Effects of cluster compactness on fungicide coverage of fruit clusters: Forty four clusters of *Vitis* interspecific hybrid 'Vignoles' were selected to represent a wide range of cluster compactness. Clusters were thoroughly sprayed with orange paint and then dissected to determine berries per cluster (compactness) and percent paint coverage of the berries. Spray coverage increased as cluster compactness decreased. The relationship was described by the model $y = 96.87 - 2.77x$; $r^2 = 0.734$; $P \leq 0.0001$. Coverage improved by about 2.77 % with each drop in berries per cm, and the compactness of clusters accounted for about three quarters of the variation in spray coverage. The relationship is generally linear within the range of compactness of our sample (about 3-18 berries per cm) and coverage is reduced to about 40-50% as maximum compactness is approached. However, the relationship would not be expected to be linear across the entire population of clusters; further increases in compactness would eventually result in a flattening of the slope as penetration approaches zero and coverage becomes limited entirely to the outside surfaces of the cluster.

Effects of prohexadione calcium (apogee) on bunch rot: Prohexadione calcium (ProCa) was applied at bloom at 50 ppm to *Vitis vinifera* 'Chardonnay', 'Pinot Noir', and 'Riesling' (two-vine plots) at the Fruit Research Station in Biglerville PA. In trials at the Lake Erie Regional Grape Research and Extension Center at North East PA, ProCa was applied at bloom at 50 and 250 ppm to 'Riesling' (single-vine plots) and 50, 150, and 250 ppm at bloom to *Vitis* interspecific hybrid 'Vignoles' (3-vine plots). All treatments were replicated 4 x and all received a core fungicide program of 2 *Botrytis* specific fungicide applications (sprayed check). Although ProCa did numerically reduce rot severity (by about 50 %) in the Biglerville trial, it did not reduce rots in the North East trial, and none of the reductions were significant on any variety at either location when compared to the core fungicide program.

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CHARACTERIZATION OF THE CYTOCHROME B CYTB GENE FROM FRUIT INFECTING *MONILINIA* SPECIES

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Monilinia fructicola and *Monilinia laxa* are the fungal pathogens causing brown rot and European brown rot of *Prunus*, *Malus* and at a lesser extend *Pyrus* spp (Strand 1999) in the Northeastern United States. While *M. fructicola* is endemic to the American continent, *Monilinia laxa* is native to Europe. In North America, *Monilinia laxa* was first detected in California (Strand 1999) and slowly migrated east with outbreaks in Michigan (Sundin personal communication) and recently in New York State (Villani and Cox 2009). Presently, the application of single site-specific fungicides (DMIs and QoIs) is the most reliable means of managing brown rot of stone fruit. Fungicide programs for brown rot begin at bloom to prevent blossom blight, and continue from shuck split to harvest as fruit susceptibility increases with ripening. The development of site-specific fungicide resistance in *Monilinia* populations, and the lack of rapid molecular testing for resistance threaten our ability to manage brown rot.

While there is a rapid molecular testing protocol detecting DMI resistance in *M.*fructicola focusing on the CYP51A1 target site gene (Luo et al., 2008), there is no information on the QoI target site gene, the *cytochrome b* (*cyt b*) gene, in *Monilinia*. The goal of this study was to clone and characterize the *cyt b* gene from different *Monilinia* species attacking fruit crops in the Eastern United States and to better understand the gene structure in the context of QoI fungicide resistance. It has been shown in various plant pathogen species, including *Blumeria graminis* f sp *tritici* (DC) Speer (Sierotski et al., 2000a), *Mycosphaerella fijiensis* Morelet (Sierotski et al., 2000b), *Venturia inaequalis* (Cooke) Winter (Steinfield et al., 2001) and *Plasmopara viticola* (Berk & Curt) Berlese & de Toni (Gisi et al., 2002), that a single nucleotide polymorphisme (SNP) can confer resistance to all QoI fungicide chemistries.

Total RNA from *M. fructicola*, *M. laxa* and *M.vaccinii corymbosi* was extracted and *cyt b* specific mRNA was amplified using primers designed based on a closely related fungal species, *Botryotinia fuckeliana*. The *cyt b* mRNA sequence of the three *Monilinia* species was 1176 base pairs in length. *M. laxa* and *M. fructicola* sequences were identical, and were 96.1% identical to that of *B. fuckeliana* sequence. *M.vaccinii corymbosi cytb* mRNA was the most divergent of three species and had only 94.8% identity with *M. laxa* and *M. fructicola* and 94.0% identity with *B. fuckeliana*. When phylogenetic comparisons were made between *Monilinia* spp. and other ascomycete species using maximum likelihood analysis, all *Monilinia* spp. were placed into the same clad (Fig.1). When compared to other ascomycetes, *Monilinia* spp and *B. fuckeliana* protein sequences had at least 98.2% or more identity with one another.

Since *M. laxa* and *M. fructicola* were identical at the RNA level, we cloned the full sequence of the *cyt b* gene, in order to see if they also were identical at the DNA level. After DNA extraction, PCR was performed on DNA samples using ATG fwd and STOP reverse primers from *B.fuckeliana* in order to clone the full gene sequence of *cytochrome b*. A fragment of approximately 12 Kb was amplified from *M. fructicola* DNA, but the same primers failed to amplify an amplicon from *M. laxa.* To clone the *cyt b* gene from *M laxa*, we designed two new primers based on the mRNA sequence from *M. laxa*. Two amplicons comprising the 5'end and 3'end of the gene were obtained. By combining the two sequences, the size of *M laxa cyt b* gene was 13505 bp. After comparing the DNA sequence with other *cytochrome b* sequences and their own mRNA sequences, the exon/intron junctions were identified. Altogether, both *Monilinia* spp displayed a similar gene structure, but were different from the reference fungus *B. fuckeliana* (Fig 2). In *B. fuckeliana*, the *cyt b* gene was composed of 5 exons and 4 introns. By contrast both brown rot *cyt b* genes contained 8 exons and 7 introns. The difference in size between the *Monilinia* spp. *cyt b* gene (close to or over 12 Kb) and *B. fuckeliana* (6.6 Kb) was explained by the structure of the 3' end of the gene. While the 5' end of each species was quite similar in sequence and structure, the last 690 bp from *B fuckeliana* corresponding to the last exon, was divided in 4 exons and 3 introns in both *M. fructicola* and *M. laxa*, accounting for a 6.1 Kb and 5.7 Kb extension of the *cyt b* gene, respectively.

In addition to characterizing the *cyt b* gene from *Monilinia*, we developed a rapid PCR based assay that distinguishes between brown rot (*M. fructicola)* from European brown (*M. laxa*). Previously, a PCR assay using ribosomal DNA (rDNA) was developed to distinguish *M. fructicola* from *M. laxa* and *M. fructigena* (Fulton and Brown, 1997; Forster and Adaskaveg, 2000). Unfortunately, multiple PCR reactions are needed in order to differentiate among the different species.

Based on the sequence and structure of the *cyt b* gene for the two *Monilinia* species tested, we designed 2 pairs of primers spanning the insertion/deletion events, which are surrounded by highly conserved regions. By using either pair of primers, we were able to differentiate these two species with a single PCR reaction. The first pair of primers (`P450 intron1-1 fwd CAGATGCTTTATTTTATTACCTGTTAC, P450 intron1-1 rev: CGCATAATCAAACTCTGCTCG`) produces an amplicon of 1614 bp for *M. laxa,* but only a 584 bp amplicon for *M. fructicola* (Fig. 3). The second of pair primers (`P450 intron6-2 fwd AGGTGAGTAGGAAATACAGATAAATG, P450 intron6-2 rev AGTTCAACTCAGATCTAAAGATACCTC`) amplifies a fragment of 619 bp for *M. fructicola,* but only a fragment of 499pb for *M. laxa* (Fig. 3). Both pairs of primers produced either no amplicon or amplicons of different sizes for other fungi commonly associated with fruit rots of stone fruit.

Using the gene sequence of the *cyt b* gene, we developed a PCR assay that produces different sized amplicons for both *M. fructicola* and *M. laxa* in a single PCR reaction, reducing the cost and effort. Given that the effectiveness of fungicides chemistries in the field is different for the two species causing brown rot in the region, such a tool could help growers better plan their chemical management programs.

FIGURES

Figure 1.

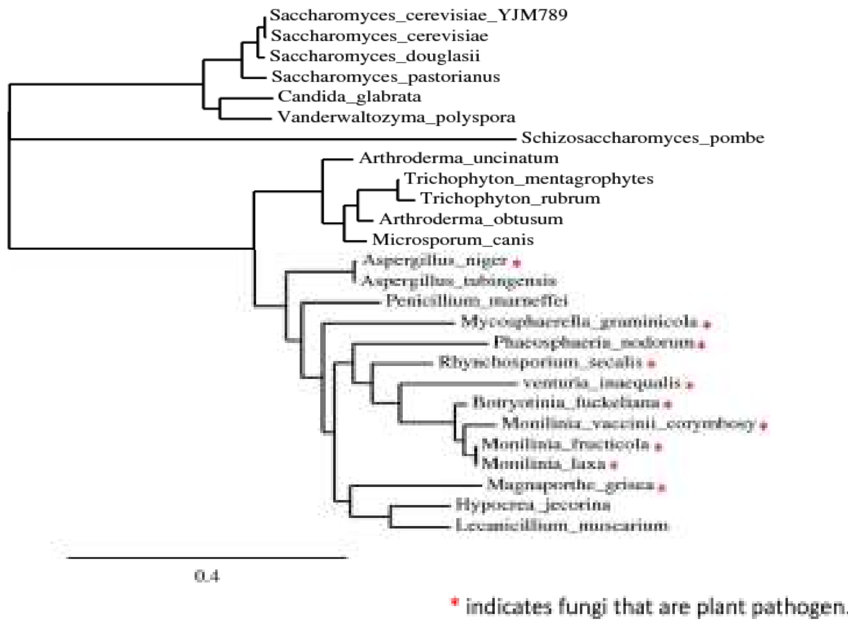

Figure 1. Phylogenetic analysis of mRNA sequences of cyt b genes from ascomycetes constructed using maximum likelihood analysis. Asterisk in red indicates ascomycetes that are plant pathogenic.

Figure 2.

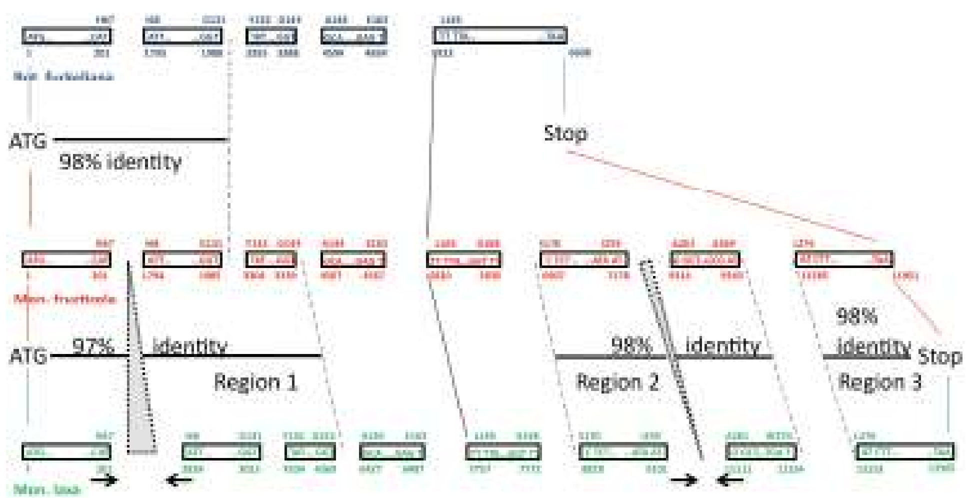

Figure 2. Structural representation of cyt b gene for *Botryotinia fuckeliana, Monilinia fructicola*, and *M. laxa. Exons are depicted as hollow boxes with introns indicated as space between boxes. All colored numbers indicate position of* exon/introns in base pairs. Gray triangles indicate intron insertion/deletions between species, while connecting lines indicate regions of homology in exons among species.

Figure 3.

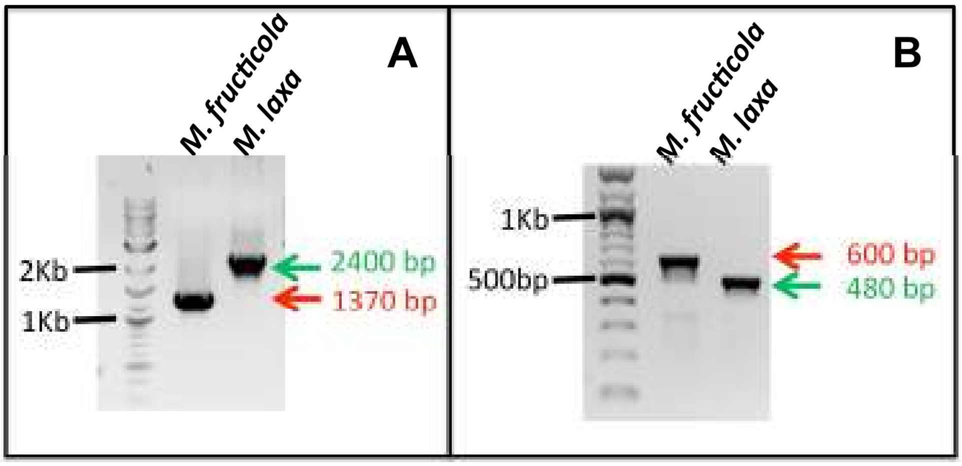

Figure 3. Agarose gel electrophoresis images of the PCR based differentiation of *Monilinia fructicola* from *M. laxa using the cyt b gene. Differentiation of Monilinia* species using primer pairs `P450 intron1-1 fwd` and rev **A**), and primer pairs `P450 intron6-2 fwd` and rev **B**). Molecular sizing bands from ladders are designated in black, while exact band sizes for *M. fructicola*, and *M. laxa* are designated in red and green, respectively.

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MANAGEMENT OF DISEASE ON A LATE-SEASON PEACH CULTIVAR WITH EXPERIMENTAL FUNGICIDES

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The experimental fungicides DPX-LEM17 (penthiopyrad), Luna Sensation (USF 2016, fluopyram + trifloxystrobin), Luna Experience (USF 2017, fluopyram + tebuconazole), YT669 (picoxystrobin), and Q8Y78 were tested for efficacy against peach diseases. DPX-LEM17 treatment timings focused on brown rot blossom blight and fruit rot control, while the other experimental fungicides were applied full season to examine control of all diseases. Fruit quality data were also recorded for the Luna treatments and standard.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2009 growing season. The test block consisted of a mixed-cultivar orchard of 14-year-old 'Autumnglo' peach, 'Suncrest' peach, and 'Redgold' nectarine. Trees of each cultivar alternated within the rows and were planted at 20 ft x 25 ft spacing. 'Autumnglo' trees were used in the experiment.

Treatments. Fungicide treatments were replicated four times in a randomized complete block design with single tree plots (Autumnglo). Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used for applications. All trees in the block received Bravo WeatherStik at 3 pt/A on 24 Mar for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 13 Jul by examining 20 shoots per tree for presence of cankers. Rusty spot (*Podosphaera leucotricha*) was evaluated on 23 Jun by counting the number of lesions on 40 fruit per tree. Scab (*Fusicladosporium carpophilum*) was evaluated on 18 Aug by examining 40 fruit per tree; fruit were sorted into categories of 0, 1-10, and >10 lesions. Harvest rot assessments were conducted on 8 Sep after most fruit had reached a "near tree-ripened" stage (a few lbs firmer than eating quality). Brown rot (*M. fructicola*), Rhizopus rot (*Rhizopus* spp.), and Anthracnose rot (*Colletotrichum* spp.) were evaluated by examining all fruit for absence or presence of disease on four or more branches per replicate tree (minimum of 100 fruit/tree).

For postharvest evaluations, 40 asymptomatic fruit were harvested from each tree and placed on benches in a greenhouse (ave. air temp. = 72.5^{o}F). Brown rot, Rhizopus rot, and Anthracnose rots were evaluated at 3 and 7 days postharvest (dph). Due to high levels of brown rot, there were not enough asymptomatic fruit on non-treated control trees for postharvest evaluation. Therefore, only treated fruit were evaluated postharvest.

Given the above observations, the dependent variables were expressed as percentage of shoots with canker (blossom blight) or percentage of fruit infected (all other diseases).

Analysis. An analysis of variance was performed on each dependent variable using the GLM procedure of the Statistical Analysis System v9.1. Means were compared using the Waller-Duncan *K*-Ratio Bayes test. Transformations were applied as needed to conform to the assumptions of normality, equality of variance, and independence of error terms.

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 21X data logger located at the research station. Observations were taken every minute and summarized every hour. Monthly temperature averages and rainfall accumulations were compared to 30-year means or sums, respectively, for Bridgeton.

Fruit Quality. At harvest, fruit from the Luna Sensation, Luna Experience, and standard (2^{nd} treatment in tables) treatments were compared for quality. A total of 50 fruit were arbitrarily removed from each replicate tree. Due to low fruit set on two Luna Experience treated trees, only two replicate trees were available for this treatment. The control was not included in the assessment due to lack of sufficient healthy fruit.

Ripeness was determined by classifying the 50 fruit into three categories (low, moderate, and high) based on the amount of yellow background color. Fruit coloration, the percent of red surface area, was visually estimated by direct fruit examination. An overall average % red area across all fruit was recorded, as well as a minimum and maximum for any given individual fruit. The number of fruit with surface blemishes was also recorded.

After the above visual assessments, 20 fruit were randomly chosen from each batch of 50 fruit for further quantitative analyses. Fruit diameter, perpendicular to the suture, and fruit weight were first recorded. Fruit firmness was then measured by a Fruit Texture Analyzer Model GS-14 (Güss, Strand, South Africa) using a 7.8 mm probe to a depth of 8.9 mm. Two firmness measurements were taken, one on each side of the fruit perpendicular to the suture; these values were averaged to provide an overall estimate of firmness. Finally, brix or % soluble solids (sugars) was assessed using an Atago PR-32α digital refractometer. Peach juice for the assessment was obtained by crushing in cheese cloth two radial wedges removed from opposite sides of each fruit.

RESULTS AND DISCUSSION

Environment. Overall, the growing season had above average rainfall. May and July, the only months in the growing season with below average rainfall, had 3.28

inches and 2.42 inches of rainfall, respectively, a shortage of 0.79 inches and 1.88 inches from the 30 year average. August had 8.04 inches of rainfall, nearly twice the average of 4.18 inches. Temperatures in April and May were above average, while temperatures in June and July remained a couple of degrees below average. August was very close to the 30 year temperature average. Average monthly temperatures this growing season were: Apr, 54.0ºF, May 62.8ºF, Jun 68.7ºF, Jul 72.9ºF, and Aug 74.8ºF.

Blossom Blight. Above average rainfall and temperatures during bloom in April were favorable for blossom blight development (Table 1). Consequently, disease pressure at bloom was high. Non-treated trees had 17.5% of shoots with blossom blight cankers and an average of 0.19 cankers per shoot (Table 2). This incidence level translates into approximately 100 cankers per tree.

All treatments except for Vangard / Adament provided significant control of blossom blight canker incidence and severity. All treatments with the exception of Vangard / Adament did not differ significantly from each other. Although unavailability of Q8Y78 prevented an application at pink, this fungicide nevertheless provided significant control of blossom blight with just two of the three bloom sprays.

Rusty Spot. Conditions for rusty spot varied throughout the susceptible period from SS to 2C. Dry and warm conditions during the time of shuck split and 1st cover were favorable for rusty spot development; however several days of cool, wet weather around the time of petal fall and 2nd cover were less conducive. Consequently, rusty spot disease pressure was moderate for highly susceptible Autumnglo. Non-sprayed control trees had 40.6% fruit infected with an average of 0.55 lesions per fruit (Table 3). In disease favorable seasons, as much as 90-100% of fruit can become infected on this cultivar.

All treatments provided significant control of rusty spot incidence and severity. The three standard Rally treatments provided 92.7%, 93.8%, and 70.7% control of rusty spot incidence with a significant difference between the two most effective treatments and the least effective treatment; the cause of this discrepancy is unknown. YT669 at both rates, Q8Y78, and Adament/Rally provided 90.6%, 90.6%, 89.2%, and 76.8% control of rusty spot incidence, respectively, and were equivalent to the two most effective standards. The two most effective Rally treatments reduced lesion density by 92.7% and 94.5%. All other treatments were equivalent to these standards with the exception of Pristine.

Scab. High inoculum levels in the form of twig lesions and frequent rain periods from SS (8 May) to 40 days pre-harvest (30 Jul) created extremely favorable conditions for scab development. Thus, disease pressure for scab was very high. Nearly 100% of fruit on control trees were infected with greater than 80% having 10 or more lesions (Table 4). Many fruit were covered with large areas of coalescing scab lesions.

All treatments except USF 2017 and Pristine significantly lowered scab incidence from that of the non-treated control. The standard Bravo/Captan treatments provided close to 50% control. All treatments except for USF 2017 provided control equivalent to these standards; control ranged from 32.7% for Pristine to 59.8% for YT669 at the 16 fl oz rate.

The Bravo/Captan standards had 73.8%-85.4% less fruit with over 10 lesions than the non-treated control. All other treatments except USF 2017 provided equivalent control of severity to the standards and each other. Substitution of Adament for Captan at 1C resulted in equivalent scab control to the standard program.

Brown Rot. Conditions were very favorable for brown rot development. The month of August had very high rainfall with much of the rain taking place at the end of the month when fruit were ripening. The first preharvest spray at 18 days before harvest was reapplied because rainfall began soon after application and continued for two days, potentially causing fungicide wash-off (Table 1). Over two inches of rainfall was accumulated during these two days. At harvest, 90.8% of fruit on non-treated control trees were infected with brown rot (Table 5).

All treatments significantly reduced brown rot levels at harvest. YT669 at 8 fl oz and Q8Y78 provided the highest level of control (92.7%). Adament, USF 2016, DPX-LEM17 at 20 fl oz, YT669 at 16 fl oz, and Pristine were equivalent to the most effective treatments and provided 85.6%-92.4% control. USF 2017, DPX-LEM at 12 fl oz and DPX-LEM17 at 16 fl oz provided 69.4%, 75.1%, and 81.6% control, respectively, and differed significantly from YT669 at 8 fl oz and Q8Y78.

At 3-dph, USF 2016 had the lowest level of brown rot infection. All treatments except USF 2017, DPX-LEM17 at 12 & 16 fl oz, and YT669 at 8 fl oz provided equivalent control to USF 2016. Although brown rot increased in all the treatments between 3- and 7-dph, those treatments that better suppressed rot at 3-dph continued to do so at 7-dph. At 7-dph, fruit treated with YT669 at 16 fl oz had the least rot. Adament, USF 2016, Q8Y78, and Pristine provided equivalent control to YT669 at 16 fl oz. USF 2017, all the DPX-LEM17 treatments and YT669 at 8 fl oz provided significantly less control than YT669 at16 fl oz.

Rhizopus Rot. Rhizopus rot was fairly low at harvest with 3.9% fruit infection on non-treated control trees (Table 5). All treated trees had 0-4% fruit rot and did not differ significantly from each other.

At 3-dph, YT669 at 8 fl oz, Q8Y78, and Pristine had no Rhizopus rot. USF 2017 and DPX-LEM at 16 fl oz treated fruit had the most rot (6.3% and 6.2%, respectively) and were significantly different from the treatments with no rot. All other treatments had some fruit rot, but did not differ significantly from the most effective treatments. By 7-dph, YT669 at 16 fl oz and Pristine treated fruit had the least Rhizopus rot (3.1% infected fruit for each treatment). USF 2017 was the least effective treatment with 24.8% fruit rot and significantly differed from the YT669 at 16 fl oz and Pristine.

Anthracnose Rot. Due to the high levels of rain, anthracnose, a rare disease in dry weather, was observed on fruit this growing season. At harvest, 3.2% of fruit on non-treated trees were infected with anthracnose (Table 7). None of the treatments were significantly different from the control at this time. At 3-dph, rot levels on all treated fruit ranged from 0%-3.4% and there were no significant differences among the treatments. At 7-dph, Pristine was the only treatment with no anthracnose infection on fruit. All treatments provided equivalent control to Pristine except USF 2016 and USF 2017.

Fruit Quality. Fruit size and color at harvest were excellent, exceeding 3 inches in diameter on average and >60% of surface area colored red (Tables 8 and 9). Based on background color, 87 to 92% of fruit were deemed ripe (moderate + high categories). Firmness of the tree-ripened fruit ranged from 4.5-5.0 lb (2-3 lb is considered fully ripe and ready to eat). No differences in any of the fruit quality parameters were observed between the standard, Luna Sensation, and Luna Experience treatments.

CONCLUSIONS

- **Luna Sensation (USF 2016)** provided control equivalent to the standard for blossom blight, scab, brown rot, and Rhizopus. In the case of blossom blight, it significantly reduced incidence and severity from that of the standard Vangard/Adament. USF 2016 provided significantly less control than the standards for rusty spot incidence and anthracnose rot. Management of peach scab was less than expected, especially given that the trifloxystrobin component has been shown to provide good to excellent anti-sporulant activity against *Fusicladosporium carpophilum* (*see* Phytopathology 98:S207). However, scab inoculum was most likely dispersed to the treatment trees from surrounding non-treated buffer trees.

- **Luna Experience (USF 2017)** provided significantly better control than the standard for blossom blight incidence and severity. However, USF 2017 provided significantly less control than the standard for rusty spot incidence, scab, and all the rots either at harvest or during one of the postharvest assessments.

- **YT669 and Q8Y78** provided equivalent control to the standard for all diseases tested. In the case of blossom blight, YT669 and Q8Y78 provided significantly better control than the standard. This is especially impressive for Q8Y78 which was not applied at pink due to a lack of material. A significant rate effect was observed between the 8 and 16 fl oz rate of YT669 for brown rot at 7-dph.

- **Pristine**, like all other treatments, provided a significantly higher level of control than the standard for blossom blight incidence and severity. Pristine provided 47.5% and 58.1% control of rusty spot incidence and severity, respectively. This was significantly less control than all three of the standard treatments for incidence and two of the standard treatments for severity. Pristine provided equivalent control to the standard for scab, brown rot, Rhizopus rot, and Anthracnose rot.

- Surprisingly, **Vangard** applied at pink and bloom followed by **Adament** at petal fall did not significantly reduce blossom blight incidence and severity. In another 2009 study on Autumnglo, Vangard applied at the same 5 oz rate for all three sprays provided excellent control (2.5% canker incidence vs. 15% on the non-treated). This implies that Adament control was lacking, but other factors may be involved.

- Trees treated with all rates of **DPX-LEM17** had significantly lower levels of blossom blight incidence and severity than trees treated with the standard. A rate effect was observed with DPX-LEM17 for management of brown rot. The highest rate always had the least fruit rot and always provided control equivalent to the Adament standard. DPX-LEM17 did not differ from the standard for control of Rhizopus or Anthracnose rots, although disease levels for these two diseases were fairly low.

Table 1. Weather and spray timings for 2009 growing season at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stage. Units for daily average air temperature and rainfall are ºF and inches, respectively.

Date	Temp	Rain	Date	Temp	Rain	Date	Temp	Rain
1-Apr	47.01	0.28	29-Apr	56.6	0.10	27-May	62.44	0
2-Apr	55.54	0.37	30-Apr	**Petal Fall**		28-May	66.82	0
3-Apr	59.72	0.55	30-Apr	54.89	0	29-May	64.45	0.23
4-Apr	54.16	0	1-May	64.08	0.05	30-May	67.56	0
5-Apr	53.23	0	2-May	61.67	0.03	31-May	66	0.04
6-Apr	54	0.64	3-May	55.16	0.37	1-Jun	**2nd Cover**	
7-Apr	42.94	0.01	4-May	52.57	0.56	1-Jun	60.65	0
8-Apr	43.06	0	5-May	54.54	0.24	2-Jun	70.43	0.65
9-Apr	**Pink**		6-May	55.99	0.45	3-Jun	68.11	1.29
9-Apr	48.52	0	7-May	64.6	0.56	4-Jun	59.02	0.29
10-Apr	54.11	0	8-May	66.89	0.01	5-Jun	58.22	1.12
11-Apr	48.72	0.30	8-May	**Shuck Split**		6-Jun	64.26	0.01
12-Apr	42.51	0	9-May	73.18	0	7-Jun	68.78	0
13-Apr	43.01	0	10-May	64.3	0	8-Jun	71.79	0
14-Apr	44.7	0.89	11-May	56.45	0	9-Jun	69.17	0.03
15-Apr	43.86	0.27	12-May	58.04	0	10-Jun	70.27	0
16-Apr	47.2	0	13-May	57.06	0	11-Jun	67.49	0.05
17-Apr	50.39	0	14-May	63.66	0	12-Jun	75.63	0.01
18-Apr	61.09	0	15-May	67.77	0.10	13-Jun	72.38	0.02
19-Apr	55.99	0	16-May	68.44	0	14-Jun	67.62	0
20-Apr	49.89	0.51	17-May	60.46	0.25	15-Jun	**3rd Cover**	
21-Apr	56.56	0.18	18-May	53.71	0	15-Jun	66.01	0
21-Apr	**Bloom**		19-May	53.19	0	16-Jun	63.09	0
21-Apr	56.56	0.15	20-May	**1st Cover**		17-Jun	60.58	0.10
22-Apr	49.31	0.07	20-May	60.67	0	18-Jun	65.3	0.84
23-Apr	50.15	0	21-May	64.5	0	19-Jun	69.06	0.01
24-Apr	54.67	0	22-May	69.06	0	20-Jun	68.28	0.39
25-Apr	67.95	0	23-May	72.82	0	21-Jun	70.27	0
26-Apr	76.99	0	24-May	73.42	0	22-Jun	69.7	0.21
27-Apr	77.49	0	25-May	72	0.01	23-Jun	70.64	0
28-Apr	74.76	0	26-May	56.77	0.38			

Table 1 – Continued-

Date	Temp	Rain	Date	Temp	Rain	Date	Temp	Rain
24-Jun	73.01	0	21-Jul	69.51	0.37	17-Aug	78	0
25-Jun	72.7	0	22-Jul	72.4	0.01	18-Aug	77.25	0.02
26-Jun	76.65	0	23-Jul	71.36	0	19-Aug	78.03	0.03
27-Jun	73.19	0	24-Jul	70.75	0.26	20-Aug	79.78	0
28-Jun	72.39	0	25-Jul	73.81	0.01	21-Aug	**18-DPH**	
29-Jun	**4th Cover**		26-Jul	77.87	0.01	21-Aug	80.86	0.07
29-Jun	72.81	0	27-Jul	76.78	0	22-Aug	74.84	2.00
30-Jun	73.89	0	28-Jul	**6th Cover**		23-Aug	76.94	0.23
1-Jul	73.24	0.19	28-Jul	78.01	0	24-Aug	**18-DPH reapplication***	
2-Jul	72.32	0.26	29-Jul	78.49	0.64	24-Aug	74.49	0
3-Jul	71.38	0	30-Jul	77.6	0.01	25-Aug	73.38	0
4-Jul	71.85	0	31-Jul	76.99	0.65	26-Aug	76.28	0
5-Jul	70.58	0	1-Aug	74.58	0	27-Aug	74.2	0
6-Jul	71.8	0	2-Aug	73.11	0.85	28-Aug	70.98	2.82
7-Jul	75.19	0	3-Aug	75.65	0.01	29-Aug	74.49	0.02
8-Jul	70.2	0	4-Aug	75.33	0	30-Aug	73.42	0.42
9-Jul	67.31	0	5-Aug	77.61	0	31-Aug	**8-DPH**	
10-Jul	66.33	0	6-Aug	68.99	0.32	31-Aug	65.81	0
11-Jul	69.17	0	7-Aug	69.09	0	1-Sep	63.08	0
12-Jul	75.08	0	8-Aug	71.69	0	2-Sep	63.44	0
13-Jul	70.63	0	9-Aug	73.93	0.80	3-Sep	65.42	0
14-Jul	**5th Cover**		10-Aug	79.21	0.01	4-Sep	71.2	0
14-Jul	69.59	0	11-Aug	**7th Cover**		5-Sep	70.44	0
15-Jul	71.18	0	11-Aug	79.11	0	6-Sep	66.69	0
16-Jul	77.54	0	12-Aug	75.25	0.14	7-Sep	**1-DPH**	
17-Jul	77.42	0.01	13-Aug	71.69	0.30	7-Sep	67.21	0
18-Jul	73.46	0	14-Aug	72.93	0	8-Sep	66.06	0
19-Jul	70.81	0	15-Aug	74.47	0	8-Sep	**Harvest**	
20-Jul	71.95	0	16-Aug	76.38	0			

*The 18-DPH spray was reapplied due to rain immediately following application and the occurrence of very heavy rain (2.3”) during the subsequent two days (22-23Aug).

Table 2. Blossom Blight Incidence and Severity [1]				
Treatment	**Rate / A**	**Timing**	**% Shoots w. Cankers** [2]	**# Cankers per Shoot** [2]
Nontreated Control	-----------------	-----------------	17.5 a	0.19 a
Vangard 75WG **Adament 50WG** Rally 40WSP + Bravo Ultrex 82.5WDG Adament 50WG Rally 40WSP + Captan 80WDG Captan 80WDG Adament 50WG	**5.0 oz** **6.0 oz** 5.0 oz + 3.8 lb 6.0 oz 5.0 oz + 3.75 lb 3.75 lb 6.0 oz	**P, B** **PF** SS 1C 2C 3C-7C 18, 8, 1 DPH	13.8 a	0.14 ab
Luna Sensation 4.17SC (USF 2016)	**4.0 fl oz**	**P, B, PF**, SS, 1C, 2C, 3C-7C, 18, 8, 1 DPH	1.3 b	0.03 c
Luna Experience 3.34SC (USF 2017)	**5.0 fl oz**	**P, B, PF**, SS, 1C, 2C, 3C-7C, 18, 8, 1 DPH	2.5 b	0.03 c
DPX-LEM17 1.67SC **Rally 40WP** Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC	**12.0 fl oz** **5.0 oz** 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb 12.0 fl oz	**P, B** **PF** SS 1C, 2C 3C-7C 18, 8, 1 DPH	0.0 b	0.0 c
DPX-LEM17 1.67SC **Rally 40WP** Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC	**16.0 fl oz** **5.0 oz** 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb 16.0 fl oz	**P, B** **PF** SS 1C, 2C 3C-7C 18, 8, 1 DPH	6.3 b	0.05 c
DPX-LEM17 1.67SC **Rally 40WP** Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC	**20.0 fl oz** **5.0 oz** 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb 20.0 fl oz	**P, B** **PF** SS 1C, 2C 3C-7C 18, 8, 1 DPH	6.3 b	0.08 bc
YT669 2.08SC + Induce	**8.0 fl oz + 32 fl oz**	**P, B, PF**, SS, 1C, 2C, 3C-7C, 18, 8, 1 DPH	1.3 b	0.01 c
YT669 2.08SC + Induce	**16.0 fl oz + 32 fl oz**	**P, B, PF**, SS, 1C, 2C, 3C-7C, 18, 8, 1 DPH	1.3 b	0.01 c
Q8Y78 2.0SC + Induce	**24.0 fl oz + 32 fl oz**	**B, PF**, SS, 1C, 2C, 3C-7C, 18, 8, 1 DPH	3.8 b	0.04 c
Pristine 38WG	**12.0 oz**	**P, B, PF**, SS, 1C, 2C, 3C-7C, 18, 8, 1 DPH	1.3 b	0.01 c

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

Table 3. Peach Rusty Spot Incidence and Severity[1]				
Treatment	**Rate / A**	**Timing**	**% Inf. Fruit**[2]	**# Lesions/Fruit**[2]
Nontreated Control	-----------------	-----------------	40.6 a	0.55 a
Vangard 75WG **Adament 50WG** **Rally 40WSP** + Bravo Ultrex 82.5WDG **Adament 50WG** **Rally 40WSP** + Captan 80WDG Captan 80WDG Adament 50WG	5.0 oz **6.0 oz** **5.0 oz + 3.8 lb** **6.0 oz** **5.0 oz + 3.75 lb** 3.75 lb 6.0 oz	P, B **PF** **SS** **1C** **2C** 3C-7C 18, 8, 1 DPH	9.4 cde	0.09 cd
Luna Sensation 4.17SC (USF 2016)	**4.0 fl oz**	P, B, **PF, SS, 1C, 2C,** 3C-7C, 18, 8, 1 DPH	13.1 bc	0.15 bc
Luna Experience 3.34SC (USF 2017)	**5.0 fl oz**	P, B, **PF, SS, 1C, 2C,** 3C-7C, 18, 8, 1 DPH	13.1 bc	0.14 bcd
DPX-LEM17 1.67SC **Rally 40WP** **Rally 40WP** + Bravo Ultrex 82.5WDG **Rally 40WP** + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC	12.0 fl oz **5.0 oz** **5.0 oz + 3.8 lb** **5.0 oz + 3.75 lb** 3.75 lb 12.0 fl oz	P, B **PF** **SS** **1C, 2C** 3C-7C 18, 8, 1 DPH	3.1 e	0.04 cd
DPX-LEM17 1.67SC **Rally 40WP** **Rally 40WP** + Bravo Ultrex 82.5WDG **Rally 40WP** + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC	16.0 fl oz **5.0 oz** **5.0 oz + 3.8 lb** **5.0 oz + 3.75 lb** 3.75 lb 16.0 fl oz	P, B **PF** **SS** **1C, 2C** 3C-7C 18, 8, 1 DPH	2.5 e	0.03 d
DPX-LEM17 1.67SC **Rally 40WP** **Rally 40WP** + Bravo Ultrex 82.5WDG **Rally 40WP** + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC	20.0 fl oz **5.0 oz** **5.0 oz + 3.8 lb** **5.0 oz + 3.75 lb** 3.75 lb 20.0 fl oz	P, B **PF** **SS** **1C, 2C** 3C-7C 18, 8, 1 DPH	11.9 cd	0.13 bcd
YT669 2.08SC + Induce	**8.0 fl oz + 32 fl oz**	P, B, **PF, SS, 1C, 2C**, 3C-7C, 18, 8, 1 DPH	3.8 de	0.04 cd
YT669 2.08SC + Induce	**16.0 fl oz + 32 fl oz**	P, B, **PF, SS, 1C, 2C**, 3C-7C, 18, 8, 1 DPH	3.8 de	0.04 cd
Q8Y78 2.0SC + Induce	**24.0 fl oz + 32 fl oz**	B**, PF, SS, 1C, 2C**, 3C-7C, 18, 8, 1 DPH	4.4 de	0.04 cd
Pristine 38WG	**12.0 oz**	P, B, **PF, SS, 1C, 2C,** 3C-7C, 18, 8, 1 DPH	21.3 b	0.23 b

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

Table 4. Scab Incidence and Severity [1]			**% Fruit** [2]		
Treatment	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated Control	-----------------	-----------------	97.5 a	16.3 a	81.3 a
Vangard 75WG Adament 50WG Rally 40WSP + **Bravo Ultrex 82.5WDG** **Adament 50WG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Adament 50WG	5.0 oz 6.0 oz **5.0 oz + 3.8 lb** **6.0 oz** **5.0 oz + 3.75 lb** **3.75 lb** 6.0 oz	P, B PF **SS** **1C** **2C** **3C-6C**, 7C 18, 8, 1 DPH	43.8 c	35.6 a	8.1 b
Luna Sensation 4.17SC (USF 2016)	**4.0 fl oz**	P, B, PF, **SS, 1C-6C**, 7C, 18, 8, 1 DPH	50.6 c	33.8 a	16.9 b
Luna Experience 3.34SC (USF 2017)	**5.0 fl oz**	P, B, PF, **SS, 1C-6C**, 7C, 18, 8, 1 DPH	90.6 ab	32.5 a	58.1 a
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + **Bravo Ultrex 82.5WDG** Rally 40WP + **Captan 80WDG** **Captan 80WDG** DPX-LEM17 1.67SC	12.0 fl oz 5.0 oz **5.0 oz + 3.8 lb** **5.0 oz + 3.75 lb** **3.75 lb** 12.0 fl oz	P, B PF **SS** **1C, 2C** **3C-6C**, 7C 18, 8, 1 DPH	48.8 c	27.5 a	21.3 b
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + **Bravo Ultrex 82.5WDG** Rally 40WP + **Captan 80WDG** **Captan 80WDG** DPX-LEM17 1.67SC	16.0 fl oz 5.0 oz **5.0 oz + 3.8 lb** **5.0 oz + 3.75 lb** **3.75 lb** 16.0 fl oz	P, B PF **SS** **1C, 2C** **3C-6C**, 7C 18, 8, 1 DPH	49.4 c	36.3 a	13.1 b
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + **Bravo Ultrex 82.5WDG** Rally 40WP + **Captan 80WDG** **Captan 80WDG** DPX-LEM17 1.67SC	20.0 fl oz 5.0 oz **5.0 oz + 3.8 lb** **5.0 oz + 3.75 lb** **3.75 lb** 20.0 fl oz	P, B PF **SS** **1C, 2C** **3C-6C**, 7C 18, 8, 1 DPH	51.9 c	40.0 a	11.9 b
YT669 2.08SC + Induce	**8 fl oz + 32 fl oz**	P, B, PF, **SS, 1C-6C**, 7C, 18, 8, 1 DPH	60.0 bc	40.0 a	20.0 b
YT669 2.08SC + Induce	**16 fl oz + 32 fl oz**	P, B, PF, **SS, 1C-6C**, 7C, 18, 8, 1 DPH	39.4 c	23.8 a	15.6 b
Q8Y78 2.0SC + Induce	**24 fl oz + 32 fl oz**	B, PF, **SS, 1C-6C**, 7C, 18, 8, 1 DPH	42.5 c	33.8 a	8.8 b
Pristine 38WG	**12.0 oz**	P, B, PF, **SS, 1C-6C**, 7C, 18, 8, 1 DPH	65.6 abc	37.5 a	28.1 b

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

Table 5. Brown Rot Harvest and Post-harvest Incidence[1]			**% Fruit Infected** [2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**7-dph**
Nontreated Control	-----------------	-----------------	90.8 a	-----	-----
Vangard 75WG Adament 50WG Rally 40WSP + Bravo Ultrex 82.5WDG Adament 50WG Rally 40WSP + Captan 80WDG Captan 80WDG **Adament 50WG**	5.0 oz 6.0 oz 5.0 oz + 3.8 lb 6.0 oz 5.0 oz + 3.75 lb 3.75 lb **6.0 oz**	P, B PF SS 1C 2C 3C-7C **18, 8, 1 DPH**	13.1 de	9.4 abc	26.3 bc
Luna Sensation 4.17SC (USF 2016)	**4.0 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	6.9 e	2.5 c	20.0 bc
Luna Experience 3.34SC (USF 2017)	**5.0 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	27.8 b	15.0 a	38.0 ab
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	12.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **12.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	22.6 bc	11.9 ab	47.5 a
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	16.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **16.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	16.7 cd	15.5 a	46.4 a
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	20.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **20.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	11.4 de	5.6 abc	33.6 ab
YT669 2.08SC + Induce	**8 fl oz + 32 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	6.6 e	11.9 ab	35.6 ab
YT669 2.08SC + Induce	**16 fl oz + 32 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	7.7 de	3.1 bc	14.4 c
Q8Y78 2.0SC + Induce	**24 fl oz + 32 fl oz**	B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	6.6 e	3.8 bc	23.8 bc
Pristine 38WG	**12.0 oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	9.5 de	5.0 bc	24.4 bc

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

Table 6. Rhizopus Harvest and Post-harvest Incidence[1]			% Fruit Infected [2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**7-dph**
Nontreated Control	-----------------	-----------------	3.9 a	------	------
Vangard 75WG Adament 50WG Rally 40WSP + Bravo Ultrex 82.5WDG Adament 50WG Rally 40WSP + Captan 80WDG Captan 80WDG **Adament 50WG**	5.0 oz 6.0 oz 5.0 oz + 3.8 lb 6.0 oz 5.0 oz + 3.75 lb 3.75 lb **6.0 oz**	P, B PF SS 1C 2C 3C-7C **18, 8, 1 DPH**	0.2 a	1.9 c	10.0 ab
Luna Sensation 4.17SC (USF 2016)	**4.0 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	0.0 a	1.3 c	9.4 ab
Luna Experience 3.34SC (USF 2017)	**5.0 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	4.0 a	6.3 a	24.8 a
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	12.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **12.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	0.3 a	1.9 bc	10.6 ab
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	16.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **16.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	0.5 a	6.2 ab	18.1 ab
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	20.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **20.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	0.0 a	1.9 bc	14.7 ab
YT669 2.08SC + Induce	**8 fl oz + 32 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	0.0 a	0.0 c	3.8 ab
YT669 2.08SC + Induce	**16 fl oz + 32 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	0.2 a	0.6 c	3.1 b
Q8Y78 2.0SC + Induce	**24 fl oz + 32 fl oz**	B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	0.0 a	0.0 c	5.0 ab
Pristine 38WG	**12.0 oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	0.0 a	0.0 c	3.1 b

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

Table 7. Anthracnose Harvest and Post-harvest Incidence[1]			**% Fruit Infected** [2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**7-dph**
Nontreated Control	-----------------	-----------------	3.2 ab	------	------
Vangard 75WG Adament 50WG Rally 40WSP + Bravo Ultrex 82.5WDG Adament 50WG Rally 40WSP + Captan 80WDG Captan 80WDG **Adament 50WG**	5.0 oz 6.0 oz 5.0 oz + 3.8 lb 6.0 oz 5.0 oz + 3.75 lb 3.75 lb **6.0 oz**	P, B PF SS 1C 2C 3C-7C **18, 8, 1 DPH**	0.2 b	0.0 a	0.6 c
Luna Sensation 4.17SC (USF 2016)	**4.0 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	0.7 ab	3.1 a	6.3 ab
Luna Experience 3.34SC (USF 2017)	**5.0 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	5.1 a	3.4 a	7.3 a
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	12.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **12.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	0.5 b	0.6 a	0.6 c
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	16.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **16.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	1.2 ab	0.0 a	1.2 bc
DPX-LEM17 1.67SC Rally 40WP Rally 40WP + Bravo Ultrex 82.5WDG Rally 40WP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	20.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **20.0 fl oz**	P, B PF SS 1C, 2C 3C-7C **18, 8, 1 DPH**	1.9 ab	0.0 a	0.6 c
YT669 2.08SC + Induce	**8 fl oz + 32 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	2.5 ab	1.9 a	3.1 abc
YT669 2.08SC + Induce	**16 fl oz + 32 fl oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	1.0 ab	0.0 a	2.5 abc
Q8Y78 2.0SC + Induce	**24 fl oz + 32 fl oz**	B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	1.5 ab	0.6 a	1.3 bc
Pristine 38WG	**12.0 oz**	P, B, PF, SS, 1C, 2C, 3C-7C, **18, 8, 1 DPH**	0.7 ab	0.0 a	0.0 c

[1]Anthracnose rot treatments, rates, and application timings in boldface; late season cover sprays may also be important.
[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

Table 8. Fruit Ripeness, Coloration, and Blemishes							
	Ripeness			Coloration			
	% Fruit[1]			% Red Surface Area[1]			Blemishes[1]
Treatment [2]	**Low**	**Moderate**	**High**	**Average**	**Min**	**Max**	**% Fruit**
Standard [3]	8.0 a	29.5 a	62.5 a	65.0 a	26.3 a	97.5 a	5.5 a
Luna Sensation 4.17SC (USF2016)	8.5 a	37.5 a	54.0 a	63.8 a	25.0 a	100.0 a	7.0 a
Luna Experience 3.34SC (USF2017)	13.0 a	34.0 a	53.0 a	70.0 a	30.0 a	100.0 a	7.0 a

[1] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).
[2] Standard & Luna Sensation samples = 200 fruit (4 reps x 50 fruit); Luna Experience sample = 100 fruit (2 reps x 50 fruit).
[3] Standard is second treatment listed in tables 2-7.

Table 9. Fruit Size, Weight, Firmness, and Brix							
	Diameter[1]		Weight[1]		Firmness[1]		Brix[1]
Treatment [2]	**(mm)**	**(inches)**	**(g)**	**(oz)**	**(N)**	**(lb)**	**(% SS)**
Standard [3]	80.3 a	3.16	274.0 a	9.7	22.1 a	5.0	12.1 a
Luna Sensation 4.17SC (USF2016)	81.8 a	3.22	288.2 a	10.2	20.2 a	4.5	12.6 a
Luna Experience 3.34 SC (USF2017)	80.4 a	3.17	272.4 a	9.6	20.8 a	4.7	12.8 a

[1] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).
[2] Standard & Luna Sensation samples = 80 fruit (4 reps x 20 fruit); Luna Experience sample = 40 fruit (2 reps x 20 fruit).
[3] Standard is second treatment listed in tables 2-7.

EFFICACY OF DMI MIXTURES ON DEVELOPMENT OF BROWN ROT ON SUNCREST PEACH

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Experimental fungicide mixtures Inspire Super (A16001; difenoconazole + cyprodinil), Quadris Top (A13703; difenoconazole + azoxystrobin), Inspire XT (A8122; difenoconazole + propiconazole), and A15909 (propiconazole + azoxystrobin) were tested for efficacy against brown rot blossom blight and fruit rot. The recently released DMI fungicide Quash (metconazole) was also included in the study.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2009 growing season. The test block consisted of a 14-year-old ‘Suncrest’ peach orchard planted at 25 ft x 25 ft spacing.

Treatments. Fungicide treatments were replicated four times in a randomized complete block design with single tree plots. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used for applications. All trees in the block received Bravo WeatherStik at 3 pt/A on 24 Mar for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 8 Jul by counting the number of cankers on 20-25 shoots per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 22 Jun by counting the number of lesions on 40 fruit per tree. Scab and harvest rot assessments were conducted on 13 Aug after most fruit had reached a “near tree-ripened” stage (a few lbs firmer than eating quality). Scab (*Fusicladosporium carpophilum*) was evaluated by examining 40 fruit per tree; fruit were sorted into categories of 1-10 and >10 lesions. Brown rot (*M. fructicola*), Rhizopus rot (*Rhizopus* spp.), and Anthracnose rot (*Colletotrichum* spp.) were evaluated by examining all fruit for absence or presence of disease on four or more branches per replicate tree (either minimum of 100 fruit per tree or all fruit on the tree if it had less than 100 fruit).

For postharvest evaluations, 40 asymptomatic fruit were harvested from each tree and placed on benches in a greenhouse (ave. air temp. = 80.6°F). Due to a combination of low fruit set and high levels of rot, some trees had less than 40 asymptomatic fruit. In these cases, all available asymptomatic fruit were used. Not enough healthy fruit were available on non-treated control trees for a postharvest assessment; therefore, only treated fruit were evaluated postharvest. Brown rot, Rhizopus rot, and Anthracnose rots were evaluated at 4 and 7 days postharvest (dph).

Given the above observations, the dependent variables were expressed as percentage of shoots with canker (blossom blight) or percentage of fruit infected (all other diseases).

Analysis. An analysis of variance was performed on each dependent variable using the GLM procedure of the Statistical Analysis System v9.1. Since some trees had low fruit set, sample sizes varied at harvest. To accommodate these differences among replicates, a weighted analysis was conducted using sample size as the weight. Means were compared using the Waller-Duncan *K*-Ratio Bayes test. Transformations were applied as needed to conform to the assumptions of normality, equality of variance, and independence of error terms.

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 21X data logger located at the research station. Observations were taken every minute and summarized every hour. Monthly temperature averages and rainfall accumulations were compared to 30-year means or sums, respectively, for Bridgeton.

RESULTS AND DISCUSSION

Environment. Overall, the growing season had above average rainfall. May and July, the only months in the growing season with below average rainfall, had 3.28 inches and 2.42 inches of rainfall, respectively, a shortage of 0.79 inches and 1.88 inches from the 30 year average. August had 8.04 inches of rainfall, nearly twice the average of 4.18 inches. Temperatures in April and May were above average, while temperatures in June and July remained a couple of degrees below average. August was very close to the 30 year temperature average. Average monthly temperatures this growing season were: Apr, 54.0ºF, May 62.8ºF, Jun 68.7ºF, Jul 72.9ºF, and Aug 74.8ºF.

Blossom Blight. Several days with rainfall over 0.10 inches occurred during pink and bloom which created favorable conditions for blossom blight. However, a below average number of mummies were present in the orchard, thereby reducing initial inoculum levels. Consequently, blossom blight disease pressure was low. Only 4.3% of shoots on non-treated trees had visible cankers (Table 2). Nevertheless, under these conditions, all treatments significantly reduced canker incidence, providing 100% control.

Rusty Spot. Conditions for rusty spot varied throughout the susceptible period from PF to 2C. Dry and warm conditions during the time of petal fall and1st cover were favorable for rusty spot development; however several days of cool, wet weather around the time of shuck split and 2nd cover were not conducive for rusty spot. Thus, on less susceptible Suncrest, disease pressure was very low. Non-sprayed control trees had only 9.4% fruit infection (Table 2).

Since all treatments received Rally at SS, 1C, and 2C, they only differed in the material applied at PF. Consequently, few differences were observed among fungicide treatments, which provided between 33% and 79.8% control. Three treatments, which received Gem, Quadris Top, and Prisitine at PF were not significantly different from the control.

Scab. High inoculum levels in the form of twig lesions and frequent rain periods from SS (1 May) to 40 days pre-harvest (4 Jul) created extremely favorable conditions for scab development, resulting in very high disease pressure. Scab incidence on non-sprayed control trees was 100% with 97.1% of fruit having 10 or more lesions (Table 3). Since this study was primarily aimed at brown rot management, fungicides applied for scab control were the same across all treatments, namely Bravo Ultrex at SS and Captan for the subsequent cover sprays between 1C and 40 days pre-harvest.

Tree phenology advanced quickly from 0% shuck split on 22 Apr to 93% shuck split on 1 May. Thus, nearly all the fruit had attained shuck split when four consecutive days of rain (>0.10 in) occurred between 3 May and 6 May, just *prior* to the shuck split application of Bravo on 6 May. Consequently, the prior PF spray may account for some of the significant differences between the treatments. Treatment programs that received petal fall sprays of Quadris Top, Inspire XT (both rates), and Gem (one of two) had significantly lower incidence than the non-treated control.

All treatments reduced disease severity by significantly lowering the number of lesions per fruit. Consequently, treatments had higher percentages of fruit than the non-treated control in the 1-10 lesion category, but lower percentages than the control in the >10 lesion category. No differences in scab severity were observed among treatments.

Brown Rot. Conditions were very favorable for the development of rots at harvest. Several rain periods occurred just prior to and during the pre-harvest fruit ripening period. One or more rain days (>0.10 in) following each pre-harvest spray (Table 1). At harvest, 86.8% of fruit on the non-treated control trees were infected with *M. fructicola*.

All of the treatments at harvest significantly reduced brown rot (Table 4). The standard Indar/Pristine/Indar provided the most control (93.9%). Quash/Pristine/Indar and Captan/Pristine/Pristine, which provided 91.6% and 86.7% control, respectively, were equivalent to Indar/Pristine/Indar. The experimental programs (Captan/Experimental/Experimental) provided between 77.1% and 84.9% control, significantly less than Indar/Pristine/Indar. There were no differences between the experimental materials. The lack of an effective fungicide (other than captan) at the 17-DPH timing in the experimental fungicide programs probably accounts for the significant difference between them and the standard. Nevertheless, the experimental programs' performances were equivalent to the Captan/Pristine/Pristine treatment.

In the postharvest test, Indar/Pristine/Indar and Quash/Indar/Pristine provided the best control of brown rot at 4-dph and 7-dph, respectively, although the differences between these two treatments were not significant. All treatments except Inspire Super and Inspire XT @ 5 fl oz provided equivalent control to the most effective treatments at both 4- and 7-dph. Only a few significant differences occurred among the experimental programs; numerically, Quadris Top had the lowest postharvest disease levels. At 4- and 7-dph, Quadris Top was the only experimental that had significantly less rot than Inspire Super, the least effective experimental material.

Rhizopus Rot. There was very little Rhizopus rot at harvest. Non-treated control trees had 0.5% infected fruit and there were no significant differences between any of the treatments (Table 5). Due to a lack of asymptomatic fruit at harvest on the non-treated trees, no postharvest assessment for Rhizopus rot was performed on non-treated fruit. At 7-dph, Indar/Pristine/Indar treated fruit had the least amount of fruit infection with 1.9%. Inspire Super and Inspire XT @ 5 fl oz had significantly higher Rhizopus fruit infection than the standard Indar/Pristine/Indar. Numerically, Quadris Top had the lowest percentage of fruit rot among the experimental programs at 7-dph.

Anthracnose Rot. Anthracnose rot was present on all treatments at harvest, but the level was very low (0.3%-2.3% fruit infection). At 7-dph, treatments ranged from 3.1%-7.5% fruit infection. At either time, no significant differences were observed.

CONCLUSIONS

- High inoculum levels and frequent rains, particularly those between the 17-DPH and 9-DPH preharvest sprays, were the most likely cause for failure of the experimental programs to manage brown rot at levels similar to the standard. Essentially, the captan applied in the experimental programs at 17-DPH provided inadequate control during the early portion of the fruit ripening period. In a drier year, these programs may have been adequate. Nevertheless, the similarly designed Pristine program still managed to provide control equivalent to the standard, albeit numerically higher.

- **Quadris Top (A13703)** provided control equivalent to the standards for blossom blight, postharvest brown rot, and Rhizopus rot. It had the lowest numerical value for brown rot and Rhizopus rot of all the experimental materials throughout the postharvest period and provided significantly more control than Inspire Super for both diseases.

- Although significant differences were not detected between the 5 and 7 fl oz rates of **Inspire XT,** a consistent, slight rate effect on brown rot and Rhizopus rot was observed. At harvest and throughout the postharvest period, fruit treated at the high rate had less brown rot or Rhizopus rot than fruit treated at the low rate.

- Substitution of **Quash** for Indar at 17-DPH resulted in brown rot control equivalent to the standard at harvest and postharvest assessments. Numerically, the Quash/Pristine/Indar treatment ranked either first or second in brown rot control among all treatments examined. Lower levels of control for those treatments having captan at 17-DPH implies that the Quash was fulfilling an important role in this three-spray preharvest program.

- All fungicide programs provided 100% control of low levels of blossom blight. However, the experimental materials should be tested in an orchard with higher disease pressure for blossom blight to better determine their efficacy against this phase of brown rot.

TABLE 1. Daily average air temperature and rainfall accumulation during the 2009 season at the Rutgers Agricultural Research and Extension Center, Bridgeton NJ. Phenological stages indicate date of fungicide treatment application. Units for temperature and rainfall data are °F and inches.

Date	Temperature	Rain
1-Apr	47.0	0.28
2-Apr	55.5	0.37
3-Apr	59.7	0.55
4-Apr	54.2	0
5-Apr	53.2	0
6-Apr	54.0	0.64
7-Apr	42.9	0.01
7-Apr	**Pink**	
8-Apr	43.1	0
9-Apr	48.5	0
10-Apr	54.1	0
11-Apr	48.7	0.30
12-Apr	42.5	0
13-Apr	43.0	0
14-Apr	44.7	0.89
15-Apr	43.9	0.27
16-Apr	47.2	0
17-Apr	**Bloom**	
17-Apr	50.4	0
18-Apr	61.1	0
19-Apr	56.0	0
20-Apr	49.9	0.51
21-Apr	56.6	0.33
22-Apr	49.3	0.07
23-Apr	50.2	0
24-Apr	54.7	0
25-Apr	68.0	0
26-Apr	77.0	0
27-Apr	**Petal Fall**	
27-Apr	77.5	0
28-Apr	74.8	0
29-Apr	56.6	0.10
30-Apr	54.9	0
1-May	64.1	0.05
2-May	61.7	0.03
3-May	55.2	0.37
4-May	52.6	0.56
5-May	54.5	0.24

Date	Temperature	Rain
6-May	56.0	0.22
6-May	**Shuck Split**	
6-May	56.0	0.23
7-May	64.6	0.56
8-May	66.9	0.01
9-May	73.2	0
10-May	64.3	0
11-May	56.5	0
12-May	58.0	0
13-May	57.1	0
14-May	63.7	0
15-May	67.8	0.10
16-May	68.4	0
17-May	60.5	0.25
18-May	53.7	0
19-May	**1st Cover**	
19-May	53.2	0
20-May	60.7	0
21-May	64.5	0
22-May	69.1	0
23-May	72.8	0
24-May	73.4	0
25-May	72.0	0.01
26-May	56.8	0.38
27-May	62.4	0
28-May	66.8	0
29-May	64.5	0.11
29-May	**2nd Cover**	
29-May	64.5	0.12
30-May	67.6	0
31-May	66.0	0.04
1-Jun	60.7	0
2-Jun	70.4	0.65
3-Jun	68.1	1.29
4-Jun	59.0	0.29
5-Jun	58.2	1.12
6-Jun	64.3	0.01

TABLE 1. – Continued –

Date	Temperature	Rain
7-Jun	68.8	0
8-Jun	71.8	0
9-Jun	69.2	0.03
10-Jun	70.3	0
11-Jun	67.5	0.04
11-Jun	**3rd Cover**	
11-Jun	67.5	0.01
12-Jun	75.6	0.01
13-Jun	72.4	0.02
14-Jun	67.6	0
15-Jun	66.0	0
16-Jun	63.1	0
17-Jun	60.6	0.10
18-Jun	65.3	0.84
19-Jun	69.1	0.01
20-Jun	68.3	0.39
21-Jun	70.3	0
22-Jun	69.7	0.21
23-Jun	70.6	0
24-Jun	73.0	0
25-Jun	72.7	0
26-Jun	76.7	0
27-Jun	73.2	0
28-Jun	72.4	0
29-Jun	**4th Cover**	
29-Jun	72.8	0
30-Jun	73.9	0
1-Jul	73.2	0.19
2-Jul	72.3	0.26
3-Jul	71.4	0
4-Jul	71.9	0
5-Jul	70.6	0
6-Jul	71.8	0
7-Jul	75.2	0
8-Jul	70.2	0
9-Jul	**5th Cover**	
9-Jul	67.3	0
10-Jul	66.3	0

Date	Temperature	Rain
11-Jul	69.2	0
12-Jul	75.1	0
13-Jul	70.6	0
14-Jul	69.6	0
15-Jul	71.2	0
16-Jul	77.5	0
17-Jul	77.4	0.01
18-Jul	73.5	0
19-Jul	70.8	0
20-Jul	72.0	0
21-Jul	69.5	0.37
22-Jul	72.4	0.01
23-Jul	71.4	0
24-Jul	70.8	0.26
25-Jul	73.8	0.01
26-Jul	77.9	0.01
27-Jul	**17-DPH**	
27-Jul	76.8	0
28-Jul	78.0	0
29-Jul	78.5	0.64
30-Jul	77.6	0.01
31-Jul	77.0	0.65
1-Aug	74.6	0
2-Aug	73.1	0.85
3-Aug	75.7	0.01
4-Aug	**9-DPH**	
4-Aug	75.3	0
5-Aug	77.6	0
6-Aug	69.0	0.32
7-Aug	69.1	0
8-Aug	71.7	0
9-Aug	73.9	0.80
10-Aug	79.2	0.01
11-Aug	79.1	0
12-Aug	**1-DPH**	
12-Aug	75.3	0.14
13-Aug	**Harvest**	
13-Aug	71.7	0.30

TABLE 2. Blossom Blight and Rusty Spot Incidence[1]			Blossom Blight[2]	Rusty Spot[2]
Treatment	**Rate / A**	**Timing**	**% Shoots w. Canker**	**% Fruit Infected**
Nontreated Control	-----------------	-----------------	4.3 a	9.4 a
Vangard 75WG ***Gem 500SC*** *Rally 40WSP* + BravoUltrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Indar 2F Pristine 38WG Indar 2F	**5.0 oz** ***3.8 fl oz*** *4.0 oz* + 3.8 lb *4.0 oz* + 3.75 lb 3.75 lb 6.0 fl oz 12.5 oz 6.0 fl oz	**P, B** ***PF*** *SS* *1C – 2C* 3C – 5C 17 DPH 9 DPH 1 DPH	0.0 b	5.0 abc
Inspire Super 2.8EW (A16001) *Rally 40WSP* + BravoUltrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Inspire Super 2.8EW (A16001)	**10.0 fl oz** *4.0 oz* + 3.8 lb *4.0 oz* + 3.75 lb 3.75 lb 10.0 fl oz	**P, B, *PF*** *SS* *1C – 2C* 3C – 5C, 17 DPH 9, 1 DPH	0.0 b	3.1 bc
Quadris Top 2.71SC (A13703) *Rally 40WSP* + BravoUltrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Quadris Top 2.71SC (A13703)	**14.0 fl oz** *4.0 oz* + 3.8 lb *4.0 oz* + 3.75 lb 3.75 lb 14.0 fl oz	**P, B, *PF*** *SS* *1C – 2C* 3C – 5C, 17 DPH 9, 1 DPH	0.0 b	6.3 ab
Inspire XT 4.17EC (A8122) *Rally 40WSP* + BravoUltrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Inspire XT 4.17EC (A8122)	**5.0 fl oz** *4.0 oz* + 3.8 lb *4.0 oz* + 3.75 lb 3.75 lb 5.0 fl oz	**P, B, *PF*** *SS* *1C – 2C* 3C – 5C, 17 DPH 9, 1 DPH	0.0 b	1.9 c
Inspire XT 4.17EC (A8122) *Rally 40WSP* + BravoUltrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Inspire XT 4.17EC (A8122)	**7.0 fl oz** *4.0 oz* + 3.8 lb *4.0 oz* + 3.75 lb 3.75 lb 7.0 fl oz	**P, B, *PF*** *SS* *1C – 2C* 3C – 5C, 17 DPH 9, 1 DPH	0.0 b	3.1 bc
A15909 2.2SE *Rally 40WSP* + BravoUltrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG A15909 2.2SE	**10.0 fl oz** *4.0 oz* + 3.8 lb *4.0 oz* + 3.75 lb 3.75 lb 10.0 fl oz	**P, B, *PF*** *SS* *1C – 2C* 3C – 5C, 17 DPH 9, 1 DPH	0.0 b	3.1 bc
Pristine 38WG *Rally 40WSP* + BravoUltrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Pristine 38WG	**12.5 oz** *4.0 oz* + 3.8 lb *4.0 oz* + 3.75 lb 3.75 lb 12.5 oz	**P, B, *PF*** *SS* *1C – 2C* 3C – 5C, 17 DPH 9, 1 DPH	0.0 b	5.0 abc
Quash 50WG ***Gem 500SC*** *Rally 40WSP* + BravoUltrex	**2.5 oz** ***3.8 fl oz*** *4.0 oz* + 3.8 lb	**P, B** ***PF*** *SS*		

82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Quash 50WG Pristine 38WG Indar 2F	*4.0 oz* + 3.75 lb 3.75 lb 2.5 oz 12.5 oz 6.0 fl oz	*1C – 2C* 3C – 5C 17 DPH 9 DPH 1 DPH	0.0 b	3.1 bc

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

TABLE 3. Scab Incidence and Severity [1]			**% Fruit** [2]		
Treatment	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated Control	-----------------	-----------------	100.0 a	2.9 b	97.1 a
Vangard 75WG Gem 500SC Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Indar 2F Pristine 38WG Indar 2F	5.0 oz 3.8 fl oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 6.0 fl oz 12.5 oz 6.0 fl oz	P, B PF **SS** **1C – 2C** **3C, 4C**, 5C 17 DPH 9 DPH 1 DPH	60.6 c	38.1 a	22.5 b
Inspire Super 2.8EW (A16001) Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Inspire Super 2.8EW (A16001)	10.0 fl oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 10.0 fl oz	P, B, PF **SS** **1C – 2C** **3C, 4C**, 5C, 17 DPH 9, 1 DPH	80.0 abc	39.2 a	40.8 b
Quadris Top 2.71SC (A13703) Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Quadris Top 2.71SC (A13703)	14.0 fl oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 14.0 fl oz	P, B, PF **SS** **1C – 2C** **3C, 4C**, 5C, 17 DPH 9, 1 DPH	62.5 c	37.5 a	25.0 b
Inspire XT 4.17EC (A8122) Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Inspire XT 4.17EC (A8122)	5.0 fl oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 5.0 fl oz	P, B, PF **SS** **1C – 2C** **3C, 4C**, 5C, 17 DPH 9, 1 DPH	65.7 bc	42.4 a	23.2 b
Inspire XT 4.17EC (A8122) Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Inspire XT 4.17EC (A8122)	7.0 fl oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 7.0 fl oz	P, B, PF **SS** **1C – 2C** **3C, 4C**, 5C, 17 DPH 9, 1 DPH	65.3 bc	31.3 a	34.0 b
A15909 2.2SE Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** A15909 2.2SE	10.0 fl oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 10.0 fl oz	P, B, PF **SS** **1C – 2C** **3C, 4C**, 5C, 17 DPH 9, 1 DPH	77.9 abc	36.9 a	40.9 b
Pristine 38WG Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Pristine 38WG	12.5 oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 12.5 oz	P, B, PF **SS** **1C – 2C** **3C, 4C**, 5C, 17 DPH 9, 1 DPH	86.7 ab	44.8 a	42.0 b

Quash 50WG Gem 500SC Rally 40WSP + **BravoUltrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Quash 50WG Pristine 38WG Indar 2F	2.5 oz 3.8 fl oz 4.0 oz + **3.8 lb** 4.0 oz + **3.75 lb** **3.75 lb** 2.5 oz 12.5 oz 6.0 fl oz	P, B **PF** **SS** **1C – 2C** **3C, 4C**, 5C 17 DPH 9 DPH 1 DPH	78.6 ab	41.5 a	37.1 b

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

TABLE 4. Brown Rot Harvest and Post-harvest Incidence[1]			**% Fruit Infected [2]**		
Treatment	**Rate / A**	**Timing**	**Harvest**	**4-dph**	**7-dph**
Nontreated Control	-----------------	-----------------	86.9 a	----	----
Vangard 75WG Gem 500SC Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Indar 2F** **Pristine 38WG** **Indar 2F**	5.0 oz 3.8 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb 3.75 lb **6.0 fl oz** **12.5 fl oz** **6.0 fl oz**	P, B PF SS 1C – 2C 3C – 5C **17 DPH** **9 DPH** **1 DPH**	5.3 d	11.3 c	30.6 bc
Inspire Super 2.8EW (A16001) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Inspire Super 2.8EW (A16001)**	10.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **10.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	19.7 b	46.4 a	64.8 a
Quadris Top 2.71SC (A13703) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Quadris Top 2.71SC (A13703)**	14.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **14.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	15.8 b	19.4 bc	31.9 bc
Inspire XT 4.17EC (A8122) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Inspire XT 4.17EC (A8122)**	5.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **5.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	15.3 bc	34.8 ab	55.1 ab
Inspire XT 4.17EC (A8122) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Inspire XT 4.17EC (A8122)**	7.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **7.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	13.1 bc	31.3 abc	49.3 abc
A15909 2.2SE Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **A15909 2.2SE**	10.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **10.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	19.9 b	31.5 abc	41.3 abc
Pristine 38WG Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Pristine 38WG**	12.5 oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **12.5 oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	11.6 bcd	19.1 bc	39.0 abc
Quash 50WG	2.5 oz	P, B			

Gem 500SC Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Quash 50WG** **Pristine 38WG** **Indar 2F**	3.8 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb 3.75 lb **2.5 oz** **12.5 oz** **6.0 fl oz**	PF SS 1C – 2C 3C – 5C **17 DPH** **9 DPH** **1 DPH**	7.3 cd	16.9 bc	26.0 c

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

TABLE 5. Rhizopus Harvest and Post-harvest Incidence[1]			**% Fruit Infected [2]**	
Treatment	**Rate / A**	**Timing**	**Harvest**	**7-dph**
Nontreated Control	-----------------	-----------------	0.5 a	-----
Vangard 75WG Gem 500SC Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Indar 2F** **Pristine 38WG** **Indar 2F**	5.0 oz 3.8 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb 3.75 lb **6.0 fl oz** **12.5 fl oz** **6.0 fl oz**	P, B PF SS 1C – 2C 3C – 5C **17 DPH** **9 DPH** **1 DPH**	0.0 a	1.9 c
Inspire Super 2.8EW (A16001) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Inspire Super 2.8EW (A16001)**	10.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **10.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	0.6 a	12.8 a
Quadris Top 2.71SC (A13703) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Quadris Top 2.71SC (A13703)**	14.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **14.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	0.4 a	3.1 bc
Inspire XT 4.17EC (A8122) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Inspire XT 4.17EC (A8122)**	5.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **5.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	1.7 a	11.2 ab
Inspire XT 4.17EC (A8122) Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Inspire XT 4.17EC (A8122)**	7.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **7.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	0.0 a	9.7 abc
A15909 2.2SE Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **A15909 2.2SE**	10.0 fl oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **10.0 fl oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	0.3 a	7.0 abc
Pristine 38WG Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG **Captan 80WDG** **Pristine 38WG**	12.5 oz 4.0 oz + 3.8 lb 4.0 oz + 3.75 lb **3.75 lb** **12.5 oz**	P, B, PF SS 1C – 2C 3C – 5C, **17 DPH** **9, 1 DPH**	0.0 a	9.6 abc
Quash 50WG Gem 500SC	2.5 oz 3.8 fl oz	P, B PF		

Rally 40WSP + BravoUltrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Quash 50WG** **Pristine 38WG** **Indar 2F**	4.0 oz + 3.8 lb 4.0 oz + 3.75 lb 3.75 lb **2.5 oz** **12.5 oz** **6.0 fl oz**	SS 1C – 2C 3C – 5C **17 DPH** **9 DPH** **1 DPH**	0.0 a	7.1 abc

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

EFFICACY OF DIFENOCONAZOLE MIXTURES ON DEVELOPMENT OF SCAB ON AUTUMNGLO PEACH

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Experimental fungicides Inspire Super (A16001, difenoconazole + cyprodinil), Quadris Top (A13703, difenoconazole + azoxystrobin), and Inspire XT (A8122, difenoconazole + propiconazole) were tested and compared to standard materials for efficacy against scab. In addition, Vangard applications during bloom were compared to Vangard alternated with Tilt, Gem, and Abound for management of blossom blight. Finally, the influence of these early and mid-season fungicide programs on brown rot development was also examined.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2009 growing season. The test block consisted of a 14-year-old ‘Autumnglo’ peach orchard planted at 25 ft x 25 ft spacing.

Treatments. Fungicide treatments were replicated four times in a randomized complete block design with single tree plots. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used for applications. All trees in the block received Bravo WeatherStik at 3 pt/A on 24 Mar for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 9 Jul by examining 20 shoots/tree for presence of cankers. Rusty spot (*Podosphaera leucotricha*) was evaluated on 25 Jun by counting the number of lesions on 40 fruit per tree. Scab (*Fusicladosporium carpophilum*) was evaluated on 20 Aug by examining 40 fruit per tree; fruit were sorted into categories of 0, 1-10, and >10 lesions. Harvest rot assessments were conducted on 9 Sep after most fruit had reached a “near tree-ripened” stage (a few lbs firmer than eating quality). Brown rot (*M. fructicola*), Rhizopus rot (*Rhizopus* spp.), and Anthracnose rot (*Colletotrichum* spp.) were evaluated by examining all fruit for absence or presence of disease on four or more branches per replicate tree (either minimum of 100 fruit/tree or all fruit on the tree if less than 100 fruit available). Given these observations, the dependent variables were expressed as percentage of shoots with canker (blossom blight) or percentage of fruit infected (all other diseases).

Analysis. An analysis of variance was performed on each dependent variable using the GLM procedure of the Statistical Analysis System v9.1. Means were compared using the Waller-Duncan *K*-Ratio Bayes test. Transformations were applied as needed to conform to the assumptions of normality, equality of variance, and independence of error terms.

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 21X data logger located at the research station. Observations were taken every minute and summarized every hour. Monthly temperature averages and rainfall accumulations were compared to 30-year means or sums, respectively, for Bridgeton, NJ.

RESULTS AND DISCUSSION

Environment. Overall, the growing season had above average rainfall (Table 1). May and July, the only months in the growing season with below average rainfall, had 3.28 inches and 2.42 inches of rainfall, respectively, a shortage of 0.79 inches and 1.88 inches from the 30 year average. August had 8.04 inches of rainfall, nearly twice the average of 4.18 inches. Temperatures in April and May were above average, while temperatures in June and July remained a couple of degrees below average. August was very close to the 30 year temperature average. Average monthly temperatures this growing season were: Apr, 54.0ºF, May 62.8ºF, Jun 68.7ºF, Jul 72.9ºF, and Aug 74.8ºF.

Blossom Blight. Above average rainfall and temperatures during bloom in April were favorable for blossom blight development (Table 1). Consequently, blossom blight canker levels were moderate to high with non-treated trees having 15.0% shoot infection (Table 1). This incidence level translates into approximately 90 cankers/tree.

All treatments significantly reduced blossom blight incidence and were equivalent to one another. Control ranged from 74.7% for Vangard / Tilt / Vangard (5 oz rate of Vangard) to 100% for Tilt / Vangard / Gem.

Rusty Spot. Conditions for rusty spot varied throughout the susceptible period from SS to 2C. Dry and warm conditions during the time of shuck split and 1st cover were favorable for rusty spot development. However, several days of cool, wet weather around the time of petal fall and 2nd cover were not conducive for rusty spot. Consequently, rusty spot disease pressure was moderate. Non-sprayed trees had 43.8% fruit infection (Table 2). In favorable years, 90-100% fruit infection can occur on highly susceptible Autumnglo.

The Gem/Rally standards provided 85.6% and 87.2% control. The experimental treatments all received Vangard at PF and Captan at 2C, neither of which is labeled for rusty spot. Nevertheless, all experimental materials significantly reduced rusty spot and Inspire XT provided equivalent control to the standard.

Scab. High inoculum levels in the form of twig lesions and frequent rain periods from SS (8 May) to 40 days pre-harvest (30 Jul) created extremely favorable conditions for scab development (Table 1). Scab incidence on non-sprayed control trees was 100% with over 99% of fruit having 10 or more lesions (Table 3). Many non-treated fruit were covered with large areas of coalescing lesions.

All treatments significantly reduced scab incidence and severity. The Bravo/Captan standards provided only 24.4% and 38.7% control of scab incidence and did not differ significantly from each other. Inspire Super and Pristine provided equivalent control to these standards. In contrast, Quadris Top and both rates of Inspire XT yielded significantly more control of scab than the standards. Quadris Top, Inspire XT at 5 fl oz, and Inspire XT at 7 fl oz reduced disease incidence by 82.5%, 70.6%, and 80.0%, respectively.

Inspire XT and Quadris Top also provided significantly more control of scab severity than the standards. These materials reduced the number of fruit with >10 lesions by 93.1-97.5% from the non-treated control. In comparison, the standards reduced the number of fruit in this same category by 72.9% and 74.2%.

Brown Rot. Conditions were very favorable for brown rot development. The month of August had very high rainfall with much of the rain taking place at the end of the month when fruit were ripening (Table 1). At harvest, 80.8% of fruit on the non-treated control trees were infected with brown rot (Table 4).

The first preharvest spray at 19 days before harvest was reapplied because rainfall began soon after application and continued for two days, potentially causing fungicide wash-off (Table 1). Over two inches of rainfall was accumulated during these two days.

Since this study was primarily designed for evaluating scab control, the same fungicides were applied during the preharvest ripening period for brown rot control. All of the treatments significantly reduced brown rot from the non-treated control and were equivalent to one another (Table 4). This result indicated that the test materials applied for blossom blight and scab management did not differentially influence brown rot control.

Rhizopus and Anthracnose Rot. There was very little Rhizopus rot at harvest. Non-treated control trees had 2.3% infected fruit (Table 4). All treatments provided 100% control of Rhizopus and were significantly different from the non-treated control. Anthracnose rot was present on all treatments at harvest, but the levels were very low (0.2-2.5% fruit infection). No significant differences were observed between the non-treated control and any of the treatments.

CONCLUSIONS

- **Quadris Top** provided excellent control of scab under high disease pressure. *This level of control has rarely been observed in past studies.* Azoxystrobin has good activity against scab, and recent results with Inspire indicate that difenoconazole also has good activity. Consequently, Quadris Top yielded the lowest levels of scab incidence and severity among all treatments in this study. The possibility of synergism between these two fungicides should be investigated.

- **Inspire XT** also provided excellent scab control. However, unlike Quadris Top, only the difenoconazole component has activity against scab. Nevertheless, the propiconazole component may be providing some synergistic action with the difenoconazole. More data are needed to determine this possibility. Finally, a slight rate effect was observed with Inspire XT, but the difference between the 5 and 7 fl oz rates was not significant.

- All experimental materials had a significant effect on rusty spot when sprayed at SS and 1C. **Inspire XT** at both rates was equivalent to the **Gem/Rally** standard. However, the experimental fungicides need to be applied to all four timings necessary for rusty spot control (PF, SS, 1C, 2C) in order to ascertain their true rusty spot efficacy.

- The treatment ending at 3C had significantly less brown rot than the non-treated control, thereby indicating that early sprays are important in reducing brown rot at harvest. This reduction may be attributed to the 100% control of blossom blight in this treatment, which eliminated within-tree inoculum (cankers) for brown rot. Similarly, lower inoculum levels and sprays [for scab] between shuck-split and pit hardening (2C) may have also lessened the occurrence of latent brown rot fruit infection.

- Vangard applied alone or in rotation with Tilt, Gem, or Abound during bloom provided good to excellent control of blossom blight canker development. No rate effect was apparent between the low and high rates of Vangard and Vangard/Tilt/ Vangard.

Table 1. Weather and spray timings for 2009 growing season at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stage. Units for daily average air temperature and rainfall are ºF and inches, respectively.

Date	Temp	Rain	Date	Temp	Rain	Date	Temp	Rain
1-Apr	47.01	0.28	29-Apr	56.6	0.10	27-May	62.44	0
2-Apr	55.54	0.37	30-Apr	**Petal Fall**		28-May	66.82	0
3-Apr	59.72	0.55	30-Apr	54.89	0	29-May	64.45	0.23
4-Apr	54.16	0	1-May	64.08	0.05	30-May	67.56	0
5-Apr	53.23	0	2-May	61.67	0.03	31-May	66	0.04
6-Apr	54	0.64	3-May	55.16	0.37	1-Jun	60.65	0
7-Apr	42.94	0.01	4-May	52.57	0.56	2-Jun	**2nd Cover**	
8-Apr	43.06	0	5-May	54.54	0.24	2-Jun	70.43	0.65
9-Apr	48.52	0	6-May	55.99	0.45	3-Jun	68.11	1.29
10-Apr	**Pink**		7-May	64.6	0.56	4-Jun	59.02	0.29
10-Apr	54.11	0	8-May	66.89	0.01	5-Jun	58.22	1.12
11-Apr	48.72	0.30	9-May	73.18	0	6-Jun	64.26	0.01
12-Apr	42.51	0	10-May	64.3	0	7-Jun	68.78	0
13-Apr	43.01	0	11-May	**Shuck Split**		8-Jun	71.79	0
14-Apr	44.7	0.89	11-May	56.45	0	9-Jun	69.17	0.03
15-Apr	43.86	0.27	12-May	58.04	0	10-Jun	70.27	0
16-Apr	47.2	0	13-May	57.06	0	11-Jun	67.49	0.05
17-Apr	50.39	0	14-May	63.66	0	12-Jun	75.63	0.01
18-Apr	61.09	0	15-May	67.77	0.10	13-Jun	72.38	0.02
19-Apr	55.99	0	16-May	68.44	0	14-Jun	67.62	0
20-Apr	49.89	0.51	17-May	60.46	0.25	15-Jun	66.01	0
21-Apr	56.56	0.33	18-May	53.71	0	16-Jun	63.09	0
22-Apr	49.31	0.01	19-May	53.19	0	17-Jun	**3rd Cover**	
22-Apr	**Bloom**		20-May	60.67	0	17-Jun	60.58	0.10
22-Apr	49.31	0.06	21-May	**1st Cover**		18-Jun	65.3	0.84
23-Apr	50.15	0	21-May	64.5	0	19-Jun	69.06	0.01
24-Apr	54.67	0	22-May	69.06	0	20-Jun	68.28	0.39

25-Apr	67.95	0
26-Apr	76.99	0
27-Apr	77.49	0
28-Apr	74.76	0

23-May	72.82	0
24-May	73.42	0
25-May	72	0.01
26-May	56.77	0.38

21-Jun	70.27	0
22-Jun	69.7	0.21
23-Jun	70.64	0

Table 1 – Continued –

Date	Temp	Rain
24-Jun	73.01	0
25-Jun	72.7	0
26-Jun	76.65	0
27-Jun	73.19	0
28-Jun	72.39	0
29-Jun	72.81	0
30-Jun	73.89	0
1-Jul	73.24	0.19
1-Jul	**4th Cover**	
2-Jul	72.32	0.26
3-Jul	71.38	0
4-Jul	71.85	0
5-Jul	70.58	0
6-Jul	71.8	0
7-Jul	75.19	0
8-Jul	70.2	0
9-Jul	67.31	0
10-Jul	66.33	0
11-Jul	69.17	0
12-Jul	75.08	0
13-Jul	70.63	0
14-Jul	**5th Cover**	
14-Jul	69.59	0
15-Jul	71.18	0
16-Jul	77.54	0
17-Jul	77.42	0.01
18-Jul	73.46	0

Date	Temp	Rain
21-Jul	69.51	0.37
22-Jul	72.4	0.01
23-Jul	71.36	0
24-Jul	70.75	0.26
25-Jul	73.81	0.01
26-Jul	77.87	0.01
27-Jul	76.78	0
28-Jul	**6th Cover**	
28-Jul	78.01	0
29-Jul	78.49	0.64
30-Jul	77.6	0.01
31-Jul	76.99	0.65
1-Aug	74.58	0
2-Aug	73.11	0.85
3-Aug	75.65	0.01
4-Aug	75.33	0
5-Aug	77.61	0
6-Aug	68.99	0.32
7-Aug	69.09	0
8-Aug	71.69	0
9-Aug	73.93	0.80
10-Aug	79.21	0.01
11-Aug	79.11	0
12-Aug	**7th Cover**	
12-Aug	75.25	0.14
13-Aug	71.69	0.30
14-Aug	72.93	0

Date	Temp	Rain
17-Aug	78	0
18-Aug	77.25	0.02
19-Aug	78.03	0.03
20-Aug	79.78	0
21-Aug	**19-DPH**	
21-Aug	80.86	0.07
22-Aug	74.84	2.00
23-Aug	76.94	0.23
24-Aug	**19-DPH reapplication**	
24-Aug	74.49	0
25-Aug	73.38	0
26-Aug	76.28	0
27-Aug	74.2	0
28-Aug	70.98	2.82
29-Aug	74.49	0.02
30-Aug	73.42	0.42
31-Aug	**9-DPH**	
31-Aug	65.81	0
1-Sep	63.08	0
2-Sep	63.44	0
3-Sep	65.42	0
4-Sep	71.2	0
5-Sep	70.44	0
6-Sep	66.69	0
7-Sep	**2-DPH**	
7-Sep	67.21	0
8-Sep	66.06	0

19-Jul	70.81	0
20-Jul	71.95	0

15-Aug	74.47	0
16-Aug	76.38	0

9-Sep	**Harvest**	

TABLE 2. Blossom Blight and Rusty Spot Incidence[1]			**Blossom Blight**	**Rusty Spot**
Treatment	**Rate / A**	**Timing**	**% Shoots w. canker**[2]	**% Fruit Inf** [2]
Non-treated Control	-----	-----	15.0 a	43.8 a
Tilt 3.6EC	**4 fl oz**	**P**		
Vangard 75WG	**5 oz**	**B**		
Gem 500SC	***3.8 fl oz***	***PF***		
Rally 40WSP + Bravo Ultrex 82.5WDG	*5 oz* + 3.8 lb	*SS*		
Rally 40WSP + Captan 80WDG	*5 oz* + 3.75 lb	*1C-2C*		
Captan 80WDG	3.75 lb	3C-7C		
Adament 50WG	6 oz	19 DPH		
Pristine 38WG	12 oz	9 DPH		
Adament 50WG	6 oz	2 DPH	1.3 b	6.3 d
Vangard 75WG	***5 oz***	**P, B, *PF***		
Inspire Super 2.8EW (A16001)	*10 fl oz*	*SS, 1C*, 3C, 4C, 6C, 7C		
Captan 80WDG	*3.75 lb*	*2C*, 5C		
Adament 50WG	6 oz	19 DPH		
Pristine 38WG	12 oz	9 DPH		
Adament 50WG	6 oz	2 DPH	2.5 b	16.9 c
Vangard 75WG	***7.5 oz***	**P, B, *PF***		
Quadris Top 2.71SC (A13703)	*14 fl oz*	*SS, 1C*, 3C, 4C, 6C, 7C		
Captan 80WDG	*3.75 lb*	*2C*, 5C		
Adament 50WG	6 oz	19 DPH		
Pristine 38WG	12 oz	9 DPH		
Adament 50WG	6 oz	2 DPH	2.5 b	13.8 c
Vangard 75WG	***5 oz***	**P, *PF***		
Tilt 3.6EC	**4 fl oz**	**B**		
Inspire XT 4.17EC (A8122)	5 fl oz	*SS, 1C*, 3C, 4C, 6C, 7C		
Captan 80WDG	*3.75 lb*	*2C*, 5C		
Adament 50WG	6 oz	19 DPH		
Pristine 38WG	12 oz	9 DPH		
Adament 50WG	6 oz	2 DPH	3.8 b	5.0 d
Vangard 75WG	***7.5 oz***	**P, *PF***		
Tilt 3.6EC	**4 fl oz**	**B**		
Inspire XT 4.17EC (A8122)	*7 fl oz*	*SS, 1C*, 3C, 4C, 6C, 7C		
Captan 80WDG	*3.75 lb*	*2C*, 5C		
Adament 50WG	6 oz	19 DPH		
Pristine 38WG	12 oz	9 DPH		
Adament 50WG	6 oz	2 DPH	2.5 b	5.0 d
Tilt 3.6EC	**4 fl oz**	**P**		
Vangard 75WG	**5 oz**	**B**		
Abound 2.08F	***15 fl oz***	***PF***		
Pristine 38WDG	*12.5 oz*	*SS, 1C*, 3C, 4C, 6C, 7C		
Captan 80WDG	*3.75 lb*	*2C*, 5C		
Adament 50WG	6 oz	19 DPH		
Pristine 38WG	12 oz	9 DPH		
Adament 50WG	6 oz	2 DPH	1.3 b	31.9 b
Tilt 3.6EC	**4 fl oz**	**P**		
Vangard 75WDG	**5 oz**	**B**		
Gem 500SC	***3.8 fl oz***	***PF***		

Rally 40WSP + Bravo Ultrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG	*5 oz* + 3.8 lb *5 oz* + 3.75 lb 3.75 lb	*SS* *1C, 2C* 3C	0.0 b	5.6 d

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

TABLE 3. Scab Incidence and Severity [1]			**% Fruit** [2]		
Treatment	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Non-treated control	-----	-----	100.0 a	0.6 d	99.4 a
Tilt 3.6EC Vangard 75WG Gem 500SC Rally 40WSP **+ Bravo Ultrex 82.5WDG** Rally 40WSP **+ Captan 80WDG** **Captan 80WDG** Adament 50WG Pristine 38WG Adament 50WG	4 fl oz 5 oz 3.8 fl oz 5 oz + **3.8 lb** 5 oz + **3.75 lb** **3.75 lb** 6 oz 12 oz 6 oz	P B PF **SS** **1C-2C** **3C-6C**, 7C 19 DPH 9 DPH 2 DPH	75.6 b	50.0 a	25.6 b
Vangard 75WG **Inspire Super 2.8EW (A16001)** **Captan 80WDG** Adament 50WG Pristine 38WG Adament 50WG	5 oz **10 fl oz** **3.75 lb** 6 oz 12 oz 6 oz	P, B, PF **SS, 1C, 3C, 4C, 6C**, 7C **2C, 5C** 19 DPH 9 DPH 2 DPH	56.9 b	33.1 b	23.8 b
Vangard 75WG **Quadris Top 2.71SC (A13703)** **Captan 80WDG** Adament 50WG Pristine 38WG Adament 50WG	7.5 oz **14 fl oz** **3.75 lb** 6 oz 12 oz 6 oz	P, B, PF **SS, 1C, 3C, 4C, 6C**, 7C **2C, 5C** 19 DPH 9 DPH 2 DPH	17.5 c	15.0 c	2.5 c
Vangard 75WG Tilt 3.6EC **Inspire XT 4.17EC (A8122)** **Captan 80WDG** Adament 50WG Pristine 38WG Adament 50WG	5 oz 4 fl oz **5 fl oz** **3.75 lb** 6 oz 12 oz 6 oz	P, PF B **SS, 1C, 3C, 4C, 6C**, 7C **2C, 5C** 19 DPH 9 DPH 2 DPH	29.4 c	22.5 bc	6.9 c
Vangard 75WG Tilt 3.6EC **Inspire XT 4.17EC (A8122)** **Captan 80WDG** Adament 50WG Pristine 38WG Adament 50WG	7.5 oz 4 fl oz **7 fl oz** **3.75 lb** 6 oz 12 oz 6 oz	P, PF B **SS, 1C, 3C, 4C, 6C**, 7C **2C, 5C** 19 DPH 9 DPH 2 DPH	20.0 c	15.6 c	4.4 c
Tilt 3.6EC Vangard 75WG Abound 2.08F **Pristine 38WDG** **Captan 80WDG** Adament 50WG Pristine 38WG Adament 50WG	4 fl oz 5 oz 15 fl oz **12.5 oz** **3.75 lb** 6 oz 12 oz 6 oz	P B PF **SS, 1C, 3C, 4C, 6C**, 7C **2C, 5C** 19 DPH 9 DPH 2 DPH	70.0 b	35.6 b	34.4 b
Tilt 3.6EC Vangard 75WDG	4 fl oz 5 oz	P B			

Gem 500SC Rally 40WSP + **Bravo Ultrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG**	3.8 fl oz 5 oz + **3.8 lb** 5 oz + **3.75 lb** **3.75 lb**	PF **SS** **1C, 2C** **3C**	61.3 b	34.4 b	26.9 b

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

TABLE 4. Brown Rot and Rhizopus Rot Incidence at Harvest[1]			**% Fruit Infected** [2]	
Treatment	**Rate / A**	**Timing**	**Brown Rot**	**Rhizopus Rot**
Non-treated control	-----	-----	80.8 a	2.3 a
Tilt 3.6EC Vangard 75WG Gem 500SC Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Adament 50WG** **Pristine 38WG** **Adament 50WG**	4 fl oz 5 oz 3.8 fl oz 5 oz + 3.8 lb 5 oz + 3.75 lb 3.75 lb **6 oz** **12 oz** **6 oz**	P B PF SS 1C-2C 3C-7C **19 DPH** **9 DPH** **2 DPH**	13.3 c	0.0 b
Vangard 75WG Inspire Super 2.8EW (A16001) Captan 80WDG **Adament 50WG** **Pristine 38WG** **Adament 50WG**	5 oz 10 fl oz 3.75 lb **6 oz** **12 oz** **6 oz**	P, B, PF SS, 1C, 3C, 4C, 6C, 7C 2C, 5C **19 DPH** **9 DPH** **2 DPH**	8.2 c	0.0 b
Vangard 75WG Quadris Top 2.71SC (A13703) Captan 80WDG **Adament 50WG** **Pristine 38WG** **Adament 50WG**	7.5 oz 14 fl oz 3.75 lb **6 oz** **12 oz** **6 oz**	P, B, PF SS, 1C, 3C, 4C, 6C, 7C 2C, 5C **19 DPH** **9 DPH** **2 DPH**	12.3 c	0.0 b
Vangard 75WG Tilt 3.6EC Inspire XT 4.17EC (A8122) Captan 80WDG **Adament 50WG** **Pristine 38WG** **Adament 50WG**	5 oz 4 fl oz 5 fl oz 3.75 lb **6 oz** **12 oz** **6 oz**	P, PF B SS, 1C, 3C, 4C, 6C, 7C 2C, 5C **19 DPH** **9 DPH** **2 DPH**	5.8 c	0.0 b
Vangard 75WG Tilt 3.6EC Inspire XT 4.17EC (A8122) Captan 80WDG **Adament 50WG** **Pristine 38WG** **Adament 50WG**	7.5 oz 4 fl oz 7 fl oz 3.75 lb **6 oz** **12 oz** **6 oz**	P, PF B SS, 1C, 3C, 4C, 6C, 7C 2C, 5C **19 DPH** **9 DPH** **2 DPH**	6.4 c	0.0 b
Tilt 3.6EC Vangard 75WG Abound 2.08F Pristine 38WDG Captan 80WDG **Adament 50WG** **Pristine 38WG** **Adament 50WG**	4 fl oz 5 oz 15 fl oz 12.5 oz 3.75 lb **6 oz** **12 oz** **6 oz**	P B PF SS, 1C, 3C, 4C, 6C, 7C 2C, 5C **19 DPH** **9 DPH** **2 DPH**	4.6 c	0.0 b

Tilt 3.6EC Vangard 75WDG Gem 500SC Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG	4 fl oz 5 oz 3.8 fl oz 5 oz + 3.8 lb 5 oz + 3.75 lb 3.75 lb	P B PF SS 1C, 2C 3C	51.9 b	0.0 b

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

EVALUATION OF ALTERNATIVES TO OXYTETRACYCLINE AND STREPTOMYCIN FOR CONTROL OF BACTERIAL SPOT IN PEACH AND FIRE BLIGHT IN APPLE

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Bacterial spot and fire blight are two highly destructive bacterial diseases of tree fruit in the Northeastern U.S. The standard method for their control is the use of the antibiotics oxytetracycline for bacterial spot and streptomycin for fire blight. With heavy reliance on antibiotics there is always the risk of bacterial resistance to the antibiotics. This study aims to test the effectiveness of alternatives to antibiotics for control of these diseases.

Bacterial spot: The bacterial spot test was carried out in a four-year-old, 4-cultivar (‘Easternglo’, ‘Beekman’, ‘Snow King’ and ‘Sweet Dream’) peach and nectarine orchard at the Penn State Fruit Research and Extension Center, Biglerville, PA. Trees received fungicide and insecticide applications according to standard commercial practice for the northeastern U.S., but early-season (dormant through bloom) copper sprays were omitted to allow build-up of bacterial inoculum. The plots were inoculated on 1 May (shuck-split) with a suspension of 1×10^7 CFUs of *X. arboricola* pv. *pruni* consisting of a mixture of strains Xap 42 and Xcp 88-301. The suspension was applied with a handgun sprayer to run-off. Treatments included: a garlic product (diallyl sulfides) applied solely or in a mixture with a low concentration of Kocide 3000; the antibiotic Kasumin applied in a mixture either with Kocide 3000 or the fungicide Captan; a Mycoshield-only treatment, and an untreated control for comparison. The experimental design was a four replicate split-plot arrangement with treatment and cultivar assigned to main-plots and sub-plots, respectively. Sub-plot treatments consisted of single trees of each cultivar. Treatments were applied dilute with a boom sprayer at 400 psi, which delivered 100.0 gal/A on 28 May, 8, 18, 30 Jun, 9, 20 Jul, and 13 Aug. Plots were rated for foliar disease severity (percent leaf area infected based on a sample of up to 60 leaves per replicate tree) on 24 Jul. Upon harvest, ten infected fruits from each sub-plot were rated for percent area infected and scored for disease severity on a 1-to-5 scale whereby, 1= no disease and 5=severe infection. Fruits with a mean score greater than 2.5 would be considered unmarketable.

There was ample rainfall for disease development, but below average temperatures kept disease levels relatively low at the trial site. Bacterial leaf spot severity was significantly affected by treatment and cultivar ($P < 0.0001$) but not by the interaction between these factors. The Kocide and Kasumin + Kocide treatments had consistently higher disease severity levels than the other treatments, including the control (Fig. 1A, B, C & D). This was possibly the result of copper injury on the foliage being attributed to bacterial spot symptoms. Treatment, cultivar and the interaction between these factors had a highly significant ($P<0.0001$) effect on both the percent fruit area covered with bacterial spots as well as the fruit disease severity score. Except for the garlic product applied alone, all treatments were effective at reducing disease severity on fruits across all cultivars (Fig 2A, B). All treatments, with the exception of garlic, also reduced the fruit severity score compared to the control on all cultivars (Fig. 3A, B). Treatments containing Kocide or Kasumin + Captan typically provided as good as or better fruit protection than the Mycoshield standard. Furthermore, these results suggest that copper compounds and the fungicide Captan may have synergistic activity on Kasumin since this antibiotic alone is generally not effective on bacterial spot. Additional research is needed to test this hypothesis and investigate whether synergistic interactions also occur between copper compounds and the garlic product.

Fire blight: Fire blight testing was carried out in a mature 'Rome Beauty' and 'Red Delicious' apple orchard at the Penn State Fruit Research and Extension Center in Biglerville, PA. Trees received insecticide and fungicide applications, including dormant copper sprays, consistent with standard commercial practice for the northeastern U.S. Experimental treatments included three biological control products (Serenade Plus, *Pantoea agglomerans* products, or Regalia), two antibiotics (Mycoshield, or Kasumin), and a copper product (Kocide 3000). A streptomycin standard treatment and an untreated control were used for comparison. The *P. agglomerans* II treatment was applied on 28 Apr, 1 May, and 5 May; all other products were applied on 28 Apr and 1 May only. Treatments were applied dilute with a boom sprayer at 400 psi, which delivered 100.0 gal/A. The experimental design was a split-plot arrangement with treatments and cultivar as main-plot and sub-plot factors, respectively. Each treatment was replicated four times. Between 21 and 36 flower clusters were tagged on each tree and inoculated on 29 Apr with a suspension of $1X10^8$ CFUs of *Erwinia amylovora* strain Ea 273. Trees were assessed for fire blight incidence (percent diseased clusters) and disease severity (0-to-4 scale, where 0=no infection; 1=1-25%; 2=26-50%, 3=51-75; 4=76=100% cluster infection) on May 18. Data were analyzed with analysis of variance and means separated using Fisher's protected LSD test (P = 0.05).

Weather was conducive for blossom infection and fire blight development resulting in high levels of infection, particularly on Rome Beauty. There was not a significant treatment cultivar interaction so data from the two cultivars were combined for analysis. Agri-Mycin, Kasumin, Mycoshield, and the *P. agglomerans* I treatments significantly reduced fire blight incidence (Fig. 4), while the Agri-Mycin and both *P. agglomerans* treatments reduced disease severity (Fig. 5). Failure of many of the biological control treatments and poor performance of the streptomycin standard is likely due to a combination of factors such as inoculation procedures and the very high disease pressure. Additional research is warranted to test these products under low to moderate disease pressure typical of commercial orchards.

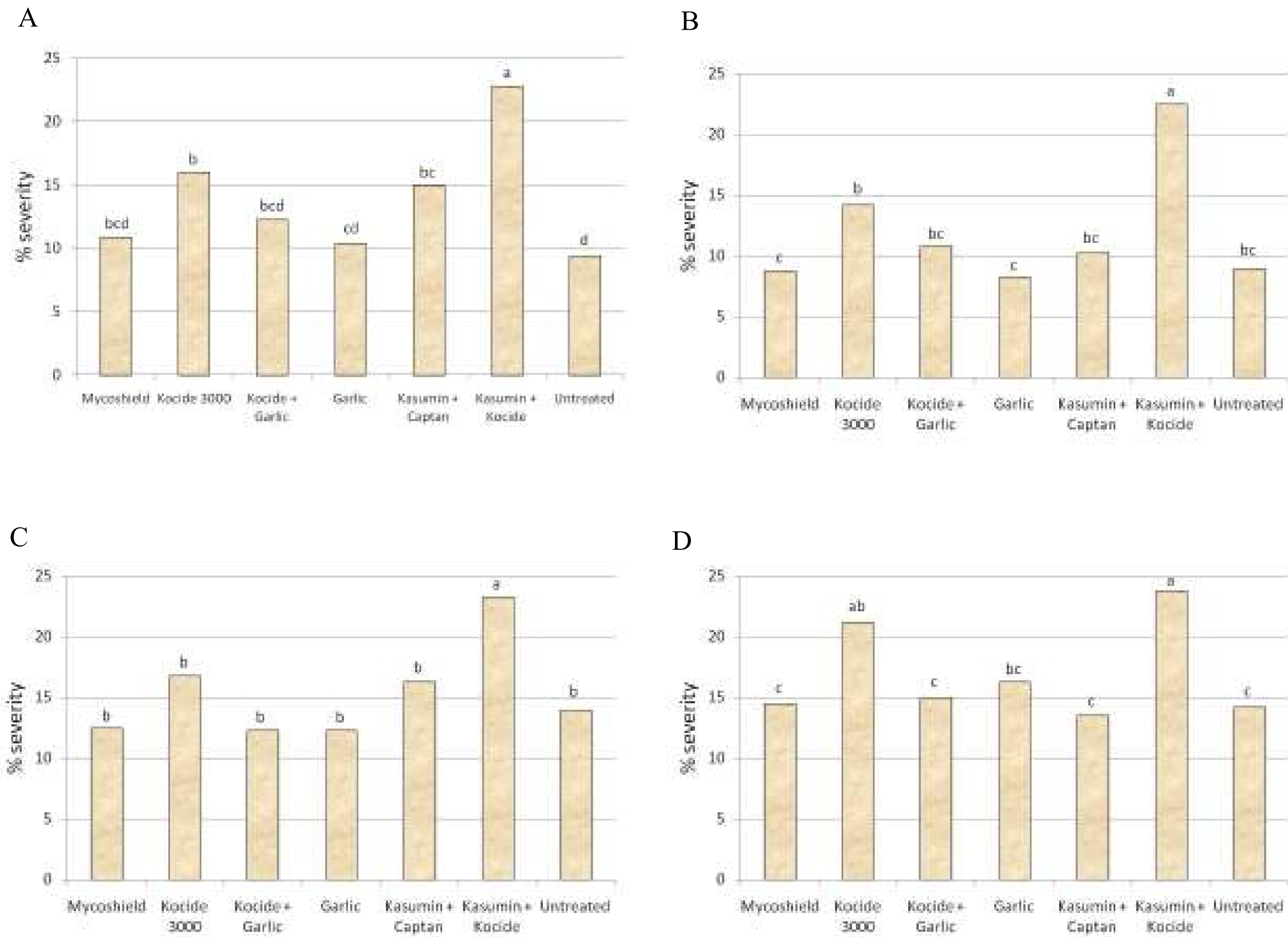
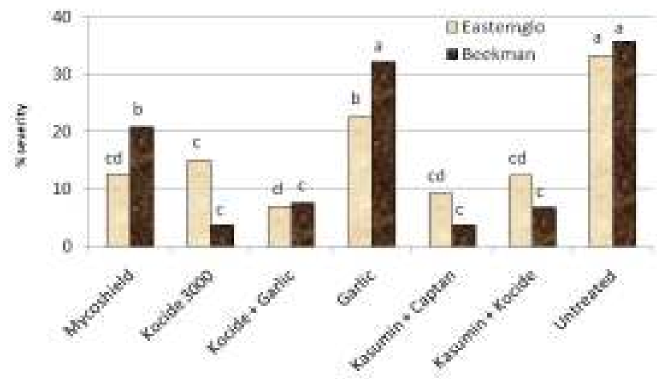


Fig. 1. Mean bacterial spot leaf severity across different treatments on ‘Easternglo’ (A) nectarine, and ‘Beekman’ (B), ‘Snow King’ (C), and ‘Sweet Dream’ (D) peaches at the Penn State Fruit Research Extension Center, in Biglerville, PA in 2009. Values are means of four replicate single-tree plots. Mean leaf severity is based on

a visual estimate of the foliar surface area infected with lesions. Column means with the same letter(s) are not significantly different according to Fisher's Protected LSD test (α=0.05).

A



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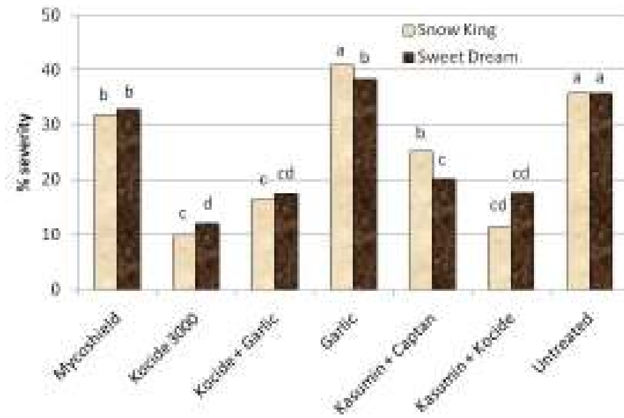
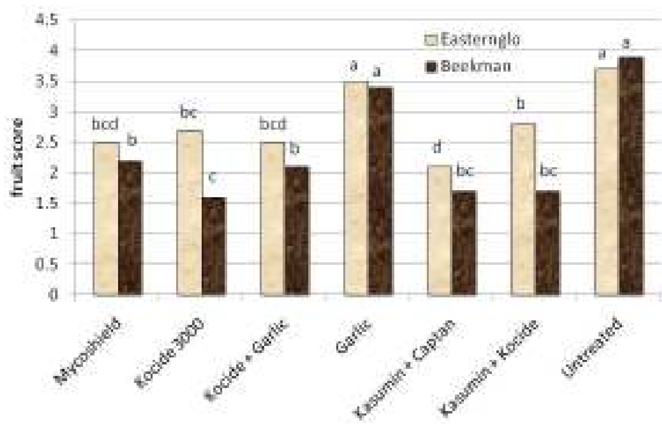


Fig. 2. Mean bacterial spot fruit severity across different treatments on 'Easternglo' and 'Beekman' (A), and 'Snow King' and 'Sweet Dream' (B) nectarine and peaches at the Penn State Fruit Research Extension Center, in Biglerville, PA in 2009. Values are means of four replicate single-tree plots. Mean severity is based on a visual estimate of the fruit surface area infected with lesions. Columns means with the same letter(s) are not significantly different according to Fisher's Protected LSD test (α=0.05).

A



B

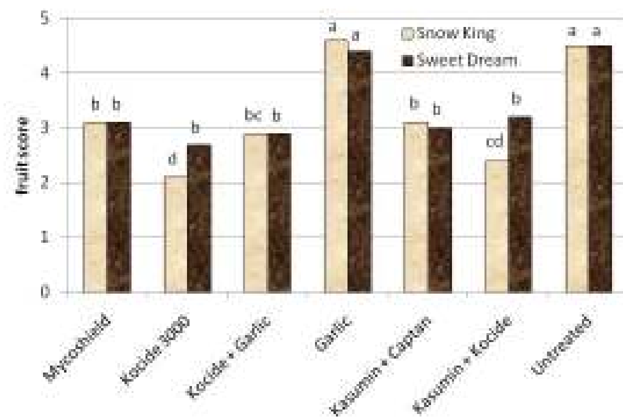


Fig. 3. Mean bacterial spot fruit score across different treatments on ‘Easternglo’ and ‘Beekman’ (A), and ‘Snow King’ and ‘Sweet Dream’ (B) nectarine and peaches at the Penn State Fruit Research Extension Center, in Biglerville, PA in 2009. Values are means of four replicate single-tree plots. Mean fruit score for disease severity based on a 1to 5 scale whereby, 1= no disease and 5=severe infection. Fruits with a mean score greater than 2.5 are considered unmarketable. Columns means with the same letter(s) are not significantly different according to Fisher’s Protected LSD test (α=0.05).

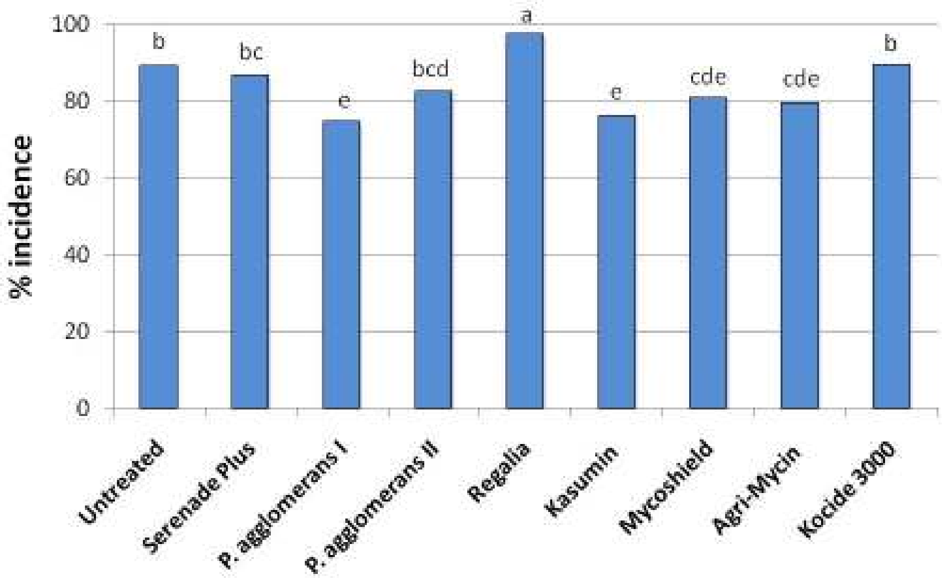


Fig. 4. Mean fire blight incidence on ‘Rome Beauty’ and ‘Red Delicious’ apples combined at the Penn State Fruit Research Extension Center, in Biglerville, PA in 2009. Values are means of four replicate single-tree plots with an average of 31 inoculated clusters per tree. Columns means with the same letter(s) are not significantly different according to Fisher’s Protected LSD test (α=0.05).

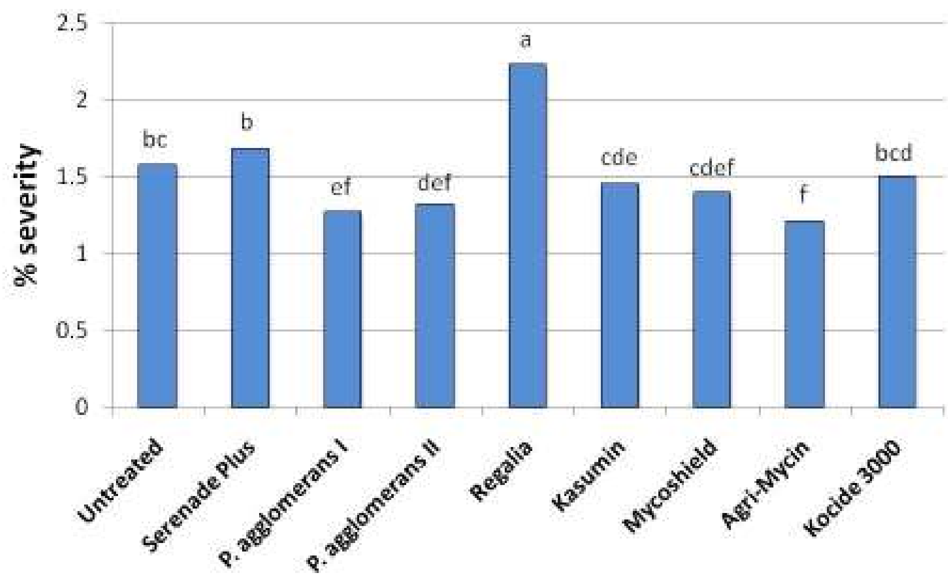


Fig. 5. Mean fire blight severity on ‘Rome Beauty’ and ‘Red Delicious’ apples combined at the Penn State Fruit Research Extension Center, in Biglerville, PA in 2009. Values are means of four replicate single-tree plots with an average of 31 inoculated clusters per tree. Severity is based on a 0-to-4 scale, where 0=no infection; 1=1-25%; 2=26-50%;

3=51-75; 4=76=100% flower cluster infection. Columns means with the same letter(s) are not significantly different according to Fisher's Protected LSD test (α=0.05).

What Statistics Should a PDMR Contain to be Included in a Meta-analysis?

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Abstract

Plant pathologists publish the results of many studies evaluating products for disease control in the journal Plant Disease Management Reports (PDMR) that could be formally synthesized in a meta-analysis. Unfortunately, most of those studies cannot readily be included in meta-analysis because they lack key statistics. The aim of this paper is to outline the statistics that should be reported in order for a study to be acceptable for a meta-analysis, and to illustrate how to obtain such statistics from computer data analysis output. The key statistics that must be reported are the measure of treatment effect (usually the mean disease levels in plots subjected to the treatment of interest) that most studies already include, and a measure of study variability, usually the variance (V). Other relevant information such as general statements about disease pressure, weather conditions etc, etc, should also be included as they can be readily coded into moderator variables.

Introduction

Pesticide tests are to plant pathology what clinical trials are to medicine; they constitute the final stages in the evaluation of promising products before registration for commercial use. The key questions being addressed in nearly all agricultural pesticide efficacy tests relate to the effectiveness and consistency of the products under evaluation across a wide range of test conditions such as cultivars, location, disease pressure etc, etc. Questions about the *effectiveness* and *consistency* of product performance are best addressed by combining results from multiple tests using appropriate statistical methods. The statistical procedures for quantitatively combining results from multiple studies are formally referred to as meta-analysis (Borenstein et al., 2009; Whitehead, 2002). The basic idea behind a meta-analysis is that a single study is not sufficient to resolve a major issue and that science is built on accumulation of knowledge from the results of many studies (Hunter and Schmidt, 2004).

Plant pathologists, regularly publish the results of fungicide testing in the *Plant Disease Management Reports* (PDMR) (formerly *Fungicide & Nematicide Tests* [F&N Tests], *Biological & Cultural Tests* [B&C Tests]). Indeed, those attending the Cumberland-Shenandoah Fruit Workers Conference average over 30 such reports each year. Unfortunately, most of these reports cannot readily be included into a meta-analysis because they lack the key statistics critical to meta-analytic procedures based on frequentist approach. For example, over 95% of the studies published on fire blight published in PDMRs did not contain the relevant statistics (Ngugi H.K., Unpublished). The aim of this paper is to outline the statistics that should be included in order for a study to be readily acceptable for meta-analysis and to illustrate how to obtain such statistics from computer data analysis output.

What statistics are necessary?

By definition, any meta-analysis sets out to determine the *mean effect size* (i.e. effectiveness) and *consistency* of any given treatment (e.g. new fungicide or biocontrol product) that has been evaluated across several studies. The two key statistics required from each individual study therefore are: (i) an estimate of the effect size, and (ii) a measure of study variability (i.e. variance). The effect size is defined as: "a value, index, parameter, or statistic which reflects the magnitude and direction of the treatment effect or the strength of a relationship between two variables (Borenstein et al., 2009). In the case of fungicide tests for example, the commonly reported effect size is the mean disease level estimated from plots treated with the test fungicide. Nearly all PDMRs that I have seen do a very good job of reporting the appropriate effect size statistic.

An equally important but rarely reported statistic is the measure of study variability. The measure of study variability is critical to a meta-analysis because one of the steps in determining the mean effect size involves weighting the effect size. The rationale behind weighting the effect sizes is to ensure that studies that provide the most precise measure of product performance contribute more to the *mean effect size* for that product computed across all studies. Weighting is usually achieved by multiplying the effect size from an individual study with the inverse of the *variance* for that study. A measure of individual study variance can be reported in various ways, including % coefficient of variation (CV), and mean square error (MSE). The variance can also be computed easily from other statistics for example the specific value of Fischer' Protected LSD which is often referred to but not reported. For example, given the value of LSD for a given variable within a study, e.g. disease severity, the variance (V) can be computed with a simple equation: $V = \frac{n \cdot (LSD/1.96)^2}{2}$ (Lipsey and Wilson, 2001; Paul et al., 2007) where n is the number of replications—usually 4 or 5 for most studies reported by in PDMRs. Care should be taken in particular with regard to CV and LSD values to be included in a report. This is because it is possible to obtain different values of these statistics depending on the study design. The value to be reported must be the one for the variable being analyzed for the case of CV, and the LSD must be the value used for mean separations as reported in the tables included in the PDMR.

Other relevant information about the study should be included in the PDMR. For example, it is helpful to provide as much information about the study conditions as possible, e.g. if disease pressure was high or other factors that might have influenced the results. Whenever possible, this information should be provided in a quantitative rather than descriptive manner. The value of this information is that it can be included in a meta-analysis as moderator variables which are akin to covariates in the standard analysis of variance or regression analyses.

Where do I find the relevant statistics?

The required statistics can be obtained from the analysis of variance output from standard statistical software such as SAS. Figure 1 below shows a typical output from analysis of variance using the GLM procedure of SAS. The % CV and MSE are in indicated in bold and italics below the model variance partitioning summary. The MSE can also be obtained by squaring the "Root MSE" which is the square-root of MSE. Other software will produce variations of this information but the MSE is almost universal in analysis of variance by all statistical software

FIG. 1. Typical printout from SAS analysis of variance using the GLM procedure

The GLM Procedure

Dependent Variable: incid

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	5046.09788	296.82929	0.77	0.7127
Error	50	19180.23504	***383.60470***		
Corrected Total	67	24226.33292			

R-Square	***Coeff Var***	***Root MSE***	incid Mean
0.208290	*23.13971*	*19.58583*	84.64162

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cult	1	685.927072	685.927072	1.79	0.1872
trt	8	3094.266718	386.783340	1.01	0.4419
cult*trt	8	1265.904091	158.238011	0.41	0.9080

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cult	1	555.706966	555.706966	1.45	0.2344
trt	8	3285.831183	410.728898	1.07	0.3985
cult*trt	8	1265.904091	158.238011	0.41	0.9080

When these statistics are not readily available, and it is difficult to envisage such a situation, the simplest way to obtain them is to run a "univariate" analysis such as the one given in figure 2 from the same data set. As with figure 1, the relevant statistics are indicated in bold and italic fonts. Note that the standard deviation, another measure of variability, of the variate being analyzed is the square-root of the variance. As with LSD, this statistic should be treated with caution because it is possible to have different values of standard deviation (e.g. those of the individual treatments within a study) from the same analysis printout. Where this information is not presented, it is still possible to compute the an estimate of variance if the specific *P* value (not the cut-off level of *P* such as is commonly used, [e.g. $P < 0.05$] BUT the actual value such as Pr >F = 0.4419 [for **'trt'** in fig. 1 above]) is indicated either in the table or in the report narrative. However, this statistic can be problematic for reasons that are beyond the scope of this paper.

Fig. 2. Typical 'univariate' analysis output from SAS software

```
        The UNIVARIATE Procedure
                 Variable:  incid
                   Moments
N                      68    Sum Weights          68
Mean            84.6416176    Sum Observations   5755.63
Std Deviation   19.0154426   Variance          361.587059
Skewness        -1.7879318   Kurtosis           3.10886415
Uncorrected SS  511392.167   Corrected SS       24226.3329
Coeff Variation 22.4658308    Std Error Mean    2.30596113


             Basic Statistical Measures
     Location                    Variability
  Mean     84.6416    Std Deviation          19.01544
  Median   90.9100    Variance              361.58706
  Mode    100.0000    Range                  77.42000
                      Interquartile Range    22.04500
```

How should these statistics be presented?

I recommend that in the typical PDMR table, one or two additional rows be included below the last treatment. One should contain the MSE value for each variable reported since this is the statistic that is most universal and least likely to cause confusion among writers. If one is so inclined, either %CV the grand mean or the LSD should be included in the other. Those using statistical services can request for this information from their statistician along with the table of means.

Acknowledgments

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Grape (*Vitis vinifera* 'Chardonnay')
Downy mildew; *Plasmopara viticola*

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Fungicide performance trial for downy mildew at Winchester, VA, 2009

Variety used in the trial was 'Chardonnay', planted in 2000, trained in divided canopy (Lyre), and spacing between vines was 6-ft between vines and 10-ft between rows. Each row contains 45 vines including boarder row (3 vines). Experimental design was completely randomized design and the experimental unit was a single vine, and every other vine in the field received treatment. i.e., vine next to the treatment did not receive any treatment, other than insecticide. Treatments were applied using 3 gallon sprayer tank which is pressurized using compressed air. The output pressure was regulated to 21 psi by CFValve system (GATE LLC). Treatment was applied using single boom with a flat fan nozzle (TeeJet 8003VS). The beginning of treatments were at pre-bloom, then it was repeated after 10 days at bloom, then rotated once with Ridomil gold copper at the first cover spray, then applied two more times with 14-day interval. Visual assessment of diseases was made four times in the season. Sixty leaves and ten clusters per vine were randomly selected assessed for diseases (a total of 240 leaves and 40 clusters per treatment), and percentage of estimated diseased area (disease severity) was recorded. Linear mixed model was used to conduct the analysis of variance (JMP 7.0.1, SAS institute, Cary NC). Treatment was considered as fixed effect, and replication was considered as random effect. Mean comparison was made with Tukey-Kramer adjustment method with overall error rate set to 0.05. Row data without transformation was used.

Weather was very conducive for downy mildew development. Winchester location received ~5.8 inches of rain from bud break to bloom. Although experiment was designed to last until the end of the season, high amount of disease on the untreated control vines forced us to terminate treatments at veraison. Disease assessment data at 24 July 09, which was taken just before the termination, is presented in this report.

Mean disease incidence of downy mildew per treatment varied from 8.3% to 94% and disease severity varied from 0.1% to 13% (Table 1). Treatment effects were significant ($P<0.001$), and disease incidence and severity showed that clear separation of treatment for downy mildew (Table 1). Overall majority of treatment suppressed the disease to 10-20% in incidence and less than 1% in severity. Given the number of infection events we observed early in the season, all treatment presented good to excellent results. Notable results include downy mildew development with Tanos treatment; however, it was applied by itself even though the label required to mix with a broad spectrum fungicide such as mancozeb. Since only a few berries were infected with downy mildew, cluster infection data was not analyzed.

Table 1. Efficacy of fungicide treatment based on disease incidence and severity of downy mildew on leaf, variety Chardonnay 2009 at Winchester AREC, VA

		Disease incidence[z]		Disease severity[y]	
Treatment name (rate/A)	**Days after first application**	**LS mean[w]**		**LS mean[w]**	
Revus 250SC (7 fl oz/A) then Ridmil Gold/Copper 65 (2lb/A)	38, 53(Revus), 67 (Ridomil), 79, 92 (Revus)	20.42	cde	0.63	cd
Revus Top 4.17 SC (6 fl oz/A) then Ridomil Gold/Copper 65 (2lb/A)	38, 53(Revus), 67 (Ridomil), 79, 92 (Revus)	9.17	ef	0.28	d
Revus Top 4.17 SC (7 fl oz/A) then Ridomil Gold/Copper 65 (2lb/A)	38, 53(Revus), 67 (Ridomil), 79, 92 (Revus)	24.17	bcd	0.91	cd
GAVEL 75 DF (3 lb/A)	38, 53, 67, 79, 92	8.33	f	0.12	d
GAVEL 75 DF (3 lb/A)	38, 53, 67, 79, 92	13.33	def	0.41	d
Dithane DF (3lb/A) then Ridomil Gold/Copper 65 (2lb/A)	38, 53(Dithane), 67 (Ridomil), 79, 92 (Revus)	35.42	b	1.89	c
Dithane DF (3lb/A) then Ridomil Gold/Copper 65 (2lb/A) then Prophyt (2 qt/A)	38, 53(Dithane), 67 (Ridomil), 79, 92 (Prophyt)	30.42	bc	1.04	cd
Untreated		93.75	a	13.30	a
Tanos[v] (8 oz/A) then Ridomil Gold/Copper 65 (2lb/A)	38, 53(Tanos), 67 (Ridomil), 79, 92 (Tanos)	90.83	a	7.82	b

[z] Disease incidence = percentage of diseased leaves
[y] Disease severity = percentage of area of leaves that is diseased
[x] Treatment number corresponds to number in Tables 2 and 3
[w] LS mean = least square mean of percentage. The same letter indicates there were no significant difference between treatment (Tukey-Kramer adjustment method, α=0.05)
[v] Applied by itself (required to mix with a broad spectrum material by the label)

Grape (*Vitis vinifera* 'Chardonnay')
Powdery mildew; *Erysiphe necator* (synonym: *Uncinula necator*)

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595 Laurel Grove Rd
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Fungicide performance trial for powdery mildew at Winchester, VA, 2009

Variety used in the trial was 'Chardonnay', planted in 2000, trained in divided canopy (Lyre), and spacing between vines was 6-ft between vines and 10-ft between rows. Each row contains 45 vines including boarder row (3 vines). Experimental design was completely randomized design and the experimental unit was a single vine, and every other vine in the field received treatment. i.e., vine next to the treatment did not receive any treatment, other than insecticide. Treatments were applied using 3 gallon sprayer tank which is pressurized using compressed air. The output pressure was regulated to 21 psi by CFValve system (GATE LLC). Treatment was applied using single boom with a flat fan nozzle (TeeJet 8003VS). The beginning of treatments were at pre-bloom, then it was repeated after 10 days at bloom, then rotated once with Ridomil gold copper at the first cover spray, then applied two more times with 14-day interval. Visual assessment of diseases was made four times in the season. Sixty leaves and ten clusters per vine were randomly selected assessed for diseases (a total of 240 leaves and 40 clusters per treatment), and percentage of estimated diseased area (disease severity) was recorded. Linear mixed model was used to conduct the analysis of variance (JMP 7.0.1, SAS institute, Cary NC). Treatment was considered as fixed effect, and replication was considered as random effect. Mean comparison was made with Tukey-Kramer adjustment method with overall error rate set to 0.05. Row data without transformation was used.

For most of the season, weather was not very conducive for powdery mildew development. Consistent rain between bud break to bloom (Winchester location received ~5.8 inches), probably promoted ascospore release; however from May 18-20th there were frost advisory issued in the area. Winchester location did not receive a frost, but the temperature dropped low enough to cause deformation of newly emerging leaves. That cold temperature may have slowed down the initial population build up for powdery mildew. Throughout the state, conditions were not favoring powdery mildew (which is not common in VA), yet, there was strong development observed at Winchester location in mid-July. Although experiment was designed to last until the end of the season, high amount of downy mildew and powdery mildew on the untreated control vines forced us to terminate treatments at veraison. Disease assessment data at 24 July 09, which was taken just before the termination, is presented in this report.

Mean disease incidence of powdery mildew per treatment varied from 0% to 92% and disease severity varied from 0% to 33% (Table 1). Treatment effects were significant (P<0.001), and disease incidence and severity showed that clear separation of treatment for powdery mildew (Table 1). Overall majority of treatment suppressed the disease to less than 2% in incidence and less than 0.1% in severity. Based on severe infection on untreated vines, all treatment presented excellent results. Disease severity on bunch is little higher than that of leaves, but it could be due to lack of coverage by low pressure spray.

Table 1. Efficacy of fungicide treatment based on disease incidence and severity of powdery mildew on leaf, variety Chardonnay 2009 at Winchester AREC, VA

		Disease incidence[z]		Disease severity[y]		Disease severity (bunch)[y]	
Treatment name (rate/A)	**Days after first application**	**LS mean[w]**		**LS mean[w]**		**LS mean[w]**	
GWN-4617 (3.4 fl oz/A) (experimental)	0, 7, 22, 33, 39, 54, 68	2.08	b	0.08	b	2.74	b
Vintage SC (4 fl oz/A) then GWN-4671 (3.4 fl oz/A) (experimental)	0, 7, 22 (Vintage), 33, 39, 54, 68, (GWN-4671)	0.00	b	0.00	b	12.75	b
Quintec (4 fl oz/A)	39, 54, 68	0.83	b	0.01	b	1.89	b
Rally 40WPS (3 lb/A) then Microthiol D (4 lb/A)	39, 54(Rally), 68 (Microthiol)	0.42	b	0.02	b	6.96	b
Rally 40WPS (3 lb/A)	39, 54, 68	2.08	b	0.04	b	6.08	b
Untreated		92.08	a	32.92	a	94.36	a
Mettle 125ME (5 fl oz/A)	39, 54, 68	0.83	b	0.01	b	4.30	b
LEM-17 (16 fl oz/A) (experimental)	39, 54, 68	1.67	b	0.05	b	0.68	b

z Disease incidence = percentage of diseased leaves
y Disease severity = percentage of area of leaves or bunches that is diseased
x Treatment number corresponds to number in Tables 2 and 3
w LS mean = least square mean of percentage. The same letter indicates there were no significant difference between treatment (Tukey-Kramer adjustment method, α=0.05)

EVALUATING NEW STONE FRUIT ROOTSTOCKS AND CULTIVARS FOR SUSCEPTIBILITY TO X-DISEASE AND TOMATO RINGSPOT VIRUS

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This paper is a preliminary report on a multi-year field trial that was established in 2009 at the Hudson Valley Lab to investigate susceptibility of new stone fruit rootstocks and cultivars to two pathogens that can destroy stone fruit plantings. Stone fruits are a minor but profitable crop in southeastern New York and southern New England. New cultivars, rootstock and planting systems are allowing growers to bring plantings into production quickly using planting designs that can keep trees small either via dwarfing rootstocks or via other management practices. In southeastern New York, some sweet cherry growers are marketing pick-your-own cherries at $5/pound and are experimenting with rain cover systems that cost roughly $50,000/A with the objective of eliminating rain cracking and bird-related damage and losses. Before investing in rain covers, growers need more information on the risk that these expensive plantings might be destroyed by X-disease or ToRSV infection before establishment costs can be recovered.

X-disease and tomato ringspot virus (ToRSV) are endemic stone fruit diseases that can destroy stone fruit plantings rapidly and unexpectedly. Growers considering new stone fruit plantings might be able to avoid these diseases completely or at least minimize the risks of tree losses if some of the newer cultivars and/or rootstocks are immune, tolerant, or hypersensitive to these pathogens. With X-disease, hypersensitive rootstocks such as 'Mahaleb' cause the infected scion to die quickly after they become infected, thereby ensuring that diseased trees do not serve as inoculum sources for further spread of the disease.

Systematic evaluation of new germplasm is also warranted because no one knows exactly what symptoms these pathogens may produce in some of the newer cultivars and rootstocks. For example, we know that 'Ulster' and several other sweet cherry cultivars produce enlarged leaf stipules when infected with X-disease, and this symptom is useful for identifying diseased trees that should be rogued from commercial plantings. However, no one has determined how many cultivars produce this diagnostic symptom. Similarly, the symptomatology of ToRSV on cherries and apricots and of X-disease on plums and apricots has not been clearly established for field-grown trees under New York conditions.

X-disease of peaches and cherries is caused by a phloem-limited phytoplasma that is spread by a number of different leafhopper species. X-disease produces distinctive symptoms and a rapid decline in peaches, but vectors are unable to acquire the pathogen from infected peaches and peach is therefore a dead-end host for X-disease. Mahaleb rootstock is hypersensitive to X-disease, so cherry trees on Mahaleb die soon after trees become on infected with X-disease, thereby limiting inoculum availability for further spread of the disease. However, sweet cherries on 'Mazzard' rootstocks develop indistinct symptoms, may survive for many years after infection, and can act as an inoculum source for further spread of the disease. Controlled inoculation trials have shown that some plum cultivars can be symptomless hosts for X-disease, but the importance of plums as sources for further spread of X-disease has not been determined. The prevalence and symptomatology of X-disease in apricots is also largely unknown.

ToRSV causes stem pitting in peach and cherry and brown line or constriction disease in prune-plums grown on 'Myrobalan' rootstocks. ToRSV is a nematode-transmitted nepovirus that has numerous herbaceous hosts. ToRSV can be introduced into orchards via infected seeds from dandelion and perhaps other herbaceous hosts, and it is then transmitted from weed hosts to fruit trees. As with X-disease, susceptibility of new rootstocks to ToRSV has not been investigated.

Our objective was to evaluate susceptibility of various cultivar/rootstock combinations using as many different combinations as we could procure for sweet cherries whereas we opted to test a more limited number of combinations for other stone fruit cultivars. The 690 cherry trees planted in April of 2009 included the cultivar/rootstock combinations shown in Table 1. An additional 448 trees of other stone fruit cultivar/rootstock combinations (Tables 2 and 3) were also planted in April of 2009. Due to space limitations and because we

Table 1. Cherry cultivars and rootstocks being evaluated for susceptibility to X-disease and ToRSV-susceptibility at the Hudson Valley Lab in Highland, NY.

		Rootstocks						
	Cultivars	Gisela 5	Gisela 6	Maz-zard	Maha-leb	MxM 14	Gisela 12	MxM 60
1	Attika	X	X	X				
2	Balaton	X	X		X			
3	Blackgold			X				
4	Danube	X	X	X				
5	Emperor Francis			X				
6	Hedelfingen			X				
7	Hudson	X	X			X		
8	Kristen			X				
9	Lapins			X				
10	Montmorency				X			
11	Rainier	X	X	X				
12	Regina	X	X	X	X			
13	Royalton					X		
14	Sam			X				
15	Summit		X	X				
16	Sweetheart	X	X	X				
17	Tieton	X	X	X				
18	Ulster	X	X	X	X		X	X
19	Van			X				
20	Whitegold	X	X	X				

anticipated that this experiment should be completed within five years, we planted trees at a very tight spacing with only 3-4 ft between trees and 12 ft between rows. Trickle irrigation was installed in all of the plantings.

For most cultivar/rootstock combinations, we planted seven trees for X-disease inoculations, seven trees for ToRSV inoculations, and six trees to serve as non-inoculated controls. Cherries were grouped together in one block and the other stone fruits were divided between two other blocks. Trees were planted using a modified randomized block design. One modification in the randomization was that trees to be inoculated with ToRSV and those intended to serve as non-inoculated controls were not mixed within rows due to concerns that root grafting between adjacent trees within rows would compromise control trees if they were intermixed with inoculated trees. The second modification in the randomization was that trees to be inoculated with X-disease were kept together on one corner of the cherry block or in a spatially separated planting for other stone fruit species so as to minimize natural leafhopper vectored transmission of X-disease from inoculated trees to trees being used for controls or for ToRSV inoculations. After establishing these constraints, the cultivar/rootstock combinations assigned to each test were randomized as single-tree replications within blocks.

In all of the tree rows used for ToRSV inoculations, a 'Stanley' plum on Myrobalan rootstock was inserted after every tenth test tree as a positive control because ToRSV produces visually distinct symptoms (brown line) on the Stanley/Myrobalan combination. In all rows used for X-disease inoculations, a 'Redhaven' peach tree on 'Bailey' rootstock was inserted after every tenth test tree because X-disease symptoms on this combination are easily detected. The matrix of cultivar/rootstock combinations included in ToRSV tests for peaches, apricots, and plums (Table 2) is more complete than the corresponding matrix for X-disease testing (Table 3) because we anticipated that variations in scion/rootstock reactions to ToRSV will be more variable than for reactions to X-disease. The X-disease evaluations included more plum cultivars specifically to evaluate cultivar effects on X-disease susceptibility.

Table 2. Peaches, apricots, and plums being tested for susceptibility to ToRSV.

	Rootstocks						
Cultivars	Bai-ley	Myro-balan	Cada-man	HBOK 10	Istara	Krymsk - 1	Con-troller 5
Peach							
Redhaven	X		X	X	X	X	X
Apricots							
Hargrand			X	X	X	X	
Orangered			X	X	X	X	
Plums							
Stanley		X	X	X	X		X
Shiro			X	X	X	X	X

Table 3. Peaches, apricots, and plums being tested for susceptibility to X-disease.

	Rootstocks						
Cultivars	Bai-ley	Myro-balan	Cada-man	Istara	Krymsk -1	Con-troller 5	Cita-tion
Peach							
Redhaven	X		X	X	X		
Apricots							
Hargrand				X			
Orangered			X	X	X		
Plums							
Stanley		X					
Shiro			X	X		X	X
Early Golden		X					
Long John		X					
President		X					

X-disease inoculations were made during July of 2009 by using the T-budding technique to insert two bark patches from a naturally infected X-diseased chokecherry (*Prunus virginianae*) into the scion of each of the test trees that were designated for X-disease inoculations. ToRSV inoculations were delayed until 2010 because some of the rootstocks were of very small caliper and the ToRSV inoculations must be made in rootstock tissue below the graft union because with natural nematode-vectored transmission of ToRSV inoculations originate in the rootstocks. To challenge test trees with ToRSV, we plan to use bark patches from a ToRSV-infected myrobalan rootstock. For both X-disease and ToRSV, we anticipate that test trees will be challenged by inserting inoculum patches into each test tree in each of two successive years. Thus, X-disease inoculations will be repeated in 2010 whereas the ToRSV inoculations will be made for the first time in 2010 and then again in 2011.

Trees will be observed for visual evidence of disease during the first several years following inoculations. However, presence/absence of the test pathogens in both scions and rootstocks will ultimately be verified either via ELISA (for ToRSV) or by using a PCR probe (for X-disease) several years after the final inoculations. Thus, we anticipate that definitive results from this field trial will not be available until after the 2013 growing season.

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BENEFITS AND LIMITATIONS OF NEW APPLE FUNGICIDES

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Introduction: The DMI fungicides have provided a reliable "backstop" for controlling apple scab for the past two decades. The DMIs had a combination of post-infection, pre-symptom, and antisporulant activities that enabled them to control scab effectively even when application timings were less than optimum. Because they were so effective at stopping scab development after infections had already occurred, they were often used as "backstops" for other low-risk IPM practices that, when used alone, might occasionally allow scab to become established in orchards. These low-risk IPM practices included omitting early-season sprays in low-inoculum orchards, opting for post-infection spray timing during the prebloom period, and alternate-row spraying without using shortened intervals between applications. With DMI fungicides, any leaf left unprotected or any scab lesion that escaped a post-infection spray was of little concern because infections missed during any given application could be arrested by the subsequent application(s).

Over the past few years, effectiveness of DMI fungicides has been compromised in many orchards by the increasing prevalence of scab strains that are resistant to the DMI chemistry. Most of these scab strains are also resistant to the benzimidazole fungicides, and many are resistant to dodine as well. If ascospores of these multi-drug resistant strains are allowed to infect just a fractional percentage of leaves before bloom, growers can no longer inactivate them and losses to apple scab will be significant, due to either damaged fruit, increased costs for protectant fungicides during summer, or both. Thus, apple growers must now revert to using higher rates of protectant fungicides during the prebloom period because failure to completely control prebloom scab can create an expensive season-long scab problem, especially if the summer is unusually cool and wet as it was in 2009. New fungicides that have more post-infection and antisporulant activity than captan or mancozeb are needed to replace the DMIs in early-season control programs.

For different reasons, new fungicides are also needed to control summer diseases such as flyspeck, sooty blotch, black rot, white rot, and bitter rot. The standard summer fungicide program in northeastern United States for the past several decades has involved regular applications of Topsin M plus Captan. This fungicide combination remains effective but is no longer adequate as the sole fungicide program for the entire summer. Some apple buyers (especially supermarket chains in England) now require a 45-day preharvest interval for Topsin M even though the EPA label for Topsin M specifies a 1-day preharvest interval. For orchards containing cultivars that are harvested in early September, that requirement eliminates Topsin M as an option after mid-July.

Even where export market requirements are not a concern, growers need an alternative to Topsin M for some of their summer sprays because the Topsin M label allows application of only 64 oz of product per acre per year. Twenty years ago, most growers achieved excellent control of sooty blotch and flyspeck (SBFS) when using 6 to 8 oz/A of either Topsin M or Benlate. Now most growers find they must use 12-16 oz/A for effective control of SBFS. The reason for this change has not be determined, but I suspect that higher rates are needed today because changes in tree structure have resulted in increasingly poor spray coverage on fruit during late summer. Taken together, the doubling of production per acre and the reduction in tree size that occurred over the past 25 years resulted in having apples spaced four times closer together on the tree today than they were 25 years ago. Tightly spaced fruit create immovable barriers for wind-born spray droplets during late summer, and I suspect that growers have compensated for reduced coverage on the back sides of fruit by increasing the fungicide dose so that the small amount of fungicide that redistributes to the back sides of fruit is still adequate for suppressing SBFS. However, when growers apply Topsin M at 16 oz/A, they can use this product only four times whereas they may need to apply a fungicide eight times during summer. Strobilurin fungicides can be substituted for Topsin M in summer sprays, but the strobilurin chemistry is being increasingly used for scab control where DMIs are no longer effective. Product labels limit apple growers to only four strobilurin applications per year. Thus, with limited availability (due to label limits) of both Topsin M and strobilurin fungicides, apple growers need to find new fungicide alternatives for summer sprays.

Methods: Similar methods were used for the two field fungicide trials reported here. All treatments were applied to drip using a handgun and tractor-powered high-pressure sprayer. Rates per 100 gallons of dilute spray were calculated by dividing the designated rate per acre by three. In both trials, treatments were applied to multi-tree plots using a randomized block design with four replicates. The early-season fungicide trial was conducted in a mature orchard wherein each plot contained one tree each of 'Jerseymac,' 'Redcort,' and 'Golden Delicious,' with all trees on M.9 rootstock. Test trees were spaced 8 ft apart within plots, with 16 ft between plots within rows, and 18 ft between rows. Rows containing test plots were separated from one another by unsprayed buffer rows, and plots within rows were separated by large red cedar trees that limited drift between plots and supplied abundant inoculum for apple rust diseases.

The summer fungicide trial was conducted in a mature orchard with two tree plots that each contained one 'Golden Delicious' tree and one tree where the lowers scaffolds were 'McIntosh' and the upper part of the tree was 'Ginger Gold,' All trees were on MM.111 rootstocks with M.9 interstems, and trees were spaced 12 ft apart within plots, with 24 ft between plots within rows, and with 25 ft between rows. Cedar trees between plots within rows minimized plot-to-plot spray drift. This orchard was located in a low-lying area with poor air drainage and was surrounded by woodlots or hedgerows that provided abundant SBFS inoculum.

The prebloom period in 2009 was relatively dry with only one significant scab infection period near tight cluster (20-22 Apr, 52 hr wetting, 47° F., 0.85 in. rain). Another major infection period occurred during bloom (3-9 May, 105 hr, 55° F., 1.76 in. rain). A few primary scab lesions were noted on unsprayed trees in an adjoining block on 6 May. Abundant primary scab was evident on unsprayed trees by 15 May. There were 9 secondary scab infection periods during the latter half of May, 16 in Jun, 13 in Jul, 7 in Aug, and 4 in Sep. June and July were very wet with leaf wetting recorded for 50% of total time in June and 37% of total time in July. Details of summer wetting periods are shown in Table 1 as an aide for interpreting results of the summer fungicide trial.

Data was collected as described in table footnotes. Data was analyzed using SuperANOVA software for the McIntosh computer.

Results for spring fungicide trial: The application intervals during the prebloom period were greater than we would recommend for commercial applications (Table 2). However, dry prebloom weather meant that treatment effects would be detectable only if treatment intervals were more extended than in a normal season.

Tebuzol applied at pink and bloom (trt 6) had less frog-eye leaf spot than any of the other DMI treatments and was just as good as Pristine (trt 9, Table 2). Trts 8-9 provided better leaf spot control than most of the DMI-Penncozeb combinations (trts 3-4-12).

Table 1. Rainfall and accumulated hours of leaf wetting (AHLW) as determined with a DeWitt string recorder for the period from petal fall (11 May) through harvest.

Spray dates and harvest dates for the summer fungicide trial	Accumulated hr of wetting from petal fall	Accumulated rainfall from petal fall	Accumulations noted during spray intervals preceding the date shown on the same line:		AHLW for periods lacking fungicide protection assuming fungicide residues were depleted by accumulated rainfall of:	
			Hours of wetting	Rainfall (inches)	2 in.	1 in. after Captan sprays, otherwise 2 in.
20-May	62	2.06	61.5	2.1		
30-May	135	2.59	73.8	0.5		
8-Jun	192	2.67	56.3	0.1		
16-Jun	325	6.92	133.3	4.3	43.8	88.5
25-Jun	439	10.36	113.8	3.4	94.3	172.6
9-Jul	558	12.12	119.8	1.8	94.3	172.6
23-Jul	684	14.31	125.8	2.2	94.3	172.6
15-Aug	913	18.66	229.0	4.4	162.6	241.0
24 Aug: GG harvest	956	20.28			162.6	241.0
8 Sep: Mac harvest	1073	21.01			162.6	331.6
17-Sep	1124	21.58	211.3	2.9	305.0	362.6
30 Sep: GD harvest	1144	22.15			305.0	362.6

Table 2. Spring fungicide trial spray dates and effects of treatments on frog-eye leaf spot.

Fungicides, formulations, and rates per 100 gal of dilute spray applied[z]	Spray dates 4/17 TC	4/25 PK	5/4 BL	5/13 PF	5/22 1C	6/6 2C	6/17 3C	Frog-eye leaf spot: Redcort (1 June)[v]
1. Control								4.96 f[w]
2. Penncozeb 75DF 1 lb	X	X	X	C[w]	C	C	C	2.71 bcd
3. Penncozeb 1 lb	X	X	X					
Rally 40WSB 1.33 oz	X	X		X	X			
Captan 80WDG 10 oz				X	X	C	C	2.83 cd
4. Penncozeb 1 lb	X	X	X					
Indar 2F 2.67 fl oz + LI-700 8 fl oz[y]	X	X		X	X			
Captan 80WDG 10 oz				X	X	C	C	3.08 d
5. Penncozeb 1 lb	X	X	X					
Tebuzol 45DF (L= 2 oz; H= 6 oz)[x]	X^{L}	X^{L}		X^{H}	X^{H}			
Captan 80WDG 10 oz				X	X	C	C	2.46 bc
6. Penncozeb 1 lb	X	X	X					
Tebuzol 45DF (L= 2 oz; H= 6 oz)[x]		X^{L}	X^{L}		X^{H}		X^{L}	
Captan 80WDG 10 oz				C	X	C	X	1.42 a
7. Penncozeb 1 lb			X					
Luna Sensation 500 SC (USF 2016A) 1.33 fl oz	X	X		X	X	C	C	2.38 b
8. Penncozeb 1 lb			X					
LEM17 200SC 4.8 fl oz + Flint 50WDG 0.33 oz	X	X		X	X	C	C	2.33 b
9. Penncozeb 1 lb			X					
Pristine 38W 5 oz	X	X		X	X	C	C	1.79a
10. Penncozeb 1 lb			X					
Flint 50WG 0.67 oz	X	X		X	X	C	C	2.46 bc
11. Penncozeb 2 lb + Vintage SC Fungicide 1SC 1.13 fl oz	X							
GWN-4617 1.13 fl oz + Pzeb 2 lb + LI-700 8 fl oz		X	X	X	X	X	X	2.50 bc
12. Penncozeb 2 lb + GWN-4616 1.13 fl oz	X							
GWN-4617 1.13 fl oz + Pzeb 2 lb + LI-700 8 fl oz			X		X		X	
Vintage SC Fungicide 3.33 fl oz + Penncozeb 1 lb		X		X		X		2.96 d
13. Penncozeb 1 lb			X			C	C	4.00 e

[z] Comment on treatments:

Trt 2 is a standard program of contact fungicides. Trts 3-4-5-6 involved DMI fungicides. Trts 7-8-9-10 involved newer fungicides that either contain a QoI fungicide or were applied in a combination with Flint (trifloxystrobin), and these were compared to Flint applied alone (trt. 10). Luna Sensation is a package mix of trifloxystrobin and fluopyram. LEM-17 (penthiopyrad) was applied with a half-rate of Flint. Pristine is a package mix of pyraclostrobin and boscalid. The test fungicides were applied on the same dates in trts 3-4-5-7-8-9-10. In trts 11-12, GWN-4617 is a mildewcide and Vintage is a new formulation of Rubigan. Trt 13 involved a limited schedule of contact fungicides. In addition to the sprays noted above, all plots including controls received air-blast applications of Penncozeb 3 lb/A on 9 April; Captan-80 30 oz/A on 24 June, 6 & 22 July, 1 Aug; Captan-80 30 oz/A plus Topsin M 13 oz/A on 16 Aug; and Captan-80 33 oz/A plus Topsin M 14 oz/A on 25 Aug.

[y] Used only 4 fl oz LI-700 in the sprays applied at TC and PK, but 8 fl oz in applications at PF and 1C.

[x] Application error: Tebuzol was applied at 6 oz/100 gal in sprays applied at PF and 1C. Thus, disease control recorded for trt 5 in samples collected on 2 Jun would have been affected by the 13 May high-rate application. However, scab usually appears on leaves only 12-14 days after infections occur, so scab ratings for trt. 6 made on 2 Jun were not affected by the application error because that error occurred only on 22 May in trt 6.

[w] C = Captan 80WDG 10 oz/100 gal was applied alone on these dates.

[v] Each tree was visually rated by 3 independent observers using a scale of 1 (= no frog-eye leaf spot) to 5 (= severe frog-eye leaf spot).

[w] Numbers within columns followed by the same small letter are not significantly different as determined using Fisher's Protected LSD ($P \leq 0.05$).

Table 3. Spring fungicide trial: effects of treatments on incidence of foliar scab.

Fungicides, formulations, and rates per 100 gal of dilute spray applied[z]	Percent terminal-leaf scab: Jerseymac 2 Jun[y]	Percent terminal-leaf scab: Redcort 2 Jun[y]	Late-season terminal leaf scab (%): Jerseymac 28 July[x]	Late-season terminal leaf scab (%): Redcort 11 Aug[x]	Late-season terminal leaf scab (%): Golden Del. 30 Jun[x]
1. Control	47.3 e[w]	32.1 g	91.8 g	92.8 e	24.0 f
2. Penncozeb 1 lb // Captan-80 10 oz	10.7 c	6.9 e	14.5 de	15.3 c	9.5 de
3. Rally 1.33 oz + Pzb 1 lb or Capt-80 10 oz	5.2 ab	6.4 de	10.8 bcde	10.0 abc	7.6 cd
4. Indar 2.67 fl oz + Pzb 1 lb or Capt-80 10 oz	4.9 ab	4.0 cd	3.5 a	5.1 ab	4.2 abc
5. Tebuzol 2 oz + Pzb 1 lb or Capt-80 10 oz	3.8 ab	2.1 abc	5.5 abc	9.9 abc	9.0 de
6. Penncozeb 1 lb // Tebuzol 2 oz + P'zeb 1 lb Capt. 10 oz// Tebuzol 2 oz//6 oz + Capt. 10 oz	2.9 ab	2.2 abc	5.2 ab	4.5 ab	2.8 ab
7. Luna Sensation 500 SC 1.33 fl oz	3.1 ab	0.8 ab	3.4 a	9.1 abc	2.1 a
8. LEM17 4.8 fl oz + Flint 0.33 oz	4.9 ab	0.7 a	2.4 a	4.1 a	1.5 a
9. Pristine 5 oz	3.6 ab	1.3 ab	7.2 abcd	11.4 bc	3.2 ab
10. Flint 0.67 oz	2.3 a	2.7 bc	4.8 ab	5.8 ab	4.5 abc
11. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700	10.9 c	5.5 de	15.7 e	9.0 abc	14.4 e
12. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700 Vintage 3.33 fl oz + Penncozeb 1 lb	7.0 b	3.9 cd	12.6 cde	10.8 bc	6.0 bcd
13. Penncozeb 1 lb // Captan-80 10 oz	19.7 d	15.2 f	49.6 f	75.8 d	13.2 e

[z] See application schedule and footnotes below Table 1.
[y] Based on observation of all leaves on 15 bourse shoots per tree.
[x] Based on observation of all leaves on 15 terminal shoots per tree.
[w] Numbers within columns followed by the same small letter are not significantly different as determined using Fisher's Protected LSD ($P \leq 0.05$).

Early-season pressure for apple scab was relatively low, and all treatments except trt 13 where some sprays were omitted provided good control of apple scab on cluster leaves and fruitlets as rated on 10 Jun (data not shown). Apple scab pressure increased during and after bloom, so treatment effects were more visible on terminal leaves that started developing during late bloom. In early-season evaluations of terminal leaf scab on Jerseymac (Table 3), trts 2-11-13 that received only protectant fungicides had more scab than other treatments. For Redcort, trts 7-8-9-10 all provided better scab control on 2 June than the standard DMI program involving Rally (trt 3). The same was true for trts 7-8 on Jerseymac leaves rated on 28 July and for trts 7-8-9 for Golden Delicious rated on 30 Jun.

A leaf sample collected from this orchard in early June and evaluated by Dr. Kerik Cox at Geneva showed that the scab population in this orchard had a mean relative growth (RG) of 46 in a system where a mean RG of 25 is considered baseline and control failures are expected in orchards with an RG ≤ 55. Furthermore, 12% of the scab isolates from this block had RGs > 90. Thus, the fact that treatments involving strobilurin fungicides outperformed the Rally treatment can be attributed to the DMI resistance level in this test block.

Trts 2 and 13 provided less control of fruit scab on Jerseymac and Redcort than any of the other treatments (Table 4). When viewed across all cultivar and rating dates, most of the other fungicide treatments provided comparable control of scab on fruit.

Cedar apple rust lesions on Redcort never enlarge very much due to host incompatibilities, but lesions were attributed to rust if we could detect any orange coloration in the centers of the lesions. On Redcort terminal leaves rated on 2 Jun, treatments that included DMI fungicides (trts 3-4-5-6-12) had less rust than treatments involving strobilurin fungicides (trts 7-8-9-10, Table 5). The latter group matched the activity of the high rate of Penncozeb applied six times in trt 12, confirming that strobilurin fungicides have protectant activity against rust but lack the post-infection activity of DMI fungicides. The high rate of Penncozeb used after bloom in trt 12 is not allowed on the label but was used here to ensure that other diseases would not interfere with mildew ratings for GWN-4617. All treatments except trt 13 provided excellent control of quince rust and cedar apple rust on fruit at harvest (Table 5).

Table 4. Spring fungicide trial: effects of treatments on incidence of fruit scab.

Fungicides, formulations, and rates per 100 gal of dilute spray applied[z]	Scab on fruitlets (%) Redcort 2 Jun[y]	Scab on fruitlets (%) Jerseymac 2 Jun[y]	Fruit scab at harvest (%) Redcort 5 Aug[x]	Fruit scab at harvest (%) Golden D. 2 Sep[x]	Fruit scab at harvest (%) Jerseymac 23 Sep[x]
1. Control	65.4 d[w]	14.1 d	99.2 e	79.1 d	51.7 b
2. Penncozeb 1 lb // Captan-80 10 oz	4.8 abc	1.0 ab	18.9 c	10.0 b	0.4 a
3. Rally 1.33 oz + Pzb 1 lb or Capt-80 10 oz	0.7 a	2.8 ab	5.8 b	2.1 a	0.8 a
4. Indar 2.67 fl oz + Pzb 1 lb or Capt-80 10 oz	3.7 ab	5.4 ab	3.5 ab	1.2 a	0.0 a
5. Tebuzol 2 oz + Pzb 1 lb or Capt-80 10 oz	0.5 a	1.9 ab	6.4 b	1.2 a	0.4 a
6. Penncozeb 1 lb // Tebuzol 2 oz + P'zeb 1 lb Capt. 10 oz// Tebuzol 2 oz//6 oz + Capt. 10 oz	1.0 a	0.0 a	2.9 ab	0.4 a	0.8 a
7. Luna Sensation 500 SC 1.33 fl oz	1.8 ab	1.4 ab	5.0 ab	0.4 a	1.3 a
8. LEM17 4.8 fl oz + Flint 0.33 oz	0.7 a	0.7 ab	1.2 a	0.4 a	2.1 a
9. Pristine 5 oz	2.3 ab	0.0 a	3.8 ab	0.0 a	0.4 a
10. Flint 0.67 oz	0.7 a	1.1 ab	4.9 ab	0.4 a	1.7 a
11. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700	5.5 bc	0.0 a	4.7 ab	2.1 a	0.8 a
12. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700 Vintage 3.33 fl oz + Penncozeb 1 lb	1.0 a	6.2 bc	5.4 b	0.8 a	0.0 a
13. Penncozeb 1 lb // Captan-80 10 oz	12.5 c	12.7 cd	86.2 d	50.4 c	n.d.

[z] See application schedule and footnotes below Table 1.
[y] Based on observation of all fruitlets on 15 clusters per tree.
[x] Based on observation of 60 fruit/tree.
[w] Numbers within columns followed by the same small letter are not significantly different as determined using Fisher's Protected LSD ($P \leq 0.05$).

Table 5. Spring fungicide trial: effects of treatments on incidence of rust diseases.

Fungicides, formulations, and rates per 100 gal of dilute spray applied[z]	Redcort term'l leaves with rust lesions 2 Jun	Quince rust on fruit at harvest (%) Jerseymac 5 Aug	Quince rust on fruit at harvest (%) Golden Del. 21 Sep	Golden Del. fruit with cedar apple rust 21 Sep
1. Control	71.8 f	50.5 c	57.2 b	31.1 d
2. Penncozeb 1 lb // Captan-80 10 oz	40.1 de	1.9 ab	0.4 a	3.8 c
3. Rally 1.33 oz + Pzb 1 lb or Capt-80 10 oz	7.6 ab	0.0 a	0.0 a	0.4 ab
4. Indar 2.67 fl oz + Pzb 1 lb or Capt-80 10 oz	10.6 ab	0.4 a	0.0 a	0.0 a
5. Tebuzol 2 oz + Pzb 1 lb or Capt-80 10 oz	11.3 ab	0.0 a	0.0 a	0.0 a
6. Penncozeb 1 lb // Tebuzol 2 oz + P'zeb 1 lb Capt. 10 oz// Tebuzol 2 oz//6 oz + Capt. 10 oz	1.4 a	0.0 a	0.0 a	0.0 a
7. Luna Sensation 500 SC 1.33 fl oz	35.5 de	1.2 ab	1.7 a	2.1 bc
8. LEM17 4.8 fl oz + Flint 0.33 oz	33.5 d	0.8 a	0.0 a	0.8 abc
9. Pristine 5 oz	29.4 d	1.5 a	0.4 a	0.8 abc
10. Flint 0.67 oz	31.0 d	1.5 ab	0.4 a	0.4 ab
11. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700	28.5 cd	0.4 a	0.8 a	0.8 abc
12. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700 Vintage 3.33 fl oz + Penncozeb 1 lb	13.7 bc	0.4 a	0.8 a	0.4 ab
13. Penncozeb 1 lb // Captan-80 10 oz	53.9 e	17.0 b	--	--

[z] See application schedule and footnotes below Table 1.
[y] Based on observation of all leaves on 15 bourse shoots per tree.
[x] Based on observation of 60 fruit/tree.
[y] Numbers within columns followed by the same small letter are not significantly different as determined using Fisher's Protected LSD ($P \leq 0.05$).

Trts 2 and 13 provided less control of mildew than any of the other fungicide treatments (Table 6). Mildew control was better in the 10 Jun ratings than in the 30 Jun ratings because the last application of test fungicides was made on 22 May for all except trts 6-11-12 and the Captan cover sprays applied during June would not be expected to control mildew.

Because most of the treatments reverted to uniform cover sprays (mostly with Captan) by the end of May, we did not expect to find treatments affecting the incidence of sooty blotch and flyspeck (SBFS) at harvest. However, trts 11-12 both received Penncozeb sprays until mid-June, and these two treatments therefore had less SBFS than other treatments (Table 6). Pristine (trt 9) and Flint (trt 10) suppressed both flyspeck and sooty blotch on Redcort better than Captan alone (trt 2) or Indar/Captan combinations (trt 4). Trt 8 had the least Golden Delicious fruit down-graded due to fruit russetting, but trts 2-3-11-12 were statistically similar to trt 8.

Table 6. Spring fungicide effects on powdery mildew, flyspeck, sooty blotch, and fruit russet

Fungicides, formulations, and rates per 100 gal of dilute spray applied[z]	% leaves with mildew: Jerseymac 10 Jun[y]	% leaves with mildew: Redcort 30 Jun[y]	% Redcort fruit affected: flyspeck 2 Sep[x]	% Redcort fruit affected: sooty blotch 2 Sep[x]	Golden Del. down-graded for russet[w]
1. Control	30.1 e[v]	56.3 e	80.4 bc	65.0 f	67.8 e
2. Penncozeb 1 lb // Captan-80 10 oz	12.3 d	38.5 d	82.9 c	31.3 cd	39.6 abc
3. Rally 1.33 oz + Pzb 1 lb or Capt-80 10 oz	1.4 abc	5.2 ab	80.0 bc	32.5 cde	42.1 abcd
4. Indar 2.67 fl oz + Pzb 1 lb or Capt-80 10 oz	2.7 c	9.6 bc	84.6 c	36.7 de	49.6 bcde
5. Tebuzol 2 oz + Pzb 1 lb or Capt-80 10 oz	1.7 abc	4.8 ab	79.7 bc	28.9 cd	54.4 cde
6. Penncozeb 1 lb // Tebuzol 2 oz + P'zeb 1 lb Capt. 10 oz//Tebuzol 2 oz//6 oz + Capt. 10 oz	0.3 ab	6.9 ab	89.4 bc	20.4 bc	54.9 cde
7. Luna Sensation 500 SC 1.33 fl oz	0.1 a	5.6 ab	80.4 bc	22.1 bc	48.8 bcd
8. LEM17 4.8 fl oz + Flint 0.33 oz	2.2 bc	5.2 ab	80.6 bc	18.9 bc	24.0 a
9. Pristine 5 oz	4.1 c	14.0 c	71.0 b	12.8 ab	45.3 bcd
10. Flint 0.67 oz	1.3 abc	7.1 b	70.2 b	9.5 a	60.6 de
11. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700	2.6 bc	8.1 b	34.8 a	4.9 a	42.2 abcd
12. GWN-4617 1.13 fl oz + P'zeb 2 lb + LI-700 Vintage 3.33 fl oz + Penncozeb 1 lb	1.2 abc	3.3 a	44.6 a	11.7 ab	33.2 ab
13. Penncozeb 1 lb // Captan-80 10 oz	23.2 e	58.8 e	86.7 c	47.9 e	--

[z] See application schedule and footnotes below Table 1.
[y] Mildew ratings were based on observation of the 8 youngest leaves on each of 15 terminals/tree
[x] Based on observation of 60 fruit/tree.
[w] From observing 60 Golden Delicious fruit/tree and noting fruit with russetting that exceeds standards for USDA Fancy grade.
[v] Numbers within columns followed by the same small letter are not significantly different as determined using Fisher's Protected LSD ($P \leq 0.05$).

Conclusions from the spring fungicide trial: All of the fungicides evaluated were reasonably effective considering the severe disease pressure that was fostered by rains from the latter half of May through June and July. None of the fungicides gave 100% control of fruit scab on Jerseymac, but the newer fungicides were all more effective than the contact fungicides applied in trt 2. Recent lab tests of scab populations in this orchard by Dr. Kerik Cox showed that QoI fungicides should still be effective in this orchard, and results of our field test confirmed that they were effective. However, this trial produced no evidence that LEM-17 or Luna Sensation will control scab, rust diseases, or mildew any better than a full rate of Flint used alone, although LEM-17 suppressed fruit russetting just as effectively as mancozeb sprays whereas other treatments involving strobilurin fungicides did not.

Results from the summer fungicide trial: Weather conditions were conducive for severe fruit russetting which is usually induced during the 45 days after petal fall and is mostly caused by growth of *Aureobasidium pullulans*, an epiphytic yeast-like fungus that benefits from extended periods of wet weather. Trts 2-3-4-7-8 had less fruit russetting on Golden Delicious than control fruit whereas trts 5-6 did not (Table 7).

Inspire Super (trts 4-5) provided superior control of both flyspeck (Table 8) and sooty blotch (Table 9) on Ginger Gold fruit rated after incubation and on Golden Delicious rated on 30 Sep. Luna Sensation (trt 7) and the standard program (trt 2) were just as effective as the Inspire Super treatments when compared for percent fruit down-graded due to SBFS (Table 9).

Conclusions from the summer fungicide trial: Inspire Super provided exceptional control of SBFS in this trial and Luna Sensation was just as effective as the Topsin-Captan standard. If labels for these products will allow applications during late summer, they might provide viable alternatives to the Topsin-Captan standard. However, Inspire Super, a DMI-containing fungicide, cannot be recommended for summer applications in orchards where DMI fungicides are still effective against apple scab because summer applications of DMIs will almost certainly speed selection for DMI-resistant scab. Thus, Inspire Super will be useful as a summer spray only where DMIs have become worthless as scab sprays.

Luna Sensation provided acceptable control of SBFS, but this product includes trifloxystrobin and therefore presumably will be labeled with the restriction against more than four sprays per year of any combination of products containing the strobilurin chemistry. Because strobilurins are still essential for scab control programs, Luna Sensation will have limited applicability for summer spray programs.

Indar and Tebuzole were relatively ineffective against SBFS under the severe conditions that prevailed in 2009 and therefore will prove most useful when used earlier in the season to control rust, mildew, and perhaps scab.

Table 7. Summer fungicide trial spray dates and effects of treatments on fruit russetting at harvest.

	Spray timing and dates							% russetted fruit	
Fungicides, formulations, and rates	6/8	6/16	6/25	7/9	7/23	8/15	9/17	Ginger	Golden Delicious
per 100 gal of dilute spray applied[z]	3c	4c	5c	6c	7c	8c	9c[y]	Gold[x]	[x]
1. Control								n.d.[w]	77.0 c[u]
2. Captan 80WDG 10 oz + Topsin M 70W 4 oz	Cpt	Cpt	X	X	X	X	X[w]	16.2 ab	34.0 a
3. Rally+Capt., then Capt. 10 oz + Topsin 4 oz	Cpt	Cpt	X	X	X	X	X[w]	14.6 a	47.5 ab
4. Inspire Super 338SE 3.97 fl oz (4 times)	X		X		X	X			
Captan 80WDG 10 oz + Topsin M 70W 4 oz		Cpt		X			X[w]	29.7 b	47.9 ab
5. Inspire Super 338SE 3.97 fl oz (5 times)	X	X		X		X	X		
Captan 80WDG 10 oz + Topsin M 70W 4 oz			X		X			25.9 ab	55.2 abc
6. Indar 2F 2.67 fl oz + LI-700 4//8 fl oz	X[8]	X	X		X	X			
Captan 80WDG 10 oz + Topsin M 70W 4 oz		X	X		X			30.3 b	58.8 bc
7. Luna Sensation 500 SC 1.33 oz	X	X		X		X	X		
Captan 80WDG 10 oz + Topsin M 70W 4 oz			X		X			16.9 ab	40.2 ab
8. Tebuzol 45W 2 oz	X	X		X		X	X		
Captan 80WDG 10 oz + Topsin M 70W 4 oz			X		X			22.1 ab	41.3 ab

[z] All plots including controls received applications of Penncozeb 3 lb/A on 9 Apr and Dithane 3 lb/A on 18 Apr. After that early-season sprays varied as follows: Trt 2 received Dithane 75DF 1 lb/100 gal on 8, 20, and 30 May. All of the other treatments (trts 3-4-5-6-7-8) all received Rally 40WSB 1.33 oz/100 gal plus Captan on 8 and 20 May followed by Captan applied alone on 30 May. In this trial, any time that Captan was applied, whether alone or in combinations, the rate was always Captan 80WDG at 10 oz/100 gal. Where "Cpt" appears in the spray-timing grid, Captan was applied alone rather than the other treatment listed for that line.

[y] The application on 9/17 was to Golden Delicious only (other cultivars had already been harvested).

[x] Sixty fruit/tree harvested 24 Aug (Ginger Gold) or 30 Sep (Golden Delicious) were rated for fruit russetting. Data show the percentage of fruit with russetting that excluded them from meeting standards for USDA Fancy grade.

[w] No data because fruit were too severely damaged by diseases to allow russet ratings.

[v] Indicates treatments where the last spray on 17 Sep also included ProPhyt 4.2L at 21.3 fl oz/100 gal.

[u] Means separations determined using Fisher's Protected LSD ($P \leq 0.05$).

Table 8. Effects of summer fungicides on the incidence of flyspeck

	% fruit with flyspeck					
	Ginger Gold [y]		Golden Delicious [x]			McIntosh fruit [w]
Fungicides, formulations, and rates per 100 gal of dilute spray applied[z]	24 Aug at harvest	after incubation	on-tree ratings [x] 1 Sep	15 Sep	30 Sep at hvst [x]	harvested 8 Sep & rated 9 Nov. [v]
1. Control	96.9 f [v]	n.d.	95 e	100 f	100.0 e	100.0 c
2. Dithane 1 lb// Capt. 10 oz// C+T	23.3 d	20.4 bc	19 a	34 bc	45.2 b	56.7 b
3. R+C// Capt. 10 oz// C+T	14.2 cd	25.7 cd	42 bc	62 cd	71.3 c	64.3 b
4. Ins-Super, 4 sprays	0.0 a	3.8 ab	0 a	2 a	7.1 a	20.9 a
5. Inspire Super, 5-times	0.5 ab	1.3 a	4 a	9 ab	11.2 a	13.4 a
6. Indar, 5-times	28.1 d	40.8 d	47 cd	67 d	87.5 d	71.5 bc
7. Luna Sensation, 5-times	5.7 bc	34.3 cd	7 a	41 cd	45.7 b	22.0 a
8. Tebuzol, 5-times	53.3 e	68.1 e	76 d	72 e	90.0 d	85.6 c

[z] See application schedule in Table 7.
[y] Based on observing 60 Ginger Gold fruit per tree. Following initial evaluations, fruit were incubated for 14 days at 70° F and 100% relative humidity to allow development in incubating SBFS infections that were present on fruit at harvest.
[x] Based on observing 20 Golden Delicious fruit/tree for on-tree ratings and 60 fruit per tree at harvest on 30 Sep.
[w] From 60 McIntosh fruit per tree. Fruit were harvested 8 Sep, then held at 35° F until they were rated on 9 Nov.
[v] Means separations determined using Fisher's Protected LSD ($P \leq 0.05$).

Table 9. Effects of summer fungicides on the incidence of sooty blotch and fruit downgraded from USDA Extra Fancy grade due to the combined incidence/severity of sooty blotch and flyspeck.

	Fruit with sooty blotch (%)				Percent out-of-grade due to SBFS on fruit [v]	
	Ginger Gold [y]		G. Del. [x]	McIntosh harvested 8 Sep, rated 9 Nov [w]		
Fungicides, formulations, and rates per 100 gal of dilute spray applied[z]	at harvest 24 Aug	after incubation	harvested 30 Sep		Golden Delicious[x]	Mc-Intosh [w]
1. Control	100.0 d	100.0 d	100.0 e	n.d.	100.0 e	100.0 e
2. Dithane 1 lb// Capt. 10 oz// C+T	22.1 b	72.0 c	36.9 b	16.3 bc	11.3 bc	9.5 abc
3. R+C// Capt. 10 oz// C+T	5.0 ab	43.4 b	69.6 c	22.4 c	19.6 c	15.1 bc
4. Ins-Super, 4 sprays	0.0 a	16.5 a	15.4 a	5.3 ab	0.4 a	1.3 a
5. Inspire Super, 5-times	0.0 a	11.2 a	15.8 a	2.2 a	2.5 ab	0.6 a
6. Indar, 5-times	18.4 bc	49.9 b	96.3 d	39.0 d	58.8 d	20.4 cd
7. Luna Sensation, 5-times	4.5 ab	53.1 b	45.2 b	9.1 ab	4.4 ab	1.3 a
8. Tebuzol, 5-times	38.3 c	73.3 c	97.5 d	50.3 d	61.7 d	31.3 d

[z] See application schedule in Table 7.
[y] Based on observing 60 Ginger Gold fruit per tree.
[x] Based on observing 25 Golden Delicious fruit/tree for on-tree ratings and 60 fruit per tree at harvest on 30 Sep.
[w] Based on observing 60 McIntosh fruit per tree.
[v] Percent fruit with SBFS that exceeded standards for USDA Fancy grade.
[u] Means separations determined using Fisher's Protected LSD ($P \leq 0.05$).

SUMMER DISEASE CONTROL WITH PHOSPHITE FUNGICIDES

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In the 1970s scientists at Rhone-Poulenc discovered the fungicidal properties of salts of phosphorus acid, often referred as phosphonates or phosphites. They differ from phosphate fertilizers in that the phosphite ion does not appear to be involved in any phase of phosphorus metabolism in the plant. The phosphites were found to have exceptional activity on oomycetes and Rhone-Poulenc commercialized fosetyl-Al as Aliette. Aliette also had some activity on apple scab, Alternaria blotch and fire blight and is currently labeled for fire blight control. However it was somewhat inconsistent in activity on diseases other than those caused by oomycetes and was never widely used by apple growers. Once the patent expired, a number of other phosphorus acid salt based fungicides began to be evaluated and marketed. In tests on various crops, these fungicides showed greater activity than would have been predicted based on the experience with Aliette. This paper summarizes work over the past 5 years on the relative activity of phosphite fungicides on summer disease of apples. These results have been previously published in Fungicide and Nematicide Test Results or Plant Disease Management Reports (1-6). Results of the studies have shown:

- The activity of phosphite fungicides on summer diseases depends on the percent phosphite in the product. BioFos which contains 20.4% phosphonate salts was significantly less active on sooty blotch and flyspeck than either Prophyt or Agri-Fos which contain ~50% phosphonate salts (3).

- When applied alone, phosphites provide about 50% control of most summer diseases and need to be combined with captan to satisfactorily control summer diseases.

- In combination with captan in the cover sprays they provide excellent control of sooty blotch and flyspeck (2,3,4,6) and provide very good fruit finish.

- In combination with captan, the phosphites adequately control black pox and will control Brooks spot under low to moderate pressure (4,5).

- The combination of captan + phosphite appears to adequately control bitter rot, but more data are needed to determine its activity on black rot and white rot.

- Some phytotoxicity may occur with repeated applications of phosphite fungicides. Terminal leaf strapping has been observed on Golden Delicious when Prophyt has been used in a full cover spray program. However it does not appear to affect fruit size or return bloom. This phytotoxicity has not been observed with other phosphites.

-

Recommended uses of phosphite fungicides in NC.

- Captan + phosphite 2nd-8th cover. Need to add zinc oxide at 3rd-6th cover on Golden Delicious to control necrotic leaf blotch. Use the high labeled rate of phosphite if bitter rot becomes a problem.

- On Delicious where Alternaria blotch is a problem, rotate captan + phosphite with Pristine in the cover sprays beginning around 2nd cover.

- On Gala where Glomerella leaf spot is a problem, rotate captan + phosphite with Pristine or Flint beginning at 2nd cover. Use a 10-day spray schedule once any symptoms are observed.

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First reports of *Monilinia laxa* in stone fruit orchards in western NY

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Monilinia fructicola and *Monilinia laxa* are the primary casual agents of brown rot of stone fruit in the eastern United States. While *M. fructicola* is causes blossom blight and brown fruit rot, *M. laxa* can infect shoots, blossom spurs, fruit and leaves. Prior to 2008, *Monilinia fructicola* was the only brown rot pathogen confirmed in New York (Luo et al., 2008), and brown fruit rot was the only concern for the stone fruit producers since temperatures are historically cool through bloom limiting concern for blossom blight.

Although *M. laxa* has been well documented in stone fruit growing regions in California and more recently Michigan, its presence has not been confirmed using modern molecular techniques in the eastern United States. of brown rot populations to develop quantitative and qualitative resistance. In June 2008, a grower in Niagara County (western) NY reported a potential control DMI control failure in a 'Surefire' tart cherry planting. Symptoms were characteristic of *M. laxa* infection as shoots, leaves, and blossom spurs were sporulating with brown rot. Additionally, gumming cankers were present on one-year-old wood. A subsequent survey of Western NY and Pennsylvania brown rot isolates collected from outbreaks displaying symptoms similar to those in Niagara County was conducted from 2008-2009. From this survey we hoped to identify the species of *Monilinia* responsible for the brown rot outbreaks, and evaluate sensitivity of *Monilinia spp.* to the DMI fungicide Indar (fenbuconazole) and the QoI fungicide Pristine (pyraclostrobin + boscalid).

One hundred seventeen putative *M. laxa* isolates were collected from three tart cherry plantings in western NY and one peach planting near Biglerville, PA from 2008-2009. All putative *M. laxa* isolates were confirmed through rDNA sequencing of the highly conserved ITS1, 5.8s, and ITS2 regions and amplification of a *M. laxa* specific region within the β-tubulin gene using polymerase chain reaction (PCR) (Ma et al., 2005). Of the 33 putative *M. laxa* isolates collected from tart cherry 'Surefire' in Niagara County NY in 2008, 9 (27%) were identified as *M. laxa* while 24 (73%) were identified as *M. fructicola.* All brown isolates removed from the shoots were *M. laxa,* whereas both species were located in the fruit. All putative *M. laxa* isolates from tart cherry 'Balaton' (Niagara County-2009) and tart cherry 'Montmorency' (Wayne County-2009) were confirmed as *M. laxa.* While most isolates were located on one-year-old shoots, the pathogen was also isolated from blossom spurs, mummified fruit, and on leaves in the 'Balaton' planting. All 2009 Pennsylvania isolates were identified as *M. fructicola.*

Sensitivity of *M. laxa* and *M. fructicola* monoconidial isolates to the DMI fungicide fenbuconazole, and the QoI fungicide Pristine (pyraclostrobin + boscalid mixed to Pristine's formulated ratio) was evaluated using mycelial relative growth assays. Briefly, 5-mm agar plugs derived from all monoconidial *Monilinia* spp. colonies were placed on potato dextrose agar amended with 0.3-µg/ml fenbuconazole (Wilcox and Burr, 1994) or 1.1-µg/ml Pristine (Villani and Cox, 2008) such that the fungal mycelium was in contact with the media. Both discriminatory doses represent 100x the historical baseline EC_{50} values for New York State.

Niagara County orchard in 2008 was the only population during our survey to have both brown rot pathogens. Within this population, the DMI fungicide, fenbuconazole, was significantly better in suppressing *M. laxa* growth than suppressing *M. fructicola* growth ($p \leq 0.0001$). On media amended with 0.3-µg/ml fenbuconazole, mean percent relative growth of *M. laxa* isolates was 4.47 ± 2.3% and 17.62 ± 1.3% for *M. fructicola* isolates. Relative growth of *M. laxa* and *M. fructicola* isolates on Pristine amended media was 23.71 ± 3.2% and 33.52 ± 1.1%, respectively.

Mean percent relative growth of the other *M. laxa* populations for fenbuconazole and Pristine was 0.522 ± 0.4% and 22.10 ± 2.7% (Niagara County-2009) and 6.07 ± 3.4% and 14.27 ± 4.0% (Wayne County-2009), rspectively. As with the 2008 population, fenbuconazole demonstrated a much higher efficacy for limiting *M. laxa* growth than did Pristine. In all likelihood, *M. laxa* was present but went undetected prior to 2008 and had been gaining exposure to QoI fungicides during applications.

Fungicide sensitivity profiles of 31 Pennsylvania *M. fructicola* isolates were similarly constructed fenbuconazole (Fig.1) and Pristine (Fig. 2) at 100x historical EC_{50} values. All isolates tested displayed both DMI resistant phenotypes and the DMI-resistant genotype characterized by a 65-bp insert, “Mona” within the *CYP51A1* gene (Luo et al., 2008). Mean percent relative growth when exposed to 0.3-µg/ml fenbuconazole was 71.44 ± 2.5%. The *M. fructicola* population also demonstrated a high degree of reduced sensitivity to Pristine with a mean percent relative growth of 40.17 ± 1.7%.

Overall, fenbuconazole was more effective in controlling all *M. laxa* populations than *M. fructicola* populations during both years of this study. Similarly, Pristine also performed better against *M. laxa* even when compared with isolates from the same orchard on the same collection date (Niagara County-2008) (Fig. 3). The detection of *M. laxa* in western New York should require an changes in brown rot management programs. Applications of the DMI fungicide, Indar 2F (fenbuconazole), during bloom may be necessary to control for brown rot caused by *M. laxa*. Additionally surveys will be necessary to monitor the spread and fungicide resistance development of the pathogen.

Figure 1.

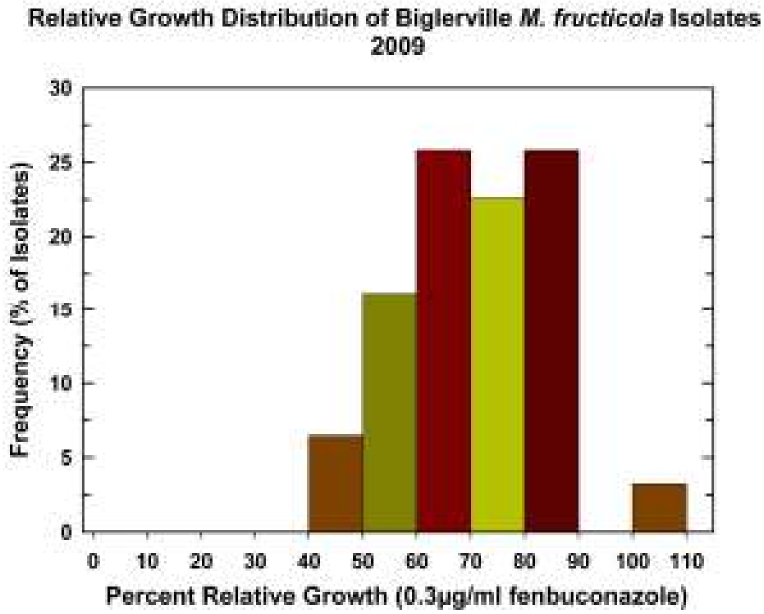

Figure 1. Percent relative growth (%RG) distributions of 31 *M. fruticola* isolates from Biglerville, PA on PDA medium amended with 0.3-µg/ml fenbuconazole.

Figure 2.

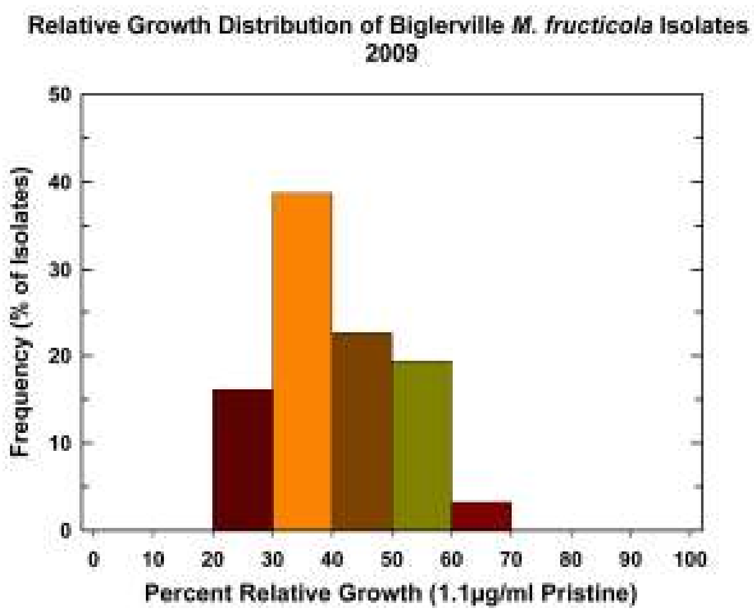

Figure 2. Percent relative growth (%RG) distributions of 31 *M. fruticola* isolates from Biglerville, PA on PDA medium amended with 1.1-µg/ml Pristine.

Figure 3.

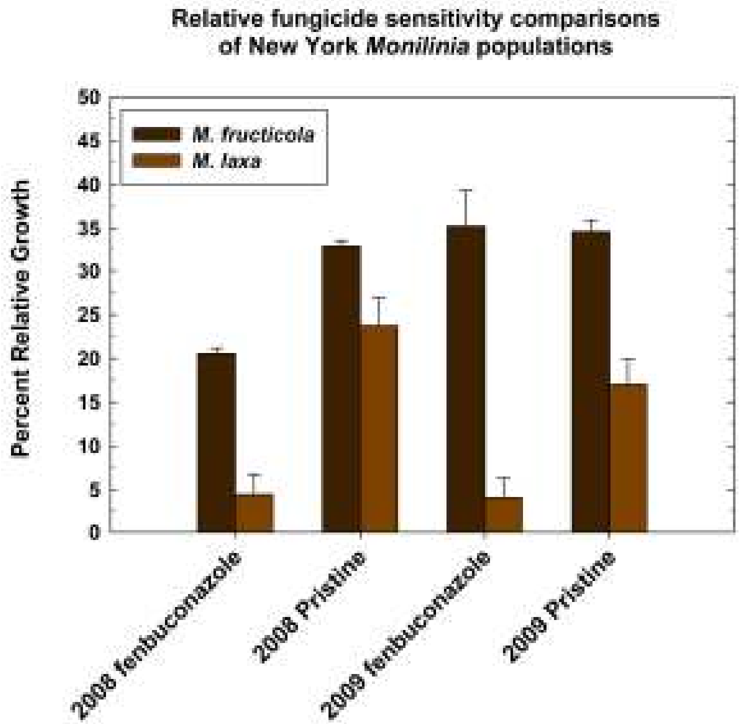

Figure 3. Comparison of *in vitro* performance of fenbuconazole and Pristine on 2008 and 2009 populations of *M. fructicola* (dark brown) and *M. laxa* (light brown).

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

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Disease control by experimental fungicides and mixtures on Golden Delicious, Idared, and York Imperial apples, 2009.

Seventeen experimental or combination treatment schedules were compared to registered treatments on 9-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 2008, which allowed mildew inoculum pressure to stabilize on 2009 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: 2 Apr (Idared ½-in greentip, #1, Golden Delicious ¼-in greentip, York greentip); 16 Apr (TC-pink); 24 Apr (pink-bloom); 5 May (petal fall); 1st-7th covers: 19 May, 2 Jun, 15 Jun, 1 Jul, 16 Jul, 30 Jul, 20 Aug. Maintenance applications applied to the entire test block with the same equipment included Asana, oil, streptomycin, Assail, Calypso, Fruitone L + Sevin XLR, Lannate LV, Calcium chloride (Yorks only), Provado, Imidan, Intrepid, Delegate, and Altacor. Inoculum placed over each Idared test tree, included: cedar rust galls 3 and 28 Apr, wild blackberry canes with the sooty blotch and flyspeck fungi, and bitter rot mummies 28 Apr. Other diseases developed from inoculum naturally present in the test area, including cedar-apple rust inoculum from red cedars in the vicinity. Foliar data are from counts of ten shoots per tree from each of four reps: 10 Jul (Golden Delicious), 22 Jun (Idared) or 6 Jul (York). Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 19 Aug and 28 Sep (Idared); 21 Sep (Golden Delicious); or 22 Sep (York). Samples were incubated at approximately 70F for indicated periods ranging from 14-23 days before final post-harvest rot evaluations. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Under sustained mildew pressure, with 33 days favorable for infection from 30 Mar- 6 Jun, Luna Sensation, a combination of trifloxystrobin + fluopyram, was superior in all mildew rating categories, including a reduction of primary inoculum, percent leaves and leaf area and percent fruit infected. Other highly effective treatments were Adament, Sovran + Rally, Flint, Flint + Rally and Topguard. There were several unexpected examples of combinations reducing mildew russetting of Idared fruit: addition of Dithane or Captan to Topguard (Trts. 16 & 17 vs. 15); adding Ziram to a reduced rate of Flint in an alternating program with Inspire (Trt. 6 & vs. 5); and adding B-1956 to Inspire in an alternating program with Flint (Trt.3 vs. 5). The amount of russet of Idared fruit did not necessarily correlate to the percent infected Idared leaves or leaf area. Scab inoculum levels were moderate, but 18 infection periods through May resulted in a strong test. Under these conditions, most treatments performed as expected. Treatments involving strobilurin fungicides were generally stronger than the SIs which were bolstered by inclusion of mancozeb or captan, as with Topguard (Trts. #15-17). Under moderate rust pressure, all treatments provided adequate commercial control. All treatments except #7-9 received Captan + Ziram as the 4th-7th cover sprays, so any differences in the summer diseases (sooty blotch, flyspeck, or rots) reflect the earlier part of the schedule among those treatments. This may have included treatments involving mancozeb (as indicated in #1 and 13-14 which had mancozeb 3-6 lb/A), treatments involving Inspire (in #2-3 and #5-6) or treatments involving Flint (as indicated in #7). Topguard alone (#15) showed weakness for summer disease control. Flint and Luna Sensation, applied through the cover sprays, generally gave good control of sooty blotch, flyspeck and the rots. Adament was significantly weaker for control of sooty blotch and flyspeck, although it contained the same amount of trifloxystrobin applied on the same schedule as Flint and Luna Sensation. Bitter rot was the predominant rot, but others making up the composite "any rot" included white rot (Botryosphaeria), Alternaria, and Phomopsis (data not shown). Although there were some differences among treatments in fruit finish in the form of russet or opalescence, there were no deleterious effects by any treatment compared to non-treated trees.

Table 1. Mildew control by experimental fungicides on Idared, Golden Delicious and York apples, 2009.

	Treatment and rate/A	App. #/ timing	Idared primary effect*	Idared leaves	Idared leaf area	Idared % fruit 19 Aug	Idared % fruit 1 Oct	Golden Del. % leaves	Golden Del. leaf area	York % leaves	York leaf area
0	No fungicide	---	1.9 j	63 j	21 e	43 f	23 fg	70 e	20 d	73 f	17 d
1	Rally 40WSP 5 oz + Penncozeb 3 lb	#1-7	5.0 fg	27 h	4 cd	7 a	6 a-c	58 d	9 bc	47 de	6 bc
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
2	Inspire Super 12 fl oz + LI-700 8 fl oz	1,3,5,7	5.1 fg	20 e-h	3 bc	32 d-f	19 d-g	56 cd	6 a-c	45 c-e	5 bc
	Flint 50WG 2 oz	2,4,6									
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
3	Inspire Super 12 fl oz + B-1956 4 fl oz	1,3,5,7	5.1 fg	27 h	3 bc	10 ab	9 a-c	59 d	9 c	49 e	7 c
	Flint 50 WG 2 oz	2,4,6									
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
4	Procure 480SC 12 fl oz	1,3,5,7	4.2 g-i	25 gh	3 bc	11 a-c	10 c-f	56 cd	7 a-c	48 e	6 bc
	Flint 50WG 2 oz	2,4,6									
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
5	Inspire Super 338SE 12 fl oz	1,3,5,7	4.6 f-i	22 f-h	3 bc	38 ef	22 e-g	56 cd	5 a-c	38 b-e	5 bc
	Flint 50WG 2 oz	2,4,6									
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
6	Inspire Super 338SE 12 fl oz	1,3,5,7	5.3 ef	20 e-h	3 bc	10 ab	8 b-e	58 d	8 bc	37 b-e	4 a-c
	Flint 50WG 1.5 oz + Ziram 76DF 3 lb	2,4,6									
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
7	Flint 50WG 2 oz	#1-7C	5.0 fg	17 d-g	3 bc	13 ab	10 b-f	47 a-c	6 a-c	32 a-c	5 a-c
8	Luna Sensation 500SC 4 oz	#1 -7C	8.9 a	2 a	1 a	9 ab	1 a	41 a	4 a	19 a	3 a
9	Adament 50WG 4 oz	#1 -7C	6.6 cd	7 b	2 b	14 a-c	7 b-d	45 ab	5 ab	25 ab	3 a
10	Flint 50WG 1.5 oz + Ziram 3 lb	#1-7	4.9 f-h	15 c-f	2 bc	17 a-d	19 d-g	57 cd	6 a-c	32 a-d	4 ab
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
11	Flint 50WG 2 oz + Rally 2 oz	#1-7	6.3 de	10 b-d	2 bc	21 b-d	13 c-f	52 b-d	5 ab	27 ab	4 ab
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
12	Sovran 50WG 4 oz + Rally 2 oz	#1-7	6.6 cd	8 bc	2 b	15 a-c	13 c-g	54 b-d	7 a-c	26 ab	3 a
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
13	GWN-4617 3.4 oz + Dithane 6 lb										
	(+ B-1956 4 fl oz, apps. 4-7)	#1-7	3.9 hi	16 d-g	3 bc	19 b-d	10 b-d	57 cd	8 bc	38 b-e	4 a-c
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
14	GWN-4617 3.4 oz + Dithane 6 lb										
	(+ B-1956 4 fl oz, apps. 4-7)	1,3,5	3.8 i	38 i	6 d	15 a-c	4 a-c	61 de	9 bc	36 b-e	4 ab
	GWN-4616 3.4 oz + Dithane 3 lb	2,4,6									
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
15	Topguard 125SC 13 fl oz	#1-3C	7.4 bc	12 b-e	2 bc	25 c-e	28 g	53 b-d	8 a-c	32 a-c	3 ab
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
16	Topguard 13 fl oz + Dithane 3 lb	#1-3C	7.7 b	16 d-g	3 bc	18 a-d	3 ab	57 cd	6 a-c	37 b-e	4 a-c
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									
17	Topguard 13 fl oz + Captan 40 oz	#1-3C	7.8 b	13 b-e	2 bc	16 a-c	5 a-c	55 b-d	7 a-c	36 b-e	5 bc
	Captan 80WDG 30 oz + Ziram 3 lb	4C-7C									

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots/tree rated 22 Jun (Idared), 6 Jul (York), 10 Jul (Golden Delicious). Test rows were non-treated border rows in 2008 to stabilize mildew inoculum pressure .
* Apparent suppressive effect rated on 6 primary mildew shoots / tree 26 Jun: scale 1-10 (1= none; 10= excellent effect).

Fungicide application dates: applied to both sides of the tree on each indicated application date at 100 gal/A as follows: 2 Apr (Idared ½-in greentip, Golden Delicious ¼"G, York greentip); 16 Apr (TC-pink); 24 Apr (pink-bloom); 5 May (petal fall); 1st- 7th covers: 19 May, 2 Jun, 15 Jun 1 Jul, 16 Jul, 30 Jul, 20 Aug.

Table 2. Scab, rust and summer disease control by experimental fungicides, 2009. VA Tech AREC.

		Scab, % leaves or fruit infected							C.-apple rust % leaves inf.	
	App. #/	Idared	Idared % fruit		G. Del		York			
Treatment and rate/A	timing	leaves	19 Aug	1 Oct	leaves	fruit	leaves	fruit	G. Del	York
0 No fungicide	---	13 f	72 f	77 d	25 i	82 e	30 f	80 c	17 d	21 b
1 Rally 40WSP 5 oz + Penncozeb 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-7 4C-7C	5 de	3 b-d	3 b	13 h	5 bc	9 e	0 a	<1 a-c	5 a
2 Inspire Super 12 fl oz + LI-700 8 fl oz Flint 50WG 2 oz Captan 80WDG 30 oz + Ziram 3 lb	1,3,5,7 2,4,6 4C-7C	3 cd	1 ab	0 a	3 b-d	0 a	1 bc	0 a	<1 a-c	6 a
3 Inspire Super 12 fl oz + B-1956 4 fl oz Flint 50 WG 2 oz Captan 80WDG 30 oz + Ziram 3 lb	1,3,5,7 2,4,6 4C-7C	3 b-d	0 a	0 a	5 c-e	0 a	1 bc	0 a	<1 ab	6 a
4 Procure 480SC 12 fl oz Flint 50WG 2 oz Captan 80WDG 30 oz + Ziram 3 lb	1,3,5,7 2,4,6 4C-7C	4 c-e	6 d	3 ab	5 c-f	3 a-c	2 c	2 a	0 a	7 a
5 Inspire Super 338SE 12 fl oz Flint 50WG 2 oz Captan 80WDG 30 oz + Ziram 3 lb	1,3,5,7 2,4,6 4C-7C	2 bc	0 a	1 ab	3 b-d	0 a	2 c	0 a	0 a	6 a
6 Inspire Super 338SE 12 fl oz Flint 50WG 1.5 oz + Ziram 76DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	1,3,5,7 2,4,6 4C-7C	3 b-d	0 a	0 a	5 c-f	1 ab	<1 bc	2 ab	0 a	5 a
7 Flint 50WG 2 oz	#1-7C	<1 a	0 a	0 a	2 ab	0 a	<1 ab	0 a	<1 c	4 a
8 Luna Sensation 500SC 4 oz	#1 -7C	<1 a	0 a	0 a	1 ab	0 a	0 a	0 a	<1 ab	5 a
9 Adament 50WG 4 oz	#1 -7C	<1 a	1 ab	1 ab	1 a	2 ab	<1 a-c	0 a	0 a	4 a
10 Flint 50WG 1.5 oz + Ziram 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-7 4C-7C	1 ab	1 ab	1 ab	3 bc	1 ab	<1 a-c	0 a	<1 bc	6 a
11 Flint 50WG 2 oz + Rally 2 oz Captan 80WDG 30 oz + Ziram 3 lb	#1-7 4C-7C	<1 a	0 a	2 ab	2 ab	3 a-c	<1 bc	1 a	0 a	6 a
12 Sovran 50WG 4 oz + Rally 2 oz Captan 80WDG 30 oz + Ziram 3 lb	#1-7 4C-7C	2 ab	0 a	0 a	1 a	0 a	<1 ab	0 a	<1 ab	6 a
13 GWN-4617 3.4 oz + Dithane 6 lb (+ B-1956 4 fl oz, apps. 4-7) Captan 80WDG 30 oz + Ziram 3 lb	#1-7 4C-7C	3 b-d	0 a	2 ab	9 f-h	1 ab	6 de	0 a	<1 bc	2 a
14 GWN-4617 3.4 oz + Dithane 6 lb (+ B-1956 4 fl oz, apps. 4-7) GWN-4616 3.4 oz + Dithane 3 lb Captan 80WDG 30 oz + Ziram 3 lb	1,3,5 2,4,6 4C-7C	3 cd	0 a	1 ab	6 d-g	0 a	7 de	1 a	<1 ab	7 a
15 Topguard 125SC 13 fl oz Captan 80WDG 30 oz + Ziram 3 lb	#1-3C 4C-7C	7 e	15 e	23 c	9 f-h	17 d	7 de	7 b	0 a	5 a
16 Topguard 13 fl oz + Dithane 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-3C 4C-7C	3 cd	4 cd	1 ab	8 e-g	0 a	8 e	0 a	<1 ab	2 a
17 Topguard 13 fl oz + Captan 40 oz Captan 80WDG 30 oz + Ziram 3 lb	#1-3C 4C-7C	5 c-e	2 a-c	4 ab	9 gh	11 c	5 d	2 a	0 a	5 a

Mean separation by Waller-Duncan K-ratio t-test ($p=0.05$). Four reps; 10 shoots/tree rated 22 Jun (Idared), 6 Jul (York), 10 Jul (Golden Delicious), or 25 fruit/tree harvested: Idared 19 Aug & 28 Sep; Golden Delicious 21 Sep; York 22 Sep.

Table 3. Control of sooty blotch and flyspeck by experimental and registered fungicides, 2009. Block 30, VA Tech AREC.

		Sooty blotch, % fruit or fruit area infected							Flyspeck, % fruit or fruit area infected				
	App. #/	Idared, 19 Aug		Idared, 1 Oct		Golden Del.		York	Idared	Idared, 1 Oct		% fruit	
Treatment and rate/A	timing	fruit	area	fruit	area	fruit	area	fruit	fruit 19Aug	fruit	area	G.Del	York
0 No fungicide	---	95 g	13 f	100 h	11 f	99 d	14 e	100 c	89 d	100 i	14 j	99 f	100 d
1 Rally 40WSP 5 oz + Penncozeb 3 lb	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	3 a-c	<1 a-c	15 a-e	<1 a-d	5 a-c	<1 a-d	0 a	0 a	47 fg	3 gh	20 c-e	3 ab
2 Inspire Super 12 fl oz + LI-700 8 fl oz	1,3,5,7												
Flint 50WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	4 a-c	<1 ab	17 a-e	1 a-d	1 a	<1 ab	0 a	0 a	3 ab	<1 ab	17 b-e	8 a-c
3 Inspire Super 12 fl oz + B-1956 4 fl oz	1,3,5,7												
Flint 50 WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	0 a	0 a	6 a-c	<1 ab	0 a	0 a	0 a	0 a	1 a	<1 a	0 a	1 a
4 Procure 480SC 12 fl oz	1,3,5,7												
Flint 50WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	0 a	0 a	21 c-f	1 b-e	7 a-c	<1 a-d	1 ab	0 a	36 ef	2 e-g	14 a-d	9 a-c
5 Inspire Super 338SE 12 fl oz	1,3,5,7												
Flint 50WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	0 a	0 a	4 ab	<1 ab	0 a	0 a	2 ab	0 a	1 a	<1 a	0 a	6 ab
6 Inspire Super 338SE 12 fl oz	1,3,5,7												
Flint 50WG 1.5 oz + Ziram 76DF 3 lb	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	1 ab	<1 a	7 a-c	<1 ab	4 a-c	<1 a-d	0 a	0 a	4 a-c	<1 a-c	12 a-d	1 a
7 Flint 50WG 2 oz	#1-7C	4 a-c	<1 a-c	13 a-e	<1 a-d	1 a	<1 ab	0 a	0 a	2 ab	<1 ab	0 a	1 a
8 Luna Sensation 500SC 4 oz	#1 -7C	4 b-d	<1 a-c	9 a-c	<1 ab	1 a	<1 ab	2 b	0 a	0 a	0 a	1 a	2 a
9 Adament 50WG 4 oz	#1 -7C	13 ef	<1 de	32 e-g	2 de	8 a-c	<1 a-d	1 ab	0 a	10 b-d	<1 b-d	2 ab	1 a
10 Flint 50WG 1.5 oz + Ziram 3 lb	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	6 a-c	<1 a-c	43 g	3 e	9 bc	<1 cd	0 a	9 bc	62 gh	5 i	25 c-e	11 a-c
11 Flint 50WG 2 oz + Rally 2 oz	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	5 c-e	<1 b-d	26 d-g	2 c-e	14 c	<1 d	0 a	1 ab	69 gh	4 hi	36 e	4 ab
12 Sovran 50WG 4 oz + Rally 2 oz	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	9 de	<1 c-e	19 b-f	1 b-e	5 a-c	<1 a-d	4 b	0 a	53 f-h	3 gh	20 c-e	18 bc
13 GWN-4617 3.4 oz + Dithane 6 lb													
(+ B-1956 4 fl oz, apps. 4-7)	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	0 a	0 a	9 a-c	<1 ab	3 ab	<1 a-c	0 a	0 a	19 de	1 d-f	12 a-c	2 a
14 GWN-4617 3.4 oz + Dithane 6 lb													
(+ B-1956 4 fl oz, apps. 4-7)	1,3,5												
GWN-4616 3.4 oz + Dithane 3 lb	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	0 a	0 a	4 a	<1 a	1 a	<1 ab	0 a	0 a	16 cd	<1 cd	0 a	3 ab
15 Topguard 125SC 13 fl oz	#1-3C												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	20 f	1 e	39 fg	2 de	12 bc	<1 b-d	3 b	8 c	70 h	4 hi	35 de	27 c
16 Topguard 13 fl oz + Dithane 3 lb	#1-3C												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	1 ab	<1 a	4 a	<1 a	3 a-c	<1 a-d	0 a	0 a	22 de	1 de	18 b-e	4 a
17 Topguard 13 fl oz + Captan 40 oz	#1-3C												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	1 ab	<1 a	9 a-d	<1 a-c	4 a-c	<1 a-d	0 a	1 ab	41 f	2 fg	25 c-e	21 c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). 4 reps; 25 fruit/tree harvested: Idared 19 Aug & 28 Sep; Golden Delicious 21 Sep; York 22 Sep.

Table 4. Control of postharvest rots by experimental and registered fungicides, 2009. Block 30, VA Tech AREC.

		Bitter rot, % fruit inf., harvest sample or post-incubation (+wk)*								Any rot, % fruit infected**			
	App. #/	Idared		Idared		Golden De.		York		Idared	G. Del.	York	
Treatment and rate/A	timing	19 Aug	+2 wk	28Sep	+3wk	21 Sep	+18 d	22 Sep	+22 d	28Sep	21 Sep	22 Sep	+22 d
0 No fungicide	---	57 e	73 e	23 b	68 d	15 d	59 h	15 c	64 e	73 e	79 f	54 d	68 g
1 Rally 40WSP 5 oz + Penncozeb 3 lb	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	5 a-c	5 ab	6 ab	9 a	1 ab	16 c-e	6 a-c	22 b-d	10 a	27 cd	8 a-c	35 d-f
2 Inspire Super 12 fl oz + LI-700 8 fl oz	1,3,5,7												
Flint 50WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	4 a-c	6 a-c	8 ab	29 bc	1 ab	31 e-g	7 a-c	20 b-d	29 b-d	37 c-e	11 c	25 c-f
3 Inspire Super 12 fl oz + B-1956 4 fl oz	1,3,5,7												
Flint 50 WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	7 a-d	11 b-d	7 ab	32 c	5 c	27 d-g	6 a-c	23 cd	33 cd	40 de	6 a-c	33 c-f
4 Procure 480SC 12 fl oz	1,3,5,7												
Flint 50WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	11 cd	15 b-d	9 ab	26 a-c	2 a-c	29 e-g	4 ab	16 a-d	26 a-d	49 e	4 a-c	36 ef
5 Inspire Super 338SE 12 fl oz	1,3,5,7												
Flint 50WG 2 oz	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	14 cd	16 cd	10 ab	26 a-c	0 a	14 c-f	4 a-c	17 a-d	27 a-d	28 cd	4 a-c	26 c-f
6 Inspire Super 338SE 12 fl oz	1,3,5,7												
Flint 50WG 1.5 oz + Ziram 76DF 3 lb	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	8 a-d	17 cd	14 ab	33 c	6 bc	31 fg	12 bc	28 d	34 d	42 de	12 c	36 f
7 Flint 50WG 2 oz	#1-7C	7 a-d	10 a-d	5 a	17 a-c	0 a	4 ab	1 a	15 a-d	17 a-d	9 ab	1 ab	23 b-f
8 Luna Sensation 500SC 4 oz	#1 -7C	3 ab	10 b-d	6 ab	22 a-c	0 a	12 b-d	0 a	2 a	23 a-d	28 cd	0 a	2 a
9 Adament 50WG 4 oz	#1 -7C	5 a-c	10 a-d	3 a	14 a-c	0 a	11 bc	0 a	4 ab	15 a-d	19 bc	0 a	5 ab
10 Flint 50WG 1.5 oz + Ziram 3 lb	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	8 a-d	14 b-d	10 ab	31 bc	1 ab	13 c-f	3 ab	9 a-d	32 b-d	29 cd	3 a-c	13 a-d
11 Flint 50WG 2 oz + Rally 2 oz	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	19 d	19 d	13 ab	28 bc	2 a-c	23 c-g	7 a-c	18 b-d	30 b-d	39 de	7 a-c	32 c-f
12 Sovran 50WG 4 oz + Rally 2 oz	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	11 b-d	14 b-d	5 a	18 a-c	2 a-c	35 g	8 a-c	25 cd	22 a-d	40 de	8 bc	27 c-f
13 GWN-4617 3.4 oz + Dithane 6 lb													
(+ B-1956 4 fl oz, apps. 4-7)	#1-7												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	3 a	4 a	10 ab	32 c	0 a	1 a	0 a	4 ab	34 d	11 ab	0 a	10 a-c
14 GWN-4617 3.4 oz + Dithane 6 lb/B-1956	1,3,5												
GWN-4616 3.4 oz + Dithane 3 lb	2,4,6												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	5 a-c	11 a-d	5 a	11 ab	0 a	0 a	0 a	10 a-d	12 a-c	8 a	0 a	16 a-e
15 Topguard 125SC 13 fl oz	#1-3C												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	18 d	19 d	6 ab	20 a-c	0 a	18 c-g	6 a-c	16 a-d	20 a-d	26 cd	6 a-c	23 b-f
16 Topguard 13 fl oz + Dithane 3 lb	#1-3C												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	5 a-c	8 a-c	7 ab	24 a-c	0 a	11 b-d	4 a-c	18 b-d	24 a-d	21 bc	4 a-c	20 b-f
17 Topguard 13 fl oz + Captan 40 oz	#1-3C												
Captan 80WDG 30 oz + Ziram 3 lb	4C-7C	8 a-d	21 d	3 a	15 ab	1 ab	19 c-g	2 a	9 a-c	16 ab	31 c-e	2 ab	20 b-f

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). 4 reps; 25 fruit/tree harvested: Idared 19 Aug & 28 Sep; Golden Del. 21 Sep; York 22 Sep.

* Samples incubated at ambient temperature (66-72ºF) for indicated period. ** “Any rot” includes all rots present in incubated sample.

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

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Evaluation of experimental fungicides and mixed schedules on Stayman, Idared, and Ginger Gold apples, 2009.

Ten combination treatments directed at fungicide resistance management approaches and broad-spectrum control, including several experimental materials, were tested on 23-yr-old trees in an area where scab fungus resistance to SI fungicides has been suspected since 2004. The test was conducted in a randomized block design with four three-cultivar replicate tree sets separated by non-treated border rows. Treatment rows had been used as non-treated border rows in 2008 to stabilize mildew inoculum pressure for 2009. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Fungicide treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 2 Apr (1/2"green, HIG); 16 Apr (open cluster, OC, Stayman and Ginger Gold; pink, Idared); 24 Apr (Stayman 50% bloom, Idared 80% bloom, Ginger Gold 30% bloom); 5 May (late petal fall). 1st – 8th covers (1C-8C): 20 May, 2 Jun, 16 Jun, 1 Jul, 15 Jul, 30 Jul, 13 Aug and 4 Sep. (Ginger Gold, harvested 4 Aug, were not treated 1 Jul and 30 Jul). Maintenance materials applied to the entire test block with the same equipment included Asana + Oil, Assail, Imidan, Provado, Intrepid, Delegate, Calypso, Lannate LV and Altacor. Inoculum over each Idared test tree included: cedar rust galls placed 3 & 28 Apr and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies placed 28 Apr. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 29 Jun (Stayman), 11 Aug (Idared) and 27 Jul (Ginger Gold). Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 4 Aug (Ginger Gold) or 28 Sep (Stayman and Idared). Stayman and Idared were again rated for post storage rots after 20 days incubation at ambient temperatures 64-76°F (mean 70°F). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Over-wintering scab inoculum was also high in this test area, and 18 infection periods through May resulted in a strong test. A comparison of fungicides applied in the critical bloom to first cover period showed Flint to be best for scab, followed by YT669, and for fruit scab control, a combination of LEM-17 + Manzate. Indar + Dithane, applied on a different schedule through 2nd cover, also gave acceptable scab control under these conditions. Increasing rates of Rally and KFD-64 did not improve control, and in some cases gave significantly poorer scab control. These conditions again illustrated questionable control by the SI+EBDC standard (Rally 5 oz + Manzate 3lb/A, Table 6) following two years of improved control using Nova + Dithane (Figs. 1 & 2). Test orchard history had earlier shown a decline in control by Nova 4-5 oz/A under consistently heavy disease pressure on foliage (in '04-'05), and the variable control illustrates the importance of weather factors and inoculum levels in the perception of "resistance". Mildew inoculum was heavy in this test block and mildew pressure was sustained, with 33 days favorable for infection from 30 Mar- 6 Jun. Under these heavy conditions more control was observed in suppression of percent area infected than in percent leaves infected (Table 5). The most suppression overall was by treatments involving Flint, YT669, or the higher rate of LEM-17 during the bloom to first cover test application period. Rate responses in mildew control occurred with LEM-17, (Trts #1&2), and with Rally (Trts #9&10), but not with KFD-64-01. We have also begun to track comparative orchard sensitivity of mildew to SI fungicides (Figs. 3 & 4) and QoIs. All treatments involving SI fungicides (Trts #6-10), gave good control of cedar-apple rust; while other treatments involving EBDC fungicides gave adequate, but somewhat weaker rust control. Flint, applied from bloom to first cover, allowed significantly more foliar rust infection than LEM-17 + Manzate. All treatments gave good control of Brooks spot. Control of sooty blotch and flyspeck was quite variable and somewhat cultivar related. The schedule involving Indar in combination with Dithane and Captan gave good sooty blotch, flyspeck and rot control on Ginger Gold, which was harvested 4 Aug. No treatment deleteriously affected fruit finish of any cultivar compared to non-treated fruit.

Table 5. Mildew control by experimental fungicides on Stayman, Idared, and Ginger Gold apples, 2009.

		Mildew, % leaves leaf area or fruit infected								
		Ginger Gold			Stayman.			Idared		
Treatment and rate/A	App. #	lvs	lf area	fruit	lvs	lf area	fruit	lvs	area	fruit
0 No fungicide	---	75 c	69 d	25 d	74 d	40 f	31 c	66 a	59 d	53 d
1 Manzate Pro-Stick 75WG 4 lb LEM17 200SC 14.5 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	67 ab	20 bc	3 ab	65 c	12 e	10 b	64 a	14 ab	38 b-d
2 Manzate Pro-Stick 75WG 4 lb LEM17 200SC 20.5 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	68 ab	11 a	4 ab	61 bc	7 b-d	3 a	62 a	12 a	42 cd
3 Manzate Pro-Stick 75WG 4 lb LEM17 200SC 14.5 fl oz + Manzate 3 lb Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	64 ab	14 a-c	0 a	64 c	9 cd	2 a	54 a	12 a	28 a-c
4 Manzate Pro-Stick 75WG 4 lb YT669 2.08SC 9 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	67 ab	12 ab	8 bc	55 ab	4 a	3 a	57 a	10 a	27 a-c
5 Manzate Pro-Stick 75WG 4 lb Flint 50WG 2 oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	60 a	11 a	4 ab	52 a	6 ab	2 a	58 a	12 ab	29 a-c
6 KFD-64-01 2.5 lb Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	HIG-3C 4-8C	67 ab	18 a-c	15 cd	64 c	7 bc	3 ab	67 a	22 c	29 a-c
7 KFD-64-01 5 lb Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	HIG-3C 4-8C	68 bc	22 c	15 cd	63 c	10 de	2 a	62 a	18 bc	32 a-c
8 Indar 2F 8 fl oz + Dithane 3 lb + LI-700 8 fl oz Indar 6 fl oz + Captan 30 oz + LI-700 8 fl oz	HIG-2C 3-8C	63 ab	21 bc	4 ab	62 bc	7 bc	5 ab	62 a	21 c	22 ab
9 Rally 40WSP 5 oz + Dithane 75DF 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-4C 5-8C	68 ab	19 a-c	7 bc	62 bc	6 bc	7 ab	61 a	22 c	26 ab
10 Rally 40WSP 7.5 oz + Dithane 75DF 3 lb Rally 7.5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-4C 5-8C	66 ab	19 a-c	3 ab	61 bc	7 bc	2 a	60 a	14 ab	18 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on ten shoots per rep 29 Jun (Stayman), 27 Jul (Ginger Gold), or 11 Aug (Idared). Randomized block design with four three-cultivar tree sets separated by untreated border rows. Treatment rows were used as non-treated border rows in 2008 to stabilize mildew inoculum pressure for 2009. Applied airblast at 100 gpa to both sides of the row on each application date.

Treatment applications: 2 Apr (1/2” green, HIG); 16 Apr (open cluster, OC, Stayman and Ginger Gold; pink, Idared); 24 Apr (Stayman 50% bloom, Idared 80% bloom, Ginger Gold 30% bloom); 5 May (late petal fall).
1st – 8th covers (1C-8C): 20 May, 2 Jun, 16 Jun, 1 Jul, 15 Jul, 30 Jul, 13 Aug, and 4 Sep. Ginger Gold not sprayed 4C or 6-8C.

Table 6. Scab, rust and summer disease control on Stayman, Idared, and Ginger Gold apples, 2009. VA Tech AREC, Winchester.

		Scab, % leaves or fruit infected						Cedar-apple rust, % leaves infected		Idared, % fruit inf.	
		Ginger Gold		Stayman		Idared				Brooks	Bitter
Treatment and rate/A	App. #	leaves	fruit	leaves	fruit	leaves	fruit	Idared	G. Gold	spot	rot
0 No fungicide	---	78 f	99 e	53 f	100 f	25 f	86 d	30 d	26 d	49 c	31 b
1 Manzate Pro-Stick 75WG 4 lb	HIG-OC										
LEM17 200SC 14.5 fl oz	BI-1C	56 de	1 a	33 de	29 d	20 ef	21 c	2 b	4 a-c	0 a	
Manzate Pro-Stick 75WG 6 lb	2C										
Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3-4C										
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C										2 a
2 Manzate Pro-Stick 75WG 4 lb	HIG-OC										
LEM17 200SC 20.5 fl oz	BI-1C	51 d	11 c	32 de	18 cd	12 b-e	4 ab	2 ab	5 bc	2 ab	
Manzate Pro-Stick 75WG 6 lb	2C										
Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3-4C										
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C										1 a
3 Manzate Pro-Stick 75WG 4 lb	HIG-OC										
LEM17 200SC 14.5 fl oz + Manzate 75DF 3 lb	BI-1C	49 cd	1 a	25 cd	3 ab	8 b-d	3 ab	2 b	2 ab	1 ab	
Manzate Pro-Stick 75WG 6 lb	2C										
Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3-4C										
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C										1 a
4 Manzate Pro-Stick 75WG 4 lb	HIG-OC										
YT669 2.08SC 9 fl oz	BI-1C	39 bc	0 a	14 b	2 ab	6 b	1 a	2 b	6 bc	0 a	
Manzate Pro-Stick 75WG 6 lb	2C										
Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3-4C										
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C										1 a
5 Manzate Pro-Stick 75WG 4 lb	HIG-OC										
Flint 50WG 2 oz	BI-1C	24 a	5 a-c	6 a	1 a	1 a	5 ab	7 c	7 c	0 a	
Manzate Pro-Stick 75WG 6 lb	2C										
Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3-4C										
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C										1 a
6 KFD-64-01 2.5 lb	HIG-3C	63 e	31 d	22 bc	28 d	13 c-e	23 c	<1 ab	2 a-c	2 ab	
Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	4-8C										0 a
7 KFD-64-01 5 lb	HIG-3C	65 e	44 d	35 e	69 e	14 de	74 d	<1 a	3 a-c	3 b	
Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	4-8C										0 a
8 Indar 2F 8 fl oz + Dithane 3 lb + LI-700 8 fl oz	HIG-2C	37 b	1 a	15 b	4 ab	6 bc	3 ab	<1 a	<1 a	1 ab	
Indar 6 fl oz + Captan 30 oz + LI-700 8 fl oz	3-8C										2 a
9 Rally 40WSP 5 oz + Dithane 75DF 3 lb	HIG-4C	49 cd	16 bc	26 c-e	9 bc	8 b-d	7 b	<1 ab	<1 a	0 a	
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C										1 a
10 Rally 40WSP 7.5 oz + Dithane 75DF 3 lb	HIG-4C	47 b-d	3 ab	29 c-e	27 d	10 b-d	5 ab	<1 ab	2 ab	0 a	
Rally 7.5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C										0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on ten shoots per rep 29 Jun (Stayman), 27 Jul (Ginger Gold), or 11 Aug (Idared), or harvest counts of 25 fruit per tree. Harvest dates: Ginger Gold 4 Aug; Stayman and Idared 28 Sep.

Table 7. Evaluation of sooty blotch and flyspeck control on Stayman, Idared and Ginger Gold apples, Winchester VA, 2009.

		Sooty blotch, % fruit or % fruit area infected						Flyspeck, % fruit or % fruit area infected				
		Stayman		Idared		Ginger Gold		Stayman		Idared		G.Gold
Treatment, rate/A, and timing	Timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit
0 No fungicide	---	100 c	31 c	100 c	32 c	100 c	17 c	99 e	10 e	100 f	9 f	75 c
1 Manzate Pro-Stick 75WG 4 lb	HIG-OC											
LEM17 200SC 14.5 fl oz	Bl-1C											
Manzate Pro-Stick 75WG 6 lb	2C											
Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb	3-4C											
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C	74 a-c	7 ab	57 ab	5 ab	5 ab	<1 ab	14 a-c	<1 a-c	2 a	<1 a	0 a
2 Manzate Pro-Stick 75WG 4 lb	HIG-OC											
LEM17 200SC 20.5 fl oz	Bl-1C											
Manzate Pro-Stick 75WG 6 lb	2C											
Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb	3-4C											
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C	48 a	6 a	68 ab	7 ab	31 b	2 b	14 a-c	<1 a-c	13 bc	<1 bc	0 a
3 Manzate Pro-Stick 75WG 4 lb	HIG-OC											
LEM17 200SC 14.5 fl oz + Manzate 75DF 3 lb	Bl-1C											
Manzate Pro-Stick 75WG 6 lb	2C											
Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb	3-4C											
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C	67 ab	6 a	61 ab	6 ab	7 ab	<1 ab	27 cd	1 b-d	21 c-e	1 c-e	0 a
4 Manzate Pro-Stick 75WG 4 lb	HIG-OC											
YT669 2.08SC 9 fl oz	Bl-1C											
Manzate Pro-Stick 75WG 6 lb	2C											
Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb	3-4C											
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C	75 a-c	7 ab	73 ab	9 b	23 ab	1 ab	22 a-d	1 a-d	21 c-e	1 c-e	0 a
5 Manzate Pro-Stick 75WG 4 lb	HIG-OC											
Flint 50WG 2 oz	Bl-1C											
Manzate Pro-Stick 75WG 6 lb	2C											
Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb	3-4C											
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C	71 ab	5 ab	44 a	4 a	8 ab	<1 ab	34 d	2 d	13 bc	<1 bc	0 a
6 KFD-64-01 2.5 lb	HIG-3C											
Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	4-8C	61 ab	4 a	62 ab	5 ab	9 ab	<1 ab	30 d	2 cd	13 cd	<1 b-d	1 ab
7 KFD-64-01 5 lb	HIG-3C											
Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	4-8C	73 a-c	7 ab	64 ab	4 ab	17 ab	2 ab	23 a-d	1 a-d	31 e	2 e	0 a
8 Indar 2F 8 fl oz + Dithane 75DF 3 lb + LI-700 8 fl oz	HIG-2C											
Indar 6 fl oz + Captan 80WDG 30 oz + LI-700 8 fl oz	3-8C	88 a-c	7 ab	80 ab	8 b	0 a	0 a	12 ab	<1 ab	4 ab	<1 ab	0 a
9 Rally 40WSP 5 oz + Dithane 75DF 3 lb	HIG-4C											
Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C	96 bc	12 b	78 b	7 ab	27 b	1 b	26 b-d	1 a-d	25 de	1 de	3 b
10 Rally 40WSP 7.5 oz + Dithane 75DF 3 lb	HIG-4C											
Rally 7.5 oz + Captan 80WDG 30 oz + Ziram 3 lb	5-8C	89 a-c	7 ab	70 ab	5 ab	5 ab	<1 ab	11 a	<1 a	13 b-d	<1 b-d	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit samples from each of four single-tree replications.
Harvest dates: Ginger Gold 4 Aug; Stayman and Idared 28 Sep. Treatment applications: 2 Apr (1/2"green, HIG); 16 Apr (open cluster, Stayman and Ginger Gold; pink, Idared); 24 Apr (Stayman 50% bloom, Idared 80% bloom, Ginger Gold 30% bloom); 5 May (late petal fall). 1st – 8th covers (1C-8C): 20 May, 2 Jun, 16 Jun, 1 Jul, 15 Jul, 30 Jul, 13 Aug and 4 Sep. Ginger Gold not sprayed 1 Jul, 30 Jul, 13 Aug and 4 Sep.

Table 8. Effect of early season treatments on post-harvest rot development of Ginger Gold apples, 2009.

			Rot incidence (%) after indicated post-harvest incubation period*										
			At harvest		Harvest + 7 days			Harvest + 13 days			Harvest + 13 days		
	Treatment and rate/A	Timing	any rot	bitter	any	bitter	Bot	any rot	bitter	Bot	Alternaria	brown	Phomopsis
0	No fungicide	---	28 c	20 c	48 e	47 e	11 d	95 f	73 e	36 d	9 b	4 b	5 b
1	Manzate Pro-Stick 75WG 4 lb LEM17 200SC 14.5 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	4 a	4 ab	12 d	7 d	7 cd	45 e	7 c	39 d	0 a	0 a	1 ab
2	Manzate Pro-Stick 75WG 4 lb LEM17 200SC 20.5 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	9 b	8 bc	12 d	11 d	4 b-d	28 d	16 d	16 c	0 a	0 a	0 a
3	Manzate Pro-Stick 75WG 4 lb LEM17 200SC 14.5 fl oz + Manzate 75DF 3 lb Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	0 a	0 a	0 a	0 a	0 a	12 bc	4 bc	8 bc	0 a	0 a	0 a
4	Manzate Pro-Stick 75WG 4 lb YT669 2.08SC 9 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	0 a	0 a	8 cd	5 cd	3 a-c	20 cd	7 c	13 c	0 a	0 a	0 a
5	Manzate Pro-Stick 75WG 4 lb Flint 50WG 2 oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	0 a	0 a	5 b-d	1 ab	4 b-d	12 bc	1 ab	10 bc	1 a	0 a	0 a
6	KFD-64-01 2.5 lb Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	HIG-3C 5C	1 a	0 a	1 ab	1 a-c	0 a	7 ab	4 bc	3 a	0 a	0 a	0 a
7	KFD-64-01 5 lb Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	HIG-3C 5C	1 a	0 a	7 b-d	5 b-d	1 ab	11 b	5 bc	5 ab	0 a	0 a	0 a
8	Indar 2F 8 fl oz + Dithane 75DF 3 lb + LI-700 8 fl oz Indar 6 fl oz + Captan 80WDG 30 oz + LI-700 8 fl oz	HIG-2C 3C&5C	0 a	0 a	0 a	0 a	0 a	3 a	0 a	3 a	0 a	0 a	0 a
9	Rally 40WSP 5 oz + Dithane 75DF 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-3C 5C	1 a	1 a	4 a-c	1 a-c	3 a-c	12 bc	1 ab	9 bc	1 a	0 a	0 a
10	Rally 40WSP 7.5 oz + Dithane 75DF 3 lb Rally 7.5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-3C 5C	1 a	1 a	4 b-d	1 a-c	3 a-c	11 bc	3 ab	8 bc	1 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Harvest counts of 25 fruit from three or four single-tree reps 4 Aug. *Rot counts following 7 and13 days' incubation at ambient temperatures. Mean max/min temperatures for 7 and 13-day incubations were 71-77°F, and 70-81°F, respectively.

Table 9. Post-storage rot incidence following treatments on Stayman and Idared apples, 2009.

			% fruit infected after 20 days warm temperature incubation following cold storage									
			Any rot		Bitter rot		Bot rot		Alternaria rot		Brown rot	
	Treatment and rate/A		Stayman	Idared	Stayman	Idared	Stayman	Idared	Stayman	Idared	Stayman	Idared
0	No fungicide	---	72 f	79 e	34 c	69 e	29 e	18 b	23 f	14 c	6 b	2 a
1	Manzate Pro-Stick 75WG 4 lb LEM17 200SC 14.5 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	16 cd	14 cd	0 a	8 cd	4 b-d	4 a	9 b-e	3 b	2 ab	1 a
2	Manzate Pro-Stick 75WG 4 lb LEM17 200SC 20.5 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	33 e	13 cd	4 b	10 cd	7 d	2 a	22 f	2 ab	2 ab	0 a
3	Manzate Pro-Stick 75WG 4 lb LEM17 200SC 14.5 fl oz + Manzate 75DF 3 lb Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	35 e	9 b-d	3 b	4 bc	7 cd	5 a	12 c-f	1 ab	4 ab	0 a
4	Manzate Pro-Stick 75WG 4 lb YT669 2.08SC 9 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	3 ab	7 bc	0 a	5 bc	0 a	0 a	1 a	2 ab	2 ab	0 a
5	Manzate Pro-Stick 75WG 4 lb Flint 50WG 2 oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-OC Bl-1C 2C 3-4C 5-8C	15 cd	5 bc	1 ab	4 bc	1 ab	1 a	14 d-f	0 a	0 a	0 a
6	KFD-64-01 2.5 lb Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	HIG-3C 4-8C	7 a-c	0 a	1 ab	0 a	1 ab	0 a	4 a-c	0 a	0 a	0 a
7	KFD-64-01 5 lb Captan 30 oz + Ziram 3 lb + Topsin M 70W 12 oz	HIG-3C 4-8C	27 de	21 d	3 ab	17 d	4 b-d	3 a	17 ef	3 b	4 ab	0 a
8	Indar 2F 8 fl oz + Dithane 3 lb + LI-700 8 fl oz Indar 6 fl oz + Captan 80WDG 30 oz + LI-700 8 fl oz	HIG-2C 3-8C	2 a	10 b-d	0 a	5 bc	0 a	3 a	2 ab	0 a	0 a	0 a
9	Rally 40WSP 5 oz + Dithane 75DF 3 lb Rally 5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-4C 5-8C	9 bc	6 bc	1 ab	2 ab	1 ab	1 a	6 b-e	3 b	0 a	0 a
10	Rally 40WSP 7.5 oz + Dithane 75DF 3 lb Rally 7.5 oz + Captan 80WDG 30 oz + Ziram 3 lb	HIG-4C 5-8C	13 c	4 ab	1 ab	1 ab	3 a-c	3 a	8 b-d	0 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Post-storage counts of 25-fruit samples rated for post storage rots after 20 days incubation at ambient temperatures 64-76°F (mean 70°F).

Treatments applied: 2 Apr (1/2”green, HIG); 16 Apr (open cluster, OC, Stayman and Ginger Gold; pink, Idared); 24 Apr (Stayman 50% bloom, Idared 80% bloom, Ginger Gold 30% bloom); 5 May (late petal fall). 1st – 8th covers (1C-8C): 20 May, 2 Jun, 16 Jun, 1 Jul, 15 Jul, 30 Jul, 13 Aug and 4 Sep.

Figure 1. 16-yr history of foliar scab control with SI+EBDC Stayman apple, Winchester, VA

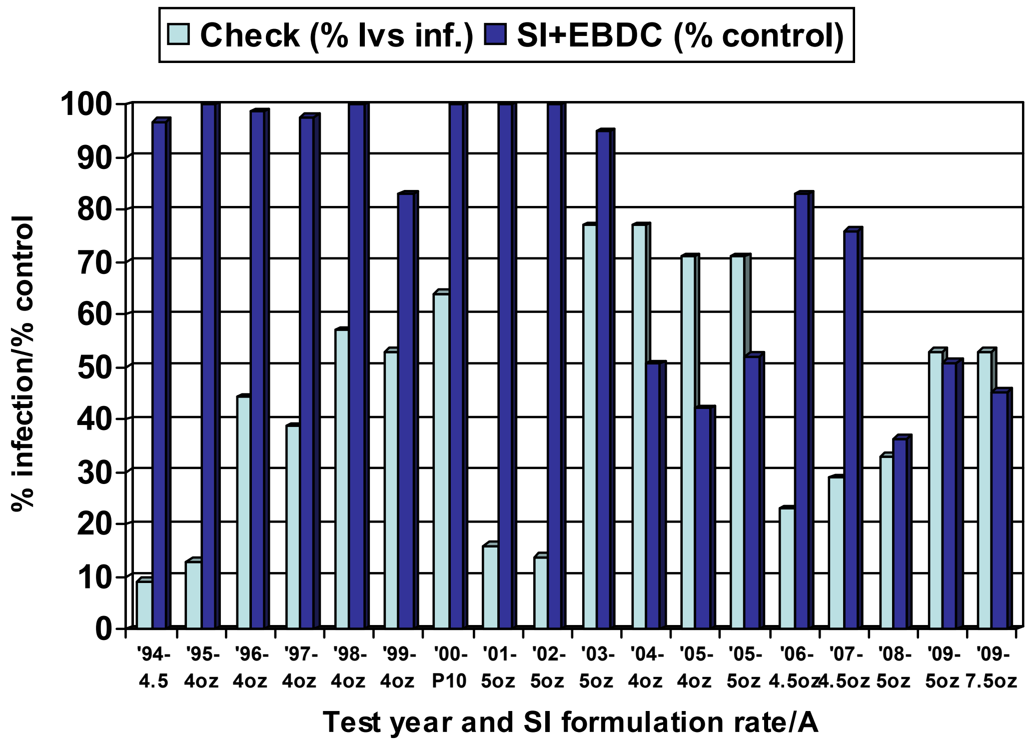


Figure 2. 16-yr history of fruit scab control with SI+EBDC Stayman apple, Winchester, VA

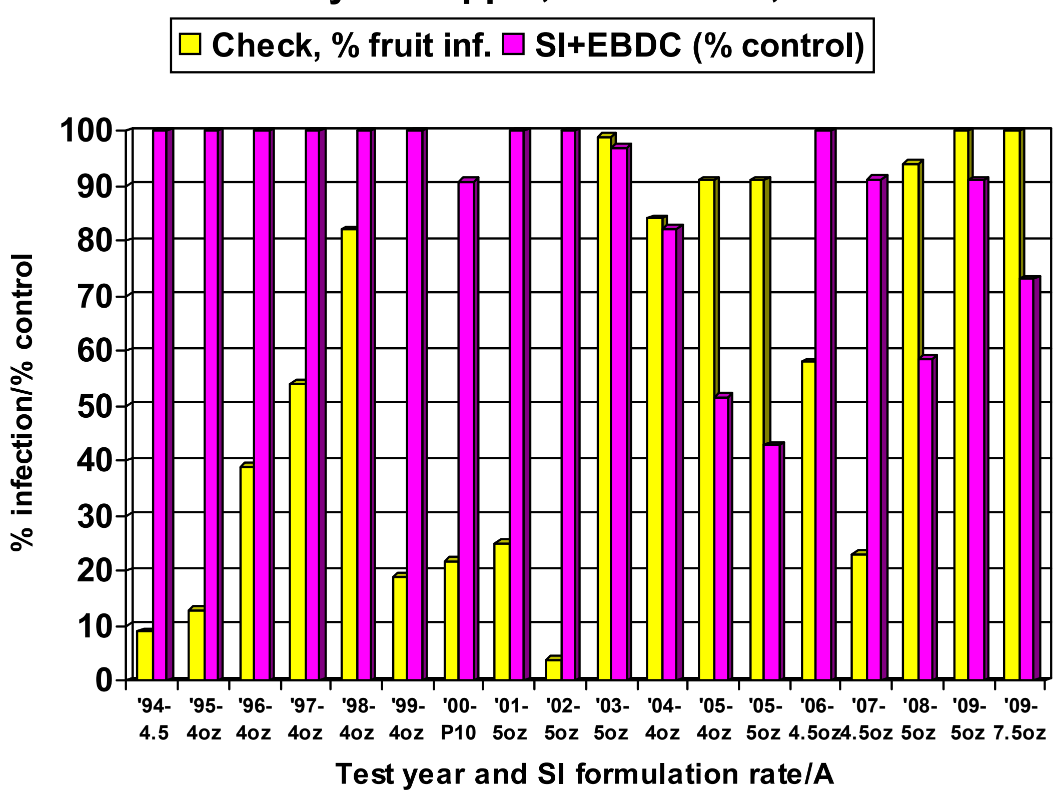


Figure 3. Control of % leaves infected with mildew by SI+EBDC Stayman and Idared apples, 1994-2009, Winchester, VA

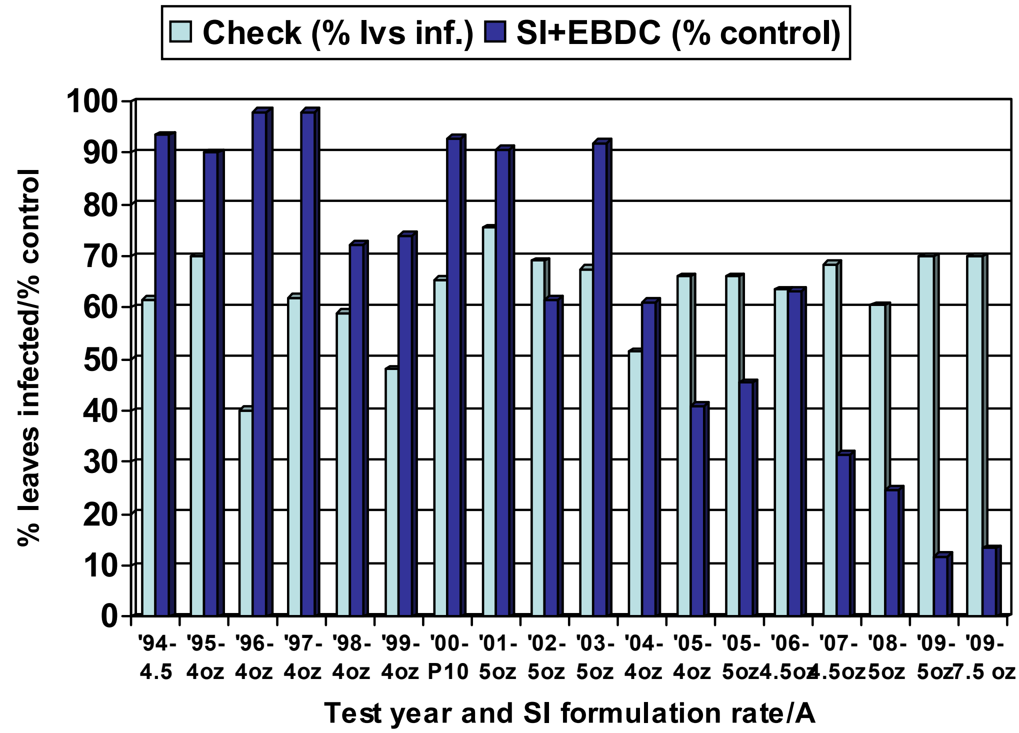


Figure 4. Control of % area infected by mildew with SI+EBDC Stayman and Idared apples, 1994-2009, Winchester, VA

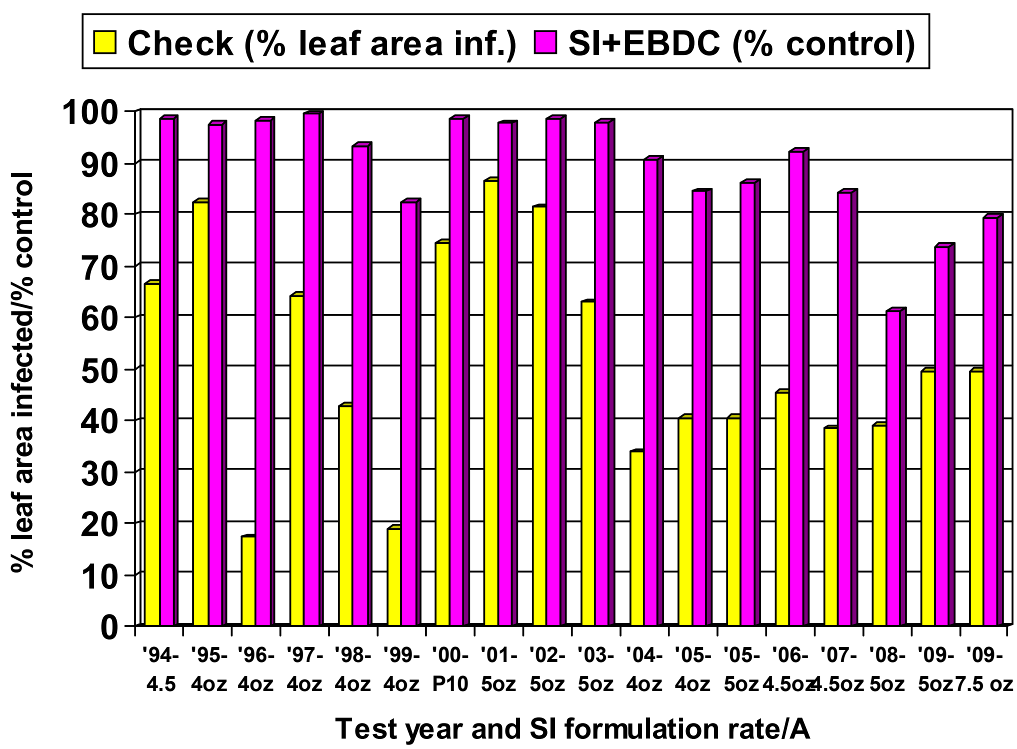


Figure 5. Control of % leaves infected with mildew by SI+EBDC and QoI
Stayman and Idared apples, 1994-2009, Winchester, VA

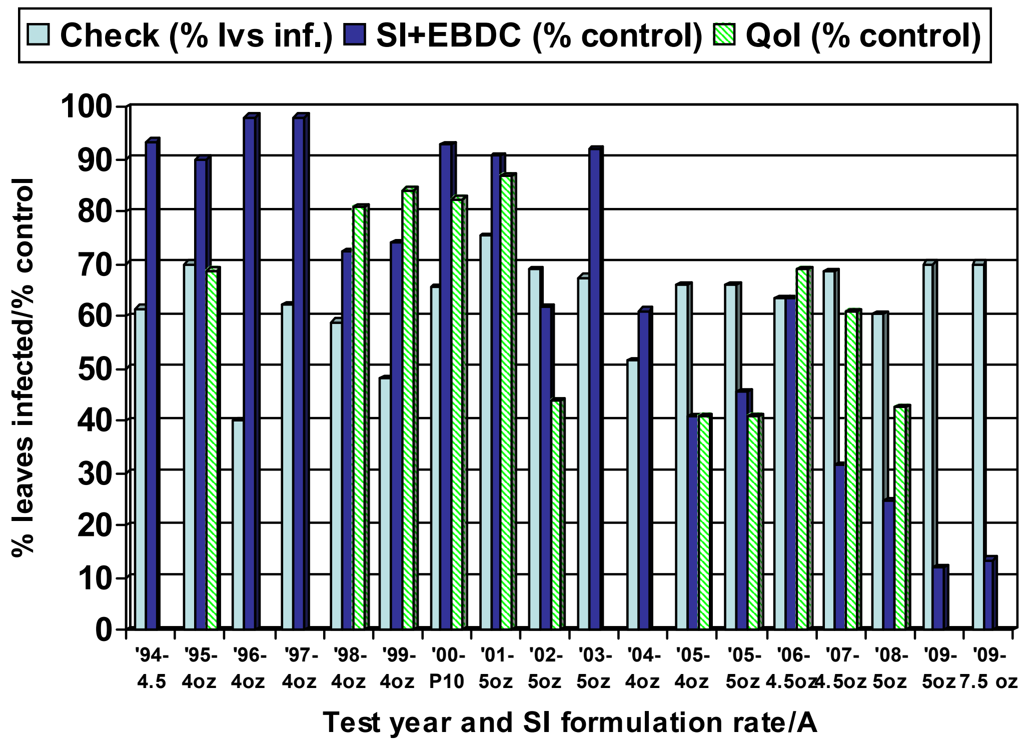
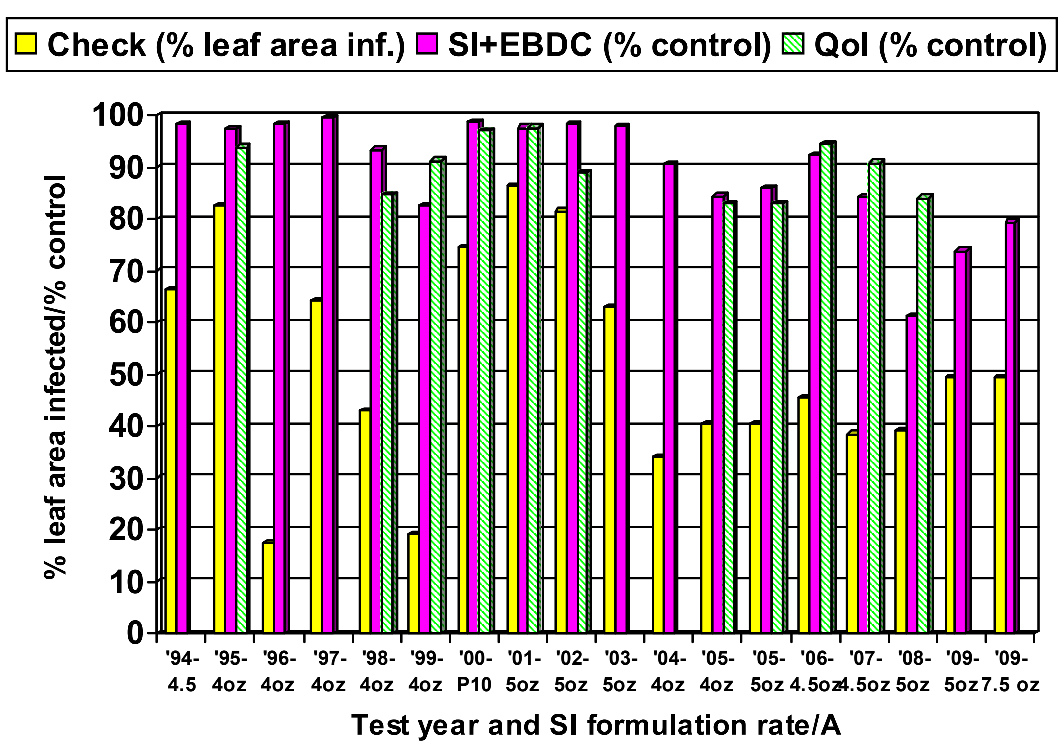


Figure 6. Control of % area infected by mildew with SI+EBDC and QoI
Stayman and Idared apples, 1994-2009, Winchester, VA



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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W. S. Royston, Jr., and S. W. Kilmer
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Winchester, VA 22602

Early season disease management with combined fungicides on Red Delicious, Golden Delicious, and Rome apples, 2009.

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 21-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 2008 to allow powdery mildew inoculum to stabilize in the 2009 test trees. Unused border Rome trees were uniformly treated with Rally 1 oz per 100 gal 15 May and 29 May to suppress disease pressure for 2010. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 400 psi as follows: 9 Apr Trts. 1& 2 only (Rome ½" greentip, Red & Golden Delicious open cluster); 16 Apr, all treatments (Rome tight cluster, TC; Golden Delicious TC- open cluster, OC, Red Delicious, pink); 24 Apr (Rome pink; G. Del. 30% bloom; R. Del. full bloom); 5 May (petal fall, PF); 1st-7th covers: 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul, 30 Jul, 20 Aug. Applied airblast dilute instead of with handgun on 30 Jul and 20 Aug. Maintenance sprays, applied separately to the entire test block with a commercial airblast sprayer, included: Supracide, Assail, Imidan, Provado, Intrepid, Lannate LV, Delegate, Calypso, and Altacor. Inoculum over each Golden Delicious test tree included: cedar rust galls placed 3, 8, and 28 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies placed 28 Apr. Other diseases developed from inoculum naturally present in the test area, including cedar-apple rust inoculum from red cedars in the vicinity. Foliar data represent averages of counts of ten terminal shoots from each of four single-tree reps 19 Jun (Golden), 20 Jul (Rome), or ten Red Delicious spur cluster leaf sets 4 Aug. Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 22 Sep (Red Delicious and Golden Delicious), or 28 Sep (Rome), placed in cold storage at 4°C and rated after 16-30 days cold storage. Following initial evaluation, fruit were incubated at mean 70°F for 17-20 days before final storage rot assessment. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Early season weather and inoculum conditions were favorable for scab, cedar-apple rust and powdery mildew. Scab inoculum levels were moderate, but 18 infection periods through May resulted in a strong test (Table 10), and scab lesions were observed on non-treated trees by 30 Apr. Trts. 1 & 2, initiated at tight cluster 9 Apr, provided protection against an infection period 14-16 Apr; later treatments were first applied at open cluster 16 Apr and required some after-infection control as well as protection against another infection period 19-21 Apr. Treatments involving Flint, Sovran or Inspire were generally the most effective for scab control among the treatments first applied at open cluster; the Rally + Dithane "standard" had the most foliar scab, suggesting reduced SI sensitivity. This treatment gave acceptable control of scab on Golden Delicious fruit, but not on Rome or Red Delicious. Indar + Dithane had significantly more scab than Inspire on foliage, but controlled fruit scab adequately. A half rate of Rally, included with Flint or Sovran, significantly improved the weaknesses of those treatments against rust (Table 11). Indar + Dithane had significantly more cedar rust than Inspire on Rome foliage. Powdery mildew control was variable, but Sovran + Rally gave the best control on the most heavily infected cultivar, Rome (Table 12). All treatments received only Captan + Ziram after 2nd cover, so any differences in summer disease control (sooty blotch, flyspeck, or rots) could be attributed to the fungicide applied before 3rd cover. The most consistent effect on these diseases was by Inspire (Table 13). Rally + Dithane had significantly fewer rots than Indar + Dithane (Table 14). There were no deleterious fruit finish effects by any treatment compared to non-treated trees; Rally + Dithane and early season treatments involving Vangard significantly improved USDA grade of Golden Delicious based on russetting (Table 12).

Table 10. Scab control on Rome Beauty, Golden Delicious and Red Delicious apple. 2009. Virginia Tech AREC.

	Treatment and formulated rate/100 gal	Timing	Scab, % leaves inf			Scab, lesions/leaf			Scab, % fruit infected		
			Rome	G. Del.	R. Del.	Rome	G. Del.	R. Del.	Rome	G. Del.	R. Del.
0	Non-treated control	---	50 e	27 e	57 f	9.0 b	4.8 c	12.1 c	86 d	84 d	93 d
1	Vangard 75WG 1.25 oz + Captan 80WDG 7.5 oz	TC									
	Vangard 1.25 oz + Captan 7.5 oz + Micro Sulf 80W 12 oz	OC-2C	18 a-c	12 c	10 bc	0.8 a	0.8 ab	0.5 a	37 c	2 ab	9 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
2	Vangard 75WG 1.25 oz + Ziram 76DF 7.5 oz	TC									
	Vangard 1.25 oz + Ziram 7.5 oz + Micro Sulf 12 oz	OC-2C	26 bc	8 bc	16 cd	2.3 a	0.5 ab	0.9 a	33 bc	9 c	22 bc
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
3	Rally 40WSP 1.25 oz + Dithane 75DF 12 oz	OC-2C	40 de	23 de	29 e	6.6 b	2.4 b	2.7 b	35 c	1 ab	41 c
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
4	Flint 50WG 0.5 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C	19 a-c	3 a	2 a	0.8 a	0.1 a	0.1 a	9 a	1 ab	3 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
5	Flint 50WG 0.5 oz	OC-2C	13 a	4 ab	3 a	1.0 a	0.1 a	0.1 a	6 a	1 ab	5 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
6	Sovran 50WG 1 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C	14 ab	9 bc	4 a	0.5 a	0.5 ab	0.1 a	8 a	0 a	5 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
7	Sovran 50WG 1 oz	OC-2C	14 a	8 a-c	5 a	0.7 a	0.3 a	0.2 a	7 a	1 ab	7 ab
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
8	Indar 2F 2 fl oz +Dithane 75DF 12 oz +LI-700 8 fl oz	OC-2C	30 cd	15 cd	17 d	2.1 a	1.1 ab	0.8 a	7 a	4 bc	7 ab
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									
9	Inspire Super 338SE 3 fl oz (new exp. product)	OC-2C	15 ab	7 a-c	6 ab	1.0 a	0.8 ab	0.3 a	13 ab	0 a	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C									

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on 10 shoots per rep 19 Jun (Golden Del.), 20 Jul (Rome), or 10 Red Delicious cluster spurs 4 Aug, or harvest counts of 25 fruit per tree.

Treatments were applied dilute to run-off: 9 Apr Trts. #1& 2 only (Rome ½" G, Red & Golden Delicious open cluster); 16 Apr, all treatments (Rome tight cluster, TC; Golden Delicious TC- open cluster, OC, Red Delicious, pink); 24 Apr (Rome pink; G. Del. 30% bloom, R. Del. full bloom); 5 May (petal fall, PF); 1st-7th covers: 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul, 30 Jul, 20 Aug. Applied airblast dilute instead of with handgun on 30 Jul and 20 Aug.

Table 11. Rust control on Rome Beauty and Golden Delicious apple, 2009. Virginia Tech AREC.

	Treatment and formulated rate/100 gal	Timing	Cedar-apple rust % leaves Rome	Cedar-apple rust % leaves G. Del.	Cedar-apple rust lesions/leaf Rome	Cedar-apple rust lesions/leaf G. Del.	Cedar-apple rust % fruit Rome	Quince rust % fruit infected Rome	Quince rust % fruit infected G. Del.
0	Non-treated control	---	60 e	31 e	3.3 d	1.7 d	24 d	3 ab	0 a
1	Vangard 75WG 1.25 oz + Captan 80WDG 7.5 oz	TC							
	Vangard 1.25 oz + Captan 7.5 oz + Micro Sulf 80W 12 oz	OC-2C	34 d	13 d	1.2 c	0.5 a-c	12 cd	2 ab	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
2	Vangard 75WG 1.25 oz + Ziram 76DF 7.5 oz	TC							
	Vangard 1.25 oz + Ziram 7.5 oz + Micro Sulf 12 oz	OC-2C	34 d	17 d	1.1 bc	0.8 bc	10 c	2 ab	1 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
3	Rally 40WSP 1.25 oz + Dithane 75DF 12 oz	OC-2C	20 c	<1 a	0.6 ab	<0.1 a	0 a	0 a	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
4	Flint 50WG 0.5 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C	11 a	5 c	0.3 a	0.1 ab	2 ab	1 ab	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
5	Flint 50WG 0.5 oz	OC-2C	19 bc	4 bc	0.5 ab	0.1 ab	10 c	5 ab	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
6	Sovran 50WG 1 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C	10 ab	12 d	0.3 a	0.6 a-c	1 a	0 a	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
7	Sovran 50WG 1 oz	OC-2C	20 c	13 d	0.4 a	0.9 c	6 bc	5 b	4 b
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
8	Indar 2F 2 fl oz +Dithane 12 oz +LI-700 8 fl oz	OC-2C	25 cd	4 bc	0.7 a-c	0.2 ab	0 a	0 a	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							
9	Inspire Super 338SE 3 fl oz (new exp. product)	OC-2C	11 ab	<1 ab	0.3 a	<0.1 a	0 a	0 a	0 a
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C							

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on 10 shoots per rep 19 Jun (Golden Del.), and 20 Jul (Rome) or harvest counts of 25 fruit per tree.

Treatments were applied dilute to run-off: 9 Apr Trts. #1& 2 only (Rome ½“ G, Red & Golden Delicious open cluster); 16 Apr, all treatments (Rome tight cluster, TC; Golden Delicious TC- open cluster, OC, Red Delicious, pink); 24 Apr (Rome pink; G. Del. 30% bloom, R. Del. full bloom); 5 May (petal fall, PF); 1st-7th covers: 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul, 30 Jul, 20 Aug. Applied airblast dilute instead of with handgun on 30 Jul and 20 Aug.

Table 12. Powdery mildew control on Rome Beauty and Golden Delicious apple, 2009. Virginia Tech AREC.

	Treatment and formulated rate/100 gal	Timing	Powdery mildew infection: % leaves Rome	% leaves G. Del.	% leaf area Rome	% leaf area G. Del.	% fruit Rome	Golden Del. fruit finish: % USDA fancy/x-fcy	russet rating (0-5)*
0	Non-treated control	---	75 e	66 d	39 e	16 e	25 a	50 b	2.9 c
1	Vangard 75WG 1.25 oz + Captan 80WDG 7.5 oz Vangard 1.25 oz + Captan 7.5 oz + Micro Sulf 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC OC-2C 3C-7C	65 d	50 c	12 cd	5 d	15 a	88 a	2.0 ab
2	Vangard 75WG 1.25 oz + Ziram 76DF 7.5 oz Vangard 1.25 oz + Ziram 7.5 oz + Micro Sulf 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC OC-2C 3C-7C	68 d	43 bc	13 d	4 b-d	13 a	85 a	2.3 a-c
3	Rally 40WSP 1.25 oz + Dithane 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	OC-2C 3C-7C	67 d	41 bc	10 cd	5 cd	9 a	86 a	2.0 a
4	Flint 50WG 0.5 oz (+ Rally 40WSP 0.5 oz PF-2C) Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	OC-2C 3C-7C	56 a-c	23 a	6 ab	3 a	19 a	70 ab	2.5 a-c
5	Flint 50WG 0.5 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	OC-2C 3C-7C	61 b-d	26 a	8 bc	3 a-c	12 a	56 b	2.9 c
6	Sovran 50WG 1 oz (+ Rally 40WSP 0.5 oz PF-2C) Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	OC-2C 3C-7C	50 a	25 a	4 a	3 ab	9 a	50 b	2.9 c
7	Sovran 50WG 1 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	OC-2C 3C-7C	54 ab	25 a	5 ab	3 ab	20 a	68 ab	2.6 bc
8	Indar 2F 2 fl oz +Dithane 12 oz +LI-700 8 fl oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	OC-2C 3C-7C	63 cd	36 b	11 cd	4 a-d	18 a	64 ab	2.8 c
9	Inspire Super 338SE 3 fl oz (new exp. product) Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	OC-2C 3C-7C	66 d	39 b	11 cd	4 a-d	22 a	68 ab	2.5 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on ten shoots per rep 19 Jun (Golden Del.), and 20 Jul (Rome). Rome trees in 2009 test were not in test in 2008 to stabilize mildew inoculum pressure for 2009.

* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet). USDA Extra fancy and fancy grades after downgrading by russet. Treatments were applied dilute to run-off: 9 Apr Trts. #1 & 2 only (Rome ½ " G, Red & Golden Delicious open cluster); 16 Apr, all treatments (Rome tight cluster, TC; Golden Delicious TC- open cluster, OC, Red Delicious, pink); 24 Apr (Rome pink; G. Del. 30% bloom, R. Del. full bloom); 5 May (petal fall, PF); 1st-7th covers: 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul, 30 Jul, 20 Aug. Applied airblast dilute instead of with handgun on 30 Jul and 20 Aug.

Table 13. Control of sooty blotch and flyspeck on Rome Beauty, Golden Delicious and Red Delicious apple, 2009. Virginia Tech AREC.

			Sooty blotch, % fruit or fruit area infected						Flyspeck, % fruit infected		
			Red Delicious		Golden Del.		Rome				
	Treatment and formulated rate/100 gal	Timing	fruit	area	fruit	area	fruit	area	R. Del.	G. Del.	Rome
0	Non-treated control	---	100 e	14 d	100 e	15 e	98 e	13 d	100 f	100 f	89 d
1	Vangard 75WG 1.25 oz + Captan 80WDG 7.5 oz	TC									
	Vangard 1.25 oz + Captan 7.5 oz + Micro Sulf 80W 12 oz	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	23 b-d	1 a-c	35 d	3 d	31 d	2 c	55 de	38 e	37 c
2	Vangard 75WG 1.25 oz + Ziram 76DF 7.5 oz	TC									
	Vangard 1.25 oz + Ziram 7.5 oz + Micro Sulf 80W 12 oz	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	48 d	3 c	13 cd	<1 cd	29 cd	2 bc	69 e	16 b-d	35 bc
3	Rally 40WSP 1.25 oz + Dithane 75DF 12 oz	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	32 cd	2 bc	17 cd	1 cd	4 ab	<1 ab	55 de	13 bc	11 ab
4	Flint 50WG 0.5 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	8 ab	<1 a	23 cd	1 cd	5 ab	<1 ab	18 ab	26 c-e	7 a
5	Flint 50WG 0.5 oz	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	7 ab	<1 a	1 ab	<1 ab	20 b-d	1 bc	22 b	1 a	24 a-c
6	Sovran 50WG 1 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	14 a-c	<1 ab	29 d	2 cd	8 a-c	<1 ab	26 bc	40 e	9 ab
7	Sovran 50WG 1 oz	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	19 a-c	1 ab	12 bc	<1 bc	19 b-d	1 bc	47 c-e	7 ab	19 a-c
8	Indar 2F 2 fl oz +Dithane 75DF 12 oz +LI-700 8 fl oz	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	20 a-c	1 ab	15 cd	1 cd	4 ab	<1 ab	35 b-d	35 de	12 a-c
9	Inspire Super 338SE 3 fl oz (new exp. product)	OC-2C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	5 a	<1 a	0 a	0 a	0 a	0 a	6 a	0 a	13 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. Harvest counts based on 25 fruit per replication.

Treatments were applied dilute to run-off: 9 Apr Trts. #1& 2 only (Rome ½" G, Red & Golden Delicious open cluster); 16 Apr, all treatments (Rome tight cluster, TC; Golden Delicious TC- open cluster, OC; Red Delicious, pink); 24 Apr (Rome pink; G. Del. 30% bloom, R. Del. full bloom); 5 May (petal fall, PF); 1st-7th covers: 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul, 30 Jul, 20 Aug. Applied airblast dilute instead of with handgun on 30 Jul and 20 Aug.

Table 14. Post-storage rot control on Rome Beauty, Golden Delicious, and Red Delicious apple, 2009. Virginia Tech AREC.

		Post-incubation storage rots, % fruit infected											
		Any rot			Bitter rot			White (Bot) rot			Alternaria rot		
Treatment and formulated rate/100 gal	Timing	Rome	G.Del	R.Del	Rome	G.Del	R. Del	Rome	G.Del	R. Del	Rome	G.Del	R.Del
0 Non-treated control	---	62 e	66 e	47 b	50 e	49 d	24 c	26 c	23 d	15 b	14 b	8 b	15 c
1 Vangard 75WG 1.25 oz + Captan 80WDG 7.5 oz	TC												
Vangard 1.25 oz + Captan 7.5 oz + Micro Sulf 80W 12 oz	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	13 a-d	27 cd	2 a	10 b-d	13 bc	0 a	2 a	14 b-d	2 a	1 a	1 a	0 a
2 Vangard 75WG 1.25 oz + Ziram 76DF 7.5 oz	TC												
Vangard 1.25 oz + Ziram 7.5 oz + Micro Sulf 12 oz	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	22 d	12 a-c	0 a	14 d	3 a	0 a	10 b	16 cd	0 a	3 a	0 a	0 a
3 Rally 40WSP 1.25 oz + Dithane 75DF 12 oz	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	4 ab	13 a	1 a	1 a	4 ab	0 a	2 a	3 a	1 a	1 a	4 ab	0 a
4 Flint 50WG 0.5 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	7 a-c	20 a-c	1 a	5 a-c	10 a-c	1 b	2 a	7 a-c	0 a	0 a	4 ab	1 b
5 Flint 50WG 0.5 oz	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	13 b-d	13 ab	0 a	6 a-d	8 a-c	0 a	5 ab	4 a	0 a	3 a	2 ab	0 a
6 Sovran 50WG 1 oz (+ Rally 40WSP 0.5 oz PF-2C)	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	11 a-d	23 a-d	2 a	6 a-d	14 bc	0 a	3 a	10 a-d	1 a	2 a	1 a	0 a
7 Sovran 50WG 1 oz	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	14 cd	34 d	1 a	11 cd	22 c	0 a	3 a	11 a-d	1 a	1 a	4 ab	0 a
8 Indar 2F 2 fl oz +Dithane 12 oz +LI-700 8 fl oz	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	5 a-c	23 b-d	2 a	2 a-c	9 ab	0 a	1 a	11 a-d	2 a	2 a	4 ab	0 a
9 Inspire Super 338SE 3 fl oz (new exp. product)	OC-2C												
Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	3C-7C	3 a	18 a-c	0 a	2 ab	10 a-c	0 a	0 a	5 ab	0	1 a	2 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on 25 fruit per tree.
Counts are means of 25-fruit from each of four single-tree reps picked 22 Sep (Red Delicious), or 28 Sep (Rome). Following 16-23 days in cold storage, fruit were incubated at mean 70°F for 18 days (Rome), or 20 days (Red Del.) before rot assessment.

Treatments were applied dilute to run-off: 9 Apr Trts. #1& 2 only (Rome ½ " G, Red & Golden Delicious open cluster); 16 Apr, all treatments (Rome tight cluster, TC; Golden Delicious TC- open cluster, OC; Red Delicious, pink); 24 Apr (Rome pink; G. Del. 30% bloom, R. Del. full bloom); 5 May (petal fall, PF); 1st-7th covers: 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul, 30 Jul, 20 Aug. Applied airblast dilute instead of with handgun on 30 Jul and 20 Aug.

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

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Early and late season disease control by experimental and registered fungicides on Nittany apple, 2009.

Seven treatments involving experimental and registered treatments were compared during the cover spray period on 28-yr-old trees with a 28-ft row spacing. The test was conducted in a randomized block design with four single-tree replicates separated by border rows. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. No fungicides applied before 8 May. Test treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 8 May (late bloom); 1st-8th covers (1C-8C): 22 May, 6 Jun, 19 Jun, 2 Jul, 16 Jul, 30 Jul, 20 Aug, and 10 Sep. Inoculum, placed over each test tree included: wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies 18 May. Other diseases developed from inoculum naturally present in the test area. Foliar fungal data based on counts of 10 shoots per tree from each of four single-tree replications 14 Aug. Fruit data are based on 25-fruit sample per rep harvested and first evaluated 6 Oct, then evaluated for rot development after 21 days at ambient temperatures 64-76ºF (mean 70ºF). Maintenance materials applied to the entire test block with the same equipment included: Asana + oil, Assail, BacMaster, Calypso, Delegate, Intrepid, Imidan, Lannate LV and Provado. Calcium chloride 6 lb/A was applied to the entire test block 10 Jul, 24 Jul, 7 Aug, and 25 Aug. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Starting the fungicide application series at late bloom 8 May, after a week of frequent scab infection periods, ensured a strong scab test. All treatments gave significant control, with Pristine and the highest rate of YT669 numerically the best and significantly better on leaves and fruit, respectively, than the "standard" involving Rally with Dithane and Captan through 2nd cover (Table 10). Replacing Rally with sulfur + ProPhyt, gave comparable control of scab. Some cedar-apple rust infection occurred at least three weeks before the first test application, but control was generally good except for observed weaknesses by Pristine and one YT669 treatment. The delayed start of the application series likely precluded a significant reduction of percent leaves infected by mildew; however all treatments significantly reduced percent leaf area and percent fruit infected. Sooty blotch and flyspeck pressure was moderately high, and all treatments gave near complete suppression of both diseases (Table 11). Pristine, and the highest rate of YT669, gave the best control of rots of which bitter rot was the most predominant. ProPhyt, added to Captan in the cover sprays, did not significantly increase control of the rots in this test. There was no significant treatment effect on fruit finish (p=0.05).

Table 15. Early season disease control by fungicides first applied to Nittany apple at petal fall.

	Treatment and rate/A	Timing	Scab, % infection lvs	les/leaf	fruit	Cedar rust inf, % lvs	Mildew, % leaves, leaf area or fruit inf. leaves	lf area	fruit
0	No fungicide	--	37 d	10.1 b	62 c	25 d	66 a	12 c	67 b
1	Dithane 75DF 3 lb + Rally 40W 5 oz	PF-1C	20 c	4.5 ab	13 b	3 a	60 a	8 b	40 a
	Captan 80WDG 30 oz + Rally 40W 5 oz	2C							
	Captan 80WDG 24 oz + Sovran 50WG 4 oz	3C, 8C							
	Captan 80WDG 2 lb	4C-7C							
2	Dithane 3 lb + MicroSulf 3 lb + ProPhyt 4.2L 2 qt	PF-1C	9 bc	0.4 a	14 b	4 a	54 a	5 a	19 a
	Captan 30 oz + MicroSulf 3 lb + ProPhyt 2 qt	2C							
	Captan 80WDG 24 oz + Sovran 50WG 4 oz	3C, 8C							
	Captan 80WDG 2 lb + ProPhyt 4.2L 2 qt	4C-7C							
3	DPX-YT669 4 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	5 ab	0.4 a	12 b	4 a	52 a	5 a	40 a
4	DPX-YT669 6 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	3 ab	0.1 a	10 b	5 ab	50 a	6 a	23 a
5	DPX-YT669 8 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	3 ab	0.1 a	8 b	10 bc	50 a	5 a	34 a
6	DPX-YT669 12 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	3 ab	0.1 a	2 a	5 ab	48 a	5 a	33 a
7	Pristine 38WG 14.5 oz + B-1956 (8 fl oz/100 gal)	PF-8C	2 a	<0.1 a	6 ab	13 c	48 a	4 a	28 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on ten shoots per rep 14 Aug or 25-fruit samples per rep 6 Oct.
Randomized block design with four single-tree replicates separated by non-treated border rows. Applied by airblast at 100 gpa to both sides of the row on each application date. No fungicides applied before 8 May.

Treatment applications: 8 May (petal fall); 1st-8th covers (1C-8C): 22 May, 6 Jun, 19 Jun, 2 Jul, 16 Jul, 30 Jul, 20 Aug, 10 Sep.

Table 16. Summer disease control by treatments first applied to Nittany apple at petal fall, 2009

			% fruit infected						
			harvest counts			after 21 days incubation			
	Treatment and rate/A	Timing	Sooty blotch	Fly-speck	Bitter rot	Any rot	Bitter rot	White rot	Alter-naria
0	No fungicide	--	45 b	82 b	28 b	61 f	49 e	13 c	8 c
1	Dithane 75DF 3 lb + Rally 40W 5 oz	PF-1C							
	Captan 80WDG 30 oz + Rally 40W 5 oz	2C							
	Captan 80WDG 24 oz + Sovran 50WG 4 oz	3C, 8C							
	Captan 80WDG 2 lb	4C-7C	0 a	0 a	4 a	22 de	15 cd	6 b	3 ab
2	Dithane 3 lb + MicroSulf 3 lb + ProPhyt 4.2L 2 qt	PF-1C							
	Captan 30 oz + MicroSulf 3 lb + ProPhyt 2 qt	2C							
	Captan 80WDG 24 oz + Sovran 50WG 4 oz	3C, 8C							
	Captan 80WDG 2 lb + ProPhyt 4.2L 2 qt	4C-7C	1 a	0 a	5 a	16 c-e	13 b-d	2 ab	3 bc
3	DPX-YT669 4 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	1 a	6 a	2 a	9 b-d	8 b-d	0 a	1 ab
4	DPX-YT669 6 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	0 a	8 a	3 a	11 bc	7 a-c	2 ab	2 ab
5	DPX-YT669 8 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	0 a	0 a	3 a	25 e	18 d	4 b	2 ab
6	DPX-YT669 12 fl oz + B-1956 (8 fl oz/100 gal)	PF-8C	0 a	0 a	2 a	7 ab	7 ab	0 a	0 a
7	Pristine 38WG 14.5 oz + B-1956 (8 fl oz/100 gal)	PF-8C	0 a	2 a	0 a	1 a	1 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Data based on 25-fruit sample per rep harvested and first evaluated 6 Oct, then evaluated for rot development after 21 days incubation at ambient warm temperatures 64-76ºF (mean 70ºF).

Treatment applications: 8 May (petal fall); 1st-8th covers (1C-8C): 22 May, 6 Jun, 19 Jun, 2 Jul, 16 Jul, 30 Jul, 20 Aug, 10 Sep.

APPLE (*Malus domestica* 'Idared')
Fireblight; *Erwinia amylovora*

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Suppression of fire blight blossom blight on Idared apple, 2009.

Two experimental materials and two rates of a copper product (C-O-C-S) were compared to streptomycin (Firewall) for blossom blight control and fruit finish effects. The test was established in four randomized blocks on 27-yr-old trees using single-tree replications with border rows between treatment rows. All treatments were applied to both sides of the tree with a Swanson Model DA-400 airblast sprayer at 100 gal/A on the morning of 17 Apr (most clusters with king bloom open), repeated on 24 Apr (full bloom) and again 28 Apr (all petals off). The test strategy was to inoculate after the first two applications, but to make a third application without a follow-up inoculation. Four selected branches per tree, each with 25 to 40 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ Erwinia amylovora cells/ml in the evening of the first two treatment days (17 Apr and 24 Apr). Infection data were based on counts of number of blossom clusters at the first inoculation. A cluster was rated as infected if it had at least one blossom with fire blight symptoms on 30 Apr or one cluster leaf with symptoms on 11 May. Maintenance materials, applied to the entire block with a commercial airblast sprayer included Rally, Dithane, Asana + oil, Calypso and Imidan.

Inoculation and weather conditions favored a strong fire blight test. In addition to the inoculations on 17 Apr and 24 Apr, natural infection periods (based on MaryBlyt) occurred on 28 Apr and at late bloom 8-9 May. Initial ratings, conducted on the relatively light infection when symptoms from the first inoculation first appeared, did not correlate well to later ratings of the amount of infection that advanced into the cluster leaves. Streptomycin (Firewall) performed as expected under these conditions, with significant suppression of cluster leaf infection by both rates. The higher streptomycin rate provided the best control. The two highest rates of undisclosed material VA-1 also gave significant reductions in per cent clusters with leaf infection 11 May. In contrast to results in 2008, C-O-C-S did not give significant (p=0.05) suppression of fire blight symptoms. All experimental treatments and C-O-C-S deleteriously affected fruit finish, significantly increased the amount of both russet, which appeared to be rate-related for both C-O-C-S and VA-1, and opalescence.

Table 17. Control of fire blight on Idared blossom clusters, 2009.

All treatments applied airblast at 100 gal/acre Treatment and rate/A (or /100 gal in tank for Regulaid)	% cluster infection and control* % clusters infected 30 Apr % inf.	 control	 % clusters with leaf inf. 11 May % inf.	 control	Fruit finish rating (0-5)** russet	 opale-scence
0 No treatment	1.6 a	---	23.9 b	---	1.5 a	0.8 a
1 Firewall 17 12 oz + Regulaid 1 pt/ 100 gal	1.5 a	6	10.5 a	56	1.5 a	0.9 ab
2 Firewall 17 1.5 lb + Regulaid 1 pt/ 100 gal	0.3 a	81	5.7 a	76	1.5 a	1.1 a-c
3 VA-1 1 qt	1.3 a	19	10.8 ab	55	3.2 b	1.5 cd
4 VA-1 2 qt	1.7 a	0	8.6 a	64	3.9 c	1.6 d
5 VA-1 4 qt	0.6 a	63	6.5 a	73	4.3 c	1.8 d
6 VA-2 2 lb	1.4 a	13	11.6 ab	51	4.2 c	1.8 d
7 C-O-C-S 50WDG 4 oz	2.1 a	0	14.3 ab	40	3.4 b	1.5 cd
8 C-O-C-S 50WDG 1 lb	0.3 a	81	11.2 ab	53	4.1 c	1.4 b-d

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

* Infection data based on counts of number of clusters at inoculation and number of clusters with any infection on inoculated branches 30 Apr and infection into cluster leaves 11 May.

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

APPLE (*Malus domestica* 'Idared')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; *disease complex*
Flyspeck; *Zygophiala jamaicensis*
Rots
Fruit finish

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Disease control by treatments first applied at petal fall for summer disease control on Idared apples, 2009.

Ten treatments involving experimental and registered fungicides were compared during the cover spray period on 28-yr-old trees with a 28-ft row spacing. The test was conducted in a randomized block design with four single-tree replicates separated by untreated border rows between treatment rows. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. Pre-test fungicides, to suppress early season diseases were applied 8 Apr (Nova 5 oz + Dithane 3 lb). The only pre-test treatment was Rally 5 oz + Dithane 3 lb/A applied with Calypso to entire block 9 Apr. Test treatments were applied as petal fall through ninth cover sprays to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 6 May, all treatments (PF, petal fall); 1st - 9th covers all treatments (1C-9C: 20 May, 2 Jun, 16 Jun, 1 Jul, 15 Jul, 30 Jul, 13 Aug, 26 Aug and 18 Sep). Maintenance insecticides applied to the entire test block with the same equipment included: Calypso, Imidan, Assail, Altacor, Provado, Intrepid, Delegate, and Lannate LV. Wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies were placed over each Idared test tree 19 May. The bitter rot fungus was inoculated into six fruit per test tree 9 Jul. Other diseases developed from inoculum naturally present in the test area. A 25-fruit sample from each replicate tree was harvested 18 Sep, 23 days after the 8th cover spray and immediately before the application, and data from these samples are designated "Pre-9C". A second 25-fruit sample from each replicate tree was harvested 19 Sep, the day after the 9C application, and data from these samples are designated "Post-9C". The samples were held in cold storage 31 days prior to evaluation 20 Oct. The samples were incubated 33 days in warm (68-73ºF) temperatures and rated 23 Nov. All percentage data were converted by the square root arcsin transformation for statistical analysis.

Although the treatment series was directed mostly at summer diseases, scab and mildew were still active when the early covers were applied. Indar + Captan gave consistently strong scab control (Table 18). Most treatments gave significant control of powdery mildew, and all gave significant control of Brooks spot. The cumulative wetting threshold of 250 hr for the presence of the sooty blotch and flyspeck fungi on unprotected fruit was reached 9 Jun, and by 1 Sep we had the third highest wetting hour total since 1994, but reduced rainfall and relatively cool weather in late August and September reduced the effects of the eighth and ninth cover spray treatments. All treatments gave significant control of sooty blotch, flyspeck and pre-incubation bitter rot (Table 19). Treatments including Topsin M in the cover sprays were generally gave better control of sooty blotch but some differences were noted, based on the early cover schedule. Inspire Super, applied at PF-1C, gave better control of sooty blotch and flyspeck than Rally + Captan applied during at this time (Trt. 1 vs. 2). Tebuzol, applied alone in the covers, was improved by the addition of Topsin M in those applications (Trt. 8 vs. 9). The category "any rot" lacked the differences one might expect from the diverse treatment schedules in the test, but this may be related to the make-up of the rots that developed in the various treatments, particularly of bitter rot vs. white rot. Treatments that were inadequate for bitter or white rot control may have been somewhat compensated by inclusion of Switch or Pristine in the pre-harvest application, but Pre-9C vs. Post-9C sampling really did not confirm this satisfactorily (Table 20).

Table 18. Scab, mildew, and Brooks spot control on Idared apple, 2009.

			Scab, % fruit		Mildew, % fruit		Brooks spot, % fruit		Opalescence rating (0-5) *	
	Treatment/rate/A, petal fall through 9th cover	Timing	Pre-9C	Post-9C	Pre-9C	Post-9C	Pre-9C	Post-9C	Pre-9C	Post-9C
0	No fungicide	---	25 d	12 bc	52 b	47 c	31 d	35 d	1.3 a	1.2 b
1	Inspire Super 338SE 11.9 fl oz	PF-1C	6 bc	0 a	27 a	20 a				
	Captan 80WDG 30 oz	2-4C					2 ab	2 ab	0.8 a	0.8 a
	Topsin M 70W 6.4 oz + Captan 30 oz	5-9C								
2	Rally 40W 4 oz + Captan 30 oz	PF-1C	5 a-c	6 a-c	26 a	29 ab				
	Captan 80WDG 30 oz	2-4C					4 a-c	3 a-c	0.9 a	1.0 ab
	Topsin M 70W 6.4 oz + Captan 30 oz	5-9C								
3	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C	6 a-c	1 a	30 a	27 a				
	Captan 80WDG 30 oz	2C					6 a-c	1 ab	0.8 a	0.9 ab
	Inspire Super 338SE 11.9 fl oz	3-4, 6-9C								
	Topsin M 70W 6.4 oz + Captan 30 oz	5C								
4	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C	8 bc	3 ab	34 ab	40 bc				
	Captan 80WDG 30 oz	2C								
	Inspire Super 338SE 11.9 fl oz	3-4, 6-8C					5 a-c	7 c	0.9 a	0.9 ab
	Topsin M 70W 6.4 oz + Captan 30 oz	5C								
	Switch 62.5WG 10 oz	9C								
5	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C	5 ab	9 bc	28 a	22 a				
	Captan 80WDG 30 oz	2, 4C					4 a-c	4 bc	0.9 a	0.9 ab
	Inspire Super 338SE 11.9 fl oz	3, 5, 7-9C								
	Topsin M 70W 6.4 oz + Captan 30 oz	6C								
6	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C	6 a-c	5 a-c	30 a	27 a				
	Captan 80WDG 30 oz	2-4C					5 a-c	10 c	1.0 a	0.8 a
	Topsin M 70W 6.4 oz + Captan 30 oz	5-8C								
	Switch 62.5WG 10 oz	9C								
7	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C	3 ab	2 ab	25 a	26 a				
	Captan 80WDG 30 oz	2-4C					5 a-c	7 c	0.9 a	0.7 a
	Topsin M 70W 6.4 oz + Captan 30 oz	5-8C								
	Pristine 38WG 18.4 oz	9C								
8	Rally 40W 4 oz + Ziram 76DF 3 lb	PF	9 bc	9 bc	32 a	31 ab	8 c	10 c	1.1 a	0.9 ab
	Tebuzol 45DF 6 oz	1-9C								
9	Rally 40W 4 oz + Ziram 76DF 3 lb	PF	13 cd	11 c	25 a	29 ab	6 bc	0 a	1.0 a	1.0 ab
	Tebuzol 45DF 6 oz + Topsin M 70W 8 oz	1-9C								
10	Indar 2F 8 fl oz + Captan 30 oz + B-1956	PF-1C	1 a	0 a	27 a	46 c				
	Captan 80WDG 30 oz	2C					1 a	2 ab	0.9 a	1.0 ab
	Indar 2F 8 fl oz+ B-1956 8 fl oz/100 gal	3-4, 6-9C								
	Topsin M 70W 6.4 oz + Captan 30 oz	5C								

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 25 fruit/rep, “No Pre-9C” sampled pre treatment 18 Sep; Post-9C sampled 19 Sep.

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

Table 19. Sooty blotch, flyspeck and bitter rot control on Idared apple, 2009.

			% fruit or fruit area inf., treated only through 8th cover (No PreH) or also with 1-day PHI (PreHar)									
			Sooty blotch, % fruit		Sooty blotch %area		Flyspeck, % fruit		Flyspeck % area		Bitter rot, % fruit	
	Treatment/rate/A, petal fall through 9th C	Timing	Pre-9C	Post-9C	Pre-9C	Post-9C	Pre-9C	Post-9C	Pre-9C	Post-9C	Pre-9C	Post-9C
0	No fungicide	---	100 d	100 d	12 d	15 d	97 e	100 g	7.0 e	7.3 g	5 a	7 b
1	Inspire Super 338SE 11.9 fl oz	PF-1C										
	Captan 80WDG 30 oz	2-4C										
	Topsin M 70W 6.4 oz + Captan 30 oz	5-9C	11 a	16 a	1 a	1 a	4 ab	7 cd	0.2 a	0.4 cd	0 a	0 a
2	Rally 40W 4 oz + Captan 30 oz	PF-1C										
	Captan 80WDG 30 oz	2-4C										
	Topsin M 70W 6.4 oz + Captan 30 oz	5-9C	26 b	31 a-c	2 b	2 ab	19 cd	19 ef	1.0 cd	1.0 ef	0 a	1 ab
3	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C										
	Captan 80WDG 30 oz	2C										
	Inspire Super 338SE 11.9 fl oz	3-4, 6-9C										
	Topsin M 70W 6.4 oz + Captan 30 oz	5C	21 ab	20 a	1 ab	1 ab	1 a	0 a	0.1 a	0 a	0 a	0 a
4	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C										
	Captan 80WDG 30 oz	2C										
	Inspire Super 338SE 11.9 fl oz	3-4, 6-8C										
	Topsin M 70W 6.4 oz + Captan 30 oz	5C										
	Switch 62.5WG 10 oz	9C	15 ab	16 a	1 ab	1 ab	2 a	1 ab	0.1 a	0.1 ab	0 a	0 a
5	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C										
	Captan 80WDG 30 oz	2, 4C										
	Inspire Super 338SE 11.9 fl oz	3, 5, 7-9C										
	Topsin M 70W 6.4 oz + Captan 30 oz	6C	22 ab	24 ab	1 ab	2 ab	3 a	2 a-c	0.2 a	0.1 a-c	0 a	0 a
6	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C										
	Captan 80WDG 30 oz	2-4C										
	Topsin M 70W 6.4 oz + Captan 30 oz	5-8C										
	Switch 62.5WG 10 oz	9C	14 ab	17 a	1 ab	1 ab	17 cd	14 de	0.9 cd	0.7 de	0 a	0 a
7	Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C										
	Captan 80WDG 30 oz	2-4C										
	Topsin M 70W 6.4 oz + Captan 30 oz	5-8C										
	Pristine 38WG 18.4 oz	9C	22 ab	27 ab	1 ab	2 ab	26 d	30 f	1.5 d	1.6 f	0 a	0 a
8	Rally 40W 4 oz + Ziram 76DF 3 lb	PF										
	Tebuzol 45DF 6 oz	1-9C	48 c	54 c	4 c	4 c	11 bc	11 de	0.6 bc	0.6 de	0 a	0 a
9	Rally 40W 4 oz + Ziram 76DF 3 lb	PF										
	Tebuzol 45DF 6 oz + Topsin M 8 oz	1-9C	22 ab	19 a	1 ab	1 ab	6 ab	6 bc	0.3 ab	0.3 bc	0 a	0 a
10	Indar 2F 8 fl oz + Captan 30 oz + B-1956	PF-1C										
	Captan 80WDG 30 oz	2C										
	Indar 2F 8 fl oz+ B-1956 8 fl oz/100 gal	3-4, 6-9C										
	Topsin M 70W 6.4 oz + Captan 30 oz	5C	24 b	42 bc	1 b	2 b	3 a	4 bc	0.2 a	0.2 bc	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 25 fruit/rep, "Pre-9C" sampled before treatment 18 Sep; Post-9C sampled 19 Sep Treatments: 6 May (PF, petal fall); 1st - 9th covers (1C-9C): 20 May, 2 Jun, 16 Jun, 1 Jul, 15 Jul, 30 Jul, 13 Aug, 26 Aug, 18 Sep. A sample was collected from each tree before the 9C application on 18 Sep (Pre-9C) and 19 Sep (Post-9C). Samples held in cold storage 31 days prior to rating 20 Oct.

Table 20. Control of post-storage rots on Idared apple, 2009

		% fruit with any rot		Bitter rot		White (Bot) rot		Alternaria	
Treatment/rate/A, petal fall through 9th cover	Timing	Pre-9C	Post-9C	Pre-9C	Post-9C	Pre-9C	Post-9C	Pre-9C	Post-9C
0 No fungicide	---	45 d	44 d	34 e	31 b	8 ef	12 b	7 b	10 c
1 Inspire Super 338SE 11.9 fl oz	PF-1C								
Captan 80WDG 30 oz	2-4C								
Topsin M 70W 6.4 oz + Captan 30 oz	5-9C	12 bc	8 a-c	8 b-d	7 a	3 b-e	1 a	1 ab	1 a
2 Rally 40W 4 oz + Captan 30 oz	PF-1C								
Captan 80WDG 30 oz	2-4C								
Topsin M 70W 6.4 oz + Captan 30 oz	5-9C	7 ab	10 a-c	3 ab	6 a	4 a-e	4 a	0 a	1 a
3 Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C								
Captan 80WDG 30 oz	2C								
Inspire Super 338SE 11.9 fl oz	3-4, 6-9C								
Topsin M 70W 6.4 oz + Captan 30 oz	5C	17 c	18 c	7 b-d	8 a	10 f	9 ab	1 ab	1 a
4 Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C								
Captan 80WDG 30 oz	2C								
Inspire Super 338SE 11.9 fl oz	3-4, 6-8C								
Topsin M 70W 6.4 oz + Captan 30 oz	5C								
Switch 62.5WG 10 oz	9C	9 a-c	7 a-c	7 b-d	4 a	1 ab	3 ab	0 a	0 a
5 Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C								
Captan 80WDG 30 oz	2, 4C								
Inspire Super 338SE 11.9 fl oz	3, 5, 7-9C								
Topsin M 70W 6.4 oz + Captan 30 oz	6C	18 c	15 c	10 cd	9 a	8 c-f	6 ab	1 ab	0 a
6 Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C								
Captan 80WDG 30 oz	2-4C								
Topsin M 70W 6.4 oz + Captan 30 oz	5-8C								
Switch 62.5WG 10 oz	9C	2 a	2 a	1 a	1 a	0 a	1 a	1 ab	0 a
7 Rally 40W 4 oz + Captan 80WDG 30 oz	PF-1C								
Captan 80WDG 30 oz	2-4C								
Topsin M 70W 6.4 oz + Captan 30 oz	5-8C								
Pristine 38WG 18.4 oz	9C	10 a-c	4 ab	6 a-c	3 a	0 a	1 a	4 ab	0 a
8 Rally 40W 4 oz + Ziram 76DF 3 lb	PF								
Tebuzol 45DF 6 oz	1-9C	19 c	12 bc	13 cd	8 a	7 d-f	4 ab	1 ab	0 a
9 Rally 40W 4 oz + Ziram 76DF 3 lb	PF								
Tebuzol 45DF 6 oz + Topsin M 70W 8 oz	1-9C	17 c	12 a-c	15 d	11 a	2 a-c	2 a	0 a	0 a
10 Indar 2F 8 fl oz + Captan 30 oz + B-1956	PF-1C								
Captan 80WDG 30 oz	2C								
Indar 2F 8 fl oz+ B-1956 8 fl oz/100 gal	3-4, 6-9C								
Topsin M 70W 6.4 oz + Captan 30 oz	5C	7 a-c	11 bc	4 ab	2 a	3 a-d	6 ab	0 a	3 b

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps; 25 fruit/rep. Treatments: 6 May (PF, petal fall); 1C-9C : 20 May, 2 Jun, 16 Jun, 1 Jul, 15 Jul, 30 Jul, 13 Aug, 26 Aug, 18 Sep. A sample was collected from each tree before the 9C application on 18 Sep (Pre-9C) and the following day (Post-9C).). Samples held in cold storage 31 days prior to rating 20 Oct. Then samples were incubated 33 days in warm (68-73ºF) temperatures and rated 23 Nov.

APPLE (*Malus domestica* ‘Golden Delicious’, ‘Empire”)
Bitter rot; *Colletotrichum acutatum*
Alternaria rot; *Alternaria* spp.
White (Bot) rot; *Botryosphaeria dothidea*

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Rot control by postharvest dip treatments on Golden Delicious and Empire apples, 2009.

An experiment was conducted to test the effectiveness of fludioxonil (Scholar) / difenoconazole (A8574) as postharvest dip treatments on Golden Delicious and Empire apples. Test fruit were selected from trees which had been uniformly sprayed with the commercial fungicides during the growing season in 2009. Fruit were picked at optimal commercial harvest time and held in cold storage until treatment. Fruit without visible rot symptoms were dipped 1 min. in 200 ppm sodium hypochlorite, allowed to dry overnight and randomized into four 20-fruit replications for the fungal inoculation test. Each fruit was inoculated in three places with the tip of a nail pressed uniformly to a depth of 5 mm after dipping in suspensions of *C. acutatum* conidia ($1X10^4$/ml) from a PDA culture. Two hours after inoculation and wounding, replicated Golden Delicious fruit samples were dipped in the indicated treatment for 30 sec, placed on fiber packing trays, allowed to dry 1 hr, then enclosed in plastic bags, and incubated at ambient temperatures, 63-72F. Empire fruit were treated 3 hr after inoculation and wounding and incubated as with Golden Delicious. Bitter rot inoculation and treatment date was 22 Oct for both cultivars. Fruit were examined and evaluated periodically as needed for rot development.

Inoculation and incubation conditions provided strong tests for both cultivars. Under these conditions, all Scholar-related treatments gave near complete control of bitter rot, Alternaria and white rots through 10-13 days incubation, based on percent fruit and percent wounds infected. The high effectiveness of the Scholar test rate precluded evaluation of any additive of A8574 effect. Penbotec and Mertect did not control bitter rot, but Captan and Captan + Mertect seemed to give some bitter rot suppression, especially on Empire. Penbotec also gave significant control of Alternaria. Penbotec, Mertect, Captan and Captan + Mertect seemed also gave significant control of white rot but were not as effective as Scholar-related treatments.

Table 21. Control of bitter rot by postharvest dip treatments on Golden Delicious and Empire apples, 2009.

	% fruit or wounds infected Bitter rot after indicated incubation												
	Golden Delicious							Empire					
	% fruit infected			% wound infected			lesion	% fruit inf.			% wound inf.		
Treatment and rate/ 100 gal dilute	6 day	8 day	12 day	6 day	8 day	12 day	radius	6 day	8 day	12 day	6 days	8 day	12 day
1 Check – no dip	100 d	100 b	100 b	100 d	100 d	100 b	10.8 f	100 c	100 c	100 c	100 d	100 d	100 d
2 Scholar 230SC 10.4 fl oz	0 a	1 a	9 a	0 a	<1 a	3 a	0.03 a	0 a	0 a	0 a	0 a	0 a	0 a
3 Scholar 10.4 fl oz + A8574 13.3 fl oz	0 a	3 a	11 a	0 a	1 a	4 a	0.05 a	0 a	0 a	0 a	0 a	0 a	0 a
4 Scholar 10.4 fl oz + A8574 20.0 fl oz	0 a	5 a	9 a	0 a	2 a	4 a	0.08 a	1 a	1 a	<1 a	1 a	<1 a	<1 a
5 Scholar 10.4 fl oz + A8574 26.6 fl oz	0 a	1 a	5 a	0 a	<1 a	2 a	0.03 a	0 a	0 a	0 a	0 a	0 a	0 a
6 Penbotec 3.34SC 1 pt	95 b	100 b	100 b	74 b	98 c	100 b	8.9 cd	100 c	100 c	100 c	90 c	99 cd	100 c
7 Captan 50W 1 lb	99 cd	100 b	100 b	85 c	100 cd	100 b	9.3 de	70 b	99 bc	100 c	37 b	75 b	94 b
8 Mertect 340F 1 pt	99 cd	100 b	100 b	88 c	98 c	99 b	8.3 c	100 c	100 c	100 c	88 c	98 c	100 c
9 Mertect 340F 1 pt + Captan 50W 1 lb	95 bc	97 b	99 b	75 b	92 b	97 b	7.4 b	66 b	98 b	100 c	35 b	70 b	93 b
10 Water dip	100 d	100 b	100 b	99 d	100 cd	100 b	9.8 e	100 c	100 c	100 c	100 d	100 d	100 c

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications of 20 fruit per rot.

Table 22. Control of Alternaria rot by postharvest dips on apples, 2009.

Treatment and rate / 100 gal dilute	% fruit or wounds inf. by Alternaria rot after indicated incubation*					
	Golden Delicious			Empire		
	% fruit inf.	% wound inf.		% fruit inf.	% wound inf.	
	8 day	8 day	13 day	8 day	8 days	13 day
1 Check – no dip	98 d	86 e	47 e	100 d	85 ef	52 d
2 Scholar 230SC 10.4 fl oz	0 a	0 a	0 a	0 a	0 a	0 a
3 Scholar 10.4 fl oz + A8574 13.3 fl oz	0 a	0 a	0 a	0 a	0 a	0 a
4 Scholar 10.4 fl oz + A8574 20.0 fl oz	0 a	0 a	0 a	0 a	0 a	0 a
5 Scholar 10.4 fl oz + A8574 26.6 fl oz	0 a	0 a	0 a	0 a	0 a	0 a
6 Penbotec 3.34SC 1 pt	13 b	5 b	0 a	10 b	4 b	0 a
7 Captan 50W 1 lb	76 c	52 c	17 b	89 c	56 c	16 b
8 Mertect 1 pt	86 c	63 d	26 c	100 d	88 f	37 c
9 Mertect 340F 1 pt + Captan 50W 1 lb	81 c	50 c	17 b	89 c	63 d	16 b
10 Water dip	100 d	86 e	38 d	100 d	83 e	43 c

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps of 20 fruit per rot.

Table 23. Control of White (Botryosphaeria) rot by postharvest dips on apples, 2009.

Treatment and rate / 100 gal dilute	% fruit or wounds inf. by white rot after indicated incubation*					
	Golden Delicious			Empire		
	% fruit inf.		% wound inf.	% fruit inf.		% wound inf.
	7 day	13 day	7 day	7 day	10 day	7 day
1 Check – no dip	71 d	89 c	52 d	73 e	88 e	41 e
2 Scholar 230SC 10.4 fl oz	0 a	3 a	0 a	0 a	0 a	0 a
3 Scholar 10.4 fl oz + A8574 13.3 fl oz	0 a	3 a	0 a	0 a	0 a	0 a
4 Scholar 10.4 fl oz + A8574 20.0 fl oz	0 a	0 a	0 a	0 a	0 a	0 a
5 Scholar 10.4 fl oz + A8574 26.6 fl oz	0 a	1 a	0 a	0 a	0 a	0 a
6 Penbotec 3.34SC 1 pt	10 b	25 b	5 b	48 d	74 d	23 d
7 Captan 50W 1 lb	14 b	38 b	7 b	15 c	34 b	5 c
8 Mertect 1 pt	15 b	38 b	8 b	14 c	54 c	5 c
9 Mertect 340F 1 pt + Captan 50W 1 lb	14 b	36 b	7 b	6 b	25 b	2 b
10 Water dip	58 c	79 c	34 c	51 d	80 d	28 d

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps of 20 fruit per rot.

PEACH *(Prunus persica* ‘Loring*)*
Scab; *Cladosporium carpophilum*
Brown rot; *Monilinia fructicola*

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Scab and brown rot control by integrated fungicide programs on Loring peach, 2009.

Two undisclosed experimental materials were compared to registered programs for broad-spectrum disease control on 17-yr-old trees. The test planting is composed of 3-tree sets, each including: Loring peach which were not treated with fungicides in 2008 to allow the buildup of scab inoculum, and Redgold nectarine and Redhaven peach which were in test in 2008, but used only for an early season leaf curl test in 2009. Brown rot inoculum was standardized in the orchard by placing three mummified fruit in each test tree 1 Apr. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 400 psi in a randomized complete block design with four replications as follows: 9 Apr (Bl, bloom); 21 Apr (PF, petal fall); 5 May (SS, shuck split); and 1st-5th covers (1C-5C): 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul. Projected 2-wk & 1-wk pre-harvest sprays (2 & 1 PH) 27 Jul and 3 Aug. Actual harvest date was 5 Aug. Commercial insecticides, applied to the entire test block at 2-3 wk intervals with a commercial airblast sprayer, included Asana XL + oil, Imidan, Lannate LV, Provado, and Sevin XLR. Scab counts were done on a sample of 30 fruit per tree replicate; brown rot was rated on the tree by counting 50 fruit per tree 4 Aug. For postharvest incubation and counts, 20 fruit per tree, not showing brown rot symptoms, were picked 5 Aug, placed on trays in polyethylene bags, and incubated at ambient temperature 68-80°F for the indicated rating period.

Heavy carry-over inoculum, infections on eight consecutive days 29 Apr-7 May, and a total of 19 infection days and nearly 8 inches of rain in May, led to a strong scab test. Bravo, applied from bloom through shuck split, gave significantly better scab control than sulfur applied during this time, and Quash gave scab control equal to Bravo. Undisclosed experimental materials VA-3 and VA-4, applied only from petal fall through first cover, because they caused severe phytotoxicity, resulted in control no better than sulfur applied during that time and scab control by VA-3 did not improve with higher rates. Rains 12 of the 19 days up to harvest, led to 25% of fruit infected with brown rot on non-treated trees, and some rot on all treated trees by harvest. Brown rot began to develop on treated fruit by the fourth day of storage incubation when 69% of non-treated fruit were infected. By the fifth day of incubation Pristine and Quash were generally less effective than Indar applied as a standard pre-harvest brown rot fungicide. Although the phytotoxicity ratings presented relate to foliar injury on shoots, effects were also observed on fruit. It was noted that at harvest, fruit from treatments VA-3 and VA-4 had poor color and finish. Fruit from the highest rate of VA-3 and from VA-4 had poor finish with healed splits of the skin, and also had fewer fruit than the lower rates of VA-3 (Trts. 3 & 4). The observed phytotoxicity to fruit, as well as the recognized effect on the general condition of those test trees, leads to some doubt about what effect this may have had on postharvest brown rot development on fruit from those trees.

Table 24. Control of brown rot and scab and phytotoxicity ratings on Loring peach, 2009.

	Treatment and rate/100 gal dilute	Timing	Scab at harvest % fruit	Scab at harvest les/fruit	Brown rot, % on tree*	Brown rot, days post-harvest 2 day	4 day	5 day	6 day	Phytotoxicity rating, 0-5**	% shoots injured**
0	No fungicide	---	93 e	19 c	28 c	21 c	69 d	98 d	100 d	0.1 ab	8 a
1	Bravo Weather Stik 6F 1 pt	BI-SS								0 a	0 a
	Microfine Sulfur 90W 3 lb	1C-5C	19 ab	1 a							
	Indar 2F 3 fl oz+ B-1956 8 fl oz	2 & 1PH			1 ab	0 a	6 a-c	25 ab	51 a-c		
2	Bravo Weather Stik 6F 1 pt	BI									
	Quash 50WG 1.25 oz	PF-SS	13 a	<1 a						0.2 ab	10 a
	Microfine Sulfur 90W 3 lb	1C-5C									
	Quash 50WG 1.25 oz	2 PH									
	Indar 2F 3 fl oz + B-1956 8 fl oz	1PH			4 ab	1 ab	9 a-c	30 bc	59 bc		
3	Bravo Weather Stik 6F 1 pt	BI	63 cd	4 ab							
	VA-3 1 qt	PF-1C								1.9 c	98 c
	Microfine Sulfur 90W 3 lb	2C-5C									
	Indar 2F 3 fl oz+ B-1956 8 fl oz	2 & 1PH			2 a	1 ab	8 ab	21 ab	51 a-c		
4	Bravo Weather Stik 6F 1 pt	BI									
	VA-3 2 qt	PF-1C	89 de	12 bc						3.5 d	100 c
	Microfine Sulfur 90W 3 lb	2C-5C									
	Indar 2F 3 fl oz+ B-1956 8 fl oz	2 & 1PH			3 ab	1 ab	5 ab	21 ab	50 a-c		
5	Bravo Weather Stik 6F 1 pt	BI									
	VA-3 4 qt	PF-1C	72 c-e	7 ab						3.6 d	100 c
	Microfine Sulfur 90W 3 lb	2C-5C									
	Indar 2F 3 fl oz+ B-1956 8 fl oz	2 & 1PH			8 b	4 ab	10 bc	23 ab	75 c		
6	Bravo Weather Stik 6F 1 pt	BI									
	VA-4 2 lb	PF-1C	72 c-e	11 bc						4.5 e	100 c
	Microfine Sulfur 90W 3 lb	2C-5C									
	Indar 2F 3 fl oz+ B-1956 8 fl oz	2 & 1PH			7 ab	0 a	3 ab	10 a	46 ab		
7	Bravo Weather Stik 6F 1 pt	BI-SS									
	Indar 2F 3 fl oz+ B-1956 8 fl oz	1C	48 bc	3 ab						0 a	0 a
	Microfine Sulfur 90W 3 lb	2C-5C									
	Indar 2F 3 fl oz+ B-1956 8 fl oz	2 & 1PH			2 ab	0 a	1 a	14 a	31 a		
8	Microfine Sulfur 90W 3 lb	BI-5C	62 c-e	6 ab						0.8 b	50 b
	Pristine 38WDG 7.25 oz	2 & 1PH			7 ab	5 b	19 c	45 c	71 bc		

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single tree reps.
Treatment dates: 9 Apr (Bl, bloom); 21 Apr (PF, petal fall); 5 May (SS, shuck split); 1st-5th covers (1C-5C): 19 May, 2 Jun, 16 Jun, 30 Jun, 14 Jul. Projected 2-wk & 1-wk pre-harvest sprays (2 & 1 PH) 27 Jul & 3 Aug. 50 fruit / tree for brown rot counts on tree 4 Aug
Actual harvest: 5 Aug; 30 fruit / tree for scab counts; 20 fruit/ tree placed on trays for incubation at ambient temperature 68-80°F.
* Brown rot counted on the tree one day after the last application. ** Phytotoxicity rated on all trees on 22 May.