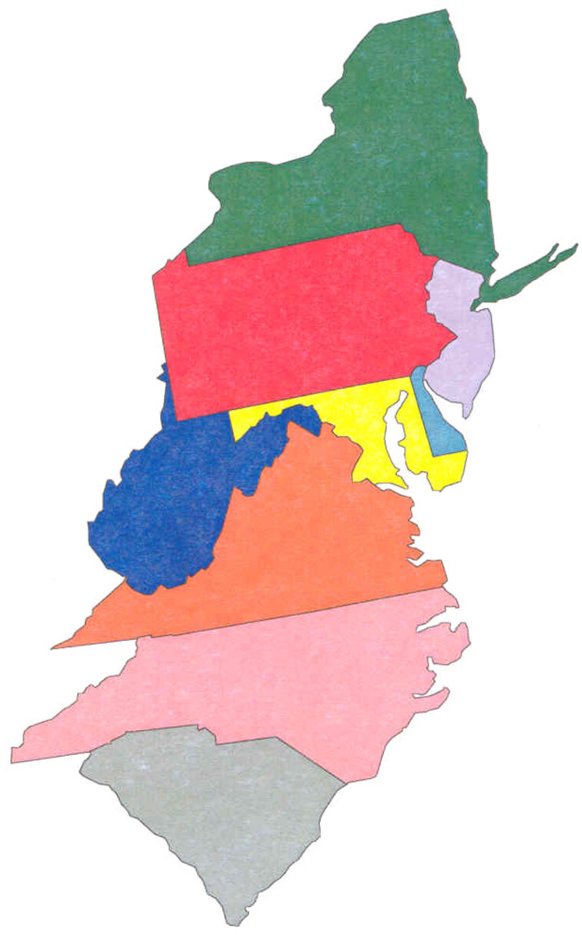
PROCEEDINGS

86th

CUMBERLAND-SHENANDOAH
FRUIT WORKERS CONFERENCE



November 18 & 19, 2010

WINCHESTER, VIRGINIA

Proceedings of the

Cumberland–Shenandoah

Fruit Workers Conference

86th Annual Meeting

November 18th and 19th, 2010

Hampton Inn and Conference Center

Winchester, VA

James F. Walgenbach, Steven J. McArtney,
William H. Hanlin, and Michael L. Parker

Mountain Horticultural Crops Research & Extension Center
NC State University
Mills River, NC

Table of Contents

Horticulture

Plant Pathology

List of Participants

Name	**Affiliation**
Agnello, Arthur	Cornell University
Atanassov, Atanas	Rutgers
Aukett, Warren	Crop Production Services
Bardsley, Sarah	Penn State
Bell, Richard	USDA – ARS - AFRS
Bergh, Chris	VA Tech
Biddinger, David	Penn State FREC
Biggs, Alan R.	WVU
Breth, Deborah I.	Cornell Coop Extn
Butler, Bryan	UMD Coop Extn
Carbaugh, David	VA Tech
Clarke, James	Fruit Consultant
Combs, David	Cornell University
Cox, Kerik	Cornell Univesity
Crassweller, Rob	Penn State
Crim, Larry	USDA – ARS – AFRS
Cullum, John	USDA – ARS – AFRS
David, Paul	Gowan
Day, Eric	VA Tech
Dell, Larry	Crop Production Services
Dimock, Mike	Certis USA
Engelman, Jean	VA Tech
Enyeart, Travis	Penn State
Frecon, Jerome	Rutgers Cooperative Extension
Halbrendt, Noemi O.	Penn State
Hancock, Torri	USDA - ARS - AFRS
Hancock, Dustin	USDA - ARS - AFRS
Hanlin, Bill	NC Coop Extn Service
Hatch, Tremain	VA Tech
Hed, Bryan	Penn State
Hickey, Kenneth	Penn State
Hitchner, Erin	Syngenta Crop Protection
Hott, Christian	USDA – ARS – AFRS
Hull, David	Crop Production Services
Hull, Larry	Penn State
Ioriatti, Claudio	FEM-IASMA, Italy
Jacobson, Brent	Cheminova, Inc.
Jentsch, Peter J.	Cornell University

Jordan, Tim	VA Tech
Krawczyk, Greg	Penn State
Lalancette, Norman	Rutgers
Lehman, Brian	Penn State
Leskey, Tracy	USDA - ARS - AFRS
Mackintosh, Bill	Crop Protection Services
Mahoney, Matt	Bayer Crop Science
Marine, Sasha	VA Tech
McArtney, Steve	NC State University
McClain, Perscilla	
McFarland, Kathleen	Rutgers
Meck, Elijah	LABServices
Meck, Michelle	LABServices
Metzger, Todd	Helena Chemical Co
Miller, Stephen	USDA - ARS - AFRS
Myers, Michael	Nichino America
Ngugi, Henry K.	Penn State
Nita, Mizho	VA Tech
Olinger, Matt	Bayer Crop Science
Olson, Brian	Dow AgroSciences
Parker, Michael	NC State University
Pfeiffer, Douglas	VATech
Polk, Dean	Rutgers
Reissig, Harvey	Cornell University
Rizio, Gene	Rutgers
Rosenberger, Dave	Cornell University
Rossell, Elwood L	Consultant - Marlboro Farms
Rucker, Ann	Rutgers
Rugh, Anthony	USDA - ARS - AFRS
Schmitt, Dave	Rutgers
Schnabel, Guido	Clemson
Shannon, Mark	Suterra LLC
Shearer, Peter W	Oregon State University
Short, Brent	USDA - ARS - AFRS
Smith, Jeanette	Crop Protection Services
Smith, Charles W	Private consultant
Stamm, Gregory	CBC America
Sutton, Turner	NC State University
Thomas, Gar	BASF
Thomson, Donn	DJS Consulting
Travis, James W	Penn State
Tworkoski, Thomas	USDA - ARS - AFRS

Veale, Carol	Rutgers
Villani, Sara	Cornell
Walgenbach, Jim	NC State University
Ward, Dan	Rutgers
Webb, Patti	Dow AgroSciences
Webb, Kevin	USDA - ARS - AFRS
Wolf, Tony	VA Tech
Wright, Starker	USDA - ARS - AFRS
Yoder, Keith	VA Tech
Zaman, Faruque	Rutgers

86th Annual Cumberland-Shenandoah Fruit Workers Conference

November 18–19, 2010

Hampton Inn and Conference Center, Winchester, VA

CONFERENCE AGENDA

Thursday, November 18th

8:00 - 9:00 a.m.	**Registration** – Pre-registration Room
9:00 - 9:05 a.m.	**Call to order** — 86th 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**
	A Pakeha's Perspective on Pip Fruit Production in Aotearoa. J. C. Bergh., Alson H. Smith, Jr. Ag Res & Ext Ctr, Virginia Tech, Winchester, VA.
10:45 - 11:00 a.m.	Break
11:00 - 11:30 a.m.	**Trends in Apple Disease Management: 1900 – 2010.** Turner Sutton, Department of Plant Pathology, NC State University, Raleigh, NC.
11:30 – 12:00 a.m.	**Apple Production in the North of Italy** Claudio Ioriatti, FEM-IASMA, San Michele all'Adige, Italy
Noon - 1:00 p.m.	**Lunch** — Washington Room
1:00 - 5:00 p.m.	**Concurrent Sessions** Entomology – Washington Room Horticulture – Madison Room Plant Pathology – Jefferson Room
5:15 - 7:15 p.m.	Mixer **(Sponsored by AgraQuest, BASF, Bayer CropScience, CBC America, Certis, Dow AgroSciences, DuPont, Nichino America, Suterra, Syngenta, United Phosphorus, and Valent)**

Friday, November 19

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

CONCURRENT SESSIONS AGENDA

Entomology – Washington Room

Thursday, November 18

1:00 – 1:15	**An overview of spotted wing drosophila, *Drosophila suzukii*, in the mid-Columbia region of Oregon.** P. W. Shearer and S. Castagnoli. Oregon State University Mid-Columbia Agricultural Research & Extension Center, Hood River, OR
1:15 – 1:30	**The emergence of brown marmorated stink bug as a severe pest of tree fruit in the mid-Atlantic.** T.C. Leskey, S.E. Wright, B.D. Short, T.J. Hancock and J.P. Cullum. USDA-ARS Appalachian Fruit Research Station, Kearneysville, WV
1:30 – 1:45	**Brown marmorated stink bug – 2010 season Pennsylvania update.** G. Krawczyk, T.R. Enyeart, L.H. Hull. Penn State University – FREC, Biglerville, PA
1:45 – 2:00	**Brown marmorated stink bug damage to NJ fruit crops – 2010.** D. Polk, A. Rucker, G. Hamiltion, D. Schmitt, W. Cowgill, A. Atanassov and N. Muehlbauer. Rutgers Cooperative Extension, Cream Ridge, NJ
2:00 – 2:15	**Revisiting tests of web-based insect management programs.** H. Reissig and A. Agnello. Cornell University, Geneva, NY
2:15 – 2:30	**Assessment of advanced –IPM field trials in NY apples – year 1.** A. Agnello, H. Reissig and P. Jentsch. NYS Agric Expt. Sta., Geneva, NY
2:30 – 2:45	**Comparison of codling moth pheromone lures for management decisions.** J.F. Walgenbach and S. C. Schoof. NC State University, MHCREC, Mills River, NC.
2:45 – 3:00	**Development of new phenology models for codling moth populations in Pennsylvania.** N. Josi, L. Hull*, E. Rajotte, and G. Krawczyk. Penn State University Fruit Research and Extension Center, Biglerville, PA
3:00 – 3:15	BREAK
3:15 – 3:30	**Predictive modeling of grape berry moth phenology using pheromone traps and PRISM.** T. Jordan and D. Pfeiffer. Virginia Tech, Blacksburg, VA
3:30 – 3:45	**Woolly apple aphid biocontrol: an update.** J.C. Bergh. Virginia Tech, Winchester, VA
3:45 – 4:00	**Effects of a reduced pesticide program on biological control in apple.** D. Biddinger, L. Hill and T. Leslie. Penn State University, Biglerville, PA
4:00 – 4:15	**Toward development of an effective monitoring trap for brown marmorated stink bug.** B.D. Short, T.C. Leskey, S.E. Wright, T.J. Hancock and J.P. Cullum, USDA-ARS Appalachian Fruit Research Station, Kearneysville, WV
4:15 – 4:30	**A redesigned electronic insect trap for automated monitoring of Lepidoptera in orchards.** B. Lehman and L. Hull. Penn State University, Biglerville, PA and J. Park and G. Holguin. Purdue University, and T. Smith and V. Jones. Washington State University
4:30 – 4:45	**Plum curculio monitoring and management in commercial blueberry farms.** F.U. Zaman, C. Rodriguez-Saona, D. Polk, T. Leskey, and J. Wise. Rutgers University, Chatsworth, NJ

Friday, November 19

9:00 – 9:15	**Mating disruption for grape root borer – 2010.** D.G. Pfeiffer, C.A. Laub, R.A. Mays and T.A. Jordan. Virginia Tech, Blacksburg, VA
9:15 – 9:30	**Evaluation of insecticides for apple maggot control.** D. Combs and H. Reissig. Cornell University, Geneva, NY
9:30 – 9:45	**Commercial orchard study comparing kaolin and oil to conventional management tools for pear psylla management.** P. J. Jentsch. Cornell University's Hudson Valley Laboratory, Highland, NY
9:45 – 10:00	**Effects of insecticide exposure on brown marmorated stink bugs: mobility, mortality, and recovery.** S.E. Wright, T.C. Leskey, B.D. Short, T.J. Hancock and J.P. Cullum, USDA-ARS Appalachian Fruit Research Station, Kearneysville, WV
10:15-Noon	**Additional presentations**

Horticulture – Madison Room

Thursday, November 18

1:00 – 1:15	**Second generation apple training system trials.** R.M. Crassweller and D.E. Smith. Penn State University, University Park, PA
1:15 – 1:30	**Grass competition may benefit peach orchards planted at high density.** T. Tworkoski and M. Glenn. AFRS, USDA-ARS, Kearneysville, WV
1:30 – 1:45	**Cover crop, rootstock and root manipulation as tools to alter vine vegetative growth and influence wine quality.** T.A. Hatch, T.K. Wolf, B.W. Zoicklein. AHS Jr. AREC, Virginia Tech, Winchester, VA
1:45 – 2:00	**Addressing apple replant issues in North Carolina.** M. Parker. NC State University, Raleigh, NC
2:00 – 2:15	**Update on developing management strategies to optimize the uses of a mobile high tunnel.** B.R. Butler. University of Maryland Extension, Westminster, MD
2:15 – 2:30	**Gene expression and endogenous hormone levels in different growth habits of peach and apple.** K. Webb, A. Callahan, R. Scorza and T. Tworkoski. AFRS, USDA-ARS, Kearneysville, WV, and C. Walsh. University of Maryland
2:30 – 2:45	**SmartFresh (1-MCP) use for retail apple operations.** M. Parker, S. McArtney, T. Hoyt and J. Obermiller. NC State University, Raleigh, NC
	BREAK
3:30 – 3:45	**Use of ReTain and NAA in a hot, dry year.** D.H. Carbaugh, S. Miller, H. Zhu, L. Crim and R. Yuan. Virginia Polytechnic Institute and State University,
3:45 – 4:00	**Effect of ReTain and/or NAA on apple quality when applied in a hot, dry season.** Steve Miller. USDA-ARS, AFRS
4:00 – 4:15	**Fruit thinning, return bloom and bitter pit studies on apple in 2010.** D.H. Carbaugh, R. Yuan and S. Miller. Virginia Polytechnic Institute and State University
4:15 – 4:30	**Thinning studies with the ethylene precursor ACC.** Steve McArtney and JD Obermiller, North Carolina State University, MHCREC, Mills River, NC
4:30 – 4:45	**Does oil enhance an apple thinning spray?** Steve Miller. USDA-ARS, AFRS
4:45 – 5:00	**Thinning studies with the photosynthetic inhibitor metamitron.** Steve McArtney and JD Obermiller, North Carolina State University, MHCREC, Mills River, NC

Plant Pathology – Jefferson Room

Thursday, November 18

1:00 – 1:15	**Highlights of apple fungicide testing in 2010.** Keith Yoder. Virginia Tech AREC, Winchester, VA
1:15 – 1:30	**Topguard: a new broad spectrum apple fungicide for 2011.** B.D. Jacobson. Cheminova, Inc. Tifton, GA
1:30 – 1:45	**Management of apple disease with fungicides at low risk of resistance.** N.O. Halbrendt and H.K. Ngugi. Penn State University, Biglerville, PA
1:45 – 2:00	**Conventional fungicide programs for apple scab and powdery mildew in 2010.** N. O. Halbrendt and H.K. Ngugi. Penn State University, Biglerville, PA
2:00 – 2:15	**How will new fungicides fit into apple disease-control programs?** D. Rosenberger. Cornell University, Ithaca, NY
2:25 – 2:30	**Evaluation of mixtures of bactericides for fire blight control on apple blossoms.** H.K. Ngugi, N.O. Halbrendt and B. L. Lehman. Penn State University, Biglerville, PA
2:30 – 2:45	**Cross-resistance to dodine, sterol demethylation inhibitor and strobilurin fungicides in populations of *Venturia inaequalis* from the eastern USA.** H.K. Ngugi. Penn State University, Biglerville, P.A and K.D. Cox. Cornell University, Geneva, NY
2:45 – 3:00	**Implications and applications of the cytochrome b gene from *Monilina* species cause brown rot of stone and pome fruit.** K. Cox and S. Villani. Cornell University, Geneva, NY
3:00 – 3:15	BREAK

3:15 – 3:30	**Difenoconazole: apple scab sensitivity and field performance on apples.** S. Villani and K. Cox. Cornell University, Geneva, NY
3:30 – 3:45	**Within season and concurrent season distribution of SI fungicide resistance in apple scab.** S. Marine and K. Yoder. Virginia Tech AHS AREC, Winchester, VA
3:45 – 4:00	**Effect of microclimate and canopy location on SI fungicide resistance in apple scab.** S. Marina and K. Yoder. Virginia Tech AHS AREC, Winchester, VA
4:00 – 4:15	**Continued decline in control of apple powdery mildew and performance of new materials. K. Yoder. Virginia Tech AREC, Winchester, VA**
4:15 – 4:30	**The walking tree, a novel approach to armillaria root rot management.** G. Schnabel. Clemson University, Clemson, SC
4:30 - 4:45	**Field kit- and web-supported fungicide resistance monitoring in commercial peach orchards for brown rot control.** G. Schnabel. Clemson University, Clemson, SC
4:45 – 5:00	**Evaluation of methods used to quantify severity of foliar symptoms of bacterial spot of peach and nectarine.** S.J. Bardsley and H.K. Ngugi. The Pennsylvania State University, Biglerville, PA

Friday, November 19

9:00 – 9:15	**Apples and fruit pathology in Shaanxi Province, China** Alan Biggs, West Virginia University, Kearneysville WVA
9:15 – 9:30	**Is glyphosate compromising apple tree health?** D. Rosenberger. Cornell University, Ithaca, NY
9:30 – 9:45	**Efficacy of difenoconazole mixtures on peach scab development.** N. Lalancette and K. McFarland. Rutgers University, Bridgeton, NJ
9:45 – 10:00	**Efficacy of difenoconazole mixtures on peach blossom blight and brown rot development.** N. Lalancette and K. McFarland. Rutgers University, Bridgeton, NJ
10:00 – 10:15	**Management of peach diseases with experimental fungicides.** N. Lalancette and K. McFarland. Rutgers University, Bridgeton, NJ
10:15 – 10:30	**Highlights of fungicide trials on wine grapes.** N.O. Halbrendt and H.K. Ngugi. Penn State University, Biglerville, PA
10:30 – 10:45	**Fungicide performance trials for grape powdery and downy mildew, 2010.** M. Nita. Virginia Tech, Winchester, VA
10:45 – 11:00	**Update on a state-wide survey of grape leaf roll disease, 2010.** M. Nita. Virginia Tech, Winchester, VA
11:00 – 11:15	**The integration of non-chemical strategies for adoption into bunch rot management programs in Pennsylvania.** B. Hed, H.K. Ngugi and N.O. Halbrendt. Penn State University, Northeast, PA
11:15 – 11:30	**Development of a map-based apple and grape disease risk assessment system.** M. Nita and K. Yoder. Virginia Tech, Winchester, VA

Business and Financial

86th Annual Cumberland-Shenandoah Fruit Workers Conference

Program Highlights and Business Meeting Minutes, November 19, 2010

Host State – North Carolina (NC State University)

NC State University hosted the 86th Annual Cumberland-Shenandoah Fruit Workers Conference at the Hampton Inn and Conference Center in Winchester, VA, on November 18-19, 2010. There were 90 participants, and 49 individuals presenting a total of 59 scientific presentations. Registration fees of $60 for pre-registration and $75 at the door were used to cover the cost of meeting rooms, Thursday lunch, breaks, and publication of the Proceedings. Jim Walgenbach served as general chair of the meeting and co-chairs and moderators included Bill Hanlin, Steve McArtney, and Mike Parker. Tracky Leskey served as treasurer.

The meeting was called to order at 9:00 AM on Thursday with a “Call of the States” that included representative from each state providing a brief summary of the 2010 fruit crop condition, weather, pest problems, and other items of interest. A central theme of reports from the mid-Atlantic states was the unprecedented damage to fruits by the brown marmorated stink bug. The General Session included a historical look at disease management trends in apples during the past 100 years by Turner Sutton, an overview of apple production in New Zealand by Chris Bergh, and an overview of apple production in the North of Italy by Caluadio Ioriatti of San Michele all’Adige, Italy.

Following lunch, the meeting was split into three concurrent sessions where 18 entomology, 13 horticulture, and 25 plant pathology papers were presented. Concurrent sessions ran from 1 PM to approximately 5:00 PM on Thursday, and were continued after the business meeting on Friday morning. Following the presentations on Thursday afternoon, a social mixer was held from 5:15 to 7:15. The mixer 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 USA.

The business meeting was called to order by Jim Walgenbach on Friday at 8:00 AM. Topics of discussion included publication of reports, future organizational structure of the CSFWC, financial report, and future meeting hosts, times and location.

Electronic versions of past copies of the CSFWC Proceedings are maintained at Virginia Tech’s Scholar site, and the CSFWC section is maintained by Doug Pheiffer. The 2010 Proceedings will again be posted at the Scholar site, and hard copies will only be sent to those specifically requesting a hard copy. Keith Yoder reported that 15 hardcopies were requested in 2009.

There was a short discussion on the need to further define eligibility of meeting participants. The invited participant list was expanded for the 2010 meeting to include “any interested agriculture professional involved with fruit regardless of their affiliation or role in the industry.” There was concern expressed that this definition could include growers, some of which may include small 100-tree operations, and opening the meeting to anybody affiliated with the industry may have a significant change in the objective and purpose. Since there seems to be no official objective or purpose of the meeting, it was suggested that a mission statement may be appropriate to formalize the intent of the meeting, which would help to clarify participation. No action was taken on this issue, although it will be addressed by a committee (see below).

Another topic of discussion was the organizational structure of the meeting. The current system of rotating organizational responsibility among states lacks continuity and involves a considerable time commitment by the general chair. The membership mailing list now exceeds 200 individuals, the trend of increasing attendance will likely continue with a more broad-based definition of eligible participants, and the very popular industry sponsored social mixer requires a significant time commitment to organize. The financial organization of the meeting is cumbersome in that the rotating organizing chair makes all monetary decisions and collects money, which is then transferred to the secretary. Jim Walgenbach proposed creating a more stable organizational structure – e.g., possibly paying an entity to organize the meeting on a permanent basis. Some skepticism was expressed about this need, and it was decided that an ad hoc committee consisting of Jim Walgenbach (chair), Brian Olson, and David Combs would address this and related issues and report at next year's meeting.

The organizations financial report (see below) was presented by Treasurer Tracy Leskey. With the current balance, receipts from 90 paid attendees ($5,655), generous contributions from industry associates for the mixer ($2,950), the organization is in good financial standing and should be able to meet all anticipated bills for 2010.

The 2011 CSFWC will be held on December 1-2, at the Hampton Inn, Winchester, VA. The traditional date of the Thursday and Friday before Thanksgiving conflicts with the 2011 Entomological Society of America Meeting. This conflict with the ESA meeting will continue through at least 2015. Pennsylvania will serve as host state for the 2011 meeting, with Greg Krawczyk serving as General Chair.

Cumberland-Shenandoah Fruit Workers Conference

2009-2010

Financial Report

Income 2009-2010

Receipts from 2009 Registration (90)	5230.00
Support for Mixer	2810.00
Interest (December 09-November 10)	11.49
Total Income	**8051.49**

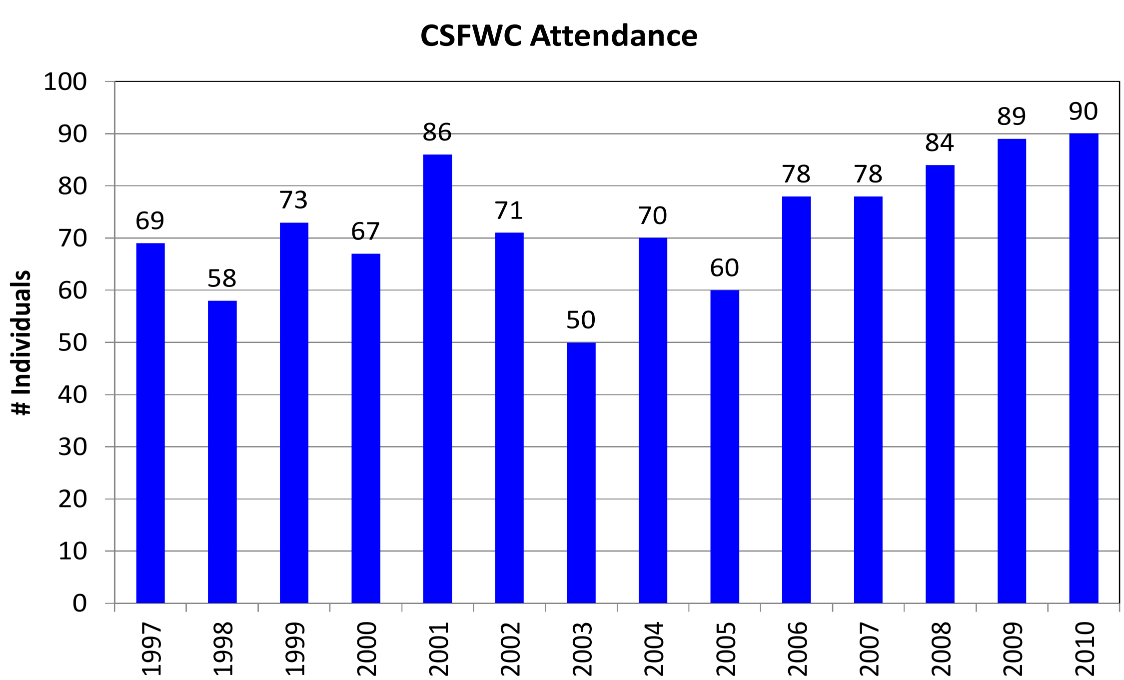
Expenses 2009-2010

Hampton Inn – room rental, luncheon, breaks, mixer	6052.39
Meeting Supplies	88.20
Proceedings	401.44
Travel Expenses for Guest Speaker (J. Brunner)	671.55
Total Expenses	**7213.58**

Total Account Balance -- November 15, 2010 ***$7383.81***

Income 2010-2011

Receipts from 2010 Registration (90)	$5,655
Support for Mixer	$2,950
Total Income	$8,605



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
2009	6052.39	67.25

Cumberland-Shenandoah Fruit Workers Conference
Future Host States

2011	Pennsylvania
2012	New Jersey / SC
2013	USDA-ARS / WV / MD
2014	New York
2015	Virginia
2016	North Carolina

Call of the States – New York 2010

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

Entomology

Our season was characterized by extremes in terms of earliness, heat, rain, and even drought. These all came with their own impact on local arthropod populations. The unusual weather started by the beginning of April, with a most un-New York-like spring, including record early occurrences of pink, bloom, and eventually petal fall in apples. A chill briefly stalled things during May (including a late frost around Mothers Day that killed a number of fruit buds of selected varieties in localized orchards), before the next heat wave that kicked in by June and hardly abated until harvest. In terms of degree day numbers, we were never less than 100 DD ahead of the historical "normal" readings on a given date, and frequently as much as 200-300 (or more). Moreover, the rain events seem to have been plentiful and generous in western NY, but scarce and sporadic in the eastern half. Still, there were apparently few real pest crises, although most growers were kept hopping and sufficiently challenged throughout the season. Fruit quality and crop size was very good for all pome fruits, stone fruits, (most) berry crops, and grapes in NY this year.

The early heat threatened to make this a banner year for **plum curculio** and **European apple sawfly**, who took advantage of the opportunity to arrive in the orchard by mid-April but then turned out causing fairly normal levels of damage as the post-petal fall temperatures dipped; most growers were able to deal with them with few problems. Flights of **oriental fruit moth** and **codling moth** similarly started ahead of schedule, but then staggered a bit during their first generation; summer flight numbers were apparently normal, showing high numbers in traditional problem sites. A current tally of western NY processors notes 240 loads of apples with internal worms detected, of which 14 loads contained 5 or more infested fruits; no load rejections have been reported. Of the larvae detected, 77% were codling moth and 23% oriental fruit moth or lesser appleworm. **Obliquebanded leafroller**, which was mostly a no-show last year, staged an early and substantial resurgence that translated into a more typical level of fruit damage in historically high-pressure sites.

High temperatures combined with adequate moisture in many area orchards to support flush foliar growth favoring populations of **European red mite** as well as **green aphids**, and **potato leafhopper** seemed to arrive in several installments. More than one report indicated that some of the older miticides are losing their edge, and control of difficult pests such as **woolly apple aphid, stink bugs** and **San Jose scale** remains a challenge. Weather no doubt was a factor also in the emergence patterns of **apple maggot**, which posted substantial trap numbers in various regions of the state.

It is becoming more commonplace to find seldom-occurring pest species these days, and this season saw outbreaks of insects like **apple mealybug, white prunicola scale**, and assorted stink bugs, including our first orchard detection of **brown marmorated stink bug** (found on a vehicle in Chazy, which had just driven from Washington Co.) Reports of BMSB were fairly widespread in the Hudson Valley in vineyards and residential areas.

Call of the States – New Jersey 2010

Dean Polk[1] and Jerome L. Frecon[2]

This report only encompasses four major fruit crops in order of importance: Blueberries; peaches; apples; and wine grapes by acreage.

Blueberries - Our acreage is about level with 2009 or 7800 acres. Blueberries bloomed earlier than normal due to the 85-95 degree weather we had in April. The crop thus matured very early and with the late crop from the southern US resulted in fair demand for NJ blueberries. Prices for 2010 have not been released but it is fair to say both fresh and process blueberry prices were less than 2009 which was down from the high market in 2008. In 2009 wholesale prices were \$1.23 per pound fresh and .62 cents per pound processed. The crop in 2009 was 53 million pounds. Yields and prices were down in 2010. We had early crop in 2010 and our normal competition from the south was late thus no market niches for NJ blueberries. Our crop was a smaller, some winter injury, less fruit set in the spring, spring frost, hail and intense heat. We use a lot of day haul labor which was harder to find. With the intense heat in June and early July some fruit got soft, didn't get harvested due to labor shortages, and was diverted to processing. The market for processed blueberries was weak and has now just recovered slightly. The fruit was large with excellent quality. Many growers were not the "happy campers" they were after the big years prior to 2009.

Peaches – Our acreage all for fresh market peaches and nectarines is about 6,500 acres and continues to decline. Peaches bloomed slightly early during 85-90 degrees temperatures. Boom was quick resulting in little time to bloom thin and hand thin blossoms. Pit hardening came early, and many growers were still pruning when they should have been thinning fruit. Harvest started early about June 20 and with the later bloom in the south there was never any strong demand for peaches. We had ample soil moisture after record snow fall and with spring rains, water supplies were good. The soil was actually too wet in some locations resulting in many 2 year and older trees dying of root asphyxiation and Phytopthora.

Fruit size was good where thinning was timely. Flavor was excellent due to the hot dry weather that occurred during the rest of the summer. Water shortages were more prevalent in the northern part of the state where most of the orchards are smaller and the fruit is direct marketed.

The wholesale market for peaches started out fair and only got worse as the season progressed. There was never much demand except where loyal NJ buyers stuck with us due to the heavy promotional program. South Carolina shipped 40% more peaches than in 2009 and Georgia had 18 % more. New Jersey shipments were down 15%. A normal crop for us is about 65 million pounds but it was probably closer to 55 million in 2010. According to NJ Ag Statistics NJ averaged .25 cents per pound in 2010 compared to 34 cents in 2009, It costs us .40 per pound to grow and market peaches. Peaches were rolling into New Jersey all summer be offered at less than 25 cents per pound with no home or market form South Carolina. California peaches and nectarine volume was similar to 2009 but price were much lower. New Jersey peach volume was down due to some sick trees, some smaller fruit size, some hail, soft fruit from the heat, labor shortages. Some fruit was picked but not sold due to low prices. The most significant pest problem was brown marmorated stink bug injury late in the season.

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[1] Statewide IPM Fruit Agent, Rutgers NJAES, Cooperative Extension
[2] Agricultural Agent, Rutgers NJAES, Cooperative Extension

Apples – Apple acreage continues to decline but exact acreage data is not available. Fruit volume is stagnant at about 40 to 45 million pounds. Wholesale apple prices in 2009 were .36 a pound down from 40 cents per pound in 2008. Preliminary prices are pegged at .35 cent in 2010. Increased numbers of our trees are planted in high density orchards particularly in the northern part of the state. About 10-15% of the total crop goes to the processor for mostly juice and the balance is sold locally. We have no remaining packing houses that ship fruit except what they handle in bins and crates for local fresh market sale or direct and agritourism markets. Apples bloomed and matured early. We lost some trees to wet feet and phytopthora, and fruit loss to scab, marmorated stink bug, and San Jose scale.

Wine grapes - This is a growth industry. We now have about 40 wineries in the state with many more on the drawing board. We need to do more survey work to collect data. With a dense population, wine consumption is high, and most of the major volume is retailed at farm wineries.

We had a great growing season leading to a good vintage at harvest. There was some hail and stink bug injury but less disease and other problems than in our wet season of 2009.

Call of the States - Pennsylvania 2010

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Horticulture: Winter was relatively mild with some significant snows early in the year. The most notable weather related event was the first week in April where temperatures reached into the mid to upper 80's resulting in an early bloom of all tree fruit crops. Normally there is a 14 to 17 day difference in bloom from the Maryland border to the New York border. This year that difference was at most 2-3 days. In central PA apples, peaches and sweet cherries were all in bloom at the same time, an occurrence that has never been observed before. The nights of May 9-10th a frost/freeze event occurred across the state resulting in minimal to major damage. The northwestern area of the state suffered the most damage with small fruitlets showing freeze damage within the cortex tissue. Growing degree days base 50°F were 767, 673 and 458 degree days above average for FREC, Rock Springs and the North East grape lab, respectively, for the period of January 1 through October 31st.

The growing season had several extended dry periods notably in June and July when only 0.86 inches of rain fell in Biglerville. However, the rain was spotty with some areas receiving more rainfall. Fruit maturity for most cultivars was advanced from a week to two weeks across the state. Fuji harvest at Rock Springs was completed on October 5th. The earliest harvest prior to this year occurred on October 16th with the average harvest date normally falling on October 22nd. The first two weeks in September were also very dry. Rain of 0.61 inches on the 12th of September resulted in some fruit cracking.
(submitted by RMC)

Plant pathology: Here is a brief description of the 2010 scab infection events that occurred during the primary period 16 Mar to 15 Jun. There was an extended primary scab season with mature ascospores being trapped in large numbers (>5000) from March 24 to mid June. On average, the ascospore counts were much higher during this year, indicating relatively good survival conditions for the scab fungus. There were 6 moderate scab infection events and 11 severe infection events. Overall, apple scab pressure was moderate and powdery mildew pressure was high in the test site. Low scab pressure presumably occurred because the early part of the growing season coincided with days with relatively low temperatures.

On fire blight, this was overall a moderate-to-low pressure year fro fire blight. The exception was for pear for which a high incidence was reported in grower orchards.

Brown rot pressure was also low as was bacterial spot on peach presumably because of dry weather. Anthracnose on peach fruit was noted in several orchards which was unusual.
(submitted by NOH and HKN)

Entomology: The 2010 season was also a very interesting year form the entomology perspective. The biofixes for our normal fruit pests were quite significantly disconnected with normal plant phonological stages: while biofix for OFM (April 03) and STLM (April 03) occurred synchronized with plant development, the biofixes of CM (April 30), TABM (May 02) and OBLR (May 23) occurred within normally expected calendar time but very late compared to the tree development.

During the season, we did not see any special, unexpected occurrence from our standard fruit pests. Hot weather created some issues with red mites. Internal fruit feeders and leafrollers still posed some control challenges in isolated orchards (high numbers of TABM in traps) resulting again in rejections of fruit by fruit processors. The other pests causing some control problem were pear psylla, plum curculio, wooly apple aphid and borers but in most cases the challenge was limited to only few, individual orchards.

The story of the season was injuries caused by brown marmorated stink bug in stone and pome fruit orchards located mostly in the southern part of the State. Starting form June significant injuries were reported from numerous stone fruit orchards with damage levels up to 40-60 percent of the fruit (mostly south-east PA). Although at a lower level, similar observations were reported later during the season from pome fruit orchards. Overall, taking into the account the entire state fruit production, based on information from growers, packing houses fruit processors and our own observations the BMSB injury were estimated to affect about 10 to 20 % of pome fruit in PA with some orchards or blocks experiencing up to 70 percent of injured fruit.
(submitted by GK and LAH)

Call of the States - Maryland 2010

The 2010 season began early after a winter that produced much more snow than normal. All crops got off to an early start and with good residual moisture from the snow. March and April were so ideal for plant growth that producers found it challenging to keep up with the fruit crop's progress. There were a few cold nights after fruit set in peaches which seemed to damage some fruit but that would later turn out to be early Brown Marmorated Stinkbug (BMSB) damage. BMSB posed the greatest threat to all fruit crops in the Major production area of Maryland in 2010. Special thanks must be given to USDA, ARS and Penn State for their support in identifying and providing information to Maryland producers during this confusing and frustrating season.

Overall, strawberries, black raspberries and blueberries presented with very good crops; yet there was severe loss in peach, apple, and red raspberries in central and western Maryland. May, June, July, and August were very dry and hot with some relief coming in September. The high temperatures were ubiquitous in Maryland but the drought was most severe in Central and Western Maryland (the primary tree fruit production area) leading to even more challenges to crop quality.

Losses in apples were 30-50% and in peaches 40-100%. Without control of BMSB in the 2011 season, several growers have indicated they will no longer be able to continue in the industry. Respectfully submitted by Bryan Butler, Central Maryland Tree Fruit Agent, University of Maryland Extension.

Call of the States – West Virginia 2010

The 2010 growing season was unusual to say the least. Pruning was hampered and delayed by several major snow storms that deposited nearly 6 feet of snow between December 19, 2009 and late February 2010. The heavy snow and slow melt turned out to be a blessing as we experienced one of the driest and hottest summers in recent memory. While March was a very wet month and April and May about normal, most fruit producing regions in WV received less than 3 inches of rain between mid-June and mid-September. Apple bloom was the second earliest on record with some cultivars near full bloom on April 4. Despite a frost/freeze event on May 10, production of apples, peaches, and cherries was down only slightly from normal levels, which may indicate that trees have been removed from some of the poorer producing sites in the state. Apple thinning was aided by a brief warm spell in early May. The early bloom translated into early maturity for all the major fruit crops. Sweet cherries were fully mature in the first week of June and Golden Delicious apples, normally mature about mid-September were ready to harvest on September 8. Very high temperatures through July and August reduced color development on red apple cultivars and there was far more sunburn evident at harvest than seen in the past. Fruit size was down slightly on peach as a result of the very dry conditions, but sugar levels were elevated in both peach and apple. Surprisingly, apples that were well thinned didn't suffer as much in size from the drought and 3 inch Golden and Fuji was not uncommon. Apple fruit drop was quite variable with excessive drop in some orchards, but only moderate drop in other orchards. The major pest affecting fruit production in WV, especially apple and peach, was the brown marmorated stink bug (BMSB). This relatively new pest began feeding on peaches in late May and continued affecting crops through the summer. Some peach growers experienced 50% or more crop damage from the BMSB. The use of pyrethroids to control BMSB resulted in increased populations of Wooly Apple Aphids and San Jose Scale in some orchards. Controlling the BMSB will be critical to the survival of area orchards and in the quality of fruit from WV in the near future. As the growing season neared an end, some growers described 2010 as "the year from hell!" *(Horticultural comments, submitted by Steve Miller, Research Horticulturist, AFRS.)*

Overall crop conditions were fair to poor, mostly due to drought conditions and extensive stink bug infestations. The eastern panhandle of WV was declared a drought emergency. At WVU-KTFREC, Bounty peaches exhibited 35% damage due to spring feeding of brown marmorated stink bug; Gala apple showed 100% damage from nymph and adult feeding in August. Hampshire and Morgan County orchards are not having BMSB problems yet; although the infestations are severe in Berkeley and Jefferson Counties. The eastern panhandle area experienced some early localized spring frost on May 9 and 10, about 10 to 14 days past apple petal fall. We had the earliest bloom since 1945 and our second earliest ever recorded since 1934. Apple scab present very early with first infections occurring on March 31. 25 infection events occurred over the entire season with adequate moisture in April and May; adequate enough to have good scab and rust pressure in our test plots. 10 scab infection periods occurred from apple GT through June 1, with 6 of those also favorable for rust infection. For fire blight, we had 5 infection periods occurred this season, April 6, April 8, April 16, May 2, and May 3. Late season fire blight blossom infections were problematic for some growers. *(Plant Pathology Comments, submitted by Alan Biggs, Professor of Plant Pathology and Extension Specialist, WVU-KTFREC.)*

Call of the States- Virginia 2010

Horticulture: It is with great sadness that we report the passing of Dr. Rongcai Yuan in 2010. Dr. Yuan's research on the molecular biology of fruit abscission was highly regarded by his peers and he will be greatly missed. Dr. Gregory Peck (Cornell University) has been recruited to fill the Fruit Crops Horticulturist position, beginning in spring 2011.

'Red Delicious' apple trees were in full bloom on April 8, 2010, two weeks ahead of normal. Most apple varieties were in bloom simultaneously. There was scattered hail damage in Frederick County in late April. A hot period in early May resulted in effective thinning, although high rates of thinners tended to cause over thinning, especially in 'Red Delicious'. Many growers reported that a May 10 frost affected at least a third of their apple, peach and sweet cherry crops. Fruit injury symptoms in apples included russet spots and rings and flattening (like quince rust) due to loss of seeds. Hot and dry conditions began in June, and July was 6° above normal. The warm temperatures and expanding crop loads throughout July led to sunburn and heat injury on exposed fruit. The excessive heat and below normal rainfall continued through September, affecting apple and peach fruit size and the color of 'Red Delicious' apples. Fall apples ripened at least one week ahead of normal, although apples and peaches were sweeter than normal. Apples were much firmer than in 2009, when soft fruit was an issue. A stop drop study in 2010 showed that these materials work very well when applied at the right time.

Prices for fresh fruit were excellent, but with a dirty apple crop, processing apple growers saw a smaller return, since more fruit were graded for juice apples.

Entomology: Despite unusually warm weather in March and April and early peach and apple bloom, biofix dates at Winchester for oriental fruit moth (April 5), codling moth (April 29) and tufted apple budmoth (May 13) were within expectations, based on data since 2000. The first flight of codling moth was very prolonged, with no apparent peak or cessation of captures in pheromone traps prior to the onset of the second flight. Unusually hot and dry conditions from June through August appeared to adversely affect the predictability of the egg hatch models for codling moth and oriental fruit moth after first brood. There were reports of high codling moth trap captures from some commercial orchards but not widespread reports of excessive injury from internal worms.

The unusually hot and dry weather did not result in unusually high spider mite pressure. Injury from rosy apple aphid, white apple leafhopper, leafminers and leafrollers was light. Potato leafhopper was abundant in June and July and required intervention in young apple blocks. There were more reports than usual of woolly apple aphid, although most of those infestations did not warrant intervention. Numbers of the woolly apple aphid predator, *Heringia calcarata*, recorded in late summer were much lower than observed in the previous two seasons.

Brown marmorated stink bug (BMSB) became very apparent starting in July. Large populations persisted through harvest of late season apples and the pest caused significant injury to apples and peaches. There were reports of early and mid season peaches showing less injury from BMSB than later varieties, and reports of apparent differences among apple cultivars. Additional BMSB injury appeared in apples and peaches after some period in cold storage. Counties in northern and central Virginia appear to support the largest BMSB populations at this time.

Virginia growers are increasingly adopting mating disruption for both apple and peach pests, although the number of growers applying for NRCS EQIP contracts under the tree fruit IPM program has decreased, following initial interest in its first two years (2008-2009).

Tree fruit pathology: Apple scab spores were first trapped Mar 22 and the first infection period was Mar 28-29. Because scab lesions appeared as early as Apr 12, an infection period Apr 13-14 was an early secondary infection period where lesions were sporulating if 1/2" greentip-tight cluster growth was not protected during the Mar 28-29 inf. periods. Protectant fungicides, applied before these first two infection periods would have given excellent control, but some did not have protectants ahead of the infection, then relied on a protectant too late after infection, allowing considerable secondary infection. Secondary infection and extended wetting periods: Apr 25-27, May 2-3, May 11-12, May 12-13, May 17-18, May 22-23, May 23-24, Jun 9, Jun 14-15, Jul 9-10, Jul 13-14, and Jul 31- Aug 1.

Early rust scab infection periods were too cool for rusts while the flowers were susceptible, and most fruit were resistant to quince and cedar rust infection by Apr 25. But cedar-apple rust infection periods occurred Apr 25-27, May 2-3, May 12-13, May 17-18, May 22-23, and May 23-24. Cedar-apple rust inoculum was mostly depleted after May 24.

Powdery mildew spores were available on infected emerging buds by Mar 30. As an indicator of relative annual mildew pressure, we note the number of days above 53º without rain as potential "mildew days". From March 30 to June 1 we had 45 mildew days this year. Since 1993, the number of such days from tight cluster to six weeks after petal fall (about third cover) has ranged from 24 (in '96 and '03) to 49 in '99. This year ranked as the second most frequent mildew weather in 18 years.

Fire blight blossom infection events occurred at our AREC Apr 8 and Apr 16 (some local areas may also have had wetting of early bloom Apr 6). Canker blight symptoms were predicted for May 1, and trauma blight symptoms were predicted to appear May 4 from blight due to hail damage Apr 25. Temperatures favored infection with wetting where late bloom was still present Apr 30-May 5, and on those days, wetting from a spray application would have been adequate for infection on an otherwise dry day. Overall it was not an unusual fire blight year but, as usual, there were scattered serious outbreaks.

Accumulated wetting hour total (starting Apr 29, 10 days after petal fall) is used to predict development of the summer fungal diseases, sooty blotch and flyspeck. The 250-hr threshold for presence of these fungi on unprotected fruit was reached on Jun 26, similar to four of the last five years, and sooty blotch and flyspeck were visible on unprotected fruit at lower elevations at our AREC (Block 13) by Jul 19. However, further wetting hour accumulation was slow and the total of 521 hr Sep 7 was lowest since we have been recording this in 1994. Accumulation of 611 hr by Oct 4 was nearly three weeks behind the previous low. A few warm extended wetting periods >7 hr, favoring apple fruit rots such as bitter rot and brown rot on ripening peaches, occurred Jun 14-15, Jul 9-10, Jul 13-14, and Aug 4, 12-13, 15-16, and 18-19.

Call of the States – North Carolina 2010

Mike Parker

The tree fruit industries in North Carolina did well in 2010 with a nice crop, available markets and good prices. Like most other areas, NC did have an early and very warm, hot, spring and summer. There were no major problems with the peach crop across the state. For apples, there was a significant fruit drop attributed to chemical thinning programs. However, further investigation indicated that there were several very warm nights in the spring that would have resulted in fruit with a reduced carbohydrate supply. Chemical thinners applied at this time were very aggressive and resulted in a heavy thinning, especially on red delicious. The year was relatively dry in the spring and early summer resulting in very few problems with scab or powdery mildew. However, in mid-summer the rains became frequent and, combined with higher temperatures, provided an opportunity for *glomerella* fruit and leaf spot to flourish. The problem started on gala and quickly spread to golden delicious primarily, while also affecting to a lesser degree fuji, jonagold, and pink lady, negatively impacting close to 1 million bushels. In terms of arthropod populations on fruits, it was a relatively uneventful year, although there were a few noteworthy items of interest. There was an increase in the number of apple orchards experiencing second generation plum curculio damage, and this is related to the more widespread use of mating disruption and reduction in insecticide use. We also experienced a somewhat higher than normal level of stink bug damage on both peaches and apples, although it was not until later in the season that we observed brown marmorated stink bug in apple orchards - this is not to say they weren't there earlier, but if so only in low numbers. Finally, a statewide trapping program for spotted wing drosophila detected this insect throughout the state, with a number of raspberry fields in the mountains having severe larval infestations later in the season.

Call of the States - South Carolina 2010
(Guido Schnabel)

The trend of the last almost ten years continues; very little rainfall past bloom and especially past pit hardening inhibited a lot of pathogen pressure. Consequently, brown rot was no issue. That is not to say that brown rot was completely absent. In fact, between SC and GA about 600 peaches with brown rot symptoms were used for location-specific monitoring. Results indicate that fungicide resistance appears to be dwindling compared to 2008 and 2009 levels. In early peach varieties we did see some Gilbertella and Rhizopus rot. Mildew as well as Anthracnose and other fruit rots were absent. However, Armillaria root rot does not seem to mind the dry conditions and is still killing trees especially on replant sites.

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Without Consent of Author

THE IMPACT OF BROWN MARMORATED STINK BUG IN NJ TREE FRUIT - 2010

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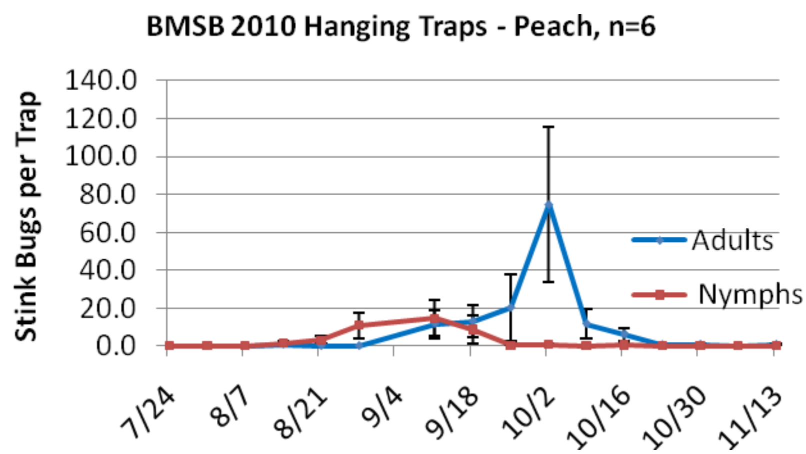
As on other mid-Atlantic states, the brown marmorated stink bug (BMSB) *Halyomorpha halys* (Stål) was a significant problem in both apples and peaches during 2010. This paper summarizes the types of damage seen, severity, trap captures, and feeding seen in relation to borders and trap placement.

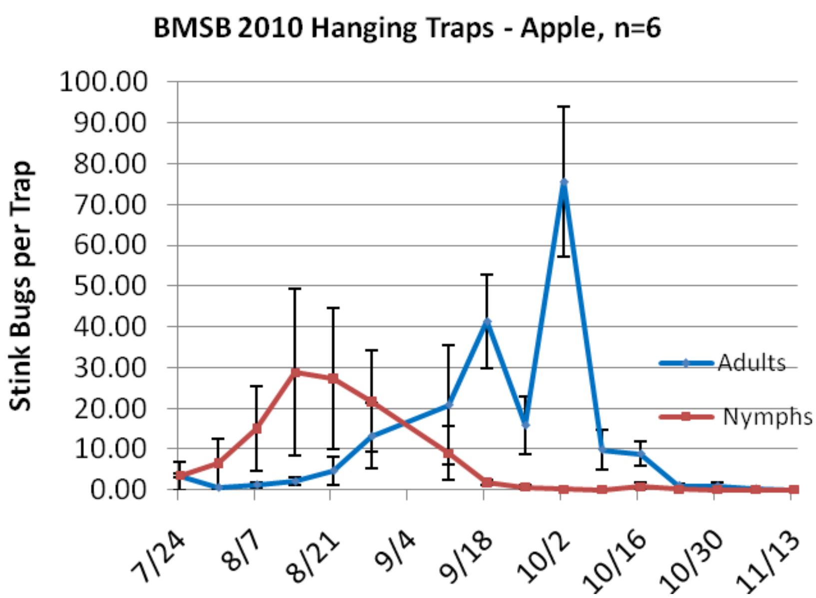
Trap records: During 2010 we placed 6 hanging pyramid traps each in peach and apple blocks. Traps consisted of 1 gal plastic ventilated jars with a boll weevil trap top inserted into the bottom of the jar. An 18" high yellow plastic Tedders type pyramid was clipped to the bottom of the jar assembly. A 5.6 mg septa containing the aggregation pheromone, *methyl 2,4,6-decatrienoate* was clipped to a short wire and hung on the inside top of the trap (Figure 1). Traps were placed on edge rows within orchard blocks at the end of July, and started to catch BMSB nymphs immediately. Nymph captures peaked by mid August in apples, but by early September in peaches. Captures of adults peaked by early October in both crops (Figure 2).

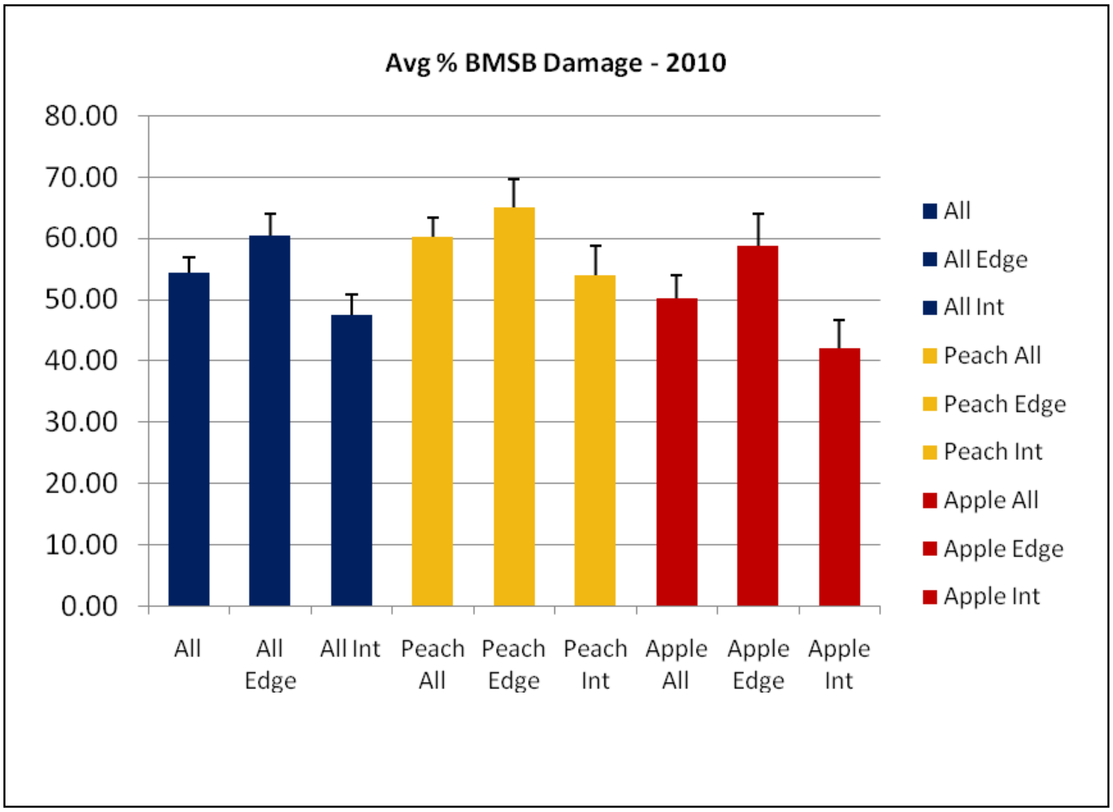
Fruit damage: We sampled fruit in the same manner as completed in other mid-Atlantic state in 2010. We sampled 10 fruit from each of 10 trees on a border row with a second sample pulled in the same manner from 10 trees on 1-2 interior rows at least 6 trees in from the border row. Fruit were cut and rated for the number of feeding injuries on each fruit: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, >10. We took a total of 66 samples across 17 farms for a total of 6,600 sampled fruit. Mean damage levels were significant. We found just over 54% damage across all sampled fruit. Damage was significantly higher towards edge rows. Interiors of peach blocks averaged almost 54% damage, while edge rows averaged 65% damage. The pattern was similar in apples where an average of 42% damage was seen on interior rows compared to 59% damage on edge rows. One peach planting was seen with 97% damage. Other blocks were only slightly damaged, but damage was present throughout NJ at some level. Total damage seen on border trees was significantly more than levels seen on interior trees (Figure 3).

Fruit damage in relation to trap location: At the end of August we noticed that fruit on a trap tree seemed to be more highly damaged with more BMSB in that tree than in neighboring trees. In order to verify this, we picked an apple planting (red delicious) with woods located near the border. We geo-referenced 7 border trees from the trap tree in each direction on the end of the block, plus 10 trees into the interior of the block along the row where the trap tree was located. During the middle of September we picked 100 fruit from each tree. Fruit was classified for the number of fruit with <10% damage, >10% damage, and % clean. The most heavily damage fruit (>10% damage) was seen on the trap tree and just next to it on the border row. This is not surprising and agrees with general field observations (Figure 4).

Figure 1. Trap and
bottle.






Avg % BMSB Damage - 2010
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
All
All Edge
All Int
Peach All
Peach Edge
Peach Int
Apple All
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ASSESSMENT OF ADVANCED IPM FIELD TRIALS IN NY APPLES – YEAR 1

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Dan Cooley & Arthur Tuttle, Univ of Massachusetts
Tracy Leskey & Starker Wright, ARS, Kearneysville, WV

This work consisted of field trials to test advanced IPM control methods for key pests in blocks of commercial orchards; 2010 was the first year of the project, and the study is expected to continue for at least one more year. There were 5 orchards in NY (and 6 in New England); at each orchard site, there was one Advanced IPM block, 3-5 acres in size, and a comparable Grower Standard control block, for purposes of comparison.

Protocols

Plum Curculio (PC): Trap trees were set up around the orchard perimeter prior to petal fall, on a 50-m spacing; each of these trap trees was baited with 4 vials containing an olfactory attractant (benzaldehyde) plus one pheromone dispenser containing a component of boll weevil aggregation pheromone, which has been shown to be attractive to plum curculio. A full block spray of a Reduced-Risk (RR) material was applied at petal fall; subsequent sprays were applied to the trap trees only (on a 10–14-day interval, for the duration of plum curculio oviposition, according to a degree day oviposition model). Fruit damage assessments were made in each trap tree and their nearest neighbor trees at harvest.

Obliquebanded Leafroller and Internal Lepidoptera: Seasonal on-tree fruit inspections were conducted to optimize insecticide treatments against this class of pests. The start of the weekly fruit inspections was at 550 DD (50°F) after biofix, to correspond with the projected 50% hatch timing of codling moth. Pheromone trap catch patterns and incidence of damage were used to determine the choice of insecticide materials and the timing of any needed sprays. Detection of one damaged fruit indicated the potential need to spray.

Apple Maggot (AM): This control strategy involved orchard perimeter placement of Pesticide-Treated Spheres (PTS) to attract and kill immigrating apple maggot females; these were baited with spinosad + sugar. A fruit volatile odor bait was used with each PTS. Unbaited sticky spheres hung in the block interior were checked for “escapes” weekly.

The Grower Standard blocks received full block sprays against each of these pests, with each respective grower determining application timing, number of sprays and material choice.

Pest Assessment

Some orchards had resident populations of PC or AM, which compromised the effectiveness of the management tactics, as they rely on the assumption that the major threat from these species is represented by individuals immigrating into the block from external areas. The spray programs used were not always adequate given the level of pest pressure present, even in the Grower Standard blocks. As a side observation, it was noted that much of the AM damage detected consisted of punctures only, with no tunnels or larvae apparent. Actual harvest damage numbers are shown in Table 1.

From the spray records collected to date, the following summaries can be offered for the participating growers:

- Grower 2, IPM block: 1 full block spray + 1 Trap Tree spray against PC; nothing further against other pests; STD block: 2 full block sprays against PC, and 1 against AM
- Grower 3, IPM block: 1 full block spray + 1 Trap Tree spray against PC; 2 full sprays against leafrollers; and 2 full sprays against AM; also, 1 full spray against aphids and tarnished plant bug; STD block: 7 full block sprays, 2 for PC, 2 for leafrollers, 2 for AM, and 1 for aphids
- Grower 4: both blocks received 1 full block spray against PC and 1 against Lepidoptera (OBLR and/or codling moth).
- Grower 5, IPM block: 1 full block spray against leafrollers, and 1 against PC; STD block: 1 full block spray plus 1 border spray against PC; 1 full spray against leafrollers, and 2 against AM.

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Growers: D. Hartley, J. Knight, P. Ten Eyck, W. Truncali, and D. Wilson
Technical Field Assistants: M. Basedow, D. Combs, J. Gianforte, J. Mattick, A. Olsen, C. Sekulic, and A. Walbridge
Financial Support: USDA NE Regional IPM Program

Table 1. Advanced IPM Harvest Evaluation, New York 2010

Site, Treatment	Int. Lep	Sting	OBLR Early	OBLR Late	AM	PC	TPB	RAA	SJS	EAS	Stink bug	Apple Scab	SB/ FS	% Clean Fruit) (Insect only)	% Clean Fruit) (Total damage)
Grower 1															
Advanced IPM	0.7	3.3	0.6	4.6	4.5	5.5	4.7	0.1	0.7	0.5	0.0	72.0	39.5	74.8	6.9
Grower Standard	1.0	1.5	1.1	6.8	0.3	6.2	6.6	0.0	1.4	0.9	0.0	62.7	69.5	74.2	12.6
Grower 2															
Advanced IPM	0.9	0.0	1.1	9.8	0.1	0.9	4.5	0.3	0.0	0.9	0.0	0.0	0.0	81.5	81.5
Grower Standard	0.0	0.0	0.0	6.0	10.3	2.1	3.6	0.0	0.2	3.4	0.0	1.4	0.0	74.4	73.0
Grower 3															
Advanced IPM	0.4	0.0	0.5	0.8	3.3	2.9	2.9	0.0	0.1	0.3	1.5	0.0	0.1	87.2	87.1
Grower Standard	0.0	0.0	0.0	0.0	0.7	0.7	1.0	0.0	0.0	0.0	1.3	0.0	0.0	96.7	96.7
Grower 4															
Advanced IPM	0.8	0.0	0.4	3.8	5.2	13.7	2.1	0.0	0.0	0.0	0.5	2.0	0.0	73.5	71.5
Grower Standard	0.0	0.0	0.0	0.4	0.0	0.7	0.7	0.0	0.0	0.0	0.2	10.1	0.0	98.0	87.9
Grower 5															
Advanced IPM	1.0	0.0	0.0	1.1	1.1	0.5	0.9	0.0	0.0	0.0	0.7	0.0	0.0	94.7	94.7
Grower Standard	0.2	0.0	0.0	0.2	0.6	0.2	1.1	0.0	0.0	0.0	0.1	0.0	0.0	97.6	97.6
Advanced IPM Avg % Clean														**82.3**	**68.3**
Grower STD Avg % Clean														**88.2**	**73.6**

Key: Int. Lep, codling moth/oriental fruit moth; Sting, shallow lep damage or apple maggot oviposition site; OBLR, obliquebanded leafroller; AM, apple maggot; PC, plum curculio; TPB, tarnished plant bug; RAA, rosy apple aphid; SJS, San Jose scale; EAS, European apple sawfly; SB/FS, sooty blotch/flyspeck

Comparison of Codling Moth Pheromone Lures for Management Decisions

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The use of pheromone-mediated mating disruption for management of codling moth and oriental fruit moth has become a common practice among North Carolina apple growers in recent years. Between 2006 and 2010, the acreage under disruption has increased from about 100 to >2,000 acres. This practice has contributed to a dramatic reduction in target pest populations and a concomitant reduction in insecticide use by participating growers.

The expanded use of mating disruption has led to a need to reevaluate pheromone trap monitoring programs to help measure the performance of mating disruption and to serve as a guide for the need for supplemental insecticide applications in mating disruption orchards. In a USDA-RAMP project in which NC State University annually monitored almost 1,000 acres of apples under mating disruption between 2007-2009, the Trécé CML2 pheromone lure was used exclusively to monitor codling moth populations, and a threshold level of 3 cumulative moths per trap (averaged across all traps) was established to dictate the need for supplemental insecticide applications in mating disruption orchards. In many areas of the country, a new pheromone lure (Trécé CM/DA Combo Lure) that contains both codling moth pheromone and pear ester extract, has become a popular lure for monitoring codling moth in mating disruption orchards. The CM/DA lure has been reported to capture more moths, due in part to the fact that the pear ester kairomone is also attractive to females. Reported here are the results of studies conducted in 2009 and 2010 to compare the performance of the CML2 and CM/DA lures in attracting codling moth to traps in both mating disruption and non-disrupted apple orchards.

Materials and Methods

Pheromone Traps. For all tests, large Delta-style traps (i.e., Pherocon VI or Suterra LPD) with replaceable sticky bottoms were used. Codling moth traps were placed in the upper portion of the canopy by attaching traps to bamboo poles and hanging poles on an upper limb. In all circumstances, traps were checked at weekly intervals and bottoms were replaced as needed to ensure a clean trapping surface.

Three-Lure Comparison. A comparison of the performance of three different codling moth lures was conducted in a non-mating disruption orchard in Henderson County in 2010. Lures compared were the Trece long life lure (CM-L2) that contained 3.5 mg of codling moth pheromone (single component), the CM-DA Combo lure loaded with 3 mg of codling moth pheromone and 3 mg of a pear ester kairomone, and the Suterra Biolure that contained 5 mg of codling moth pheromone that was released through a controlled release membrane. All lures were replaced in traps at 12-wk intervals, the length each was advertised to remain attractive to codling moths. Each trap was replicated 3 times in a RCBD, and traps were rotated within replicates each week. Replicates consisted of individual 5-acre blocks of 'Rome Beauty' trees, such that trap density was 1.7 acres per trap. Cumulative number of moths captured during the first generation (trap totals from 3 May to 28 June) and second plus third generations (5 July to 27 September) were subjected to a two-way ANOVA.

Two-Lure Comparison. The CM-L2 and CM-DA Combo lures were compared in a diversity of orchards that included both codling moth mating disrupted and non-disrupted orchards, as well as orchards that had historically low, medium and high codling moth populations. In 2009, two traps each containing CML2 lures and CM/DA Combo lures (4 traps total) were placed in each of 9 different mating disruption orchards and four different non-disruption orchards. Orchard block size varied among location, but traps were hung at a density of approximately 1 per 5 acres. A similar design was used in 2010, except that traps were erected at higher densities (on average, one trap per 1.8 acres), and there were a total of 10 different study sties, with each site having a mating disruption and non-disrupted block where traps were erected. Although orchard size varied among locations, an equal number of L2 and CM/DA traps were contained in each block. Traps were checked weekly to record moth numbers. In 2009, all moths captured in traps baited with CM/DA lures were sexed. Moth captures in traps baited with L2 and Combo lures were averaged across all locations and cumulative trap capture during first and second generation were compared by a paired t-test. Trap captures in mating disruption and non-mating disruption blocks were compared separately.

Current recommendations for supplemental insecticide use against codling moth in mating disruption orchards is based on a threshold level of 3 cumulative moths per trap (averaged across all traps in an orchard). This threshold was selected after examining trapping records and damage levels during a 2007-2009 RAMP project in which about 1,000 acres of orchards under mating disruption were monitored annually for 3 years. This threshold is based on the use of CM-L2 pheromone lures in Pherocon VI or Suterra LPD traps hung in the upper third of the canopy. To estimate how this threshold level related to traps baited with CM-DA Combo lures, average capture in traps baited with L2 lures when cumulative capture was ≥3 moths per trap was plotted against the cumulative capture in corresponding traps baited with CM-DA lures. Data from 2009 and 2010 were used for this plot, which resulted in 26 and 22 comparisons during the first and second generation flight periods, respectively.

Results

Three-Lure Comparison. Based on cumulative first and second generation codling moth captures in traps baited with different pheromone lures, CM/DA and Biolures captured more moths than L2 lures during both flight periods in a non-mating disruption orchard (Fig. 1). However, codling moth populations varied considerably among the 3 replicate blocks, and ANOVAs were

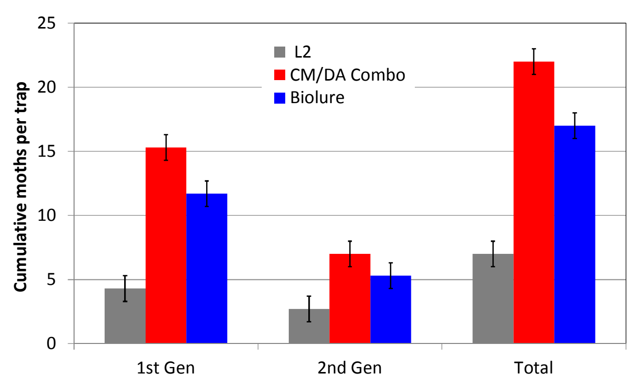

Fig. 1. Mean (SEM) moth capture in pheromone traps baited with different pheromone lures. Henderson County, NC. 2010.

not significant for either the first (F=4.73, df= 2,4, P = 0.088), second (F=1.93, df=2,4, P=0.33) or both generations (F=3.37, df=2,4, P=0.147).

2009 Comparison of CML2 and CM/DA Lures. Seasonal trap captures in orchards with different codling moth population pressure and management tactics (mating disruption versus non-mating disruption) are shown in Fig. 2 and 3. Regardless of population pressure or the use of mating disruption, considerably more moths were captured in traps baited with CM-DA Combo lures compared with L-2 lures during first generation flight. However, there was little difference between the two lures during the second (and partial third) generation.

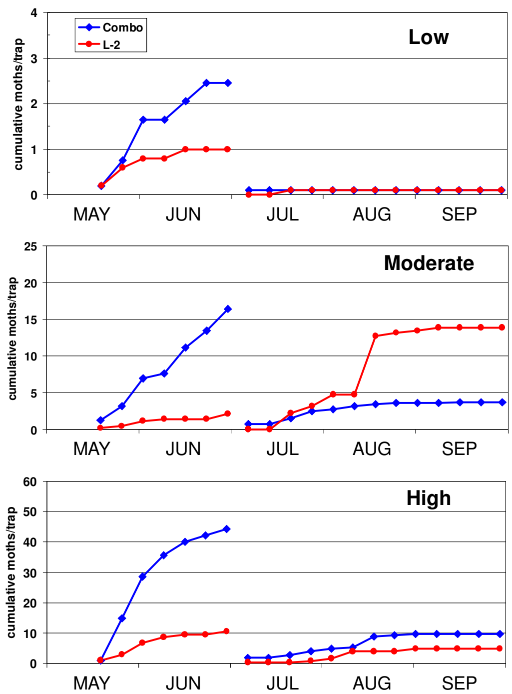

Fig. 2. First and second generation cumulative pheromone trap captures of codling moth with CM-DA Combo and L-2 Lures in mat disruption orchards with low, moderate, and high moth densities.

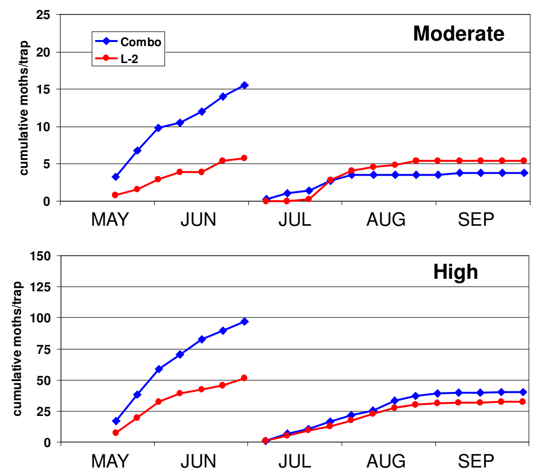

Fig. 3. First and second generation cumulative pheromone trap captures of codling moth with CM-DA Combo and L-2 Lures in non-mating disruption orchards with moderate and high moth densities.

The higher moth capture in traps with CM/DA Combo vs. L-2 lures during the first generation appeared to be due to the lure's greater attractiveness to male moths rather than its attractiveness to females. Of the 917 moths captured in all Combo-lure traps during the first generation, only 4.5% were females. The percentage of females may have been slightly higher, but a high percentage of moths could not be identified when trap captures were high due to the poor condition of moths (Fig. 4).

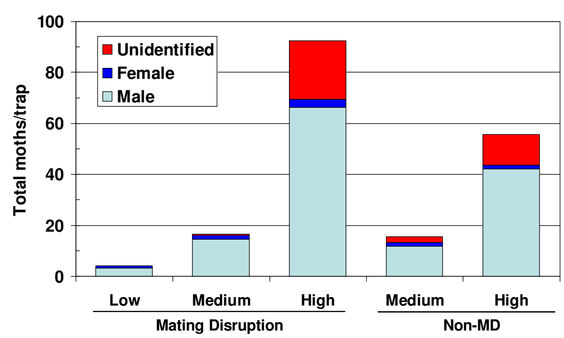

Fig. 4. Mean number of male and female codling moths captured traps baited with in CM/DA Combo lures during first generation flight in mating disruption and non-mating disruption (Non-MD) orchards with low, medium and high moth populations.

2010 Comparison of CML2 and CM/DA Lures. A similar pattern of codling moth capture in traps baited with L2 versus CM/DA lures was again observed in both mating disruption and non-mating disruption blocks. During the first generation, traps baited with CM/DA lures caught significantly more moths than L2 lures (in MD blocks t = 1.98, df = 9, P = 0.039; in non-MD blocks t = 2.36, df = 7, p = 0.025), but there was no difference in trap captures during the second generation (in MD blocks t = 0.117, df = 9, P = 0.45; in non-MD blocks t = 1.02, df = 7, P=0.171). This trend was consistent in both mating disruption (Fig. 5) and non-mating disruption orchards (Fig. 6). Furthermore, this trend of higher captures in CM/DA lures during first but not second generation was also consistent regardless of the codling moth density in mating disruption orchards.

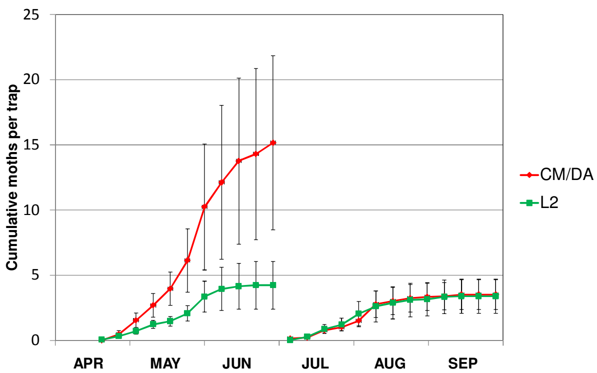

Fig. 5. Mean cumulative moth capture in pheromone traps baited with L2 versus CM/DA Combo lures in mating disruption blocks. Henderson County, NC. 2010.

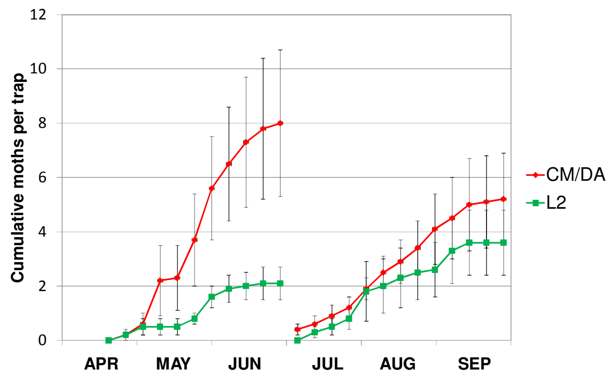

Fig. 6. Mean cumulative moth capture in pheromone traps baited with L2 versus CM/DA Combo lures in non-mating disruption blocks. Henderson County, NC. 2010.

Shown in Fig. 7 is the relationship between cumulative codling moth trap captures with L2 and CM-DA lures when L2 traps reached a threshold of ≥ 3 cumulative codling moths in mating disruption orchards. Although regressions were significant for both the first ($F = 24.2$, df = 1, 25, $P < 0.01$) and second generation ($F = 20.4$, df = 1, 21, P = < 0.01) generations, the relationship was not strong as indicated by r^2 values of 0.49. These results suggest that a threshold of 3 cumulative moths/trap with L2 lures is equivalent to approximately 9 moths/trap with CMDA lures during first generation flight, but only about 1.2 moths during the second generation, indicating that fewer moths were captured with CM/DA lures versus L2 lures during the second generation.

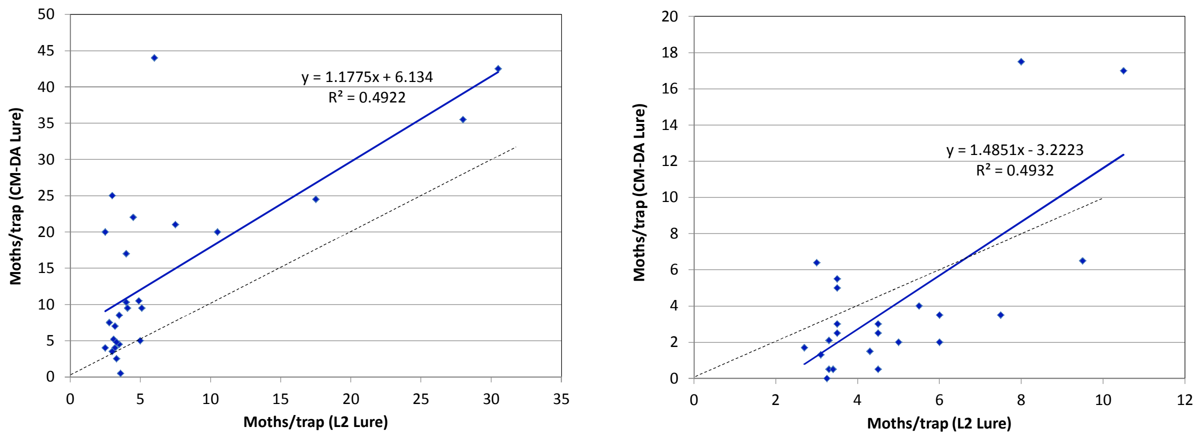

Fig. 7. First (left) and second (right) generation codling moth capture in pheromone traps baited with CM-DA lures when traps with L2 lures were ≥3 moths/trap. Dashed lined represents line with slope of 1.

Conclusions

Trapping studies conducted over a two year period in >20 different apple orchards demonstrated that CM/DA lures captured significantly more moths than CML2 lures during the first generation, but there was no difference in capture during the second (and third) generations. This relationship was consistent in both mating disruption and non-disrupted orchards. CM/DA Combo lures captured on average about 3X more moths than L2 lures at a L2 threshold of 3 moths per trap, but there was no difference between the two lures during second generation flight. In general, second generation trap captures were considerably lower than first generation at all test sites, which may have affected results. Considering the higher cost of CM/DA lures and the need to alter threshold levels between generations, there appears to be little incentive for growers or scouts to abandon the use of L2 lures in favor of CM/DA lures.

Not for Citation or Publication
Without Consent of the Author

A REDESIGNED ELECTRONIC INSECT TRAP FOR AUTOMATED MONITORING OF LEPIDOPTERA IN ORCHARDS

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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 insecticide applications to reduce material and labor costs. Automation of the insect trapping process has the potential to further reduce labor costs by limiting the time and travel costs associated with this procedure. In addition to updating a previously designed infrared based trap, a bio-impedence based electronic sex pheromone prototype trap was also designed and tested in the field in 2010 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.

Two newly designed automated traps were field-tested in 2010. One was a completely redesigned trap based on bio-impedance operation and the other was an improved version of a trap tested previously in 2009 using infrared technology for insect detection. The bio-impedance trap or "Z-trap" used an electrically charged coil design with a pheromone lure located inside the coil. The high-voltage electric grid consisted of a pair of metallic coils spaced approximately 5 mm apart from each other. The traps were equipped with six D-cell batteries to power the microcontroller and coil. There was no current flow until an insect contacted the coil. When an insect contacted the coil, current would flow and the insect was stunned and collected in a collector below the coil. Each time an electrical discharge occurred, the microcontroller recorded the time of the event. The properties of each electric discharge (i.e., the amplitude and duration of the electric current pulse) could then be analyzed to determine whether the event was caused by a target insect, a non-target insect or environmental event (i.e., rainfall). The traps were also equipped with wireless technology that allowed data to be transmitted from the orchard to a central location.

In June 2010, 10 Z-traps were deployed in an experimental orchard at the Washington State University Tree Fruit Research and Extension Center in Wenatchee, WA, and 10 were deployed at the Pennsylvania State University Fruit Research and Extension Center in Biglerville PA. Traps were identical except for the coils, which varied in length, width, coil wire diameter, and by the spacing between the individual coil wires. For three months, the traps were used to monitor populations of CM and OFM (PSU only) in the orchards with the same number of large plastic delta (LPD) traps used as controls. Z-traps at WSU and PSU were modified after the first four weeks of testing with various modifications of the external structure, including the incorporation of the coil and electronics in bucket traps or large plastic delta traps. All traps in Pennsylvania were adapted to mount a large plastic delta (no sticky bottom) over the coil.

At PSU, Z-trap capture rates ranged from zero to more than 300 moths per trap throughout the test period. However, due to problems with the electronics on certain traps, the length of time a trap remained in the field was variable, with two of the traps operating for less than two weeks while several others operated through the season. The proportion of moth capture compared to individual delta traps ranged from zero to 76 percent and averaged around 30 percent throughout the test period, but individual moth capture was greatly affected by the coil design and the species of moth being captured. The total capture ratio of CM across all functioning Z-traps compared to LPD traps throughout the test period was about nine percent. Figure 1(a) shows the performance of one CM trap compared to an LPD throughout the test period and indicates when the traps were modified. Figure 1(b) shows data from the same trap starting when the trap was modified with a LPD. The capture ratio of OFM across all functioning Z-traps versus the LPD traps throughout the test period was 38 percent. Figure 2 shows the performance of one OFM trap compared to a large plastic delta throughout the test period. After modifying the traps with LPD bottoms and larger funnels with a smaller stem inside diameter, the capture ratio more than doubled to approximately 68 percent. Numerous trap alterations were tested at WSU, with the bucket trap modified with a coil capturing approximately 56 percent (85 moths) of the total delta trap capture (152 moths). A trap modified with an LPD similar to the traps used at PSU and all other trap variations at WSU caught significantly fewer moths than the modified bucket trap.

Six redesigned infrared (IR) traps were deployed in an orchard at the Pennsylvania State Fruit Research and Extension Center in Biglerville, PA in early September, 2010. Three were equipped with codling moth pheromone lures and three were equipped with oriental fruit moth pheromone lures. All traps were converted to OFM only traps by September 24. The total percent capture of the IR traps relative to the LPD's was about 13 percent. Nearly all of the captures were OFM. The low capture rates in the traps in 2009 was thought to be, in part, from moths being repelled by ultrasonic waves emitted by the electronics, but this premise was ruled out with research conducted in a wind tunnel at WSU in 2010. Traps in 2010 still contained a Vapona™ strip inside the collecting bucket. We recently learned that the Vapona™ strips were found to be somewhat repellent to certain moth species. Also, we discovered that the moths can occasionally escape from the buckets so it is probable that either factor or a combination of the two could be responsible for the low capture rates.

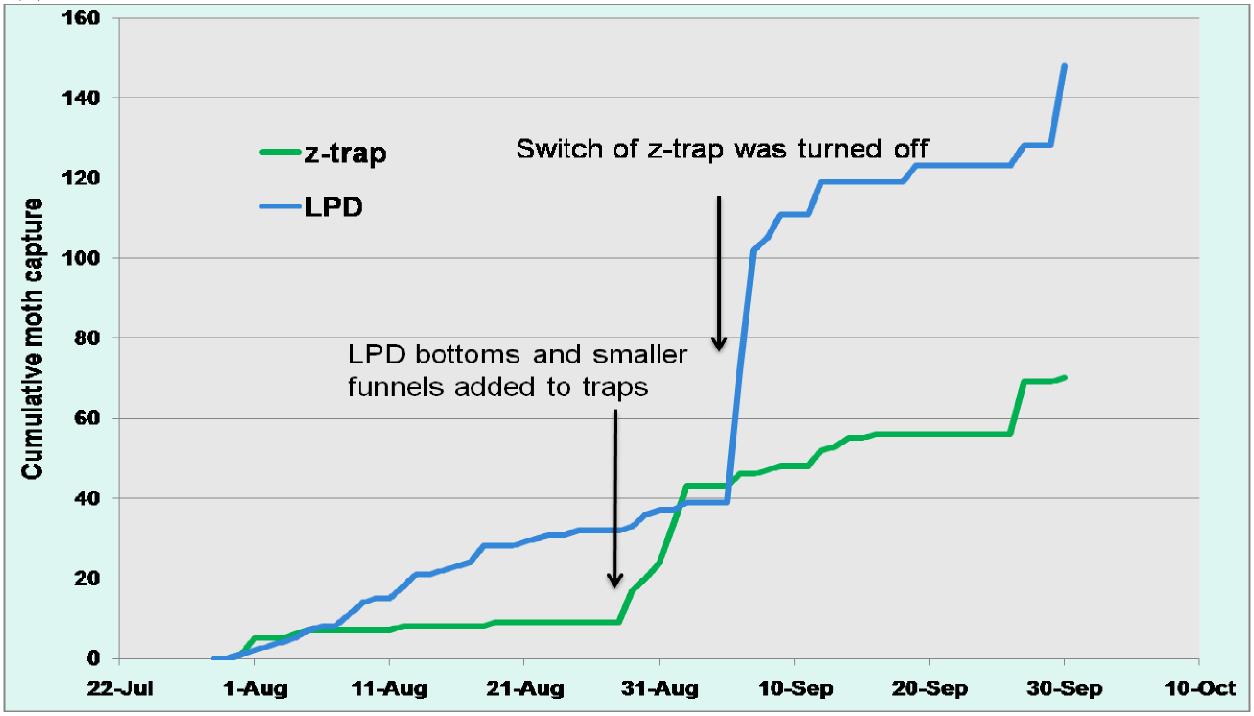
A small study was also conducted to test the escape rates of CM and OFM adults out through the funnel stem attached to collectors used in the Z-trap. A standard bucket trap was used for comparison. The test was conducted three days for OFM and four days for CM. Ten OFM adults (24-48 h old) and were added to each container while five CM adults (24-48 h old) were used for a second study. Moths were replaced daily and counted to determine the escape rate. Funnel stem inside diameters were cut to measure 10, 20, and 30 mm. Bucket trap inside diameter also measured 30 mm. Escape rates of combined species from the 10, 20, and 30 mm funnel opening and the bucket trap were 4, 27, 33 and 19 percent respectively. Escapes by CM only were much lower with rates of 0, 1, 8, and 1.5 percent, respectively, while escape rates of OFM adults were 9, 54, 58, and 37 percent, respectively.

Capture efficiency of the Z-traps was significantly improved by the end of the testing period in 2010 compared to early in the testing period. Changes for 2011 will likely include a modification to the outside structure to improve moth capture and to allow for a simplistic and efficient method to interchange components for field testing. Future designs may incorporate GPS units and mapping software and feature integration of the bio-impedence and infrared based systems.

Acknowledgments:

The authors wish to acknowledge the funding for portions of this study from the USDA Specialty Crop Research Initiative to Carnegie Mellon University (lead institution) for the project "Comprehensive Automation for Specialty Crops," (CASC is funded under award no. 2008-51180-04876) and the Washington State Tree Fruit Research Commission.

(a)



(b)

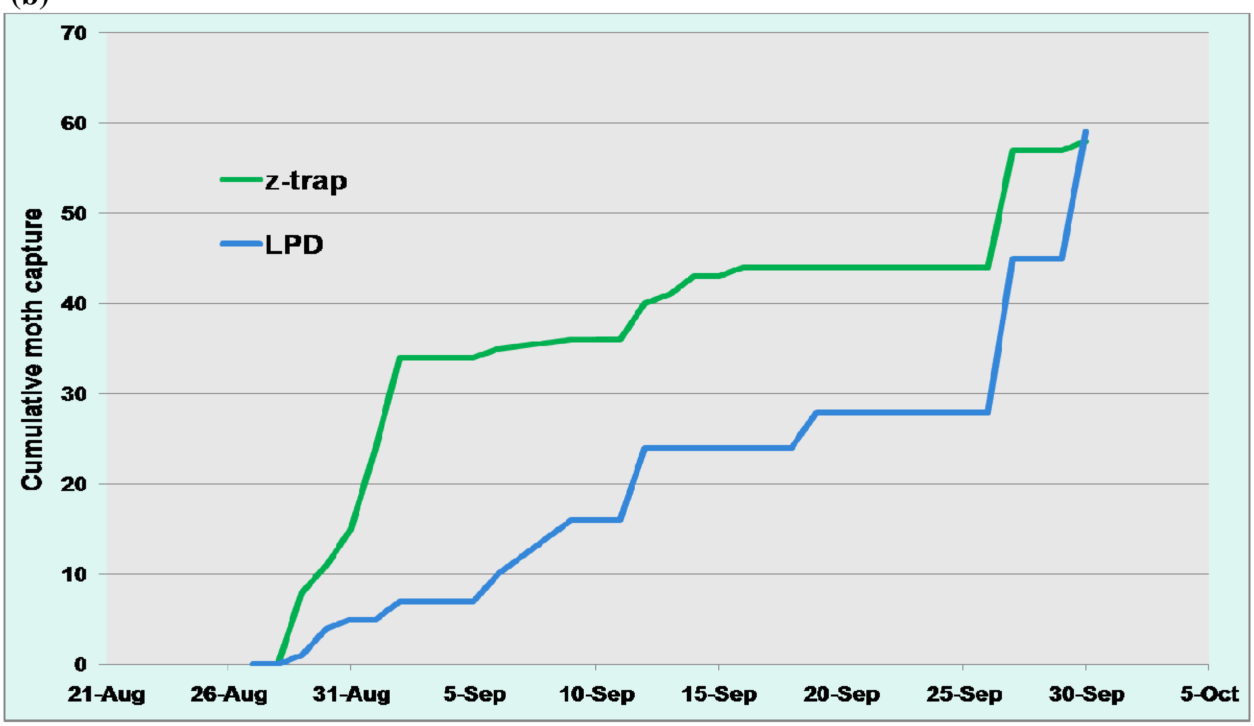


Figure 1. (a) Cumulative moth capture of a Bio-impedance based insect trap (Z-trap) on codling moth compared to a standard large plastic delta trap at an orchard at the Penn State Fruit Research and Extension Center in 2010. The arrows indicate when the trap bottoms were modified and when the switch on the trap was found turned off, presumably by contacting a tree branch. Figure 1(b) shows cumulative moth capture of the same trap starting after the attachment of a standard large plastic delta trap around the trap coil.

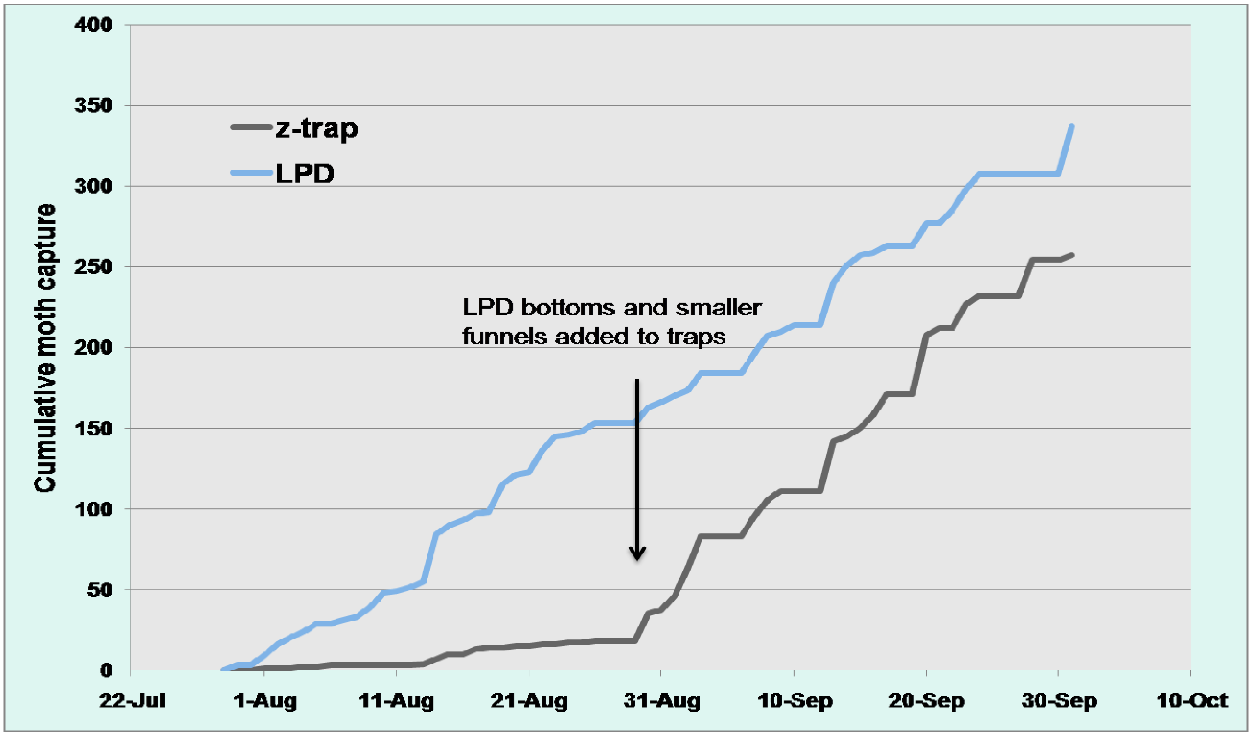


Figure 3. Cumulative moth capture of a Bio-impedance based insect trap (Z-trap) on oriental fruit moth compared to a standard large plastic delta trap at an orchard at the Penn State Fruit Research and Extension Center in 2010. The arrow indicates when the trap bottoms and collector funnels were modified.

Table 1. Percent of moths escaping from containers with funnels inserted at PSU in 2010. Funnel stem inside diameters (ID) were cut to 10, 20 and 30 mm. A standard bucket trap with a 30 mm opening was used for comparison. Averages are out of five moths (CM) and ten moths (OFM) per day over a four day (CM) and three day (OFM) period. Moths were counted and replaced daily.

	Funnel hole size – ID			
	10 mm	20 mm	30 mm	bucket
Codling moth	0	1.2	8.2	1.6
Oriental fruit moth	9	54	58	37.5
Combined	4.5	27.6	33.1	19.6

Plum Curculio Monitoring and Management in Commercial Blueberry Farms

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Abstract

Plum curculio is a native pest of several fruit crops in the Northeastern US, including blueberries. In recent years, plum curculio infestations have increased in New Jersey blueberries. Thus, better methods to monitor and control plum curculio populations in blueberry fields are desperately needed. Here, we evaluated the efficacy of attractant-based traps currently used in other crops to monitor this pest in blueberry fields. We also evaluated the efficacy of a pre-bloom application for controlling plum curculio as well as post-bloom applications of reduced-risk insecticides. Pyramid traps baited with grandisoic acid and benzaldehyde captured higher numbers of plum curculio adults compared with unbaited traps. No distance effect was observed in numbers of adults captured in traps placed at different distances from field edges. Combinations of a pre-bloom Rimon application and post-bloom applications with Imidan or Avaunt provided the best adult and larval plum curculio control.

Plum curculio, *Conotrachelus nenuphar* (Herbst), is a native pest of several fruit crops in the Northeastern US, including apples, pears, plums, peaches, nectarines, apricots, and blueberries (Whitcomb 1929; Racette *et al.* 1992). Its feeding preference varies among host plants. Leskey and Wright (2007) reported Japanese plum to be the most preferred host, followed by European plum, peach, sweet cherry, tart cherry, apricot, apple, and pears. In blueberries, plum curculio has historically been reported as an occasional pest (Beckwith 1943, 1944; Fulton 1946; Mampe and Neunzig 1967). However, in recent years, levels of plum curculio infestations have increased in New Jersey blueberries. Thus, this pest has now become a major concern among blueberry growers in the region, making it a top research priority.

Adult activity in New Jersey blueberries begins during bloom. At this stage, adults are observed feeding on flower petals until young fruits are available for oviposition (C.R-S. personal observation). Females can lay several hundreds of eggs (Mampe and Neunzig 1967), and make characteristic crescent-shaped oviposition scars on young fruits. Infested berries will turn prematurely blue and drop from bushes (Antonelli *et al*. 1992). In addition to oviposition and feeding damage, plum curculio larvae are a significant contamination issue in harvested fruit of early blueberry cultivars. Contamination is less likely to occur in mid- to late season cultivars because infested fruit usually drops from the bush before harvest (Antonelli *et al*. 1992; personal observation). It is generally thought that early season activity of adult plum curculio mostly occurs along the field edges, near the forest boundaries. The forest understory surrounding blueberry farms often contains wild blueberries and other related species that can serve as alternative hosts for the adults, and thus a source of infestation.

Our current monitoring methods rely on the use of beating trays to record adult activity and visual observations of oviposition scars on berries. There are no current thresholds based on these monitoring methods and they are labor-intensive and inaccurate. A better method to monitor plum curculio populations that can more accurately predict the time of insecticide applications is desperately needed. Since adults are active during bloom and feeding scars are not noticeable until berries are already damaged, a monitoring tool that can detect early adult activity will allow growers to make better management decisions. Improved monitoring may be a way to address this need. An attractant lure, consisting of the fruit volatile benzaldehyde and the plum curculio aggregation pheromone grandisoic acid, successfully attracts plum curculio adults in commercial apple orchard (Leskey and Wright 2004).

Historically, growers have used broad-spectrum insecticides, such as Guthion, Diazinon, and Lannate, to control cranberry fruitworm and other pests soon after bloom. These compounds helped maintain plum curculio populations below economic threshold levels (Polavarapu *et al.* 2004). However, after the enactment of the US Environmental Protection Agency's (EPA) Food Quality Protection Act (1996), restrictions were imposed on the use of some of these insecticides. New target-specific "reduce risk" compounds are encouraged for use by EPA to replace broad-spectrum insecticides. Reduced-risk insecticides hold numerous benefits such as efficacy on pests resistant to conventional compounds, safety to beneficial insects, and lower exposure risks to farm workers. Thus, testing the toxicity of new reduced-risk insecticides against plum curculio is critical for their adoption among blueberry growers in New Jersey and for maintaining a competitive edge in the modern blueberry commercial market that requires fruit that is free from insects.

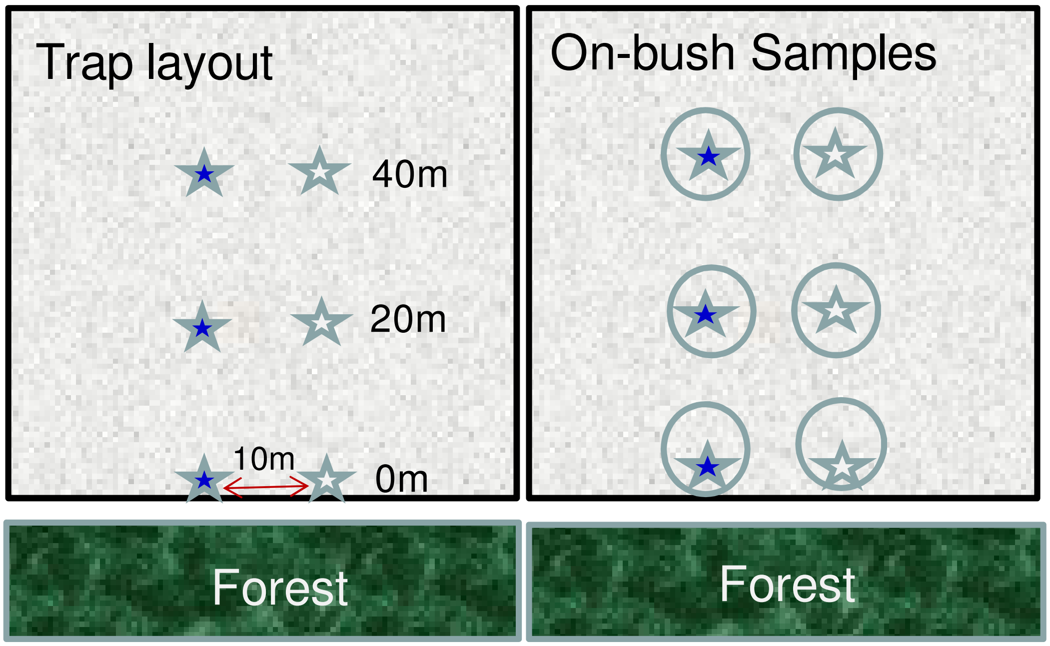
Objectives:

1. Test the efficacy and positioning of monitoring traps (baited with an attractant lure and un-baited) for plum curculio in blueberries.
2. Conduct field experiments to evaluate the efficacy of new reduced-risk insecticides against adult and immature plum curculio.
3. Conduct laboratory experiments to evaluate the effects of new reduced-risk insecticides on plum curculio larval emergence (curative control).

Materials and methods:

Plum Curculio Monitoring: A study was conducted in 4 commercial highbush blueberry farms to investigate the response of plum curculio adults to traps baited with benzaldehyde and grandisoic acid. Four 1-acre plots were selected in each farm (total of 16 plots). All plots faced the forest, and had a history of high plum curculio infestation. In each plot, we placed baited and un-baited pyramid traps (Leskey and Wright 2004). Pyramid traps were placed at 0, 20, and 40 m from the field edge (Fig. 1). Baited and un-baited traps were placed 10 m apart. Traps were placed prior to bloom (on 12 April) and monitored twice per week until 15 July. In addition, five bushes near each trap were sampled for adult plum curculio using beating sheet trays to correlate trap captures with on-bush counts (Fig. 1).

Fig. 1. Schematic layout for plum curculio monitoring traps and on bush samplings in highbush blueberry fields



Plum Curculio Control: This experiment tested the efficacy of a post-bloom application of acetamiprid (Assail 30SG; 5.3 oz/ace), indoxacarb (Avaunt 30WG; 6 oz/acre), and phosmet (Imidan 70WP; 1.33 lb/acre; grower standard), with and without a pre-bloom application of novaluron (Rimon 8.3EC; 30 fl oz/acre), on plum curculio adult and larval (curative) mortality in highbush blueberries. The experiment was conducted in three commercial blueberry (cv. Bluecrop) fields in Hammonton, New Jersey. Each field was divided into seven ~1 acre plots, and all plots had one of their sides facing the woods. Four of the plots were treated with Rimon before bloom and then treated after bloom with either Assail, Avaunt, or Imidan. The other three plots were left untreated before bloom but received a post-bloom application of Assail, Avaunt, or Imidan. Treatments were assigned randomly to plots, and farm was used as replicate. The pre-bloom Rimon treatment was applied on 11-13 April, and the post-bloom treatments were applied on 15-17 May. Bloom lasted from 3-4 weeks. Treated plots were separated by a buffer row. Applications were made with a Pak-Blast® model MBICO28 Sprayer (Rear's Mfg Co., Eugene, Oregon) on a John Deere 5320N Tractor. For pre-bloom applications, the sprayer was calibrated to deliver 25 gal of vol per acre at 150 psi using eight nozzles with D5 orifices, yielding 80 ml per bush. For post bloom applications, the sprayer was calibrated to deliver 40 gal of vol per acre at 300 psi using eight nozzles with D5 orifices, yielding ~140 ml per bush.

Adult plum curculio counts were taken on 12-14 May (3 d before the post-bloom treatments), and on 19–21 May and 24–26 May (4 and 9 d after the post-bloom application, respectively). Adults were sampled using a standard white cloth beating sheet (Great Lakes IPM, Vestaburg, MI), by beating 1/5 of 45 different bushes in each plot. Total number of adults was recorded per plot and then divided by 9 to obtain numbers per bush. To investigate the effects of Rimon, Assail, Avaunt, and Imidan on larval survival (curative control), fruit with plum curculio oviposition scars was collected from each plot on each of the three sampling dates. Fruit samples (1000 fruit per plot) were placed on clean moist sand in 160 ml plastic Dixie® cups (Bio-Serv, Frenchtown, NJ) (N = 10 fruit per cup), kept in the laboratory (~25 °C) for four weeks, and then checked for plum curculio larval emergence.

Data on number of plum curculio adults and percent of larval emergence were analyzed using ANOVA, and means separation by Fisher's LSD test at $\alpha = 0.05$. If needed, data were log transformed, and percent data were arcsine square-root transformed prior to analysis.

Curative Control: Three experiments were conducted in the laboratory to test the curative effects of Imidan, fenpropathrin (Danitol 2.4EC; 16 fl oz/acre), Assail, thiamethoxam (Actara 25WG; 4 oz/acre), Rimon, and Avaunt on three different plum curculio larval age classes. All fruit was obtained from an untreated blueberry cv. Bluecrop field located at the Rutgers PE Marucci Center (Chatsworth, New Jersey). For experiments with 0-3 d-old larvae, plum curculio adults were collected from blueberry fields and placed in a vented plastic box on 21 May with un-infested fruit clusters (N = 80-90) to allow for oviposition. Infested fruit was then kept in a 25°C incubator (15:9 L:D) for 3 d before being treated with insecticides (see below). For experiments with 3-6 d-old larvae, fruit clusters were examined in the field for plum curculio oviposition scars on 10 May to remove any infested fruit. Un-infested clusters (N = 75) were then bagged using fiber sleeves (Temkin International, Payson, UT), and five field-collected plum curculio adults were placed inside each bag on 17 May, and left to oviposit for 3 d. After oviposition, fruit clusters were collected, brought to the laboratory, inspected for plum curculio oviposition scars, and incubated at 20°C for 3 d before being treated with insecticides. For experiments with larvae older than 7 d, fruit showing plum curculio oviposition scars were field-collected on 17 May and kept for 7 days at 20°C, before being treated with insecticides.

For all experiments, fruit was spread out prior to insecticide treatment on a 30 cm x 30 cm tray made of hardware cloth. The surfactant Latron B-1956 was added to all spray mixes prior to application at 0.125% vol. Applications were made with R&D CO_2 backpack sprayer, using a 1-L plastic bottle. The sprayer was calibrated to deliver 4.3 ml/sec at 30 psi with a single ConeJet TXVS 4 nozzle. Trays were shaken during application to cause fruit to roll and be coated on all sides. Applications took 3-4 sec yielding 13-17 ml. Treated fruit were left overnight on trays to dry before being placed on clean moist sand in 160 ml plastic Dixie® cups. Cups were then capped with ventilated lids, kept on trays in an incubator (25°C, 15:9 L:D), and checked for larval emergence 15 and 30 d after treatment by washing the sand through a fine sieve. Fruit was then placed back in the cup with clean sand. After 30 d, fruit was dissected to ensure no developed larvae were missed. Total numbers of emerged plum curculio larvae were recorded for each date, and data from both dates were summed prior to analysis. Data were analyzed using ANOVA, and means separation by Fisher's LSD test. Percent emergence data were arcsine square-root transformed before analysis.

Residue Analysis: Non-infested fruit samples were collected from blueberry fields located at the Rutgers PE Marucci Center and sprayed following a similar protocol as described above. After 24 hrs, insecticide-treated fruits were frozen for residue analysis. Later, each fruit was dissected to separate the skin, outer flesh, and inner flesh to the pit. Frozen fruit were cut in half with a razor blade, and a cork borer was used to cut cores from the inside of the berries out through the skin. Flesh sections were cut with a razor blade. After sectioning, samples were prepared for residue analysis following protocol developed by Wise et al. (2007). An HPLC method was used to detect and quantify the residual compounds.

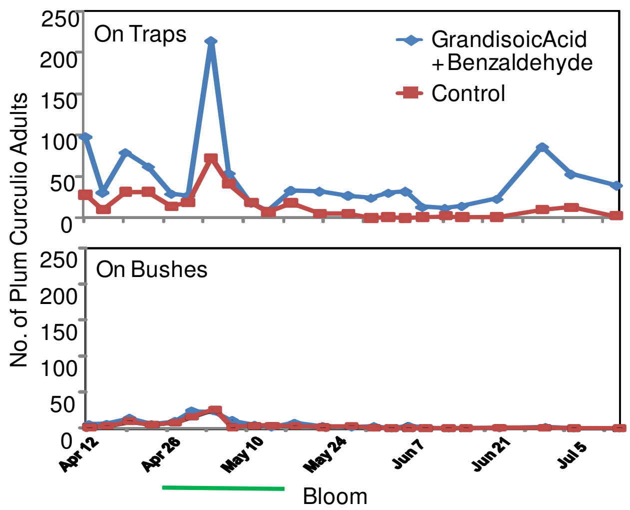


Fig. 2. Total captures of plum curculio adults in pyramid traps baited with and without attractants and on bushes.

Results and Discussions:

Plum Curculio Monitoring: Pyramid traps baited with grandisoic acid and benzaldehyde captured higher numbers of adult plum curculio than un-baited traps. Both baited and un-baited traps captured plum curculio adults before and during bloom; however, only baited traps captured adults in significant numbers after bloom (Fig. 2). Beating sheet samples showed a similar pattern of population abundance on bushes; however, numbers of adults on bushes were lower compared with those on traps.

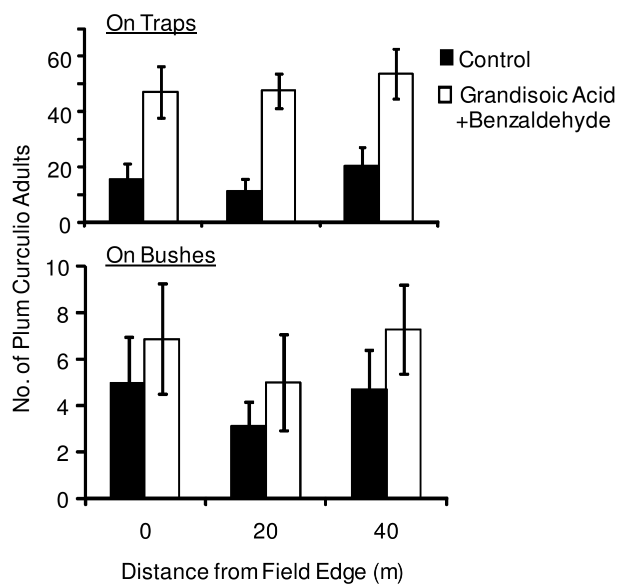


Fig. 3. Total captures of plum curculio adults in pyramid traps placed at various distances from field edges near forest and on bushes.

No distance effect was observed in adults captured between traps placed at field edges versus inside the fields. However, at all three distances, baited traps captured significantly higher numbers of adult plum curculio than un-baited traps. Similarly, on bush counts showed no differences in the number of adult plum curculio at different distances (Fig. 3). Our preliminary results do not support the hypothesis that plum curculio adults in blueberry fields are mainly coming from wooded areas.

Plum Curculio Control: The numbers of adult plum curculio were not significantly different among plots sampled 3 days before post-bloom applications, indicating that Rimon has no insecticidal effect on adults (Fig. 4). However, post-bloom applications of Imidan and Avaunt significantly lowered the number of adult plum curculio (Fig. 4). Assail did not have an effect on adult plum curculio populations.

Larval emergence data showed a low larval emergence from plots treated with a pre-bloom Rimon application (Fig. 5). Larval emergence was lower in plots treated with a post-bloom application of Imidan, Avaunt, or Assail and a pre-bloom application of Rimon than plots treated with post-bloom applications of Imidan, Avaunt, or Assail without any pre-bloom Rimon application (Fig. 5). These results suggest an additive effect of a pre-bloom Rimon application with a post-bloom application of Imidan, Avaunt or Assail on plum curculio larval emergence.

Curative Treatments: All insecticide treatments significantly reduced the percentage of larval emergence than the control treatment (Fig. 6). No larval emergence was observed from fruit treated with Imidan and Assail irrespective of the time of oviposition. Actara was also effective in reducing larval emergence except for a few emerging from fruit treated > 7 days after oviposition. Danitol, Rimon, and Avaunt showed reduced effectiveness when used > 7 days after oviposition, indicating that the curative efficacy of these insecticides is reduced as the larvae matures and/or moves towards the center of the fruit.

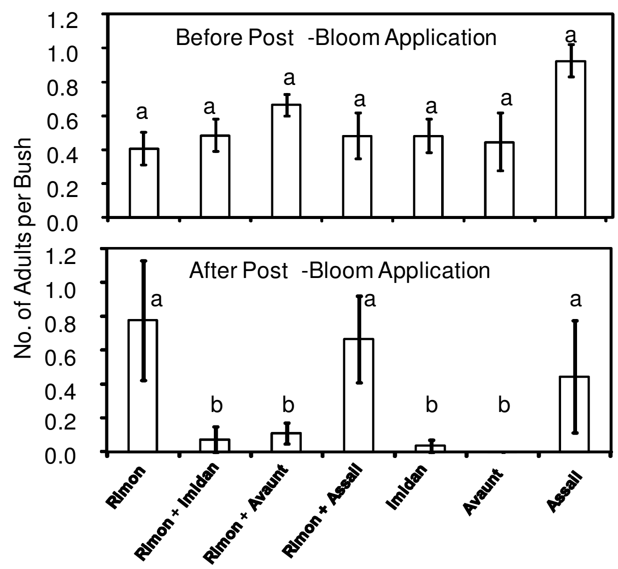


Fig. 4. Adult plum curculio captures in fields before and after post-bloom insecticide applications.

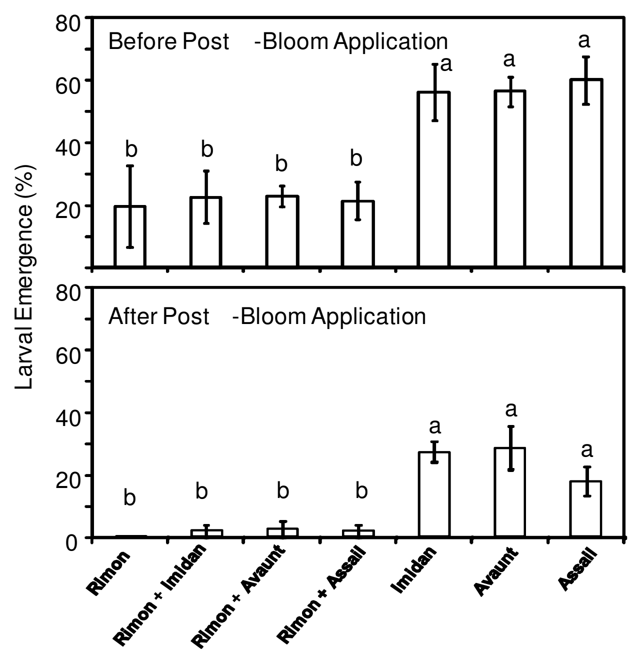


Fig. 5. Plum curculio larval emergence from fruit before and after post-bloom insecticide applications.

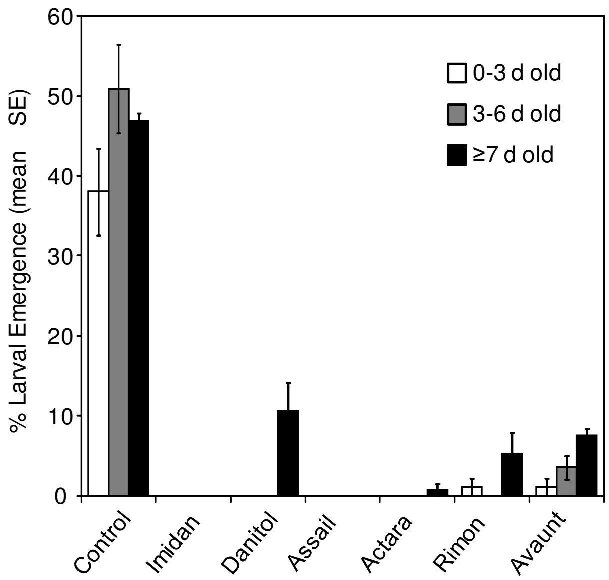


Fig. 6. Plum curculio larval emergence following exposure to insecticides after several (0 to >7) days of oviposition.

Residue Analysis: Imidan and Assail had the greatest amount of active ingredient in the inner flesh of fruit (Fig. 7). This result confirms our results from the curative experiment where Imidan and Assail were very effective in reducing percent larval emergence. In contrast, Danitol, Rimon, and Avaunt residues were low inside the fruit, which confirms the lower effectiveness of these insecticides when applied a week or more after oviposition. Surprisingly, Actara had low penetration but high curative efficacy even several days after oviposition.

Conclusions:

This study demonstrates that pyramid traps, baited with benzaldehyde and grandisoic acid, have great potential in monitoring adult plum curculio activities in blueberry fields. Our data also show that different classes of insecticides affect adult plum curculio survival and larval emergence differentially. The chitin inhibitor Rimon did not affect adult survival; however, pre-bloom Rimon applications reduced larval emergence. The organophosphate Imidan (grower standard) reduced survival of both adults and larvae. The oxadiazine Avaunt provided good adult control, but only weakly affected larvae developing inside the fruit. The neonicotinoid Assail was weak against adults, but reduced larval emergence. Similarly, the neonicotinoid Actara reduced larval emergence. Assail and Actara are systemic insecticides. Finally, the synthetic pyrethroid Danitol most effectively reduced emergence of < 7 d old larvae. Overall, a combination of a pre-bloom Rimon application with a post-bloom application of either Imidan or Avaunt provided best plum curculio control in blueberries by having both adulticidal and larvicidal (curative) activity.

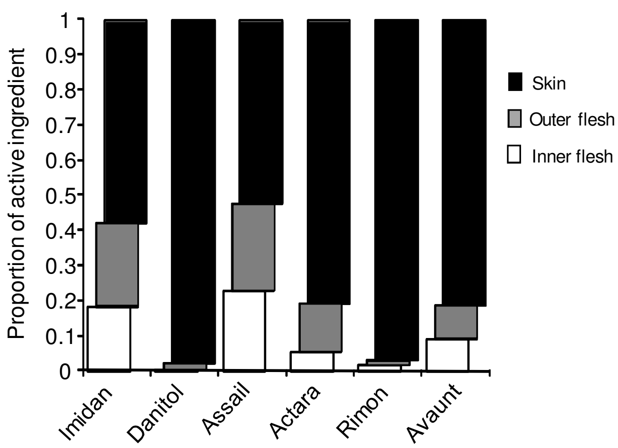


Fig. 7. Proportion of active ingredient recovered in the skin, outer flesh, and inner flesh of blueberries.

Acknowledgements:

The authors would like to thank Rob Holdcraft, George Cappuccio, and Daniel Quiros-Molina for their help with data collection. Thanks to Atlantic Blueberry Company, Variety farms, Macrie Brothers, and Big Buck farms for providing sites to conduct field experiments. Funding for this project was provided by the New Jersey Blueberry Research Council DuPont, UPI, and Chemtura.

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CONTROL OF GRAPE ROOT BORER USING MATING DISRUPTION - 2010

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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 80% (in 2009, exuviae counts in this vineyard were reduced by about 97%). In the moderately infested vineyard, there was no significant reduction; in 2009, 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 years prior to the beginning of this study.

Table 1. Grape root borer exuviae per 10-vine samples, with 10 samples taken per plot (100 vines) (2010).

Vineyard	Control	Mating Disruption
Patrick County	0.0	0.0 ns
Orange County	0.6	0.5 ns
Northampton County	3.5	0.7 **

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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Elimination of Brown Marmorated Stink Bug from Winegrape Clusters at Harvest - 2010

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I. Introduction: In 2010, brown marmorated stink bug (BMSB), *Halyomorpha halys* Stal, was found infesting vineyards in Virginia. Although it was first found in Virginia in 2004, it has taken several years to build to high population levels. There is potential for pest status in vineyards from several avenues: injury to berries, introduction of rots such as Botrytis, delays from post harvest sorting, contamination of wine at crush, and as a nuisance in tasting rooms. Fewer than 10 bugs per lug can impart a detectable taint to juice (Fiola pers. comm.). High numbers on grapevines aroused concern by vineyard and winery managers (Kelly 2010). In response,

II. Materials and Methods: A vineyard in Rappahannock County had high populations of BMSB reported in clusters, with detectable taint in pressed juice. After discussions with the vineyard manager it was decided to compare airblast treatment of two insecticides having a 0 day preharvest interval (PHI); the materials selected were pyrethrin (PyGanic) and clothianidin (Belay). Pretreatment counts were made on 2 September, in late afternoon. The block was to be divided into two sections to be treated. Counts were made in two sections in the edge and two sections of the interior, of each treatment area. Several rows were to be left untreated. After counts were complete, the grower applied PyGanic and Belay at the rates of 64 fl oz/A, and 6 fl oz/A, respectively. The following morning, counts of BMSB were made as soon as there was sufficient light, immediately before pickers moved through the rows.

III. Results and Discussion: In pretreatment counts, 40% of the clusters in vineyard edge contained BMSB, with about 4% in the vineyard center. BMSB appeared to be invading the vineyard from surrounding trees. In the post treatment count, BMSB were found not mainly in clusters, but dispersed in vine foliage. Most bugs were in the adult stage, but the presence of final instar nymphs demonstrated the use of grape as a reproductive host by BMSB. In the untreated rows, 26.7% of the vines contained BMSB (Table 1). PyGanic completely eliminated BMSB; this was a significant difference. Belay was intermediate in effect, not significantly different from either pyrethrin nor untreated control.

Chemical control is an option to eliminate BMSB from clusters at harvest, in order to prevent transporting bugs into the winery in lugs or bins. The most effective material for this purpose, pyrethrin, is not expected to provide sufficient residual activity for conventional control of BMSB. One of the most effective classes of pesticides for conventional control is the pyrethroid class. However problems from these insecticides include limited efficacy, recovery of knocked down bugs, continued immigration of BSMB, and induction of secondary pests. A specific concern in the latter regard is grape mealybug, with resulting transmission of grapevine leafroll virus.

Table 1. Post-treatment counts of brown marmorated in grapevines the morning following an afternoon application of 0-day preharvest interval insecticides, in Rappahannock County VA (2010).

	Vines with Stink Bugs		SB / Vine	
Clothianidin	1	6.7%	0.1	ab
Pyrethrin	0	0%	0	a
Control	4	26.7%	0.7	b

Tukey's HSD, α = 0.05

IV. References Cited:

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Not for Citation or Publication
Without Consent of the Author

EVALUATION OF INSECTICIDES AGAINST APPLE MAGGOT, 2010

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In an effort to find an OP replacement for Apple Maggot (AM) control, a field plot was designed in a Wayne Co., NY commercial orchard with a history of AM pressure. Plots were arranged in a RCB design and replicated three times in a 9-tree block consisting of 'Jonagold'. Applications were made every 10-14 days from the first fly catch on 6 Jul and continued on this schedule until 16 Aug for a total of 4 sprays in each treatment. See Table 1 for a complete list of materials, rates and timings. Materials were applied with a conventional air-blast sprayer manufactured by Rears Manufacturing at 100 gpa. 'Sticky Red Sphere' AM traps were placed along the edge of the test orchard to determine the level of pressure from an adjacent abandoned orchard, and were checked weekly. Fruit was evaluated on 1 Sep by destructive sampling 100 apples from each replicate inspecting for AM punctures and tunnels. Damage was considered a 'sting' if only an oviposition scar occurred and a 'tunnel' if internal breakdown of the flesh occurred deeper than 1/8" under the skin of the apple. Data was transformed and subjected to an AOV with SuperAnova. Means were separated with Fisher's Protected LSD Test ($P<0.05$).

Pressure from the adjacent abandoned orchard proved to be very high as cumulative counts from the AM traps indicate (Table 2). Oviposition punctures were present in every treatment and did not significantly differ from each other, indicating that AM may have a tolerance for contact with them. AM tunnels were also present in every one of the treatments and although there was very little statistical separation, it is apparent which treatments were more effective than others. While only one treatment separated from the untreated check plot, the range of damage is quite variable. Materials that require ingestion were not effective as those only requiring contact. The industry standard for AM control Guthion 50 WSB was just as effective as all of the other plots. Calypso 4F was the only material to have significantly better control than the untreated check.

Evaluation of Insecticides Against Apple Maggot, 2010

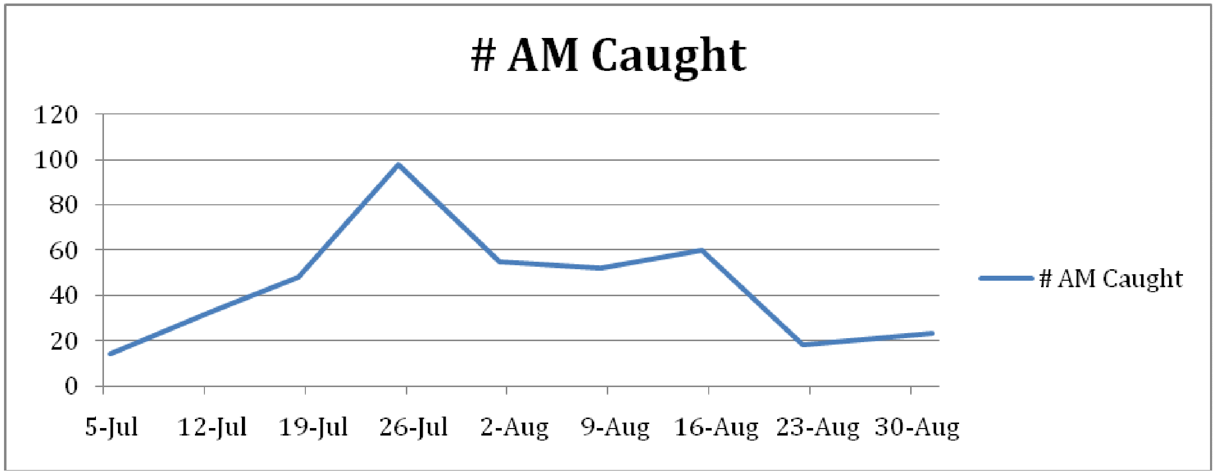
Table 1

Treatment	**Rate/A**	**Timing**	**% AM Sting @ Harvest**	**% AM Tunnels @ Harvest**
Actara 25W	5.0 oz	every10-14 days* after 1st fly catch	32.3 a	13.4 ab
Avaunt 30WDG	5.5 oz	every10-14 days* after 1st fly catch	38.3 a	15.0 b
Calypso 4F	6.0 oz	every10-14 days* after 1st fly catch	19.3 a	2.0 a
Altacor	4.5 oz	every10-14 days* after 1st fly catch	18.0 a	5.3 ab
Delegate 25W	6.5 oz	every10-14 days* after 1st fly catch	26.7 a	9.0 ab
Guthion 50WSB	1.5 lb	every10-14 days * after 1st fly catch	15.3 a	5.3 ab
Assail 70WP	3.4 oz	every10-14 days* after 1st fly catch	17.8 a	5.9 ab
Untreated Check			19.0 a	17.3 b

Means within a column followed by the same letter are not significantly different
(Fisher's Protected LSD Test, $P \leq 0.05$). Data was transformed arcsine (Sqrt *x*) prior to analysis.

* - application dates were 6 Jul, 21 Jul, 3 Aug and 16 Aug

Table 2



AM Caught
120
100
80
60
40
20
0
5-Jul
12-Jul
19-Jul
26-Jul
2-Aug
9-Aug
16-Aug
23-Aug
30-Aug
AM Caught

Commercial Orchard Study Comparing Organic Materials To Conventional Tools For Pear Psylla Management

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Abstract: Pear production in NYS is managed on nearly 2000 acres, with yearly crop yields producing roughly 16,500 tons valued at 3.85 million dollars. In the Hudson Valley region, pears comprise about 800 acres (USDA, 2005). The principle pests of pear production in the Northeastern US are pear psylla, *Cacopsylla pyricola* (Foerster), and Fabraea leaf spot, *Fabraea maculata*. These two pests cause premature defoliation, reduced size, quality and yield of fruit, followed by premature decline and eventual death of susceptible pear varieties. Insecticide resistance has resulted in lower levels of pear psylla insecticide susceptibility, reducing effectiveness of current pest management strategies. Recent studies conducted at Cornell University's Hudson Valley Laboratory have demonstrated excellent control of the pear psylla using two unique OMRI products. The kaolin clay product Surround WP (anhydrous aluminum silicate) and highly refined horticultural oils (HRO's) were used successfully in pre-bloom and season long insect management programs to maintain psylla populations below economic thresholds. Furthermore, we observed applications of HRO's suppressing Fabraea leaf spotting and subsequent reduction in defoliation of HRO treated pear trees compared to untreated trees. Seasonal use of HRO's for Northeast pear management beyond the pre-bloom stage has yet to be adopted in commercial orchards. This study, conducted in a commercial Hudson Valley pear orchard in Milton, NY demonstrated the commercial use of these two OMRI products as pest management tools for pear psylla management to achieve commercial levels of control. Additional variables of air induction nozzles compared to commercial hollow disk nozzles in airblast applications to study the effects of off target drift; sprayer speed and volume were employed across field plot treatments. The need for season long management of *Fabraea* using applications of fungicides at ten day to two-week intervals reduce the additional application costs of bi-weekly HMO applications for post bloom pear psylla management.

Procedures: To determine the efficacy of OMRI materials on populations of pear psylla throughout the season we conducted comparative commercial orchard and controlled field plot studies in 2010. The components of this research fall into these two study groups. The first conducted in a one-acre experimental pear orchard at Cornell University's Hudson Valley Laboratory in Highland, NY. The second study conducted at a commercial pear orchard of LM Clarke, in Milton, NY.

Research Farm Trials: From 2005 to 2010 controlled field plot studies were made to determine the efficacy of OMRI materials on populations of pear psylla, however only 2010 results will be reported. Trials employing four-tree plots were replicated four times in a replicated complete block design. The 2010 early season 'Bartlett' phenology was the earliest in recent history, beginning at swollen bud on 19 March, 1st egg on 16 March, white bud (WB) on 8 April, delayed dormant application (DD) on 9 April, King Bloom on 10 April, 1st egg appl. on 13 April, petal fall (PF) on 20 April, > 5mm on 26 April, PF application was delayed until 28 April for plum curculio, 10dp PF on 13 May, 28 dp PF on 5 June; control of 3rd generation psylla on 30 June. 'Bartlett' was harvested on 12 August in which we collected and evaluated 100 fruit per treatment across 4 replicates.

Early applications targeted overwintering adult and first generation of pear psylla. During the period from bud burst through 1st cover, evaluations to determine treatment effects on springform adult ovipositional deterrence, including subsequent 1st generation nymph emergence were conducted. Pre-bloom evaluations for pear psylla egg and nymph populations using 25 buds on 5 perimeter 1st year shoots per tree beginning on 13 April. Seasonal leaf assessments through the season beginning with 25 basal leaves of 5 shoots on 20, 27 April and 4 May and continuing for all subsequent evaluations by removing 1 distal, 1 proximal and 3 mid-shoot leaves of 5 shoots per treatment through the remainder of the season. Sampling dates for foliar presence of psylla nymphs were 27 April, 4, 11, 27, May; 9, 18 June and 6 July. Samples were removed to the laboratory where target pests were counted using a binocular scope. Adult numbers were assessed on 6, 18, 29 May, 16 June, 17 July using 3-minute vacuum sweeps of perimeter apical shoot foliage using a handheld vacuum and screened collection bottles. Fifty Bartlett fruit were harvested per treatment on 18 August and scored for insect damage. The transformation using the Log_{10} (X + 1) was applied for adult and foliar evaluations. To stabilize variance, percentage data were transformed by arcsine *(square root of x) prior to analysis. Fisher's Protected LSD (P=<0.05) was performed on all data; untransformed data are presented in tables. Each plot contained four trees of alternating 30 year-old 'Bartlett' and 'Bosc' cultivars, 12' in-row x 18' drive-row spacing, 12 ft in height. All dilutions are based on 400 gallons/acre with plot requirements ranging from 20 to 50 gallons increasing seasonally with developing canopy. Treatments were applied using a three point hitch tractor mounted high pressure 'Pak-Tank' sprayer using a pecan handgun operated at 300 psi delivering $\geq$350 GPA sprayed to runoff.

One of two 'OMRI experimental plots' employed a single 3% HMO application at first observation of egg laying followed by a single pre-bloom (green cluster - white bud) and bi-weekly post bloom applications at a 1% dilution rate in a season long program of 4 applications using 1 nymph per leaf thresholds. This was compared to a second plot employing Surround WP at 50#/A beginning at first egg observation followed by a white bud application and a single petal fall application. Bi-weekly post bloom applications of HMO at a 1% dilution rate followed in a season long program of 5-7 applications using 1 nymph per leaf thresholds.

HVL Experimental Orchard 2010

	Dates of application					
Insecticide / rate of product per acre	9 Apr	13 April	13 May	5 June	16 June	30 June
1. BioCover Oil 1% v/v	x		x	x	x	x
2. Surround WP 50 lb;	x		x			
BioCover Oil 1% v/v				x	x	x
3. Esteem 35WP 5.0 oz./A		x				
AgriMek 0.15EC 20.0 fl.oz./A			x	x		
4. Untreated						
		DD	PF	2C	3C	4C

Notes: Applications based on 400 gallons/A dilute vol. for concentrate calculations. Imidan 70WP at 16 lbs/A applied on 13 May for PC mgt. in Trmt. 3. Sovran @ 6 oz./A + Topsin @ 8 oz./A was applied over entire orchard on 6 August.

Commercial Farm Trials: One ten-acre commercial orchard divided into nine blocks were used to evaluate the effectiveness of OMRI certified pest management materials compared to commercial programs for the control of pear psylla on 34 year old European pear varieties of Bartlett and Bosc. Applications were made using a John Deere tractor mounted three-point hitch PTO powered airblast sprayer. Trees were 12'H x 10'W spaced at 22' row spacing. Reduction of travel speed, increased volume output and use of air induction nozzles to both reduce off-target drift and increase droplet size were employed in two OMRI programs employing hollow-cone and air induction nozzles. Dry weather in 2010 did not afford for the evaluation of *Fabraea* leaf spot in commercial blocks.

Blocks 1 & 2 contain a 5-acre block to which commercial insecticides are applied using hollow-cone nozzles. A single application of Asana XL 0.66EC at 19.2 fl.oz./A pre-bloom and a single or twice applied spray of AgriMek 0.15 EC using 20.0 oz./A were made to blocks 1 & 2 respectively. Blocks 3, 4 & 5, within a 1.75-acre block received applications of OMRI materials at 100 GPA / 1.25 mph, 200 GPA / 1.25 mph and 100 GPA / 2.5 mph respectively using hollow cone nozzles. Block 6, 7 & 8, within a 1.75-acre block received applications of OMRI materials at 100 GPA / 1.25 mph, 200 GPA / 1.25 mph and 100 GPA /

2.5 mph respectively using air-induction nozzles. Block 5 consisted of 5 untreated trees. Application timings for OMRI materials were made at the onset of pear psylla ovipositional or nymph emergence events (Chart 1)

LM Clarke Orchard

Block #	Materials (# of sprays)	Nozzle type	GPA	PSI	Travel Speed
1	Conventional program (3)	hollow cone	100	150	2.50 mph.
2	Conventional program (2)	hollow cone	100	150	2.50 mph.
3	OMRI program (5)	hollow cone	100	150	1.25 mph.
4	OMRI program (5)	hollow cone	200	150	1.25 mph.
5	OMRI program (5)	hollow cone	100	150	2.50 mph.
6	OMRI program (5)	air induction	100	150	1.25 mph.
7	OMRI program (5)	air induction	100	150	2.50 mph.
8	OMRI program (5)	air induction	200	150	1.25 mph.
9	Untreated control				

Foliar evaluations of insecticidal efficacy were conducted throughout the season in each treatment of 4 replicates throughout blocks or plots. Pear psylla oviposition was evaluated by sampling terminal cuttings containing 5 buds and the eggs deposited on buds were counted using dissecting scopes. Bi-weekly leaf samples of 25 leaves per treatment were collected and evaluated for pear psylla nymphs and eggs. Vacuum samples of adult pear psylla made using 3-minute foliage sweeps to determine adult presence. Trees in each block or plot were rated for % defoliation. Harvest fruit evaluations will be conducted on 15 August for Bartlett and 1 September for Bosc with 100 fruit per treatment sampled and rated for % injury for all fruit feeding insects, Fabraea, sooty mold, russet, and phytotoxicity.

Results of Research Farm Trials: Over a 5-year period we observed that two to three early season applications of Surround WP at 50#/A followed by 3-7 late season 1% oil applications were comparable in pear psylla management to the most effective conventional treatments in statistical evaluations of efficacy. Surround WP was found to be comparable to commercial management in controlling early season pear psylla populations while also reducing the fruit feeding of plum curculio. Beginning two weeks after the last Surround application using bi-weekly applications of a 1% concentration of HMO's demonstrated comparable reductions of both pear psylla oviposition and subsequent nymph population, feeding damage to foliage and fruit compared to the commercial standard (Tables 1-3). HMO applications also decreased the incidence of Fabraea leaf spot and defoliation of foliage (Table 4). HMO's employed during the season to gain control of pear psylla populations appear to be most effective when applied prior to the onset of egg laying and hatch for each generation.

2010 Pear Psylla Evaluation

Table 1.

Insecticide rate of product per acre	Mean number of pear psylla eggs per 25 buds/leaves				
	13 Apr	24 Apr	17 May	29 May	2Jul
1. BioCover Oil 3% / 1% v/v	79.3 b	3.0 a	0.0 a	47.8 bc	31.3 a
2. Surround WP 50 lb; BioCover Oil 1% v/v	3.8 a	3.0 a	0.5 a	61.0 bc	17.8 a
3. Esteem 35WP 5 oz.; AgriMek 0.15EC + BioCover Oil 0.25% v/v	101.3 b	87.0 b	3.3 a	10.5 a	5.5 a
12. Untreated	142.0 b	88.8 b	3.5 a	111.5 c	7.8 a
P value log (n+1) transformed data	0.005	<0.001	0.467	0.015	0.175

Table 2.

Insecticide rate of product per acre	Mean # of pear psylla nymphs per 25 buds/lvs				
	13 Apr	24 Apr	17 May	29 May	2 Jul
1. BioCover Oil 3% / 1% v/v	5.8 bc	10.5 a	2.0 a	4.3 abc	8.3 a
2. Surround WP 50 lb; BioCover Oil 1% v/v	1.0 a	11.0 a	1.0 a	3.3 a	4.5 a
3. Esteem 35WP 5 oz.; AgriMek 0.15EC + BioCover Oil 0.25% v/v	1.5 ab	8.8 a	1.8 a	6.5 abc	5.3 a
12. Untreated	3.8 ab	56.2 a	5.3 a	27.0 d	4.3 a
P value log (n+1) transformed data	0.040	0.070	0.682	0.012	0.693

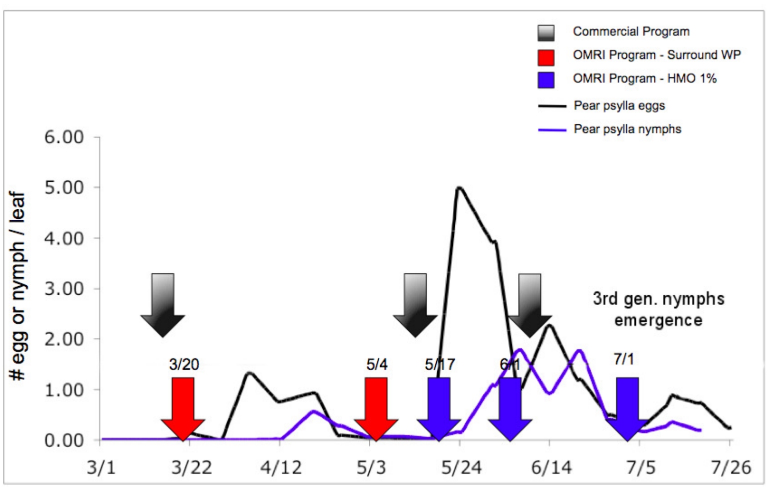
Table 3.

Insecticide rate of product per acre	Mean no. of pear psylla adults per 3 min. sweeps	
	29 May	2 Jul
1. BioCover Oil 3% / 1% v/v	4.8 a	1.3 abc
2. Surround WP 50 lb; BioCover Oil 1% v/v	11.8 a	1.8 abc
3. Esteem 35WP 5 oz.; AgriMek 0.15EC + BioCover Oil 0.25% v/v	5.5 a	2.3 bcd
12. Untreated	13.8 a	6.0 d
P value log (n+1) transformed data	0.065	0.023

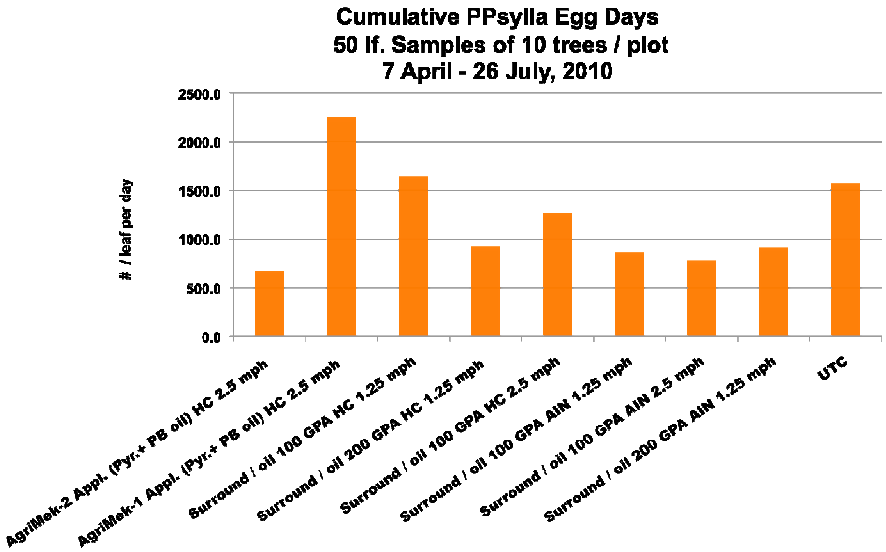
Table 4.	% Fabraea L.S.		% Defoliation
	8	22	12
Insecticide rate of product per acre	July	July	August
1. BioCover Oil 3% / 1% v/v..........................	45.0 a	56.3	12.7 a
2. Surround WP 50 lb; .... BioCover Oil 1% v/v	53.5 ab	71.0	12.1 a
3. Esteem 35WP 5 oz.;................................. AgriMek 0.15EC + BioCover Oil 0.25% v/v	53.5 ab	74.8	11.3 a
12. Untreated	89.3 c	99.8	25.9 b
P value of arcsin(Sqrt(x)) transformed data	0.001	0.001	0.006

Results of Commercial Farm Trials: In 2010 relatively dry conditions were conducive for long residual of OMRI materials requiring fewer applications than in 'wet years'. We observed similar results of the commercial part of this trial to that of our small plot trials. Two early season applications of Surround WP at 50#/A followed by 3 mid-late season 1% oil applications were comparable in pear psylla management to the 3 grower applied conventional treatments. Two applications of AgriMek gave the best overall ovipositional deterrence (Graph 2). The use of air induction nozzles (AIN) generally provided comparable season long egg laying reductions compared to the commercial program and better overall results than hollow-cone nozzles in the OMRI progrm. Higher gallonage rates of application using either hollow-cone or air induction provided better results than lower application rates (Graph 2).

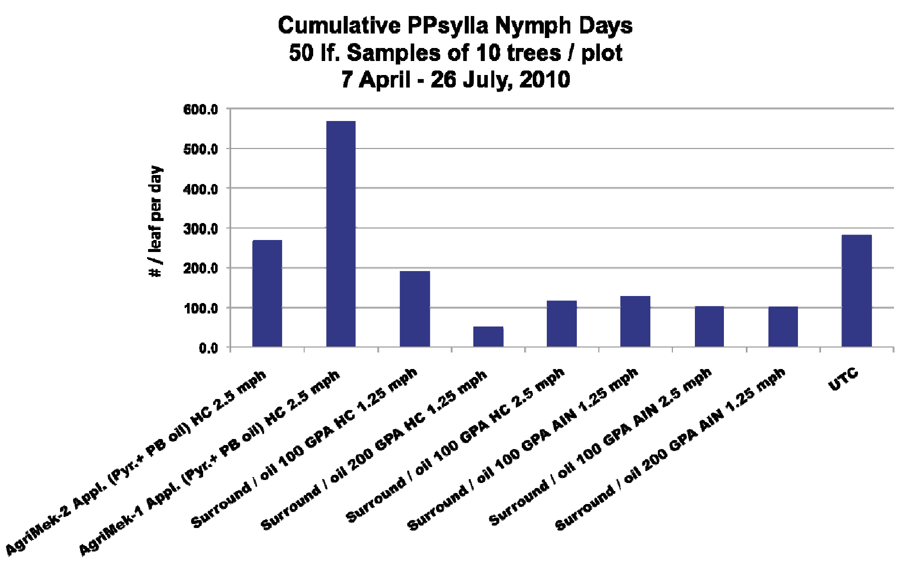
Chart 1. Application Timing for Pear Psylla Mgt. Milton, NY - 2010



Graph 1. Evaluation of Pear Psylla Egg Accumulation. Milton, NY - 2010



Graph 2. Evaluation of Pear Psylla Nymph Accumulation. Milton, NY - 2010



From five years of experimental field data and the first year commercial pear insect management results, we conclude that the use of these two OMRI materials provided effective control of pear psylla and can be use as synthetic insecticide replacements. The use of these materials will assist growers in reducing the reliance on synthetic insecticide programs, especially for pear psylla control while achieving lower levels of Fabraea leaf spotting and defoliation. Rotational use may reduce the potential for psylla to develop insecticide resistance. HMO's or Surround WP act to smother and repel, not acting on the insect metabolic pathways through target site bonding that may lead to site modification and loss of efficacy. Additional testing needs to be completed to determine the commercial efficacy of HMO to control pear psylla in years of normal rainfall and efficacy in managing *Fabraea maculata.*

NOT FOR PUBLICATION WITHOUT CONSENT OF THE AUTHOR

Second Generation Apple Training System Trials

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In recent years the apple industry has seen a dramatic change in production systems. In the last decade of the previous century and into the current century the Vertical Axe (Lespinasse, 1986) was becoming the dominant training systems around the world. Recent work suggests that some form of mechanization through the use of platforms can increase labor efficiency and reduce production costs. (Baugher et al., 2009). Therefore, this trial looked at narrower canopy type systems to potentially take advantage of new mechanically assisted technologies.

Materials & Methods

A planting of Rubinstar Jonagold/B.9 and Daybreak Fuji/M.9 NAKB T337 was established at the Horticulture Research Farm at Rock Springs, PA (40.71^{o} latitude, 77.95^{o} longitude) in 2008. Four training systems were chosen based partly on previous work. (Crassweller & Smith, 2008, Crassweller & Smith, 2009). The systems based on those trials were a vertical axe (A), minimally pruned (MP) and a tall trellis (TT). The fourth system, the tall spindle (TS) in the trial was based upon work done by Robinson et al. (2006). The A was handled conventionally with permanent lower scaffolds and pinching of shoots higher in the canopy. MP is a system primarily developed for use in processing apple plantings due to the lack of need for enhanced coloring of the fruit. In the previous study MP system produced the highest yield. The TT system was chosen based on the previous study (Crassweller & Smith, 2009) where it was determined based upon fruit density increasing the height of the trellis wall to approximately 2.75 m yields would be equivalent to production from an Axe system. Trees were spaced at 1.5 x 4.25 m on a 2.75 m tall 4 wire trellis with wires spaced at 0.75, 1.5, 2.25 and 2.75 m. There were three blocks with two replications per block. The four systems were randomized within each block.

Initial pruning in the TS, A and MP systems consisted of removing low and broken branches and dead shoot tips on the Jonagold trees. For both cultivars the leaders were attached to the bottom wire, limbs were bent below horizontal for the TS system and new shoots were pinched above the base scaffolds for the A and MP systems. In the TT system the number of limbs was reduced to two strong limbs just below the wire running parallel with the wire. The limbs were attached to the lower wire with limbs at a 45^{o} angle The leader was headed just below the second wire and attached to the wire.

Annual data collected included trunk circumference, trunk growth, number of flower clusters, number and weight of harvested fruit and size distribution of harvested fruit. Calculated data included trunk cross sectional area (TCA), percent fruit set, yield in kg/ha, crop load (#fruit/cm^2 of TCA), efficiency (g/cm^2). Crop load was adjusted by hand in both 2009 and 2010. Labor efforts for pruning and training of the systems was measured in all three years. Analysis of variance was conducted on the data and where it was significant a Tukey-Kramer mean separation test was utilized to separate the means.

Results

At the end of the third growing season there were no significant differences in tree size as measured by TCA nor were there differences in annual increment of trunk growth (data not shown). The TT system which required more pruning did show a nonsignificant trend to be slightly smaller and the MP system was beginning to appear slightly larger. There was no significant difference in total number of flower clusters per tree and flower density in 2009. In 2010 the MP system had significantly higher total number of clusters per tree and flower density compared to the TT system (Table 1). Percent fruit set, however, on the TT system was higher than the set on any of the other systems.

There were no significant differences in the average number of fruit per tree in 2009, but in 2010 the Jonagold in the A system had fewer fruit per tree than the MP system (Table 2). In the Fuji MP had greater number of fruit than the TT system. Yield (kg/ha) was also not significant for either cultivar in either year (Table 3). However, Fuji had greater yields in both years. It is interesting to note that the increase between years for Jonagold was by a factor of 3.2 while that for Fuji was only 2.2. Efficiency was not influenced by training system in either year (Table 4). Crop load in 2009 was not different by system. However, in 2010 the MP Jonagold had a significantly higher crop load than the A system and in Fuji it was significantly greater the TT system. The lack of difference in yields in the first two cropping years (2nd and 3rd leaf) indicates that any system would be equal if that was the only factor measured although generally Fuji had greater yields than Jonagold.

Part of the study is also to eventually look at economics of the study including fruit size distribution and labor efficiency. In 2009 there was no difference in the size distribution of the fruit. However in 2010 the percent of fruit varied by size (Figure 1).The distribution of Jonagold fruit was greatest in the 77 to 83 mm diameter range but not different by training system. Surprisingly, there was not a typical bell shaped curve you might expect but rather was skewed more to the larger sizes. Size differences by system occurred in the 71 to 76 mm and the class >83 mm. In the smaller class the TT system had significantly more fruit than the A system. The reverse was true in the largest class with the A system having more than the TT system. Fuji size distribution profile (Figure 2) was unlike that of Jonagold. The greatest distribution fell in the 65 to 70 mm class, with the MP system having significantly more fruit than either the TS or A systems. There was a second peak for Fuji in the 77 to 83 mm class. Here the TS, A and TT systems outperformed the MP system. This may have been the result of the higher crop load carried by the MP system although the crop load was only significantly higher than the TT system. It does appear that the crop load on Fuji for the MP system is slightly skewed to the left (smaller fruit). Again the fruit distribution did not bear a typical bell curve with a unexpected drop in the 71 to 76 mm size class.

With the increasing scarcity of labor it is important to determine if there are differences in amount of labor to care for these different systems. In the year of planting (2008) the TT system required the least amount of pruning and training labor for both cultivars (Table 5). The TS, A and MP required the least amount of initial pruning but required mid-summer shoot pinching (2 times) whereas the TT did not require pinching. In the two succeeding years, the TT required more pruning and training labor because this system is summer pruned in mid July. The MP system generally had the lowest labor requirement but not always significantly lower than other systems.

Conclusions

The planting is too young to draw any strong conclusions. However, it is notable that yields did not suffer by cropping the trees the year after planting and the third leaf yield was impressive. We anticipate the MP system will begin to distinguish itself in yield in the fourth leaf as it did in the previous study with York Imperial. The question will be if fruit color and quality can be maintained.

Acknowledgements

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Table 1. 2010 Flowering characteristics by cultivar and system.

System	Total # Clusters/Tree	Clusters/TCSA $\#/cm^2$	% Fruit Set
	Rubinstar Jonagold		
Tall Spindle	229 bc	39 b	38 a
Axe	211 ab	36 b	38 a
Tall Trellis	126 a	24 a	62 b
Minimally Pruned	314 c	49 c	36 a
P-Value	0.0005	0.0001	0.0001
	Daybreak Fuji		
Tall Spindle	177 ab	26 b	68 a
Axe	177 ab	24 ab	65 a
Tall Trellis	101 a	15 a	95 b
Minimally Pruned	219 b	31 b	71 a
P-Value	0.0084	0.0014	0.0150

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

Table 2. Average number of flowers per tree in 2009 and 2010

System	2009		2010	
	Rubinstar Jonagold			
Tall Spindle	9.5	a	39.9	ab
Axe	8.8	a	34.8	a
Tall Trellis	8.9	a	36.4	ab
Minimally Pruned	9.3	a	46.3	b
P-Value	0.9938		0.0377	
	Daybreak Fuji			
Tall Spindle	14	a	53	ab
Axe	17	a	52	ab
Tall Trellis	15	a	37	a
Minimally Pruned	14	a	65	b
P-Value	0.8568		0.0299	

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

Table 3. Yield (Kg/ha) by cultivar and system in 2009 and 2010

System	2009		2010	
	Rubinstar Jonagold			
Tall Spindle	3,792	a	11,607	a
Axe	3,521	a	10,589	a
Tall Trellis	3,254	a	10,084	a
Minimally Pruned	3,587	a	13,199	a
P-Value	0.9589		0.0877	
	Daybreak Fuji			
Tall Spindle	5,500	a	13,237	a
Axe	6,479	a	13,311	a
Tall Trellis	5,509	a	9,231	a
Minimally Pruned	5,080	a	14,578	a
P-Value	0.8125		0.0709	

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

Table 4. Yield efficiency (g/cm^2) and crop load (#fruit/cm^2) in 2009 and 2010 by cultivar and system.

System	Efficiency, g/cm^2	Crop Load, #/cm ^{2}	Efficiency, g/cm^2	Crop Load, #/cm ^{2}
Rubinstar Jonagold	2009		2010	
Tall Spindle	403 a	1.5 a	853 a	4.5 ab
Axe	390 a	1.5 a	747 a	3.8 a
Tall Trellis	370 a	1.5 a	815 a	4.5 ab
Minimally Pruned	358 a	1.4 a	859 a	4.6 b
P-Value	0.9528	0.9922	0.0771	0.0369
Daybreak Fuji				
Tall Spindle	536 a	2.1 a	859 a	5.3 ab
Axe	559 a	2.3 a	792 a	4.8 ab
Tall Trellis	586 a	2.5 a	609 a	3.7 a
Minimally Pruned	503 a	2.1 a	903 a	6.2 b
P-Value	0.8945	0.8664	0.0526	0.0158

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

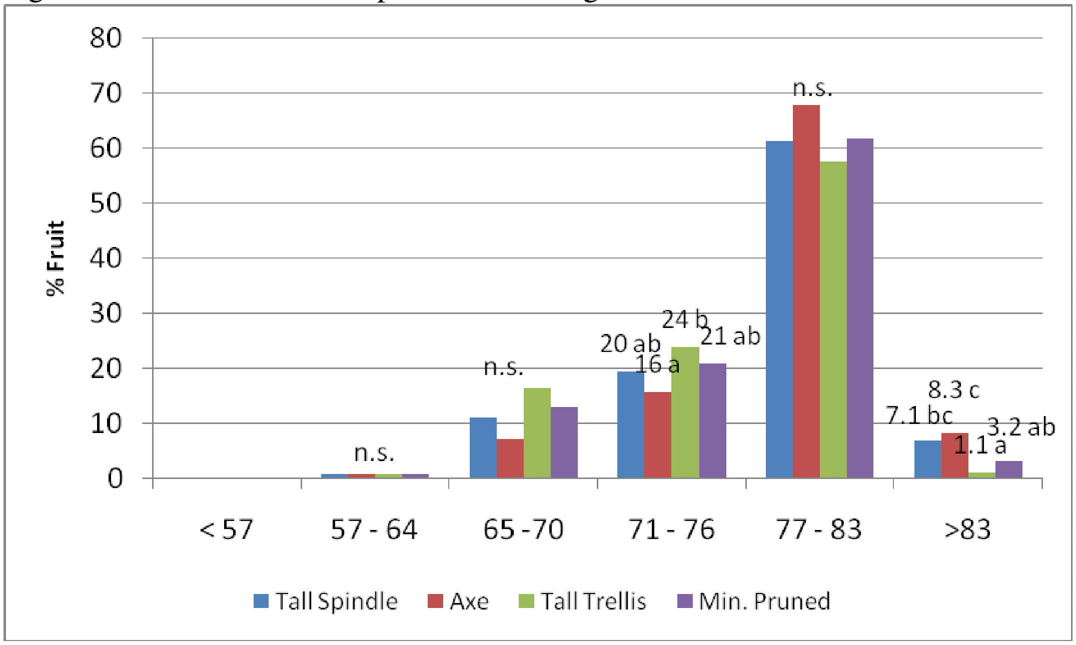
Table 5. Yearly total labor time* by cultivar and system for Jonagold and Fuji at Rock Springs.

System	2008	2009	2010
	Rubinstar Jonagold		
Tall Spindle	7.1 c	4.0 b	10.4 a
Axe	5.8 b	2.4 ab	9.3 a
Tall Trellis	3.6 a	9.0 c	22.1 b
Minimally Pruned	5.7 b	0.7 a	10.7 a
P-Value	0.0001	0.0001	0.0001
	Daybreak Fuji		
Tall Spindle	8.3 b	4.4 a	16.0 a
Axe	7.7 b	2.9 a	15.5 a
Tall Trellis	3.7 a	13.1 b	26.0 b
Minimally Pruned	7.4 b	1.7 a	15.5 a
P-Value	0.0001	0.0001	0.0001

*Activities include winter pruning and training, summer pinching or pruning, limb postioning and crop load adjustment.

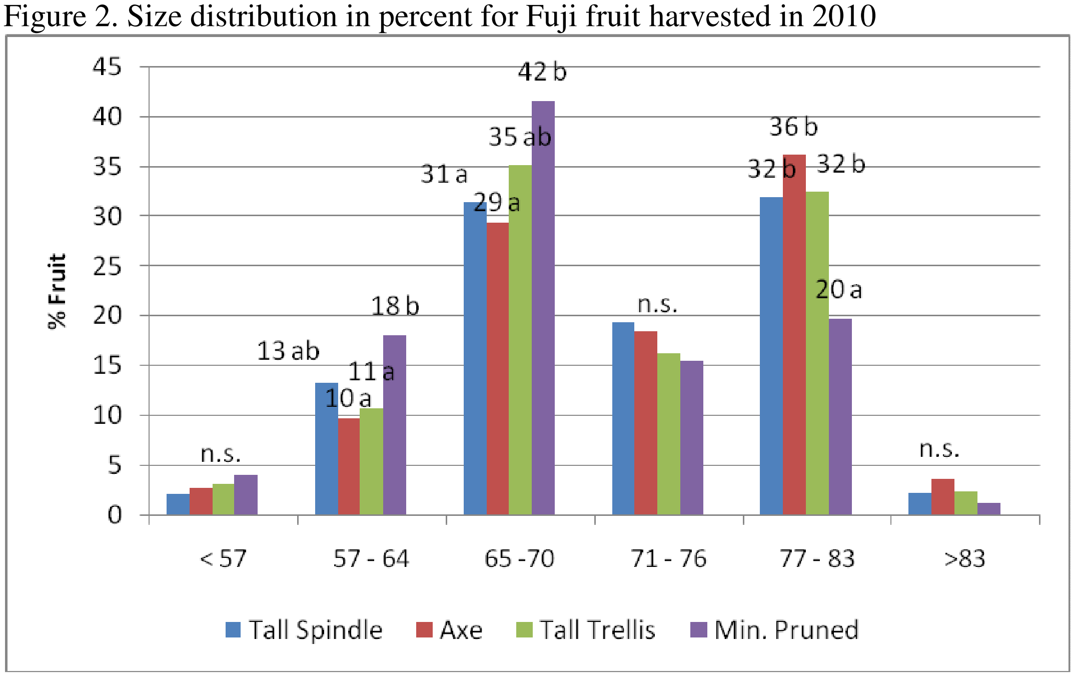
Letters refer to Tukey-Kramer mean separation, P = 0.05

Figure 1. Size distribution in percent for Jonagold fruit harvested in 2010



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

Figure 2. Size distribution in percent for Fuji fruit harvested in 2010



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

GRASS COMPETITION MAY BENEFIT HIGH DENSITY PEACH ORCHARDS

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Previous research demonstrated that grass competition dwarfed and reduced yield of individual peach trees (*Prunus persica* (L.) Batsch) grown in narrow vegetation free areas (VFA). In this report the area-based yield of two peach cultivars ('Redskin' and 'Jersey Dawn' on 'Lovell') was estimated for two planting densities in two VFAs to compare potential economic returns from trees with different crop loads. The analysis indicated that even though grass competition reduced yield of individual peach trees, the concomitant reduction in tree size should enable greater tree density which may increase economic returns per hectare.

Introduction

High density tree plantings can be used to obtain earlier and greater yield per ha in apple and peach orchards (Jackson, 1989; Marini and Sowers, 2000). Size controlling rootstocks facilitate close plantings in apple but rootstocks are not widely available to regulate peach tree size. Consequently intensive pruning may be required to maintain fruit bearing wood and tree size but such pruning may have undesirable biological and economic effects (Myers, 1993). Intense pruning can stimulate excessive shoot regrowth that can adversely affect fruit quality and require another cycle of intense pruning. Alternatively, shoot growth can be suppressed with root pruning, physical or chemical restriction, or competition (Atkinson, 1997; Chalmers et al., 1981; Glenn and Welker, 1996; Schupp and Ferree, 1989; Williamson and Coston, 1989). In a mesic environment grass competition can dwarf peach trees and reduce annual pruning but yield per tree declines (Tworkoski and Glenn, 2001; Tworkoski and Glenn, 2010). Relevant to this finding is the question; can the reduced yield per tree caused by grass competition be countered by increased tree density to maintain or increase yield per ha? This report does not provide an unequivocal answer but it does offer evidence to support the potential benefit for planting peach trees at high densities with managed ground cover competition. The objective was to estimate, for comparison, the economic return per ha of peaches collected from trees grown in low and increased density with grass competition.

Materials and Methods

Trees ('Redskin' (RS) and 'Jersey Dawn' (JD) on 'Lovell') were planted in 1993 in the field near Kearneysville, WV in a 0.6 or 2.4 m vegetation free areas (VFA) with a 4.6 x 6.1 m spacing (370 trees/ha) as described in the companion article to this report (Tworkoski and Glenn, 2010). Half the trees were pruned intensely and half received reduced pruning, resulting in lower and greater crop loads, respectively. From 2004 to 2007 fruit were harvested, counted, and weighed by size class so that marketable fruit weight per tree could be related to total crop load per tree. Fruit were classified as marketable if they were 6.3 cm or larger in diameter and more than 90% of all crop loads were marketable.

To evaluate effects of grass competition on tree growth, trunk diameters were measured 20 cm above the graft union of each tree and averaged for each cultivar grown in each VFA. The trunk cross sectional area (TCSA) was calculated by the area of a circle using trunk diameter divided by two for the radius. Yield efficiency was calculated for each tree each year by dividing the weight of marketable fruit by TCSA. Regression analysis was used to determine the relationship between yield efficiency and crop load.

In 2006, average packinghouse prices for half bushels (approximately 11.4 kg) of peaches from Georgia, New Jersey, and South Carolina on July 17 (approximately mid-season) were \$7.83, 10.33, and 12.83 (U.S.) for size classes 5.7-6.3, 6.3-7.0, and >7.0 cm, respectively (Walker, 2007). These prices were used to estimate the value of all marketable fruit (crop value) for each tree and its corresponding crop load (i.e. crop value per tree = Σ (kg fruit X dollar value/kg) for size classes 5.7-6.3, 6.3-7.0, and >7.0 cm). For trees grown in the 0.6 and 2.4 m VFA, the crop value per ha was calculated as the product of crop value per tree and 370 trees/ha (the actual planting density) for each crop load. In addition, for trees grown in the 0.6 m VFA, crop value per ha was calculated as the product of the crop value per tree and 444 trees/ha (i.e. a hypothetical increased tree density of 20% to balance the tree size reduction caused by grass). Regression analysis was used to determine the relationship between crop value and crop load. Pruning weight and time were also estimated at a higher tree density for the 0.6 m VFA. Based on the measured annual pruning weights per individual tree grown in the 0.6 and 2.4 m VFA (Tworkoski and Glenn, 2010), annual pruning weights per ha were calculated for tree densities of 370 and 444 trees/ha for 2.4 and 0.6 m VFA, respectively. Pruning costs were calculated as the product of pruning time per tree (0.08 and 0.19 hr/tree for 0.6 and 2.4 m VFA, respectively) by a wage estimate (\$7.25/hr) by projected tree density.

Results

The crop value increased with increased crop loads of 200 to 400 fruit per tree for RS and JD in both VFAs (Fig. 1A and B). In both RS and JD, tree size was reduced by approximately 20% by grass competition (Tworkoski and Glenn, 2010). Trunk diameters of RS and JD in the 0.6 m VFA were 15.4±2.2 and 14.2±2.0 cm, respectively compared to RS and JD in the 2.4 m VFA that were 19.3±2.4 and 18.1±2.2 cm, respectively (data not shown). In conjunction with reduced trunk diameters, the weight of pruned shoots were reduced at least 50% in the 0.6 compared to the 2.4 m VFA (Fig. 1C). Pruning time was also less in the 0.6 compared to the 2.4 m VFA (4.9 and 11.2 min/tree, respectively) (Tworkoski and Glenn, 2010). Yield efficiency increased with crop load for both cultivars and VFAs (Fig. 1D). The rate of yield efficiency increase was greater in the 0.6 than the 2.4 m VFA for both RS and JD at 370 trees/ha. Because trees were smaller when grown in 0.6 m than 2.4 m VFA (Tworkoski and Glenn, 2010) the effect of increasing tree density on crop value per ha was evaluated for the 0.6 m VFA. The crop value per ha at different crop loads was estimated for a 20% increased tree density of 444 trees/ha for trees in 0.6 m VFA and compared with tree density of 370 trees/ha for trees in 2.4 m VFA (Fig. 1A and B). With the increased tree density at most crop loads, the crop value per ha of both RS and JD in 0.6 m VFA exceeded that of trees grown at 370 trees/ha in 2.4 m VFA.

In this study, only limited estimates of management costs could be considered with trees grown with different densities and VFAs. Annual pruning costs of 5- to 7-year-old trees were estimated to be $263 and $501/ha for trees grown in 0.6 m VFA with 444 trees/ha and 2.4 m VFA with 370 trees/ha, respectively (data not shown). Also, the 0.6 m VFA required less herbicide than the 2.4 m VFA; the estimated average annual cost for herbicides were $17.54 and $70.19/ha/yr, respectively (data not shown). Although these variable costs appeared less with trees grown in 0.6 m VFA with 444 trees/ha, initial fixed costs were higher. An initial capital investment in an offset swing-wing mower (Van Wamel BV, Energieweg 1, 6658AE Beneden-Leeuwen, The Netherlands; estimated cost of $5,500) was beneficial to manage grass below trees grown in 0.6 m VFA. Clearly, planting costs ($3.75/tree in 1993) also would increase proportionately with tree density.

Discussion

The dwarfing effect of grass on peach trees through competition for water and minerals was established by previous research (Belding et al., 2004; Glenn et al., 1996; Meagher and Meyers, 1990; Tworkoski and Glenn, 2001; Tworkoski and Glenn, 2010). Dwarfed peach trees had reduced yield and there may be additional adverse effects from grass competition. Increased mowing will likely be necessary for trees grown in narrow VFAs but this may be counterbalanced, in part, by reduced herbicide use. We have used offset swing-wing mowers to effectively control grass beneath large and small peach trees (Van Wamel BV, The Netherlands). As a counterpoint to adverse effects, there may be benefits of planting trees in narrow VFAs. Grass likely will increase organic matter and decrease bulk density of soil in orchards with narrow compared to wide VFAs (Tworkoski and Miller, 2001). In addition, smaller trees in narrow VFA require reduced pruning (Fig. 1C; Tworkoski and Glenn, 2010). Compared with the 2.4 m VFA with 370 trees/ha, trees grown in 0.6 m VFA with 444 trees/ha, were estimated to have 48% less pruning and 75% less herbicide costs.

In this report we used the same yield and value return per tree with trees grown in 0.6 m VFA, for two planting densities. This calculation resulted in greater value return per ha at the higher density but if yield per tree decreased with increased density then such value returns would not be obtained. However, yield loss per tree in 0.6 m VFA would not likely occur with up to 20% increase in density (444 trees/ha). This inference is based on the finding that in 0.6 m VFA, tree size was reduced by approximately 20% and that density could be increased by this amount without crowding (Tworkoski and Glenn, 2010). With crop loads less than 400 fruit per tree the value return per ha of trees grown in 0.6 m VFA and 444 trees / ha will exceed that of trees grown in 2.4 m VFA and 370 trees / ha (i.e. 20% increased density; Fig. 1A and B). A field experiment is needed to establish the tree density that can be supported in narrow VFAs to increase yield and such research is currently being conducted. It is noteworthy that the estimates for crop value per ha in this report were presented to facilitate comparisons, rather than to predict actual return.

There are a number of potentially beneficial as well as costly effects of planting trees in narrow VFA but it is evident that to counterbalance the loss of yield per tree increased tree density per ha would be necessary. Benefits may include reduced costs for pruning and for herbicides but other costs would increase with trees grown in narrow

VFAs. High peach tree density in narrow VFAs require greater initial capital investment in trees and mowers but it may also provide earlier marketable cropping, particularly if reduced pruning is coupled with increased density. Selective irrigation and fertilization to trees in narrow VFA may provide additional tools to manage such high density plantings.

Conclusion

The experiment indicated that growing trees in 0.6 m VFA reduced yield and dollar return per tree but with increased tree density the dollar return per ha may be greater in trees in 0.6 m than 2.4 m VFA. This increased return per ha coupled with reduced pruning costs due to suppression of excessive vegetative growth and potential earlier yield may justify greater initial capital investment in trees for higher tree density.

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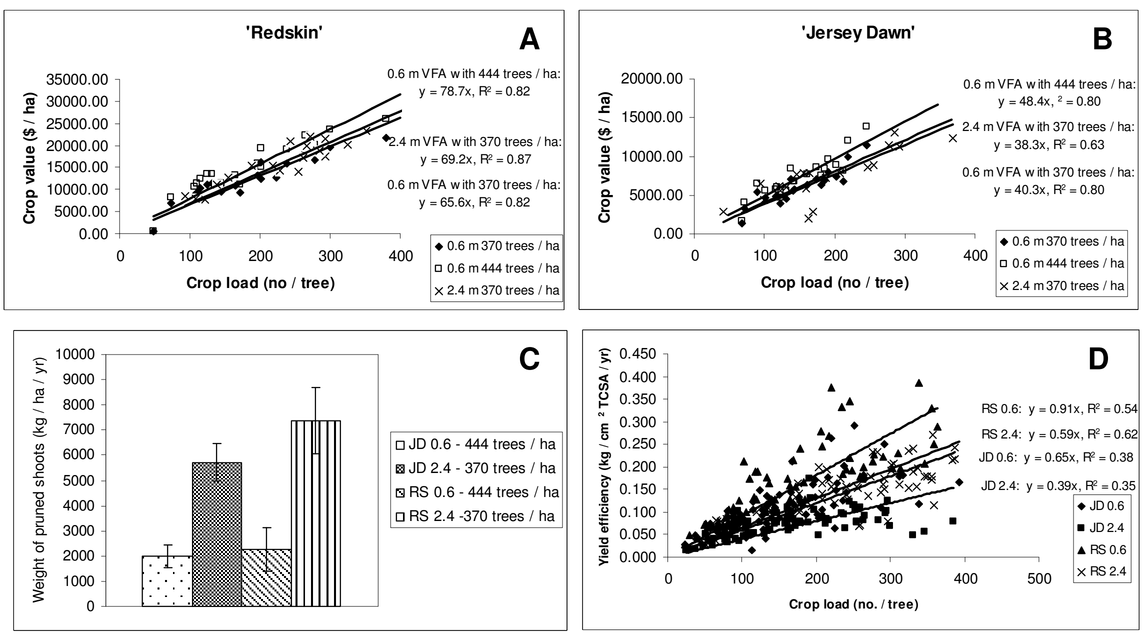

Fig. 1. Crop value (A and B), pruning weight (C), and yield efficiency (D) of 'Jersey Dawn' (JD) and 'Redskin' (RS) peach trees that were grown in 0.6 and 2.4 m vegetation-free areas (VFA). Crop value was estimated for 2.4 m VFA with 370 trees/ha and for 0.6 m VFA with 370 and 444 trees/ha (A and B). TCSA = trunk cross-sectional area; bars represent two standard deviations of the mean.

COVER CROP, ROOTSTOCK, AND ROOT MANIPULATION AS TOOLS TO ALTER VEGETATIVE GROWTH AND ALTER POTENTIAL WINE QUALITY

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Vineyards (*vitis Vinifera*) in Virginia are characterized by having excessive vegetative growth. This excessive growth is associated with surplus soil moisture available to the vines throughout the growing season.

Research at AHS Jr. AREC in Winchester VA identified three practices that can be used to manage the vegetative growth of cv. Cabernet Sauvignon (*vitis Vinifera* L.). The three treatments are under the trellis cover crops (UTCC), low vigor rootstocks and root restriction (RR).

Cabernet Sauvignon (#337) was planted in 2006 in a field strip-split-split plot design. The whole plot factor was under the trellis ground cover. The vine rows were managed with a 1 meter wide strip kept weed free below the trellis or with a full groundcover planting of sod (creeping red fescue). The next level of treatments were three low vigor rootstocks; 101-14, 431-A, and riparia Gloire. The last level of treatments was a comparison of root manipulation. Vines were planted with no restriction of the root zone (NRR) or were planted inside a fabric pot holding 0.015 m^3 of soil, placed in the bulk soil. The hypothesis of this work is that treatments that predictably reduce the rate and duration of vegetative growth will produce fruit with increased wine quality potential. The objectives of this project were to: characterize the effect that these treatments have on the vegetative growth of these vines, and investigate what influences these treatments have on the fruit and subsequent wine.

Dormant pruning weights were collected from vines with these treatments in 2008 and 2009. In both years vines with an herbicide strip had significantly heavier pruning weights than vines UTCC. Vines grafted to the rootstock riparia Gloire had significantly lighter pruning weights than vines grafted to the other two rootstocks. Vines with RR had significantly lighter pruning weights than vines with NRR. The effects these treatments had on pruning weight seem to be additive. Vines with the combination of UTCC, grafted to the rootstock riparia Gloire that had RR had by far lighter pruning weights than vines with other combinations.

The differences in vegetative growth can be attributed to differences in plant water status though the growing season. Vines with UTCC had a more negative water status than vines with an herbicide strip below the trellis. Vines with RR had a much more negative water status that vines with NRR.

These treatments also altered the vine's components of yield. Vines with UTCC had lighter clusters, lighter berries and fewer berries per cluster than vines with an herbicide strip below the trellis. Vines grafted to the rootstock riparia Gloire had heavier clusters, heavier berries and more berries per cluster than vines grafted to the other rootstocks. Vines with RR had lighter cluster, lighter berries and fewer berries per cluster than vines with NRR.

Vines were harvested by treatments with the same target sugar levels. In 2009, vines with RR were harvested 2 days before vines with NRR. All vines were harvested with similar brix levels, which created a platform to investigate how these treatment influence fruit quality with respect to wine.

Fruit was frozen after harvest and then transported to the Enology Grape Chemistry Group's facilities at Virginia Tech. Four treatments were selected for wine making, with 3 replicates of each treatment. The treatments for winemaking were Herbicide with NRR, Herbicide with RR, UTCC with NRR, and UTCC with RR. Each replicate used 34 kg. of fruit and winemaking techniques were identical between the lots.

Finished wine was analyzed with spectroscopy. Wine from treatments with UTCC had higher color density than wines from treatments with an herbicide strip below the trellis. Wine from treatments with RR had more color density than wine from treatments that NRR.

This project identified three treatments that can be used in a humid growing environment to curtail vine vegetative growth. This project made a platform of various vine sizes that can be used to inspect the influence of vine vegetative growth on fruit and wine quality.

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Developing Management Strategies to Optimize the Uses of a Mobile High Tunnel System 2010 Season Update

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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.

Construction was completed in the early fall of 2009 and the tunnel stood up to 50 mph winds; yet November and December brought higher winds with gusts in excess of 60 mph leading to a near catastrophic failure of the ground post securing the structure in position. This was due to the fact that the standard 36 inch ground posts were cut in half to save time and effort during installation. The tunnel did pull free of the ground and moved approximately one foot off the rails. The tunnel was subsequently re-secured to the ground with full length ground posts which did hold in 60 mph gusts experienced, as well as several heavy snows with two in excess of two feet in depth during January and February. With the full length ground posts to hold the tunnel in place, the structure appeared to show adequate flexibility and strength to handle a much worse than average winter in the mid-Atlantic region.

The annual Chandler strawberries were harvested April 28 through June 23 yielding 252 quarts from 210 plants @4.00/qt. grossing $840.00. On June 23 the tunnel was moved over the Brandywine Heirloom tomatoes that were planted on May 10. Tomatoes were harvested from June 6 through October 29 yielding 680 pounds of marketable fruit @3.00/lb. grossing $2,040.00. On October 29 the tunnel was moved over the Josephine red raspberries. Harvest of the raspberries had begun on July 6, yet brown marmorated stink bug (BMSB) damage coincided with fruit ripening and adequate control was never achieved during the 2010 season. It should be noted that BMSB severely damaged the fruit and planting did not recover; even in November in protected culture the raspberries produced little marketable fruit as they continued to bloom into late November.

After one season of production it appears that the Mobile Tunnel allows too much cold air in around the base of the structure for good season extension. Since the baseboard and end walls must be raised off the ground so that the structure can move from one location to another, it is difficult to prevent winds from blowing under the tunnel and cold air on frosty mornings from seeping into the tunnel. The drafty nature of this structure considerably reduces the structure’s capacity to provide a suitable microclimate for season extension during the winter, spring or fall. At this time, a suitable material is being sought that will provide an adequate barrier to the cold air without impeding the movement of the structure.

This ongoing work will continue to examine the functionality and practicality, as well as the profitability of the mobile system. Observations and 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 Authors

Use of AVG and NAA in a Hot, Dry Year.

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This paper and work is dedicated to the memory of Dr. Rongcai Yuan who initiated the original studies in 2009.

Reducing preharvest fruit drop and maintaining fruit quality are important to apple growers. Excessive drop and poor fruit quality can have a significant effect on grower returns. The objective of this study was to evaluate the response of 'Bisbee Delicious' apples to preharvest applications of AVG (aminoethyoxyvinylglincine, ReTain) and NAA (naphthaleneacetic acid, Fruitone-L) in a hot, dry growing season. Applications at various timing and rates were considered. This study was a continuation of work begun in 2009 on fruit drop in 'Bisbee Delicious" apple trees.

Mature 'Bisbee Delicious'/MARK trees were selected for the study. These were the same group of trees used in the 2009 (Yuan) study. All sprays were applied by hand with a high-pressure handgun sprayer to the point of first drip. Bloom in 2010 was about 2 weeks ahead of normal for all varieties, including the 'Bisbee Delicious'. Based on previous harvest dates and starch index (SI) ratings, September 7 was determined to be the optimum maturity (SI = 4.0) date in 2010.

Yuan (2009) reported that the combination of AVG and NAA was more effective in reducing preharvest fruit drop and maintaining fruit quality than either material used alone. He also reported that a combined spray of AVG and NAA at a reduced rate of AVG could effectively reduce preharvest fruit drop and extend the harvest window when applied two weeks before harvest (WBH) compared to the conventional 4 WBH application for AVG. In 2009, a single application of AVG at 125 $mg \cdot L^{-1}$ 4 WBH (a commercial recommended spray) effectively reduced preharvest fruit drop up to 4 weeks after the optimum harvest date. The 2009 year was considered a "normal" growing season with near average temperatures and adequate to above average moisture. Fruit ethylene levels were reduced on the initial harvest date by AVG and combination sprays of AVG and NAA, but not by NAA alone at the conventional 2 WBH timing (Table 1). Four weeks after the initial harvest ethylene levels were lowest in the conventional AVG treatment (4 WBH at 125 $mg \cdot l^{-1}$) or a combined treatment of AVG + NAA at either 4 & 2 wks or 2 & 2 wk timing (Table 1).

In contrast the 2010 growing season was marked by temperatures well above normal and near drought conditions (Fig. 1 and 2). The pattern of ethylene production in control fruit was about normal (Fig. 3), but somewhat delayed (Table 2) compared to the level for the initial harvest date in 2009. The contrasting conditions between 2009 and 2010 led to differences in response between the two years, most notably in the pattern of fruit drop (Table 3) and fruit firmness (Table 4). In 2010, treatments with AVG at 125 mg·L^{-1} at weekly intervals beginning 5 WBH indicated that sprays applied 1 or 2 WBH will provide superior drop control and maintain fruit firmness better than sprays applied at the conventional 4 WBH timing. A combined spray of AVG and NAA was superior to either material alone and application of AVG at 2 WBH in the combined spray was better than application of AVG at 4 WBH. As in 2009, a half rate (62 mg·L^{-1}) spray of AVG combined with NAA was as effective as the full rate AVG + NAA spray. The delay in fruit maturity due to AVG treatment generally resulted in a reduction in fruit size at harvest (Tables 5 and 6). Surface red color was reduced on the initial harvest date by AVG alone at 4 wks or when AVG was applied at 4 and 2 wks before harvest (Table 7), but color on later harvest dates was not affected. The response for soluble solids concentration (SSC) was similar (Table 8). Based on the starch index (SI) rating, control fruit were mature on 7 Sept., the initial harvest date, but fruit in all other treatments except NAA alone were delayed in their maturity (Table 9). The level of water core was quite variable when recorded on the initial harvest date (7 Sept., Table 10), but about 2 wks later some of the best drop control treatments (AVG at 2 wks or AVG + NAA at 2 wks) also exhibited the least amount of watercore.

Our results strongly suggest that when preharvest conditions are hot and dry a combined spray of AVG + NAA both applied 2 WBH may be superior to application at the conventional 4 and 2 WBH timing. These results agree with findings reported by Robinson et al. (2010) for ‘McIntosh’ apples in New York.

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Fig. 1. Average high temperature for growing season (April – September) recorded at the Virginia Tech. Fruit Research Station, Winchester, VA.

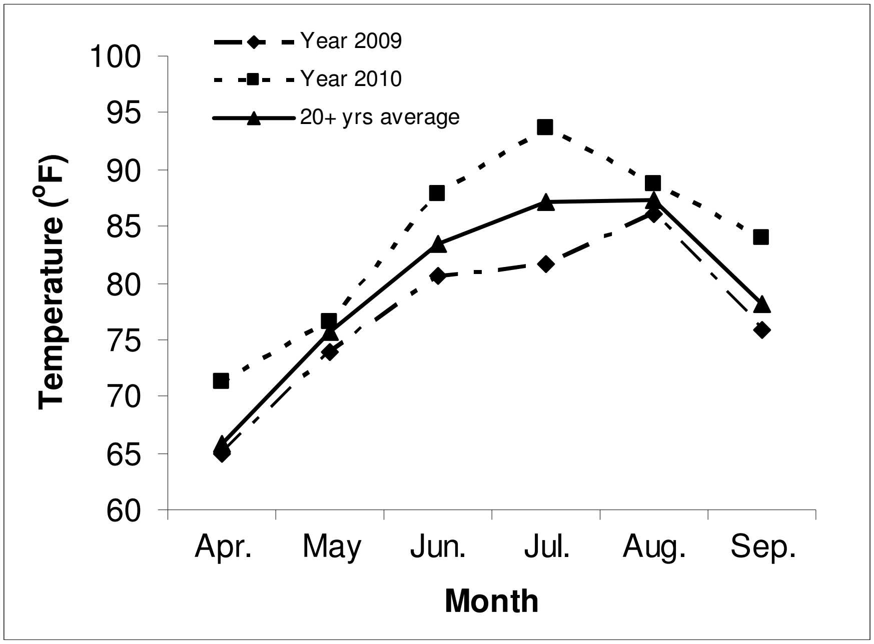

Fig. 2. Total monthly rainfall recorded for growing season (April – September) at the Virginia Tech. Fruit Research Station, Winchester, VA.

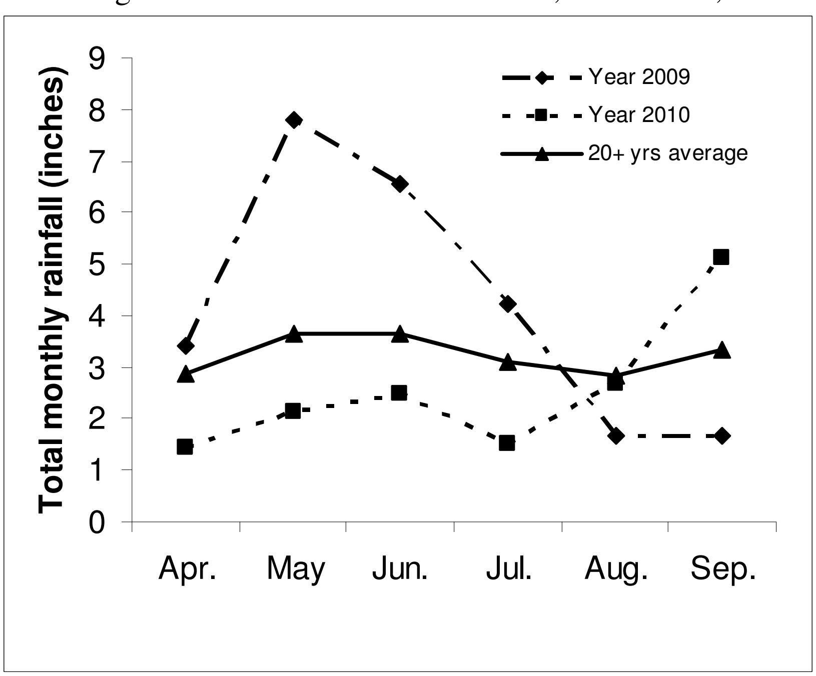

Table 1. Effects of preharvest applications of sprayable 1-MCP, AVG and NAA on fruit ethylene of 'Bisbee Delicious'/Mark apples (2009).

Treatment	Application time (WBH)[z]	Ave. High Temp.	Temp. for 3 days (Day of application + 2 days after)	Concentration ($mg \cdot L^{-1}$)	Fruit ethylene (ul/kg/h)		
					Sept 21	Oct 6	Oct 21
Control	-			-	20.8 a[y]	16.6 a	15.2 a
AVG	4	86.6	88.5	125	0.1 b	2.7 cd	1.8 c
AVG	4	86.6	88.5	62.5	3.6 b	6.9 bcd	4.9 bc
NAA	2	78.1	78.5	10	25.0 a	14.0 ab	7.2 bc
AVG +	4	86.6	88.5	125	0.2 b	1.0 d	2.0 c
NAA	2	78.1	78.5	10			
AVG +	4	86.6	88.5	125	0.2 b	1.0 d	4.0 bc
NAA	4 &2	86.6 & 78.1	88.5 & 78.5	10			
AVG +	2	78.1	78.5	125	0.4 b	0.9 d	2.4 c
NAA	2	78.1	78.5	10			
AVG +	2	78.1	78.5	62.5	3.8 b	5.1 cd	3.6 bc
NAA	2	78.1	78.5	10			
AVG +	2	78.1	78.5	46.875	3.7 b	6.3 cd	5.6 bc
NAA	2	78.1	78.5	10			
AVG +	2	78.1	78.5	31.25	0.3 b	10.1 abc	7.3 bc
NAA	2	78.1	78.5	10			
1-MCP	2	78.1	78.5	160	0.8 b	6.4 cd	7.3 bc
1-MCP +	2	78.1	78.5	80	6.2 b	8.6 bcd	8.5 b
NAA	2	78.1	78.5	10			

[z] Full bloom occurred on April 23, 2009. Apples matured on or about the normal expected date for cultivar and rootstock. WBH = weeks before harvest.

[y] Mean separation within columns by Duncan's multiple range test, P=0.05.

Table 2. Effects of preharvest applications of AVG and NAA on fruit ethylene of 'Bisbee Delicious'/Mark apples (2010).

Treatment	Application time (WBH)[z]	Ave.High Temp.	Temp.for 3 days (Day of application + 2 days after)	Concentration ($mg \cdot L^{-1}$)	Fruit ethylene (ul/kg/h)		
					Sept 7	Sept 21	Oct 5
Control	-			-	4.30 a[y]	17.33 a	13.9 a
AVG	5	92.5	89.8	125	0.16 b	1.99 cd	3.3 bc
AVG	4	97.4	88.2	125	0.10 b	2.13 cd	7.5 b
AVG	3	90.8	85.1	125	0.08 b	0.84 d	4.0 bc
AVG	2	72.0	79.7	125	0.11 b	1.11 d	0.5 c
AVG	1	94.6	86.7	125	0.04 b	0.95 d	0.6 c
AVG + NAA	4 2	97.4 72.0	88.2 79.7	125 10	0.12 b	5.77 c	1.7 c
AVG + NAA	2 2	72.0 72.0	79.7 79.7	125 10	0.06 b	1.36 d	0.2 c
AVG + NAA	4 2	97.4 72.0	88.2 79.7	62.5 10	0.43 b	10.88 b	4.1 bc
AVG + NAA	2 2	72.0 72.0	79.7 79.7	62.5 10	0.14 b	0.88 d	0.2 c
AVG	4 2	97.4 72.0	88.2 79.7	62.5 62.5	0.10 b	1.01 d	1.3 c
NAA	2	72.0	79.7	10	4.52 a	19.82 a	7.1 b

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest

[y] Mean separation within columns by Duncan's multiple range test, *P*=0.05.

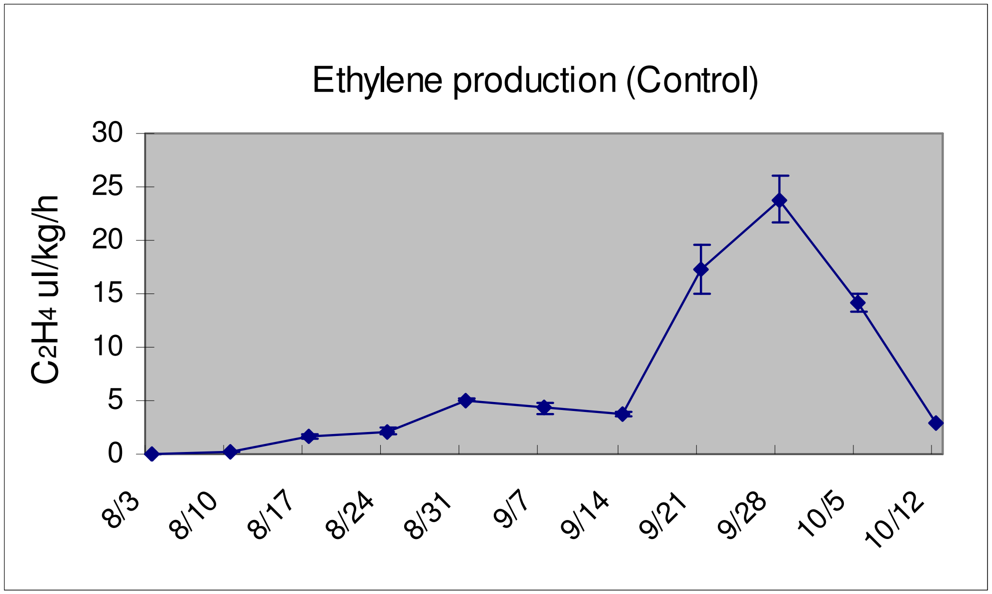

Fig. 3. Evolution of ethylene production from 5 weeks before optimum harvest to 5 weeks post optimum harvest (2010).

Table 3. Effects of preharvest applications of AVG and NAA on fruit drop of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH)[z]	Concentration ($mg \cdot L^{-1}$)	Cumulative fruit drop (%)									
				Aug 18	Aug 25	Aug 31	Sept 7	Sept 14	Sept 21	Sept 28	Oct 5	Oct 12	Oct 19
1	Control	-	-	0.8 a[y]	1.5 a	2.5 a	3.4 a	6.6 a	9.6 a	22.2 a	54.8 a	67.4 a	78.6 a
2	AVG	5	125	0.8 a	1.1 a	1.1 a	2.2 ab	4.3 ab	5.2 b	6.9 b	13.2 cdef	26.4 d	33.9 d
3	AVG	4	125	0.4 a	0.8 a	0.8 a	1.1 b	2.0 b	4.1 b	7.5 b	20.4 bc	36.2 bc	44.2 bc
4	AVG	3	125	1.1 a	1.4 a	1.6 a	2.2 ab	2.9 b	4.3 b	4.9 b	14.7 cd	29.7 bcd	39.8 c
5	AVG	2	125	0.3 a	0.7 a	0.8 a	1.2 b	1.5 b	2.2 b	2.4 b	4.7 efg	9.3 f	17.4 f
6	AVG	1	125	0.6 a	0.7 a	1.0 a	1.4 ab	2.4 b	2.7 b	2.8 b	5.1 efg	15.5 ef	23.4 e
7	AVG + NAA	4	125	0.4 a	1.0 a	2.0 a	2.1 ab	2.9 b	4.1 b	4.7 b	8.0 defg	18.2 e	26.0 e
		2	10										
8	AVG + NAA	2	125	0.7 a	1.0 a	1.1 a	1.5 ab	1.9 b	2.4 b	2.5 b	3.4 g	8.3 f	13.1 f
		2	10										
9	AVG + NAA	4	62.5	0.8 a	1.7 a	1.9 a	2.2 ab	3.9 ab	5.7 b	6.8 b	13.7 cde	31.0 bcd	40.3 c
		2	10										
10	AVG + NAA	2	62.5	0.8 a	1.4 a	1.4 a	2.0 ab	2.4 b	3.2 b	3.3 b	4.4 fg	9.1 f	13.9 f
		2	10										
11	AVG	4	62.5	0.8 a	1.0 a	1.2 a	2.0 ab	3.8 ab	5.2 b	5.7 b	12.0 cdefg	27.9 cd	38.2 cd
		2	62.5										
12	NAA	2	10	0.5 a	0.8 a	1.0 a	1.2 b	3.3 ab	5.2 b	7.6 b	23.5 b	38.3 b	47.2 b

[z] Apples were removed from underneath tree weekly. Remaining apples on the tree were counted after last drop count. Full bloom occurred on April 8, 2010.

Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest.

[y] Mean separation within columns by Duncan's multiple range test, P=0.05.

Table 4. Effects of preharvest applications of AVG and NAA on fruit firmness of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH)[z]	Concentration ($mg \cdot L^{-1}$)	Date when fruit firmness (lb) was determined		
				Sept 7	Sept 21	Oct 5
1	Control	-	-	18.6 b[y]	16.7 bc	14.5 e
2	AVG	5	125	19.4 a	17.2 ab	15.6 c
3	AVG	4	125	18.4 b	17.1 ab	15.7 bc
4	AVG	3	125	18.7 ab	17.0 ab	15.6 c
5	AVG	2	125	19.1 ab	17.1 ab	16.1 ab
6	AVG	1	125	18.9 ab	17.4 ab	16.0 abc
7	AVG + NAA	4	125	18.6 b	17.1 ab	16.2 a
		2	10			
8	AVG + NAA	2	125	18.9 ab	17.5 a	16.1 ab
		2	10			
9	AVG + NAA	4	62.5	18.8 ab	17.5 a	15.1 d
		2	10			
10	AVG + NAA	2	62.5	18.5 b	17.2 ab	16.3 a
		2	10			
11	AVG	4	62.5	19.1 ab	17.6 a	16.1 ab
		2	62.5			
12	NAA	2	10	18.6 b	16.3 c	13.8 f

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest.

[y] Mean separation within columns by Duncan's multiple range test, *P*=0.05.

Table 5. Effects of preharvest applications of AVG and NAA on fruit diameter of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH) [z]	Concentration ($mg \cdot L^{-1}$)	Date when fruit diameter (cm) was determined		
				Sept 7	Sept 21	Oct 5
1	Control	-	-	7.85 a [y]	7.82 a	8.20 ab
2	AVG	5	125	7.65 ab	7.84 a	8.04 abc
3	AVG	4	125	7.27 bcd	7.56 abcd	7.61 cd
4	AVG	3	125	7.42 bc	7.69 abc	7.95 abcd
5	AVG	2	125	7.26 bcd	7.31 bcd	7.64 cd
6	AVG	1	125	6.95 d	7.19 d	7.58 cd
7	AVG + NAA	4	125	7.34 bcd	7.50 abcd	7.69 bcd
		2	10			
8	AVG + NAA	2	125	7.20 cd	7.25 cd	7.65 cd
		2	10			
9	AVG + NAA	4	62.5	7.41 bc	7.78 a	8.09 abc
		2	10			
10	AVG + NAA	2	62.5	7.21 cd	7.20 d	7.51 d
		2	10			
11	AVG	4	62.5	7.56 abc	7.68 abc	7.97 abcd
		2	62.5			
12	NAA	2	10	7.67 ab	7.74 ab	8.34 a

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest.
[y] Mean separation within columns by Duncan's multiple range test, *P*=0.05.

Table 6. Effects of preharvest applications of AVG and NAA on fruit weight of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH) [z]	Concentration ($mg \cdot L^{-1}$)	Date when fruit weight (g) was determined		
				Sept 7	Sept 21	Oct 5
1	Control	-	-	228.92 a [y]	232.94 a	263.04 ab
2	AVG	5	125	202.72 abcd	230.86 a	252.84 abc
3	AVG	4	125	175.84 cde	204.7 abc	206.78 de
4	AVG	3	125	191.58 bcd	221.42 ab	238.74 abcde
5	AVG	2	125	179.54 cde	186.80 bc	203.66 de
6	AVG	1	125	159.1 e	179.24 c	206.34 de
7	AVG + NAA	4	125	185.56 bcde	199.36 abc	218.80 bcde
		2	10			
8	AVG + NAA	2	125	179.26 cde	180.46 c	213.44 cde
		2	10			
9	AVG + NAA	4	62.5	194.18 bcd	229.92 a	254.74 abc
		2	10			
10	AVG + NAA	2	62.5	176.04 de	181.24 c	194.48 e
		2	10			
11	AVG	4	62.5	206.40 abc	222.80 ab	249.12 abcd
		2	62.5			
12	NAA	2	10	211.06 ab	220.88 ab	274.18 a

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock.
WBH = weeks before harvest.
[y] Mean separation within columns by Duncan's multiple range test, *P*=0.05.

Table 7. Effects of preharvest applications of AVG and NAA on red color of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH) [z]	Concentration (mg·L^{-1})	Date when red color (%) was determined		
				Sept 7	Sept 21	Oct 5
1	Control	-	-	83.0 ab [y]	92.8 a	96.0 ab
2	AVG	5	125	82.1 ab	92.1 a	96.0 ab
3	AVG	4	125	73.7 b	89.5 a	92.9 b
4	AVG	3	125	76.4 ab	91.8 a	95.0 ab
5	AVG	2	125	83.8 ab	92.1 a	94.4 ab
6	AVG	1	125	84.7 a	92.1 a	96.5 a
7	AVG + NAA	4	125	79.8 ab	89.3 a	95.4 ab
		2	10			
8	AVG + NAA	2	125	82.8 ab	93.3 a	95.6 ab
		2	10			
9	AVG + NAA	4	62.5	81.1 ab	94.4 a	92.9 b
		2	10			
10	AVG + NAA	2	62.5	83.9 ab	94.5 a	95.9 ab
		2	10			
11	AVG	4	62.5	74.3 b	92.2 a	93.8 ab
		2	62.5			
12	NAA	2	10	81.1 ab	93.6 a	95.4 ab

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest.

[y] Mean separation within columns by Duncan's multiple range test, *P*=0.05.

Table 8. Effects of preharvest applications of AVG and NAA on soluble solids of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH)[z]	Concentration (mg·L^{-1})	Date when soluble solids was determined		
				Sept 7	Sept 21	Oct 5
1	Control	-	-	13.3 ab [y]	14.3 a	15.5 ab
2	AVG	5	125	13.0 ab	14.2 a	15.1 ab
3	AVG	4	125	12.5 b	14.4 a	14.6 ab
4	AVG	3	125	13.0 ab	13.7 a	15.2 ab
5	AVG	2	125	13.3 ab	13.8 a	15.3 ab
6	AVG	1	125	13.6 a	13.6 a	15.3 ab
7	AVG + NAA	4	125	13.1 ab	13.8 a	15.6 a
		2	10			
8	AVG + NAA	2	125	13.1 ab	13.9 a	15.1 ab
		2	10			
9	AVG + NAA	4	62.5	13.0 ab	14.1 a	15.3 ab
		2	10			
10	AVG + NAA	2	62.5	12.5 b	13.6 a	14.4 b
		2	10			
11	AVG	4	62.5	13.3 ab	14.3 a	15.5 ab
		2	62.5			
12	NAA	2	10	13.4 ab	14.4 a	15.6 a

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest.

[y] Mean separation within columns by Duncan's multiple range test, *P*=0.05.

Table 9. Effects of preharvest applications of AVG and NAA on starch of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH) [z]	Concentration (mg·L^{-1})	Date when starch (0-8) was determined		
				Sept 7	Sept 21	Oct 5
1	Control	-	-	4.04 a [y]	6.20 ab	7.58 a
2	AVG	5	125	3.00 de	5.52 bcde	7.10 bc
3	AVG	4	125	3.16 bcde	5.86 abcd	7.04 bc
4	AVG	3	125	3.44 b	5.62 bcde	7.08 bc
5	AVG	2	125	3.30 bcd	5.00 de	7.00 c
6	AVG	1	125	3.06 cde	5.16 cde	6.92 c
7	AVG + NAA	4 2	125 10	3.36 bc	5.52 bcde	7.04 bc
8	AVG + NAA	2 2	125 10	2.92 e	5.20 cde	6.94 c
9	AVG + NAA	4 2	62.5 10	3.50 b	5.90 abc	7.46 ab
10	AVG + NAA	2 2	62.5 10	3.00 de	4.86 e	6.82 c
11	AVG	4 2	62.5 62.5	3.18 bcde	5.76 abcd	7.16 bc
12	NAA	2	10	4.12 a	6.50 a	7.58 a

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest.

[y] Mean separation within columns by Duncan's multiple range test, P=0.05.

Table 10. Effects of preharvest applications of AVG and NAA on water core of 'Bisbee Delicious'/Mark apples (2010).

No	Treatment	Application time (WBH)[z]	Concentration ($mg \cdot L^{-1}$)	Date when water core (%) was determined		
				Sept 7	Sept 21	Oct 5
1	Control	-	-	10.0 abc [y]	38.0 ab	94.0 a
2	AVG	5	125	20.0 a	41.0 a	80.0 ab
3	AVG	4	125	1.0 c	40.0 a	68.0 b
4	AVG	3	125	11.0 abc	24.0 abc	75.0 ab
5	AVG	2	125	16.0 ab	13.0 cd	62.0 bc
6	AVG	1	125	4.0 bc	21.0 abcd	62.0 bc
7	AVG + NAA	4	125	4.0 bc	19.0 cde	60.0 bc
		2	10			
8	AVG + NAA	2	125	2.0 bc	19.0 cde	42.0 cd
		2	10			
9	AVG + NAA	4	62.5	2.0 bc	5.0 cd	80.0 ab
		2	10			
10	AVG + NAA	2	62.5	2.0 bc	1.0 d	32.0 d
		2	10			
11	AVG	4	62.5	0.0 c	24.0 abc	82.0 ab
		2	62.5			
12	NAA	2	10	0.0 c	16.0 cd	80.0 ab

[z] Full bloom occurred on April 8, 2010. Apples matured about one week ahead of the normal expected date for cultivar and rootstock. WBH = weeks before harvest.

[y] Mean separation within columns by Duncan's multiple range test, *P*=0.05.

Return Bloom Following Thinning in 2009

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This abstract and the work is dedicated to the memory of Dr. Rongcai Yuan

Thinning is essential in most years and on most varieties of apple. Early thinning can improve crop load, fruit size in the current growing season and return bloom in the year after thinning. Obtaining a good return bloom may be as important, if not more so, than reducing the current crop load. Environmental conditions in the eastern U.S. and especially in the mid-Atlantic can make thinning difficult. It is important that we continue the replicated evaluation of thinning agents to improve the efficacy of the chemical thinning process and thus the prospects for a good return bloom. This is part of that effort.

Carbaryl (Sevin XLR Plus) + 6-benzyladenine (6-BA, MaxCel) + oil, or naphthyleneacetic acid (NAA, Fruitone-L) + oil applied at various timings and rates to 'Delicious', 'Golden Delicious', 'Gala', and 'Pink Lady' provided adequate fruit thinning in 2009 and resulted in acceptable return bloom in 2010 (Tables 1, 2, 3, and 4). For most varieties thinning at about the 10 mm stage of growth produced the best results. For "Golden Delicious' (Table 2), application of thinners after the 15 mm fruit growth stage resulted in poor thinning and poor return bloom, but for 'Gala' (Table 3) and 'Pink Lady' (Table 4) the later timing (after 15 mm growth) did show some response to thinning and return bloom.

In contrast, 'Suncrisp', 'York', and 'Fuji', that responded well to carbaryl + 6-BA + oil in thinning showed poor return bloom (Tables 5, 6, and 7). In 'Suncrisp' despite significant thinning at the 8.4 mm fruit growth stage there was almost zero return bloom (Table 5). 'Suncrisp', 'York', and 'Fuji' are considered strongly biennial bearing and the results suggest that such cultivars may benefit most in terms of return bloom if thinned before the post petal fall stage of fruit development. Two sprays of NAA (10 ppm) + ethephon (450 ppm) applied about 5 to 7 weeks after bloom enhanced return bloom in 'York', but had no effect on return bloom in 'Fuji'.

Table 1. Influences of Sevin XLR Plus on fruit thinning of ‘**Delicious’/Mark** in 2009[X].

No	Color	Treatment	Rate		Time of Application		Fruit/cm^2 limb cross sectional area[Y]	Percent Return Bloom (0-10, 10 meaning All Clusters Flowering)
			Pint/100 gal	mL/gal	Date	Fruit size (mm)		
1	W/BK	Control	-	-	-	-	10.2 a[z]	2.0 b
2	RD	Sevin XLR	1	4.73	5/8	10	4.7 b	9.5 a
		+ 6-BA	1.5	7.09				
		+ Oil	4	18.92				

[X] Full bloom occurred on April 23, 2009.
[Y] Fruit/cm^2 limb cross sectional area were determined on June 6, 2009.
[Z] Mean separation within column by Duncan’s new Multiple Range Test.

Table 2. Influences of Sevin XLR Plus, 6-BA (MaxCel), and ethephon on fruit thinning of '**Golden Delicious'/M.9** in 2009[W].

No	Treatment	Rate		Time of Application		Fruit/cm² limb cross sectional area[Y]	Fruit weight (grams)[X]	Fruit length (cm)	Fruit diam (cm)	Stem-End Russet (0-5)	Side Russet (0-5)	Percent Return Bloom (0-10, 10 meaning All Clusters Flowering)
		Pint/100 gal	mL/gal	Date	Fruit size (mm)							
1	Control	-	-	-	-	9.8 a[z]	147.8 b	6.38 b	6.98 b	2.3 a	2.0 c	0.6 e
2	NAA (liquid) + Oil	0.22 4	1.08 18.92	4/30	Petal Fall	10.0 a	151.7 b	6.48 b	7.02 b	2.1 a	2.4 b	0.6 e
3	NAA (liquid) + Oil	0.22 4	1.08 18.92	5/12	10.3	3.5 b	203.4 a	7.14 a	7.74 a	1.9 ab	2.1 bc	7.1 a
4	Sevin XLR + 6-BA + Oil	1 2 4	4.73 9.95 18.92	5/12	10.3	4.0 b	202.6 a	7.18 a	7.73 a	2.1 a	2.6 a	6.1 ab
5	NAA (liquid) + Oil	0.22 4	1.08 18.92	5/18	15.3	8.7 a	154.2 b	6.53 b	7.09 b	1.9 ab	2.2 bc	4.6 bc
6	NAA (liquid) + Oil	0.22 4	1.08 18.92	5/24	20.7	7.8 a	155.3 b	6.54 b	7.07 b	1.7 b	2.0 c	3.2 cd
7	Sevin XLR + 6-BA + Oil	1 2 4	4.73 9.95 18.92	5/24	20.7	8.5 a	153.6 b	6.43 b	7.05 b	1.9 ab	2.0 c	1.3 de
8	Ethephon + Oil	1.5 4	6.997 18.92	5/24	20.7	9.1 a	150.3 b	6.39 b	7.01 b	2.2 a	2.1 bc	1.4 de

[W] Full bloom occurred on April 24, 2009.
[X] Fruit quality was determined on Sept 21 2009.
[Y] Fruit/cm² limb cross sectional area were determined on June 9, 2009.
[Z] Mean separation within column by Duncan's new Multiple Range Test.

Table 3. Influences of Sevin XLR, 6-BA (MaxCel), and ethephon on fruit thinning of '**Gala'/M.9** in 2009[W].

No	Treatment	Rate		Time of Application		Fruit/cm^2 limb cross sectional area[Y]	Fruit weight (grams)[X]	Fruit length (cm)	Fruit diam (cm)	Percent red color (0-100)	Fruit finish (0-5)	Percent return bloom (0-10, 10 meaning All Clusters Flowering)
		Pint/100 gal	mL/gal	Date	Fruit size (mm)							
1	Control	-	-	-	-	11.4 a[Z]	127.7 f	5.82 e	6.69 c	55.5 a	1.47 c	2.7 d
2	Sevin XLR	1	4.73	4/30	Petal Fall	1.6 e	187.2 a	6.87 a	7.42 a	62.0 a	1.71 ab	9.9 ab
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
3	Sevin XLR	1	4.73	5/5	8.3	1.9 e	182.5 ab	6.77 ab	7.35 a	67.0 a	1.75 a	10.0 a
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
4	Sevin XLR	1	4.73	5/8	10.1	3.0 de	174.3 bc	6.56 bc	7.30 a	66.0 a	1.54bc	9.1 ab
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
5	Sevin XLR	1	4.73	5/12	11.6	2.7 de	170.1 cd	6.56 bc	7.23 a	69.6 a	1.54 bc	9.2 ab
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
6	Sevin XLR	1	4.73	5/15	15.1	3.8 d	159.3 d	6.41 c	7.03 b	62.3 a	1.45 c	9.0 b
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
7	Sevin XLR	1	4.73	5/21	19.7	6.3 c	142.5 e	6.11 d	6.87 bc	54.6 a	1.40 c	3.9 c
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
8	Ethephon	1.5	6.997	5/21	19.7	9.0 b	137.5 ef	5.95 de	6.79 c	67.9 a	1.56 bc	4.0 c
	+ Oil	4	18.92									

[W] Full bloom occurred on April 23, 2009.
[X] Fruit quality were determined on August 21, 2009.
[Y] Fruit/cm^2 limb cross sectional area were determined on June 6, 2009.
[Z] Mean separation within column by Duncan's new Multiple Range Test.

Table 4. Influences of Sevin XLR, 6-BA (MaxCel), and ethephon on fruit thinning of ‘**Pink Lady’/M.9** in 2009[W] .

No	Treatment	Rate		Time of Application		Fruit/cm^2 limb cross sectional area [Y]	Fruit weight (grams)[X]	Fruit length (cm)	Fruit diam (cm)	Percent Red Color (0-100)	Fruit Finish (0-5)	Percent Return Bloom (0-10, 10 meaning All Clusters Flowering)
		Pint/100 gal	mL/gal	Date	Fruit size (mm)							
1	Control			-		7.7 a [Z]	116.5 d	6.00 cd	6.33 d	68.6 a	1.38 c	4.1 d
2	Sevin XLR	1	4.73	5/5	8.2	1.4 d	174.8 a	6.97 a	7.20 a	58.5 ab	1.88 a	8.9 a
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
3	Sevin XLR	1	4.73	5/5	8.2	1.2 d	169.4 ab	6.92 a	7.15 a	64.0 ab	1.77 ab	8.5 a
	+ 6-BA	1	4.97									
	+ Oil	4	18.92									
4	Sevin XLR	1	4.73	5/12	11.9	2.6 c	162.8 b	6.84 a	7.07 a	62.8 ab	1.34 c	8.4 a
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
5	Sevin XLR	1	4.73	5/18	17.0	6.9 ab	129.6 c	6.23 b	6.57 bc	70.4 a	1.20 c	4.9 c
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
6	Sevin XLR	1	4.73	5/21	19.6	5.8 b	129.7 c	6.22 b	6.62 b	62.8 ab	1.19 c	5.5 bc
	+ 6-BA	2	9.95									
	+ Oil	4	18.92									
7	Sevin XLR	2	9.46	5/21	19.6	6.6 ab	127.1 c	6.10 bc	6.59 b	52.3 b	1.27 c	5.5 bc
	+ 6-BA	4	19.9									
	+ Oil	4	18.92									
8	Ethephon	1.5	6.997	5/21	19.6	6.3 b	115.8 d	5.86 d	6.41 cd	59.4 ab	1.45 bc	5.8 b
	+ Oil	4	18.92									

[W] Full bloom occurred on April 22. 2009.
[X] Fruit quality were determined on October 26, 2009.
[Y] Fruit/cm^2 limb cross sectional area was determined on June 8, 2009.
[Z] Mean separation within column by Duncan’s new Multiple Range Test.

Table 5. Influences of Sevin XLR and 6-BA (MaxCel), on fruit thinning of '**Suncrisp'/M.9** in 2009[W].

No	Treatment	Rate: Pint/100 gal	Rate: mL/gal	Time of Application: Date	Time of Application: Fruit size (mm)	Fruit/cm^2 limb cross sectional area[Y]	Fruit weight (grams)[X]	Fruit length (cm)	Fruit diam (cm)	Stem-End Russet (0-5)	Side Russet (0-5)	Percent return bloom (0-10, 10 meaning All Clusters Flowering)
1	Control	-	-	-	-	11.9 a[Z]	145.3 c	6.15 c	7.00 c	2.05 a	3.07 a	0.07 a
2	Sevin XLR + Oil	1 4	4.73 18.92	5/8	8.4	7.4 b	191.1 b	6.79 b	7.67 b	2.16 a	3.19 a	0.12 a
3	Sevin XLR + 6-BA + Oil	1 1 4	4.73 4.73 18.92	5/8	8.4	6.2 b	195.3 b	6.87 b	7.78 ab	1.95 a	2.93 a	0.35 a
4	Sevin XLR + 6-BA + Oil	1 2 4	4.73 9.95 18.92	5/8	8.4	4.5 b	221.7 a	7.14 a	7.90 a	2.21 a	3.20 a	0.32 a

[W] Full bloom occurred on April 27, 2009.
[X] Fruit quality were determined on September 29, 2009.
[Y] Fruit/cm^2 limb cross sectional area were determined on May 26, 2009.
[Z] Mean separation within column by Duncan's new Multiple Range Test.

Table 6. Effects of early applications of NAA and ethephon on return bloom of **'York'/M.9** (2010).

No	Treatment	Rate	Time of Application		Flowering clusters/cm² limb cross sectional area[Y]	% Return bloom
			Date	Fruit Size (mm)		
1	Control	-	-	-	0.6 c[Z]	3 %
2	NAA + Ethephon (Dilute)	4 oz. + 1.5 pts 100 gal water	6/1 & 6/12	24.7 & 32.9	3.4 b	19 %
3	NAA + Ethephon (Concentrate)	8 oz. + 3 pts 50 gal water	6/1 & 6/12	24.7 & 32.9	2.1 bc	12 %
4	No blooms, 2009	-		-	17.9 a	100 %

[Y] Flowering clusters/cm² limb cross sectional area were determined on April 12, 2010.
[Z] Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

Table 7. Effects of early applications of NAA and ethephon on return bloom of **'Fuji'/M.9** (2010).

No	Treatment	Rate	Time of Application		Flowering clusters/cm² limb cross sectional area[Y]
			Date	Fruit Size (mm)	
1	Control	-	-	-	0.2 a[Z]
2	NAA + Ethephon (Dilute)	4 oz. + 1.5 pts 100 gal water	6/1 & 6/12	24.7 & 32.9	0.6 a
3	NAA + Ethephon (Concentrate)	8 oz. + 3 pts 50 gal water	6/1	24.7	0.8 a
4	NAA + Ethephon (Concentrate)	8 oz. + 3 pts 50 gal water	6/1 & 6/12	24.7 & 32.9	1.0 a

[Y] Flowering clusters/cm² limb cross sectional area were determined on April 12, 2010.

Does Oil Enhance an Apple Thinning Spray?

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Thinning young fruitlets is a critical task in apple production. Efficacy of plant growth regulators (PGRs) used for fruit thinning is influenced by many factors including the PGR used, stage of fruit development, environmental conditions (primarily temperature and light), crop load, tree age and vigor, and apple cultivar. Additives to the spray mixture, such as adjuvants or spray oils, have long been implicated as means to enhance the activity of PGR thinning sprays (Byers, 2003). While some evidence exists supporting this contention and many commercial thinning recommendations include the addition of an adjuvant or oil (Pfeiffer, 2010), the ability and consistency of a dormant spray oil to increase the activity of a thinning spray continues to be questioned. This paper reports a group of field trials with two common thinning PGRs with or without spray oil added. Some additional thinning studies conducted in 2009 and 2010 are included where oil was added to the post-bloom thinning sprays. These studies also included bloom or other apple thinning treatments.

All sprays were applied in the morning between 7 AM and 9 AM with a Durand-Wayland 3-pt hitch p.t.o. airblast sprayer. Seven apple cultivars were treated with thinners: ‘Sansa’, ‘Ultima Gala’, ‘Crimson Crisp’, ‘Hampshire’, ‘Autumn Rose Fuji’, ‘Enterprise’, and ‘Golden Delicious’. Trees ranged in age from 4th leaf through 9th leaf. The ‘Sansa’ and ‘Gala’ trees were on M.26 rootstock; all other trees were grafted to the B.9 rootstock. In 2009 the post-bloom sprays were applied on 13 May or 20 May. Post-bloom sprays were applied 4 May or 5 May in 2010. Eugenol bloom sprays were applied 14 Apr. 2010 on ‘Enterprise’ and ethephon was applied 13 May 2010. Average size of lateral fruits ranged from 9 mm to 12 mm for all treatments except where ethephon or carbaryl (Sevin XLR Plus) + oil was applied as a “rescue” thinner; these sprays were applied when fruit averaged about 18 mm diameter or slightly larger. Spray treatments were applied to whole trees in 3 randomized complete blocks with10-tree plots (except for ‘Golden Delicious’ which had 3-tree plots). At maturity fruit from whole trees were harvested, counted, sized and weighed, and trunk circumference recorded. When fruit reached a starch index rating of 4.0 or greater (on a scale of 1 to 8 where 1 = fully immature and 8 = fully over mature) they were considered mature. Crop load {fruit density [number fruit/cm^2 trunk cross-sectional area (TCSA)]} was calculated from fruit counts and trunk size measurements.

Temperatures in 2010 at the time of application of the 6-BA or NAA + carbaryl sprays were considered acceptable (Fig. 1) and daytime or night-time highs were not excessive, which can enhance thinner activity (Byers, 2003). Oil combined with 6-BA and carbaryl enhanced thinning in ‘Sansa’, but oil combined with NAA and carbaryl had no effect (Table 1). All treatments resulted in significant thinning in ‘Ultima Gala’ (Table 1). There was a slight, but non-significant crop load response when oil was added to either thinning mixture in ‘Ultima Gala’. The ‘Crimson Crisp’ trees had an acceptable crop load before thinning (5.7 fruit/cm^2 TCSA) (Table 2). All thinning treatments resulted in a reduction in crop load and there was no additional thinning when oil was added to the mixture. When the thinners were applied to 'Hampshire' all treatments reduced crop load compared to the control trees and the addition of oil to the 6-BA + carbaryl spray increased thinning (Table 2). There was a slight, but non-significant increase in thinning when oil was included in the NAA + carbaryl spray on 'Hampshire'. 6-BA + carbaryl had a slight but non-significant thinning effect on the 'Autumn Rose Fuji' but when oil was included in the spray mixture there was a significant thinning effect (Table 3). NAA + carbaryl with or without oil had no significant thinning activity on the 'Fuji' trees. The mixture of 6-BA + carbaryl + oil had no thinning effect on 'Golden Delicious' a somewhat surprising result (Table 4) since 'Golden Delicious' is usually responsive to 6-BA + carbaryl. A eugenol bloom spray at 3 % (3 gal/100 gal) significantly over thinned while a 1 % eugenol spray had no effect on crop load. Both 6-BA + carbaryl and NAA + carbaryl, with or without oil added, thinned 'Enterprise' apples in 2010 (Fig. 2). The addition of oil did not enhance the thinning activity of either mixture. In 'Enterprise' in 2010, 6-BA produced greater thinning activity than NAA. In 2009, 6-BA + carbaryl + the adjuvant Regulaid over-thinned and when oil was substituted for Regulaid, this mixture nearly defruited the 'Enterprise' trees (Fig. 3). Thinning with NAA + carbaryl + Regulaid was equal to the 6-BA + carbaryl + Regulaid mixture (Fig. 3).

These trials indicate that the addition of superior oil at 1 qt/100 gal. may enhance the thinning activity of post-bloom thinners such as 6-BA, carbaryl, or NAA, but many factors are involved and the activity of a chemical thinning spray with or without oil is not easily predicted. Among trials with 6-BA and carbaryl, 71% showed enhanced activity or a trend toward enhanced activity when oil was included. Among trials with NAA and carbaryl, 50% indicated a trend toward enhanced activity with oil, but none clearly demonstrated enhanced activity.

Literature Cited

Byers, R.E. 2003. Flower and fruit thinning and vegetative:fruiting balance. p. 409-436. In: D.C. Ferree and I.J. Warrington (eds.). Apples: botany, production and uses. CABI Publishing, MA.

Pfeiffer, D.G. (ed.). 2010. Virginia, West Virginia, and Maryland 2010 spray bulletin for commercial tree fruit growers. Virginia Coop. Ext. Publ. 456-419. pp.137-143.

Table 1. Effect of 6-BA or NAA plus carbaryl with or without dormant spray oil on crop load and fruit weight in 'Sansa' and 'Ultima Gala' apples on M.26 rootstock.

Treatment[z]	Rate of application (product/100 gal)	Crop load (fruit/cm^2 TCSA)	Fruit wt. (g)
		---------- 'Sansa' -------------	
Control	0	7.3 a	131 b
6-BA + carbaryl	2 qt. + 1 pt.	7.8 a	127 b
6-BA + carbaryl + oil	2 qt. + 1 pt. + 1 qt.	1.6 b	160 a
NAA + carbaryl	2 oz. + 1 pt.	4.5 ab	139 ab
NAA + carbaryl + oil	2 oz. + 1 pt. + 1 qt.	5.4 ab	146 ab
		--------- 'Ultima Gala' -----------	
Control	0	11.9 a	116 b
6-BA + carbaryl	2 qt. + 1 pt.	4.7 b	144 a
6-BA + carbaryl + oil	2 qt. + 1 pt. + 1 qt.	3.3 b	148 a
NAA + carbaryl	2 oz. + 1 pt.	4.4 b	145 a
NAA + carbaryl + oil	2 oz. + 1 pt. + 1 qt.	3.6 b	150 a

Sprays applied 4 May 2010 with airblast sprayer at 80 gpa (equivalent to calculated tree-row-volume). 6-BA was MaxCel, NAA was Fruitone-L, and carbaryl was Sevin XLR Plus; oil was 70-sec. superior spray oil. 'Sansa' lateral fruit at time of application averaged 11.5 mm diameter and 'Ultima Gala' were 10.5 mm average diameter. 'Sansa' harvested 3 Aug and 'Ultima Gala' harvested 17 Aug.

Table 2. Effect of 6-BA or NAA plus carbaryl with or without dormant spray oil on crop load and fruit weight in ‘Crimson Crisp’ and ‘Hampshire’ apples on B.9 rootstock.

Treatment[z]	Rate of application (product/100 gal)	Crop load (fruit/cm^2 TCSA)	Fruit wt. (g)
		------- ‘Crimson Crisp’ -------	
Control	0	5.7 a	130 c
6-BA + carbaryl	2 qt. + 1 pt.	1.8 b	146 b
6-BA + carbaryl + oil	2 qt. + 1 pt. + 1 qt.	1.6 b	144 b
NAA + carbaryl	2 oz. + 1 pt.	1.5 b	147 b
NAA + carbaryl + oil	2 oz. + 1 pt. + 1 qt.	1.6 b	163 a
		-------- ‘Hampshire’ -----------	
Control	0	11.4 a	123 c
6-BA + carbaryl	2 qt. + 1 pt.	7.7 b	165 b
6-BA + carbaryl + oil	2 qt. + 1 pt. + 1 qt.	3.9 c	183 a
NAA + carbaryl	2 oz. + 1 pt.	9.0 b	155 b
NAA + carbaryl + oil	2 oz. + 1 pt. + 1 qt.	6.7 b	170 ab

Sprays applied 4 May 2010 with airblast sprayer at 80 gpa (equivalent to calculated tree-row-volume). 6-BA was MaxCel, NAA was Fruitone-L, and carbaryl was Sevin XLR Plus; oil was 70-sec. superior spray oil. ‘Crimson Crisp’ lateral fruit at time of application averaged 9 mm diameter and ‘Hampshire’ were 11 mm average diameter. ‘Crimson Crisp’ harvested 26 Aug and ‘Hampshire’ harvested 15 Sept.

Table 3. Effect of 6-BA or NAA plus carbaryl with or without dormant spray oil on crop load and fruit weight in ‘Autumn Rose Fuji’ on B.9 rootstock.

Treatment[z]	Rate of application (product/100 gal)	Crop load (fruit/cm^2 TCSA)	Fruit wt. (g)
Control	0	10.7 a	118 b
6-BA + carbaryl	2 qt. + 1 pt.	7.4 ab	152 a
6-BA + carbaryl + oil	2 qt. + 1 pt. + 1 qt.	5.7 b	173 a
NAA + carbaryl	2 oz. + 1 pt.	7.6 ab	122 b
NAA + carbaryl + oil	2 oz. + 1 pt. + 1 qt.	9.7 a	145 ab

[z] Sprays applied 4 May 2010 with airblast sprayer at 80 gpa (equivalent to calculated tree-row-volume). 6-BA was MaxCel, NAA was Fruitone-L, and carbaryl was Sevin XLR Plus; oil was 70-sec. superior spray oil. ‘Autumn Rose Fuji’ lateral fruit at time of application averaged 11mm diameter. Fruit harvest 29 Sept.

Table 4. Effect of several bloom and post-bloom thinners on crop load and fruit weight in ‘Golden Delicious’/B.9, 2010.

Treatment[z]	Rate of application (product/100 gal)	Crop load (fruit/cm^2 TCSA)	Fruit wt. (g)
Control	0	12.1 a	105 a
Hand thinned	-----	6.3 cd	137 a
6-BA + carbaryl + oil	2 qt. + 1 pt. + 1 qt.	10.0 abc	128 a
Liquid lime sulfur	3 gal.	11.1 ab	115 a
Ammonium thiosulfate	6 gal.	7.6 bc	139 a
Eugenol	1 gal.	12.4 a	105 a
Eugenol	3 gal.	2.9 d	130 a

[z] Sprays applied with airblast sprayer at about 140 gpa, 10% above the calculated tree-row volume. Hand thinned 3 June; bloom thinners applied 12 Apr. (late full bloom); 6-BA (MaxCel) + carbaryl (Sevin XLR Plus) + oil applied 5 May when lateral fruit averaged 12 mm diameter. Fruit harvested 17 Sept.

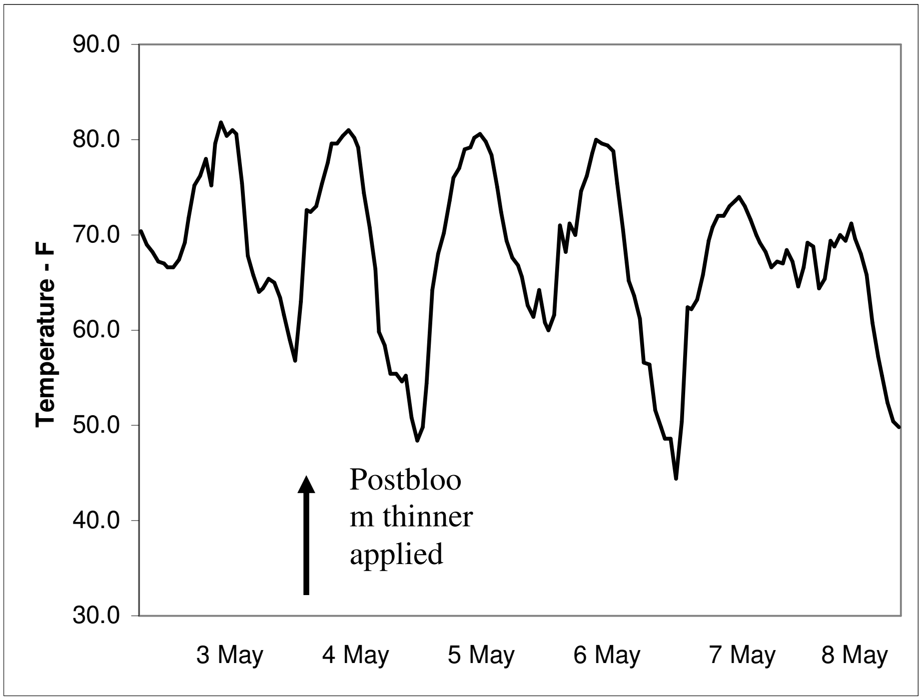

Fig. 1. Daily temperature plot for period 3 May though 8 May. Application of 6-BA or NAA plus carbaryl with or without oil on the morning of 4 May to ‘Sansa’, ‘Ultima Gala’, ‘Crimson Crisp’, ‘Hampshire’, and ‘Autumn Rose Fuji’. Post bloom treatments in 2010 to ‘Golden Delicious’ and ‘Enterprise’ (except ethephon applied 13 May) applied on 5 May.

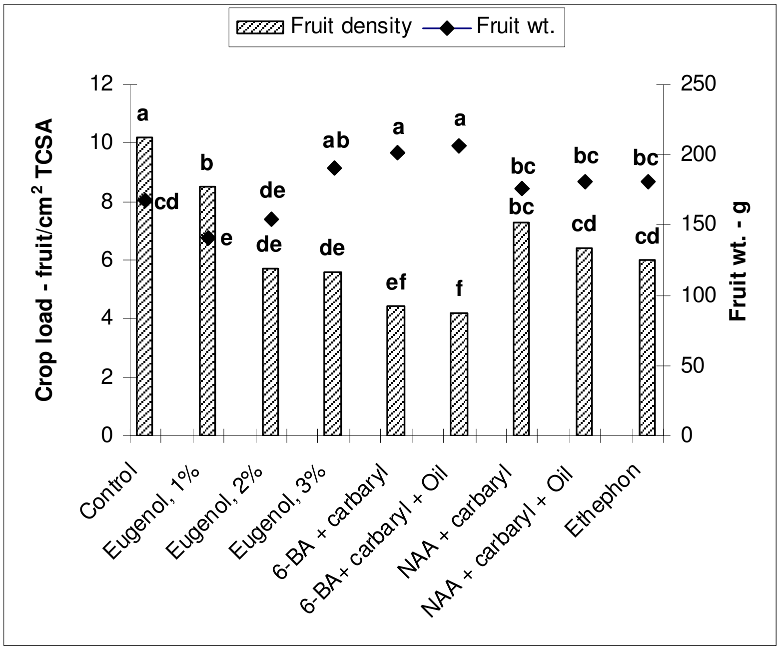

Fig. 2. Effect of several chemical thinners on crop load and fruit weight in 'Enterprise'/B.9 apples in 2010. Eugenol is a bloom thinner; 6-BA is MaxCel and carbaryl is Sevin XLR Plus; NAA is Fruitone-L.

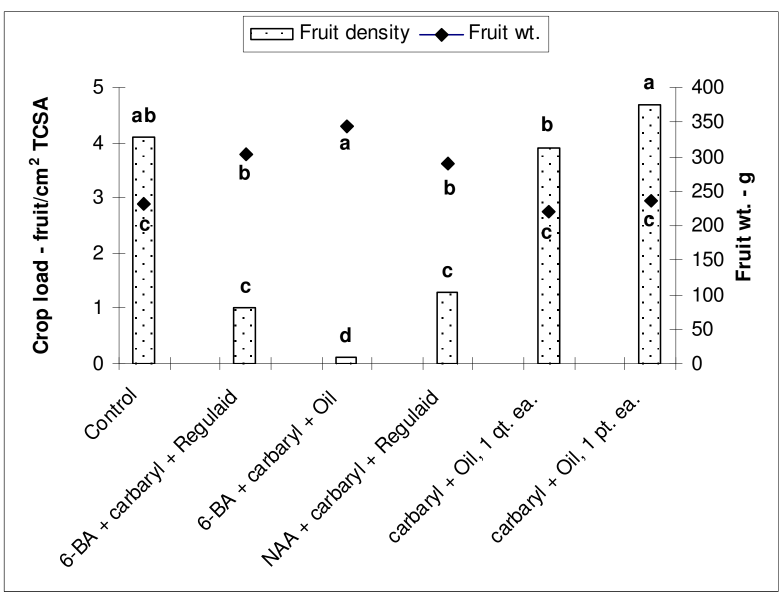

Fig. 3 Effect of several chemical thinners on crop load and fruit weight in 'Enterprise'/B.9 apples in 2009. 6-BA was MaxCel; carbaryl was Sevin XLR Plus; and NAA was Fruitone-L. Oil was 70-sec superior oil. The carbaryl + oil sprays were "rescue" thinners applied at the 18 mm stage.

Effect of Thinning Sprays Applied at Two Day Intervals on 'Delicious' and 'Gala' Apples.

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Successful chemical thinning in apple is dependent on a number of factors. Environmental conditions have long been associated with the chemical thinning response and are known to play a significant role along with the stage of fruit development, bloom density, tree vigor, tree age, and several other factors. Recommendations for chemical thinning in apple indicate that sprays can be applied from petal fall to after fruit have reached 20 mm size or slightly larger. However, most chemical sprays are recommended when fruit are about 10 to 12 mm in size. Applying the same spray treatment to different sets of comparable trees at two day intervals over a period from about 5 mm (near petal fall) to about 15 mm growth stage may reveal an optimum timing for application. The objective of this study was to evaluate the thinning response of 'Delicious' and 'Gala' apples when sprayed at 2-day intervals beginning at late petal fall.

Mature 'Bisbee Delicious'/MARK and 'Gala'/M.9 trees were chosen for the study. Sprays were applied dilute with a handgun at moderate pressure to the point of first drip. 'Bisbee Delicious' had six whole-tree reps per treatment and 'Gala' had five whole-tree replications per treatment. For the 'Bisbee Delicious' the thinning spray treatment was 6-benzyladenine (6-BA, MaxCel) + carbaryl (Sevin XLR) + oil at 100 ppm + 1 pt/100 gal. + 2 qts/100 respectively. The first spray was applied on 22 Apr. when fruit averaged 6.15 mm diameter and the last spray was applied on 5 May when fruit averaged 13.7 mm diameter. The same spray treatment was applied to 'Gala' on the same dates. 'Gala' apples averaged 5.93 mm diameter on 22 Apr. and 14.62 mm on 5 May. In addition, a second treatment was applied to 'Gala' in which the 6-BA was replaced by 5 ppm naphthaleneacetic acid (NAA, Fruitone-L). The daily mean temperature was calculated from the high and low temperature reading for that day. Fruit density (or crop load) (fruit/cm^2 cross-sectional area) was determined on 18 May for 'Bisbee Delicious' and 19 May for 'Gala'.

All treatments reduced crop load In 'Bisbee Delicious' compared to the unsprayed check (Table 1). Treatment between the 7.75 mm stage (27 Apr.) and the 9.56 mm stage (1 May) severely over thinned the 'Bisbee Delicious' trees. This period was associated with a sharp rise in the daily mean temperature (Fig. 1). On 1 May the mean daily temperature reached about 23.3°C (74°F) from a mean low of about 11.1°C (52°F) on 27

Apr. Many recommendations for thinning focus on a fruit size of 10 to 12 mm as optimum for response to 6-BA and carbaryl (Sevin), but the present data suggests temperature patterns may have a greater impact on the thinning response than fruit size. In this test, 'Delicious" was very sensitive to the thinning treatment between about 8 and 10 mm stage. 'Delicious' was also responsive between about 12 and 14 mm size.

Application of 6-BA + carbaryl + oil on 'Gala' over thinned when sprays were applied between 27 Apr. and 1 May, a response similar to that observed in the 'Bisbee Delicious' (Table 2). When NAA was substituted for 6-BA, significant thinning occurred, but not to the extent seen with 6-BA. However, more thinning did occur just prior to and during the warm period (Fig. 2), similar to that observed in 'Delicious'. Thinning improved fruit size of 'Gala' compared to the control fruit, except for the final spray treatment on 5 May when the fruit had reached 14.56 mm diameter. Neither the 6-BA + Sevin + oil or the NAA + Sevin + oil treatment on this date increased size over the control fruit despite a significant reduction in crop load.

These tests demonstrate that 'Delicious' and 'Gala' are sensitive to these combinations of thinning chemicals over a wide range of fruit sizes beginning about petal fall (about 5 mm) to about 15 mm stage and support earlier findings (Byers, 2003) that elevated temperatures soon after thinner application can significantly increase the thinning response.

Literature Cited

Byers, R.E. 2003. Flower and fruit thinning and vegetative:fruiting balance. p. 409-436. In: D.C. Ferree and I.J. Warrington (eds.). Apples: botany, production and uses. CABI Publishing, MA.

Table 1. Influences of 6-BA with Sevin XLR on fruit thinning of '**Bisbee Delicious'/Mark** in 2010[Z].

No	Color	Treatment[Y]	Rate of 6-BA	Time of Application		Fruit/cm² limb cross sectional area[X]
			ppm	Date	Fruit size (mm)	
1	W	Control	-		-	3.92 a[W]
2	R	6-BA + Sevin XLR + Oil[X]	100	4/22/10	6.15	0.92 d
3	FO	6-BA + Sevin XLR + Oil	100	4/24/10	6.61	0.59 d
4	Y	6-BA + Sevin XLR + Oil	100	4/27/10	7.75	0.09 e
5	RD	6-BA + Sevin XLR + Oil	100	4/29/10	8.26	0.01 e
6	OBKS	6-BA + Sevin XLR + Oil	100	5/1/10	9.56	0.10 e
7	PBKD	6-BA + Sevin XLR + Oil	100	5/3/10	11.61	1.37 c
8	CKR	6-BA + Sevin XLR + Oil	100	5/5/10	13.7	3.20 b

[Z] Mature 'Bisbee Delicious'/Mark (17 to 23 years old). Full bloom occurred on April 8, 2010.
[Y] 6 replications. Sevin at 1 pt with 2 qt of oil. Sevin was Sevin XLR Plus.
[X] Fruit/cm² limb cross sectional area determined on May 18, 2010.
[W] Mean separation within column by Duncan's new Multiple Range Test.

Table 2. Influences of 6-BA and NAA with Sevin XLR on fruit thinning of '**Gala'/M. 9** in (2010)[Z].

No	Color	Treatment[Y]	Rate	Time of Application		Fruit/cm^2 limb cross sectional area[W]	Fruit size at harvest (inch)
			ppm	Date	Fruit size (mm)		
1	W	Control	-		-	8.81 a[V]	2.58 f
2	R	6-BA + Sevin + Oil[X]	100	4/22/10	5.93	3.08 cd	2.80 bcd
3	B	NAA + Sevin + Oil	5	4/22/10	5.93	3.81 c	2.74 cde
4	FO	6-BA + Sevin + Oil	100	4/24/10	6.21	2.69 cd	2.83 abc
5	HP	NAA + Sevin + Oil	5	4/24/10	6.21	3.7 c	2.78 cde
6	Y	6-BA + Sevin + Oil	100	4/27/10	7.76	0.68 e	2.90 ab
7	PUR	NAA + Sevin + Oil	5	4/27/10	7.76	2.7 cd	2.80 bcd
8	RD	6-BA + Sevin + Oil	100	4/29/10	8.25	0.6 e	2.94 a
9	BKD	NAA + Sevin + Oil	5	4/29/10	8.25	2.26 cde	2.84 abc
10	OBKS	6-BA + Sevin + Oil	100	5/1/10	9.56	0.55 e	2.92 a
11	PBKS	NAA + Sevin + Oil	5	5/1/10	9.56	1.43 de	2.91 ab
12	PBKD	6-BA + Sevin + Oil	100	5/3/10	12.5	3.49 c	2.75 cde
13	YRD	NAA + Sevin + Oil	5	5/3/10	12.5	3.59 c	2.70 de
14	CKR	6-BA + Sevin + Oil	100	5/5/10	14.62	5.74 b	2.68 ef
15	CKY	NAA + Sevin + Oil	5	5/5/10	14.62	4.02 c	2.68 ef

[Z] Full bloom occurred on April 9, 2010. Trees 10 yrs old.
[Y] 5 replications.
[X] Sevin was liquid Sevin XLR Plus. Sevin at 1 pt with 2 qt of oil.
[W] Fruit/cm^2 limb cross sectional area were determined on May 19, 2010.
[V] Mean separation within column by Duncan's new Multiple Range Test, P =0.05.

Fig.1 Effect of 6-BA on fruit thinning in 'Red Delicious' apples (Mark, 2010)

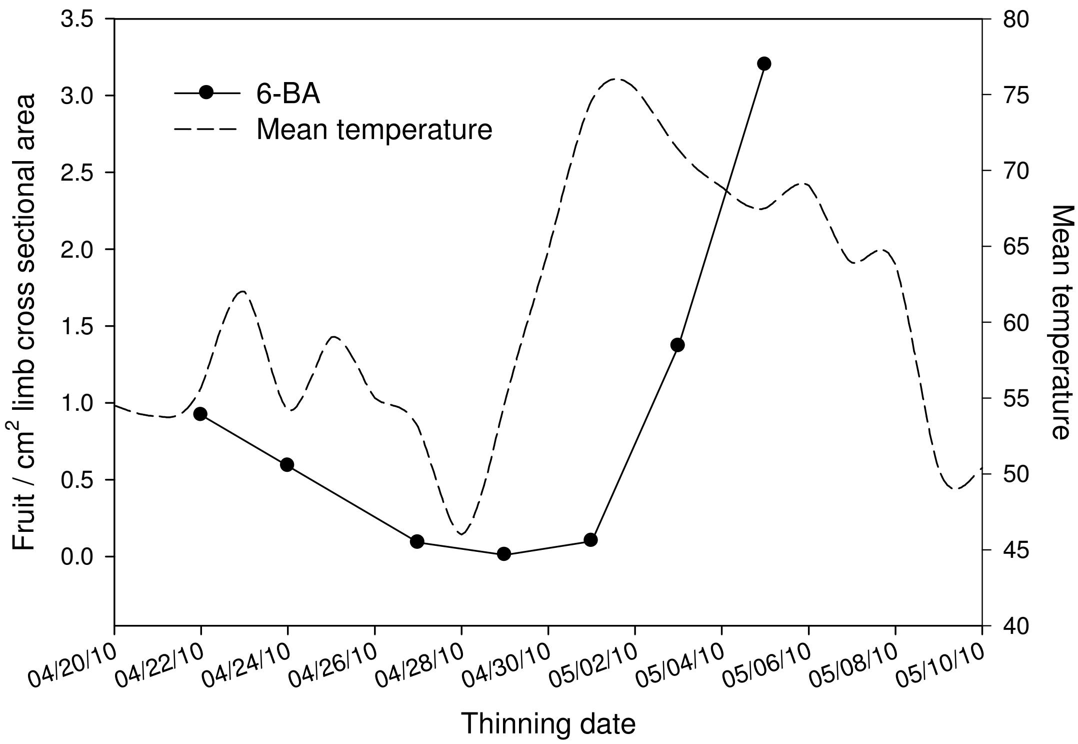
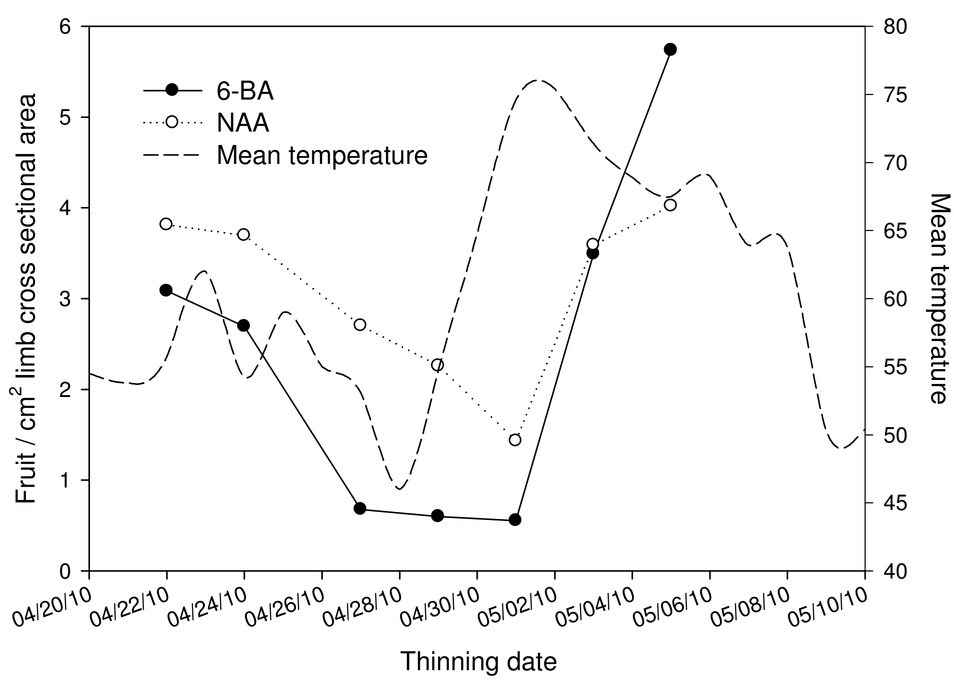


Fig. 2 Effect of 6-BA and NAA on fruit thinning in 'Gala' apples (M.9, 2010)



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*
Fruit finish

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Evaluation of experimental fungicides and mixed schedules on Stayman, Idared, and Granny Smith apples, 2010.

Ten combination treatments directed at fungicide resistance management approaches and broad-spectrum control, including several experimental materials were tested on 24-yr-old trees in an area where scab fungus resistance to SI fungicides has been suspected since 2004 (Figures 1 & 2). 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 2009 to stabilize mildew inoculum pressure for 2010. 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: 1 Apr (1/2" green-tight cluster, TC); 12 Apr (late bloom, Bl); 23 Apr (petal fall); 1st – 6th covers*:* 5 May, 20 May, 3 Jun, 25 Jun, 15 Jul and 5 Aug. Maintenance materials applied to the entire test block with the same equipment included Supracide 3 pt + oil, Assail, NAA 10 ppm + Sevin 2 pt + Regulaid, Imidan, Provado, Intrepid, Delegate, and Calypso. Inoculum over each Idared test tree included: cedar rust galls placed 8 Apr and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies placed 12 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 28 Jun (Idared), 12 Jul (Stayman), or 25 Aug (Granny Smith). Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 20 Sep (Idared), 4 Oct (Stayman) or 18 Oct (Granny Smith). Percentage data were converted by the square root arcsin transformation for statistical analysis.

The likelihood of powdery mildew resistance to SIs at Winchester became evident during 2009 (Figures 3 & 4). In this test block, control of powdery mildew by Nova (myclobutanil) 4 oz/A, based on percent leaves infected, ranged from 72-98% from 1994-2003. In 2009-10 control by Rally 5 oz/A of percent leaves infected by mildew was only 12%. In 2009, a higher Rally rate (7.5 oz/A) gave only slightly better control than the more typical 5 oz/A, further suggesting mildew resistance to SIs (Figure 3). In 2010, mildew conidia were available on infected emerging buds 30 Mar, and 45 of the 61 days in April and May were favorable for mildew infection. Qualitative assessment of treatment effects (first data column, Table 1) on primary powdery mildew development, showed excellent effects by Topguard (+ captan, Trt. 4) and Luna Sensation (Trt. 5). Luna Sensation gave the best mildew control overall. Topguard combinations and Fontelis + oil also showed good control in several mildew rating categories. Based on percent leaves infected, the "old standard" Rally (Trt. 1), did not give control that was significantly different (p=0.05) from non-treated Idared trees and was generally the weakest treatment overall. All treatments gave significant control of leaf area and most gave significant control of percent fruit infected. Treatments 6-8 & 10 lacked some early mildew control because they started the season at tight cluster with Manzate + Vangard for scab control rather than with an effective mildew fungicide. SI resistance in the scab fungus has been present in the test area since 2004 but this was adequately covered by inclusion of the protectant fungicide mancozeb or captan (Table 2). The protectant fungicides also protected against Brooks spot. Foliar cedar-apple rust infection was light and all treatments gave significant control. With the fewest cumulative wetting hours in at least the past 17 years, summer disease pressure was light and under these conditions all treatments, covered in the late sprays by Captan + Ziram, gave significant control of sooty blotch and flyspeck (Table 3). Apart from what was judged to be mildew russetting, there was no significant reduction in fruit finish by any treatment and several treatments had a positive effect on russet or opalescence compared to non-treated fruit.

Table 1. Powdery mildew control on Stayman, Idared, and Granny Smith apples, 2010. Block #13.

	Treatment and formulated rate/acre	Timing	Idared primary effect*	% leaves or leaf area or fruit infected ** Idared leaves	Idared area	Idared fruit	Stayman lvs	Stayman area	Stayman fruit	Granny Smith lvs	Granny Smith area	Granny Smith fruit
0	No fungicide	---	1.6 f	70 f	50 f	52 d	73 d	39 e	28 d	83 e	48 f	77 d
1	Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	TC-3C	3.9 e	62 ef	17 e	36 bc	63 c	14 d	8 c	70 d	14 e	15 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										
2	Flint 50WG 2 oz + Manzate Pro-Stick 3 lb	TC-3C	6.3 bc	54 de	9 cd	22 a	47 b	7 bc	6 bc	56 bc	8 bc	30 c
	Captan 80WDG 30 oz + Ziram 3 lb	4C →										
3	Topguard 13 fl oz + Manzate Pro-Stick 3 lb	TC-3C	6.4 bc	43 bc	7 bc	25 ab	50 b	7 bc	1 a	49 bc	7 b	22 bc
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										
4	Topguard 13 fl oz + Captan 80WDG 2.5 lb	TC-3C	8.1 a	42 bc	6 b	31 a-c	49 b	7 bc	6 bc	48 bc	6 b	26 bc
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										
5	Luna Sensation 500SC 5 fl oz	TC-3C	7.5 ab	21 a	2 a	26 ab	34 a	3 a	7 c	28 a	4 a	4 a
	Captan 80WDG 30 oz + Ziram 3 lb	4C →										
6	Manzate Pro-Stick 75WG 4 lb + Vangard 4 oz	TC										
	Fontelis 200SC 20 fl oz	BI-1C	5.0 c-e	42 bc	6 b	51 d	52 b	7 bc	2 ab	53 bc	10 c-e	24 bc
	Manzate Pro-Stick 75WG 6 lb	2C										
	Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3C										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										
7	Manzate Pro-Stick 75WG 4 lb + Vangard 4 oz	TC										
	Fontelis 200SC 20 fl oz/A + Damoil 1 gal	BI-1C	5.6 cd	42 bc	7 bc	20 a	48 b	6 ab	8 c	50 bc	8 bc	26 bc
	Manzate Pro-Stick 75WG 6 lb	2C										
	Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3C										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										
8	Manzate Pro-Stick 75WG 4 lb + Vangard 4 oz	TC										
	Fontelis 14 fl oz/A + Manzate 3 lb+ Damoil 1 gal/100 gal	BI-1C	4.4 de	50 b-d	11 d	45 cd	53 b	10 cd	6 bc	60 cd	12 de	26 bc
	Manzate Pro-Stick 75WG 6 lb	2C										
	Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3C										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										
9	Fontelis 200SC 20 fl oz/A + Damoil 1 gal/100 gal	TC-2C	5.5 cd	39 b	6 b	27 ab	45 b	6 ab	5 a-c	45 b	7 bc	20 bc
	Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3C										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										
10	Manzate Pro-Stick 75WG 4 lb + Vangard 4 oz	TC										
	Flint 50WG 2 oz	BI-1C	4.5 de	51 cd	11 d	36 bc	54 bc	8 bc	7 c	53 bc	10 cd	27 bc
	Manzate Pro-Stick 75WG 6 lb	2C										
	Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3C										
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →										

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications. Treatment rows were used as non-treated border rows in 2009 to stabilize mildew inoculum pressure for 2010. Applied airblast at 100 gpa to both sides of the row on each date.

**Apparent suppressive effect rated on six Idared primary mildew shoots / tree, four reps 29 Jun: scale 1-10 (1= none; 10= excellent effect).*

** Infection rated on 10 shoots/tree 28 Jun (Idared), 12 Jul (Stayman), or 25 Aug (Granny Smith), or 25-fruit samples picked from each of four single-tree reps 20 Sep (Idared), 4 Oct (Stayman) or 18 Oct (Granny Smith).

Table 2. Scab and cedar rust control on Stayman, Idared and Granny Smith apples, 2010. Block #13.

		Scab, % leaves infected			Scab, % fruit infected**			% lvs c-a rust	Brooks spot, %	
Treatment and formulated rate/acre	Timing	Stayman	Idared	Granny Smith	Stayman	Idared	Granny Smith	Idared	Stayman	Idared
0 No fungicide	---	37 f	16 d	49 f	68 c	57 c	65 d	7 d	2 a	10 b
1 Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-3C 4C →	14 e	4 c	14 e	2 ab	2 ab	5 c	<1 a	0 a	0 a
2 Flint 50WG 2 oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 3 lb	TC-3C 4C →	2 ab	<1 a	3 ab	0 a	0 a	1 ab	0 a	0 a	0 a
3 Topguard 13 fl oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-3C 4C →	8 cd	2 bc	9 de	4 b	0 a	3 a-c	<1 a	0 a	0 a
4 Topguard 13 fl oz + Captan 80WDG 2.5 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-3C 4C →	5 bc	<1 a	5 bc	2 ab	1 ab	3 a-c	0 a	0 a	0 a
5 Luna Sensation 500SC 5 fl oz Captan 80WDG 30 oz + Ziram 3 lb	TC-3C 4C →	1 a	<1 a	2 a	0 a	3 ab	2 a-c	0 a	0 a	0 a
6 Manzate Pro-Stick 75WG 4 lb + Vangard 75WG 4 oz Fontelis 200SC 20 fl oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC BI-1C 2C 3C 4C →	10 de	<1 ab	9 de	3 ab	4 b	6 c	2 bc	0 a	1 a
7 Manzate Pro-Stick 75WG 4 lb + Vangard 75WG 4 oz Fontelis 200SC 20 fl oz/A + Damoil 1 gal/100 gal Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC BI-1C 2C 3C 4C →	8 cd	1 ab	10 de	3 ab	6 b	4 bc	3 c	1 a	0 a
8 Manzate Pro-Stick 75WG 4 lb + Vangard 75WG 4 oz Fontelis 14 fl oz/A + Manzate 3 lb +Damoil 1 gal/100 gal Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC BI-1C 2C 3C 4C →	5 bc	1 ab	7 cd	4 b	3 ab	5 bc	<1 a	0 a	0 a
9 Fontelis 200SC 20 fl oz/A + Damoil 1 gal/100 gal Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC-2C 3C 4C →	4 b	<1 a	5 bc	3 ab	4 b	0 a	<1 ab	0 a	0 a
10 Manzate Pro-Stick 75WG 4 lb + Vangard 75WG 4 oz Flint 50WG 2 oz Manzate Pro-Stick 75WG 6 lb Rally 40WSP 5 oz + Manzate Pro-Stick 75WG 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	TC BI-1C 2C 3C 4C →	5 bc	<1 ab	6 b-d	3 ab	2 ab	1 ab	<1 ab	0 a	0 a

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

** Infection rated on 10 shoots/tree 28 Jun (Idared), 12 Jul (Stayman), or 25 Aug (Granny Smith), or 25-fruit samples picked from each of four single-tree reps 20 Sep (Idared), 4 Oct (Stayman) or 18 Oct (Granny Smith).

Table 3. Control of Brooks spot and rots, and fruit finish effects by fungicides on Stayman, Idared, and Granny Smith apples, 2010.

		% fruit infected, postharvest counts						Fruit finish ratings (0-5)*				
		Sooty blotch			Flyspeck			Russet		Opalescence		
Treatment and rate/A		Stayman	Idared	Granny	Stayman	Idared	Granny	Stayman	Granny	Stayman	Idared	Granny
0 No fungicide	---	96 c	81 c	90 b	18 c	13 c	14 b	2.3 c	1.4 c	1.3 b	1.7 e	1.3 b
1 Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	TC-3C							1.8 a-c	1.1 ab	1.3 b	0.9 a-c	1.1 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	23 ab	27 b	10 a	2 ab	0 a	3 a					
2 Flint 50WG 2 oz + Manzate Pro-Stick 3 lb	TC-3C							2.0 a-c	0.9 ab	1.4 b	0.8 ab	0.9 ab
Captan 80WDG 30 oz + Ziram 3 lb	4C →	27 b	10 ab	4 a	0 a	1 ab	0 a					
3 Topguard 13 fl oz + Manzate Pro-Stick 3 lb	TC-3C							1.9 a-c	1.0 ab	1.3 b	0.7 a	0.8 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	22 ab	4 a	5 a	3 ab	1 ab	0 a					
4 Topguard 13 fl oz + Captan 80WDG 2.5 lb	TC-3C							2.1 c	1.0 ab	1.4 b	1.0 a-d	0.8 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	13 ab	9 ab	4 a	0 a	0 a	0 a					
5 Luna Sensation 500SC 5 fl oz	TC-3C							1.5 a	0.8 a	0.7 a	0.9 a-d	0.8 a
Captan 80WDG 30 oz + Ziram 3 lb	4C →	22 ab	13 ab	6 a	1 ab	0 a	1 a					
6 Manzate Pro-Stick 4 lb + Vangard 4 oz	TC											
Fontelis 200SC 20 fl oz	BI-1C											
Manzate Pro-Stick 75WG 6 lb	2C							1.9 a-c	0.9 a	1.3 ab	1.1 cd	0.9 ab
Rally 5 oz + Manzate Pro-Stick 3 lb	3C											
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	30 b	23 b	13 a	1 ab	0 a	2 a					
7 Manzate Pro-Stick 4 lb + Vangard 4 oz	TC											
Fontelis 20 fl oz/A + Damoil 1 gal/100 gal	BI-1C											
Manzate Pro-Stick 75WG 6 lb	2C							2.1 bc	0.9 a	1.3 b	1.1 b-d	0.7 a
Rally 5 oz + Manzate Pro-Stick 3 lb	3C											
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	35 b	7 ab	7 a	4 ab	0 a	1 a					
8 Manzate Pro-Stick 4 lb + Vangard 4 oz	TC											
Fontelis 14 fl oz/A + Manzate 3 lb + Damoil	BI-1C											
Manzate Pro-Stick 75WG 6 lb	2C							2.0 a-c	1.3 bc	1.4 b	1.0 a-d	1.1 ab
Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3C											
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	7 a	13 ab	4 a	2 ab	0 a	0 a					
9 Fontelis 200SC 20 fl oz/A + Damoil 1 gal	TC-2C							1.6 ab	1.0 ab	1.0 ab	1.1 b-d	0.9 ab
Rally 40WSP 5 oz + Manzate Pro-Stick 3 lb	3C											
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	27 ab	20 ab	8 a	6 b	3 b	3 a					
10 Manzate Pro-Stick 4 lb + Vangard 4 oz	TC											
Flint 50WG 2 oz	BI-1C											
Manzate Pro-Stick 75WG 6 lb	2C											
Rally 5 oz + Manzate Pro-Stick 3 lb	3C							1.8 a-c	1.0 ab	1.0 ab	1.2 d	1.0 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	24 ab	15 ab	8 a	3 ab	0 a	2 a					

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Postharvest counts of 25 fruit from each of four replications.
Postharvest counts of 25-fruit samples picked from each of four replications 20 Sep (Idared), 4 Oct (Stayman) or 18 Oct (Granny Smith).
* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe opalescence or russet, not presumed to be related to mildew).

Figure 1. 17-yr history of foliar scab control with SI+EBDC Stayman apple, Winchester, VA

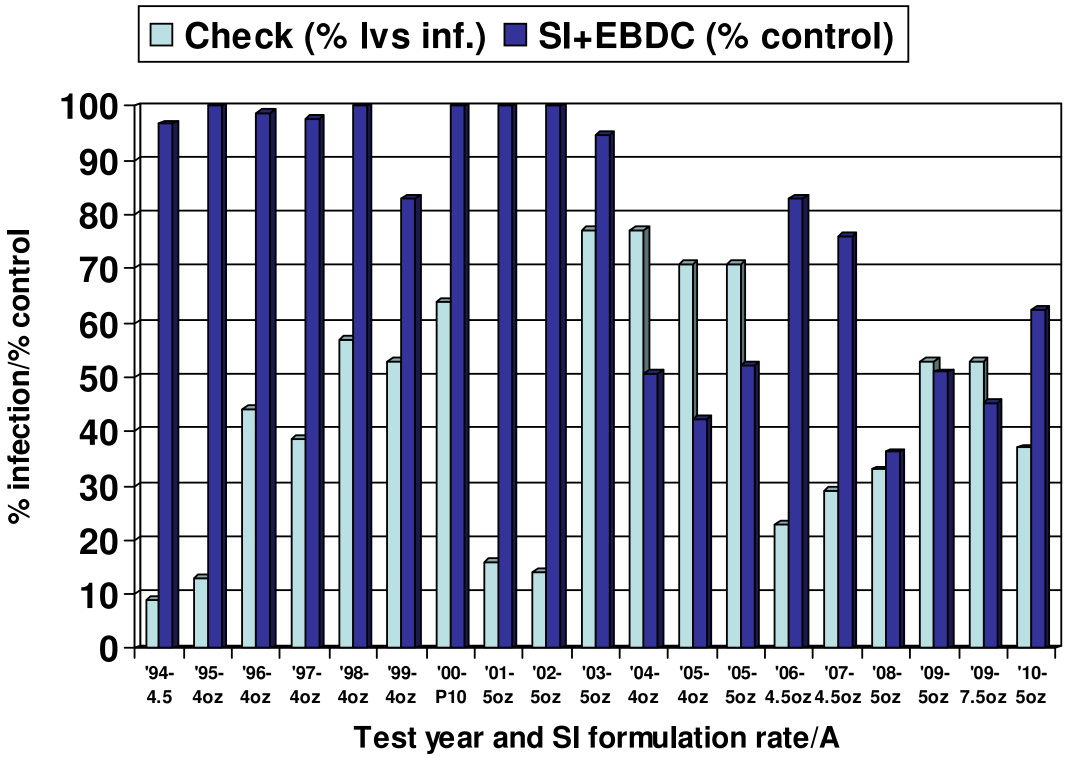


Figure 2. 17-yr history of fruit scab control with SI+EBDC Stayman apple, Winchester, VA

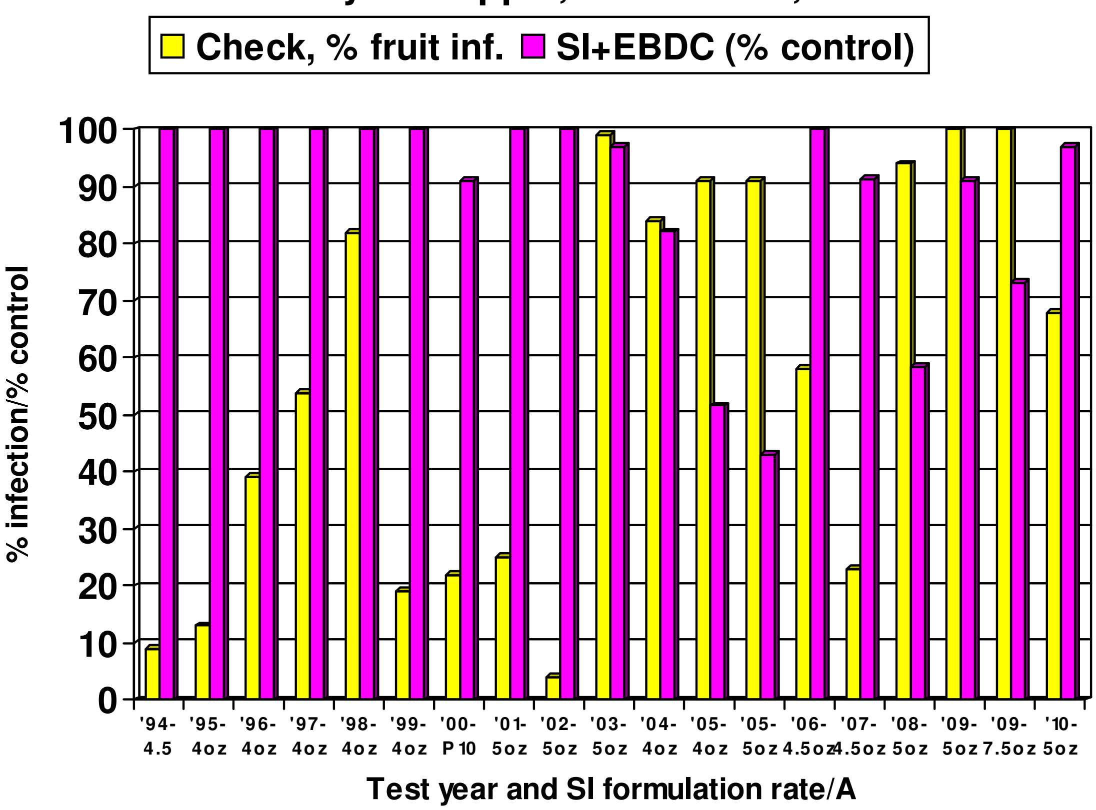


Figure 3. Control of % leaves infected with mildew by SI+EBDC and QoI

Stayman and Idared apples, 1994-2010, Winchester, VA

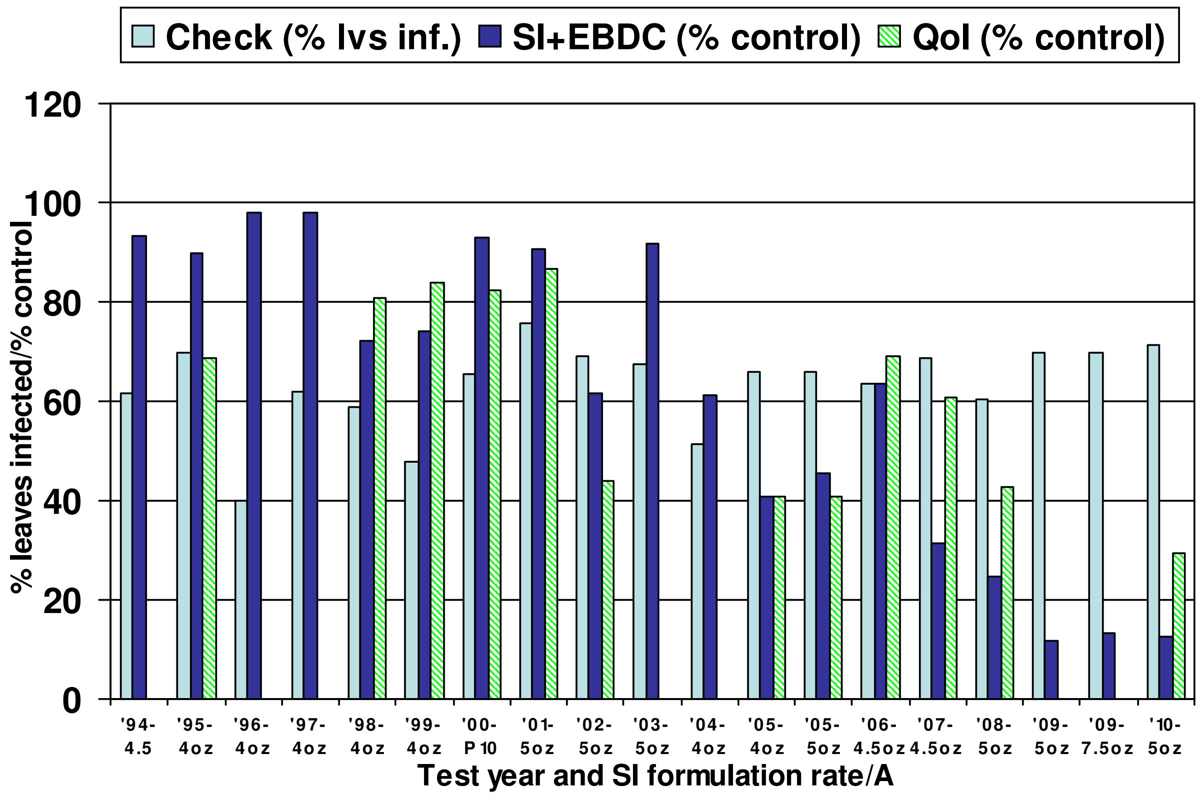
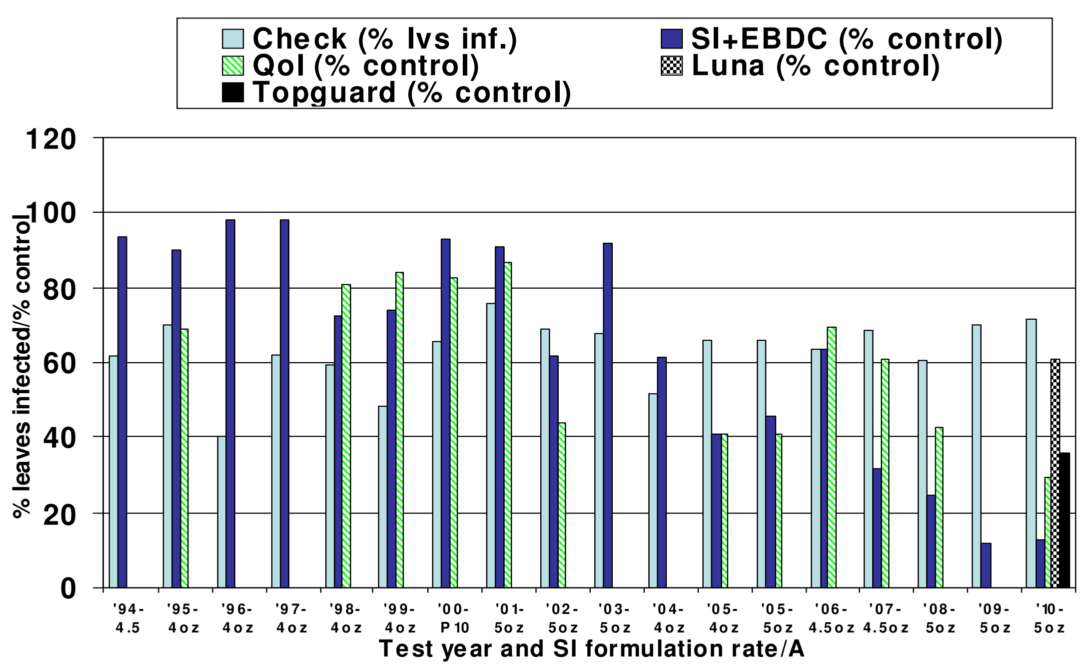


Figure 4. Control of % leaves infected with mildew by SI+EBDC and other fungicides

Stayman and Idared apples, 1994-2010, Winchester, VA



APPLE (*Malus domestica* ''Idared')
Powdery mildew; *Podosphaera leucotricha*
Scab; *Venturia inaequalis*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Fruit finish

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Control of powdery mildew and other diseases by experimental fungicides and mixed schedules on Idared apples, 2010.

Sixteen experimental and registered combination treatments were directed at powdery mildew control in an area where SI fungicide effectiveness is declining. The test was established as four randomized blocks on 28-yr-old trees using single-tree replications with border rows between treatment rows. Treatment rows had been used as non-treated border rows in 2009 to stabilize mildew inoculum pressure for 2010. 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 (tight cluster); 12 Apr (bloom-petal fall); 1st through 7th covers (1C-7C): 23 Apr, 7 May, 20 May, 3 Jun, 18 Jun, (7th app, 5th cover), 8 Jul and 12 Aug. Maintenance materials applied to the entire test block with the same equipment included Supracide 3 pt + oil, FireWall, Assail, Imidan, Provado, Intrepid, Delegate and Calypso. Wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies were placed as inoculum over each Idared test tree 4 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten terminal shoots per tree 14 Jun. Apparent suppressive effect on appearance of primary mildew was rated on six primary mildew shoots / tree, 29 Jun using a scale of 1-10 (1= none; 10= excellent effect). Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 22 Sep and placed in cold storage until evaluation 14 Oct. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The possibility of powdery mildew resistance to SIs at Winchester became evident during 2009. In this test block, control of powdery mildew by Nova (myclobutanil) 4 oz/A, based on percent leaves infected, ranged from 75-95%. In 2010, control by Rally (myclobutanil) 5 oz/A of percent leaves infected by mildew was only 8%. In 2010, mildew conidia were available on infected emerging buds 30 March, and 45 of the 61 days in April and May were favorable for mildew infection. Qualitative assessment of treatment effects (first data column, Table 1) on primary powdery mildew development, showed excellent effects by Topguard (Trt. 14) and Luna Sensation/Indar treatments (#6-8). Generally, these treatments also gave the best mildew control overall. Based on percent leaves infected, several registered treatments (#1-5), involving combinations of Rally, Sulfur and Flint, did not give control that was significantly different (p=0.05) from non-treated trees. Under this heavy disease pressure it is more appropriate to base comparative effectiveness on percent leaf area infected. All treatments gave significant control of leaf area and percent fruit infected. Luna Sensation treatments (#7 & 8) gave outstanding suppression of mildew infection of fruit. Sulfur (#5) and GWN-4617, in combination with Penncozeb (#12), had the weakest effect on primary powdery mildew, and generally, the weakest mildew control overall. Among the older registered materials, (#1-5), the combination of Flint + Sulfur gave the best control of percent leaf area and percent fruit infected. SI resistance in the scab fungus has been present in the area in 2004. Foliar scab and cedar-apple rust infection were light but fruit scab infection reached 23% of non-treated fruit (Table 2). Under these conditions, all treatments gave significant control but there were notable weaknesses by Rally + Sulfur (#2) and Flint + LI6262 (#10), which was significantly weaker than Flint alone (#9). With the fewest cumulative wetting hours in at least the past 17 years, summer disease pressure was light and under these conditions all treatments gave adequate control. Apart from what was judged to be mildew russetting, there was no significant difference in fruit finish of fruit by any treatment compared to non-treated fruit.

Table 4. Powdery mildew control on Idared apples, 2010. Block #15. Virginia Tech AREC.

			Primary mildew	Mildew infection			
				% leaves		% fruit infected	
	Treatment and rate /A	Timing	effect*	% lvs	% area	% fruit	% area
0	No fungicide	---	1.8 h	73 e	61 i	74 h	11 h
1	Rally 40WSP 5 oz + Penncozeb 75WG 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	5.7 a-d	67 c-e	20 g	37 c-g	4 d-f
2	Rally 40WSP 5 oz + Microfine Sulfur 90W 8 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	5.2 b-e	64 b-e	15 b-g	58 gh	8 gh
3	Flint 50WG 2 oz + Penncozeb 75WG 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	4.1 e-g	69 de	18 d-g	37 c-f	4 cd
4	Flint 50WG 2 oz + Microfine Sulfur 90W 8 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	5.0 b-f	62 a-e	11 a-d	31 b-d	4 c-e
5	Microfine Sulfur 8 lb + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	3.7 fg	67 de	20 g	42 d-g	5 d-g
6	Luna Sensation 500SC 5 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1,3,5,7 #2,4,6,8 7C	6.9 a	51 a	8 a	22 a-c	2 a-c
7	Luna Sensation 500SC 5 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-2, 5-6 #3-4, 7-8 7C	6.8 a	59 a-d	18 c-g	8 a	<1 a
8	Luna Sensation 500SC 5 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-2, 4-5 #3, 6-8 7C	6.0 ab	49 a	10 ab	16 ab	1 ab
9	Flint 50WG 2 oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Flint 50WG 2 oz	#1-2, 4-5 #3 & 6 5C →	5.0 b-f	52 ab	13 a-f	38 c-g	5 d-f
10	Flint 50WG 2 oz + LI6262 3.2 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Flint 50WG 2 oz + LI6262 3.2 fl oz	#1-2, 4-5 #3 & 6 5C →	5.8 a-c	54 a-c	13 a-e	35 c-e	4 cd
11	Flint 50WG 2 oz + Liberate 3.2 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Flint 50WG 2 oz + Liberate 3.2 fl oz	#1-2, 4-5 #3 & 6 5C →	4.2 e-g	62 a-e	21 g	25 b-d	3 cd
12	GWN-4617 3.4 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	3.1 gh	60 a-d	20 fg	53 e-g	7 e-g
13	GWN-4617 3.4 fl oz + Flint 2 oz + Penncozeb 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	4.3 d-g	58 a-d	11 a-c	39 c-g	5 d-f
14	Topguard 13 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	6.8 a	51 a	9 a	27 b-d	3 b-d
15	Inspire Super 2.82EW 12 fl oz Omega 4SC 12 fl oz Inspire Super 2.82EW 12 fl oz + Penncozeb 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-2 #3-4 #5-7 6C →	4.4 c-g	65 b-e	18 e-g	52 e-g	8 fg
16	Inspire Super 2.82EW 12 fl oz + Penncozeb 3 lb Omega 4SC 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-2, 5-7 #3-4 6C →	4.0 e-g	67 de	32 h	56 f-h	7 fg

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar counts based on 10 shoots from each of four single-tree replications rated 14 Jun or 25 fruit per replication harvested 22 Sep and placed in cold storage until evaluation14 Oct.
* Apparent suppressive effect rated on six Idared primary mildew shoots / tree, four reps 29 Jun: scale 1-10 (1= none; 10= excellent effect).

Table 5. Early season and summer disease control on Idared apples, 2010. Block #15.

			Scab infection		% lvs Inf.	% fruit infected	
	Treatment and rate /A	Timing	% lvs	% fruit	c-a rust	Sooty blotch	Fly speck
0	No fungicide	---	2.5 ef	23 e	1.9 c	32 c	5 b
1	Rally 40WSP 5 oz + Penncozeb 75WG 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	1.2 de	1 ab	0.4 ab	1 a	0 a
2	Rally 40WSP 5 oz + Microfine Sulfur 90W 8 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	3.1 f	9 d	1.0 bc	0 a	0 a
3	Flint 50WG 2 oz + Penncozeb 75WG 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	0.6 a-d	0 a	0.1 a	0 a	0 a
4	Flint 50WG 2 oz + Microfine Sulfur 90W 8 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	0 a	2 ab	0.4 ab	2 ab	0 a
5	Microfine Sulfur 8 lb + Penncozeb 75DF 3 lb Covers: Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	0.7 b-d	0 a	0 a	0 a	0 a
6	Luna Sensation 500SC 5 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1,3,5,7 #2,4,6,8 7C	0.2 ab	1 ab	0 a	0 a	0 a
7	Luna Sensation 500SC 5 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-2, 5-6 #3-4, 7-8 7C	0.7 b-d	3 bc	0.1 a	0 a	0 a
8	Luna Sensation 500SC 5 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-2, 4-5 #3, 6-8 7C	0.1 ab	0 a	0 a	2 ab	0 a
9	Flint 50WG 2 oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Flint 50WG 2 oz	#1-2, 4-5 #3 & 6 5C →	0 a	0 a	0 a	0 a	0 a
10	Flint 50WG 2 oz + LI6262 3.2 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Flint 50WG 2 oz + LI6262 3.2 fl oz	#1-2, 4-5 #3 & 6 5C →	0 a	5 cd	0.1 a	1 a	1 a
11	Flint 50WG 2 oz + Liberate 3.2 fl oz Indar 2F 8 fl oz + Penncozeb 75DF 3 lb Flint 50WG 2 oz + Liberate 3.2 fl oz	#1-2, 4-5 #3 & 6 5C →	0.9 a-d	0 a	0.3 ab	1 a	0 a
12	GWN-4617 3.4 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	0.8 cd	2 ab	0.1 a	8 b	1 a
13	GWN-4617 3.4 fl oz + Flint 2 oz + Penncozeb 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	0.2 a-c	1 ab	0.4 ab	0 a	0 a
14	Topguard 13 fl oz + Penncozeb 75DF 3 lb Captan 80WDG 30 oz + Ziram 3 lb	#1-4C 5C →	0.3 a-c	1 ab	0.3 ab	0 a	0 a
15	Inspire Super 2.82EW 12 fl oz Omega 4SC 12 fl oz Inspire Super 2.82EW 12 fl oz + Penncozeb 3 lb Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-2 #3-4 #5-7 6C →	0.6 a-d	0 a	0 a	0 a	0 a
16	Inspire Super 2.82EW 12 fl oz + Penncozeb 3 lb Omega 4SC 12 fl oz Captan 80WDG 30 oz + Ziram 76DF 3 lb	#1-2, 5-7 #3-4 6C →	0.6 b-d	0 a	0 a	0 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar counts based on 10 shoots from each of four single-tree replications rated 14 Jun or 25 fruit per replication harvested 22 Sep and placed in cold storage until evaluation 14 Oct.

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, 2010.

Fifteen experimental or combination treatment schedules were compared to registered treatments on 10-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 2009 which allowed mildew inoculum pressure to stabilize on 2010 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: 1 Apr (tight cluster, TC); 12 Apr (full pink-full bloom); 23 Apr (full bloom, York; petal fall, Golden Delicious; 7-mm fruit, Idared); 1st 6th cover (1C-6C): 7 May, 20 May, 3 Jun, 25 Jun, 15 Jul, 2 Aug. Maintenance applications applied to the entire test block with the same equipment included Supracide, oil, FireWall, Assail, Calypso, NAA 15 ppm + Sevin, Provado, Imidan, Intrepid, and Delegate. Inoculum placed over each Idared test tree included wild blackberry canes with the sooty blotch and flyspeck fungi, and bitter rot mummies 6 May. 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: 22 Jun (Idared), 30 Jul (Golden Delicious) or 1 Jul (York). Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 24 Sep (Idared and Golden Delicious); or 1 Oct (York) and evaluated after 24 days storage at ambient temperatures 61-71°F. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew pressure was high in this test block with conidia available from late March and 45 of the 61 days in April and May were favorable for mildew infection. Rally + Penncozeb (Trt #1), Flint + Rally and Flint alone (Trts #14& 15) gave the best suppression of primary mildew (first data column in Table 1. Treatments involving Flint (#13-15 and the highest rate of GWN-4617 (Trt #5) gave the best control or mildew under the highest pressure on Idared. The first scab infection occurred 29 March just before the first treatment application 1 Apr. Many of the scab infection periods occurred with rather light amounts of rainfall. Under these conditions, treatments involving Flint or high rates of protectant fungicides gave the best control of scab on leaves and fruit. Combinations of GWN-4617 + GWN-4700 did not adequately control scab or cedar-apple rust, and especially the combination at the higher rates (Trts #11&12). Under light summer disease pressure, most treatments gave adequate control of Brooks spot, sooty blotch, flyspeck and post-storage rots. The higher rates of GWN-4617 + GWN-4700 (Trts #11&12) also had the most post-storage rots, with Alternaria being the most commonly noted rot organism. Although there were significant differences in fruit finish, no treatments had more russet or opalescence than no-treated fruit.

Table 6. Mildew control on Idared, Golden Delicious and York apples, 2010.

		Idared primary	Mildew , % leaves, leaf area or fruit infected							
			Idared			Golden Del.		York		
Treatment and rate/A	Timing	effect*	leaves	lf area	fruit	lvs	area	leaves	area	fruit
0 No fungicide	---	2.1 d	68 f	46 h	54 g	60 c	17 h	59 f	11 b	12 d
1 Rally 40WSP 5 oz + Penncozeb 75DF 3 lb	TC-3C	6.0 a	45 a-e	8 d-g	5 a	45 b	7 g	36 e	4 a	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
2 GWN-4617 3.4 fl oz + Penncozeb 75DF 6 lb	TC-3C	4.3 a-d	49 b-f	12 g	10 a-e	40 b	5 d-f	33 de	3 a	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
3 GWN-4617 5.1 fl oz + Penncozeb 75DF 6 lb	TC-3C	4.1 a-d	43 a-e	8 c-f	8 a-e	35 b	4 bc	27 c-e	4 a	5 bc
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
4 GWN-4617 6.8 fl oz + Penncozeb 75DF 6 lb	TC-3C	4.9 a-c	36 a-d	5 a-d	8 a-d	40 b	5 ef	26 cd	3 a	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
5 GWN-4617 8.5 fl oz + Penncozeb 75DF 6 lb	TC-3C	4.9 a-c	29 ab	4 a-c	9 a-c	38 b	4 cd	25 b-d	3 a	1 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
6 GWN-4617 3.4 fl oz + Captan 60 oz	TC-3C	3.5 cd	46 b-e	9 e-g	15 b-f	36 b	4 c-f	25 cd	3 a	1 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
7 GWN-4617 3.4 fl oz + Penncozeb 3 lb +										
Captan 80WDG 30 oz	TC-3C	3.5 cd	49 c-f	8 d-g	12 a-e	36 b	5 c-f	24 b-d	3 a	0 a
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
8 GWN-4617 3.4 fl oz +GWN-4700 80W 4 oz	TC-3C	4.1 a-d	55 d-f	11 fg	27 f	38 b	4 c-f	23 b-d	3 a	9 cd
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
9 GWN-4617 3.4 fl oz +GWN-4700 80W 5 oz	TC-3C	3.7 b-d	53 d-f	8 d-g	9 a-e	36 b	4 c-e	30 de	3 a	7 cd
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
10 GWN-4617 3.4 fl oz +GWN-4700 80W 6 oz	TC-3C	4.4 a-d	47 b-e	5 a-e	27 f	38 b	5 c-f	27 c-e	3 a	7 cd
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
11 GWN-4617 6.8 fl oz +GWN-4700 80W 4 oz	TC-3C	4.3 a-d	56 ef	9 e-g	15 b-f	40 b	6 fg	30 de	3 a	4 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
12 GWN-4617 6.8 fl oz +GWN-4700 80W 5 oz	TC-3C	5.4 a-c	48 b-f	6 b-e	20 ef	42 b	5 d-f	24 b-d	3 a	1 ab
Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →									
13 Flint 50WG 2 oz + Penncozeb 75DF 3 lb	TC-3C	5.3 a-c	32 a-c	4 ab	8 ab	22 a	3 ab	19 a-c	2 a	2 ab
Captan 80WDG 30 oz + Ziram 3 lb	4C →									
14 Flint 50WG 2 oz + Rally 40WSP 2.5 oz	TC-3C	5.9 ab	25 a	3 a	17 c-f	20 a	3 ab	12 a	2 a	3 ab
Captan 80WDG 30 oz + Ziram 3 lb	4C →									
15 Flint 50WG 2 oz	TC-3C	6.0 ab	26 a	4 a-c	18 d-f	17 a	2 a	16 ab	2 a	0 a
Captan 80WDG 30 oz + Ziram 3 lb	4C →									

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots/tree rated 22 Jun (Idared), 1 Jul (York), and 30 Jul (Golden Delicious). Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 24 Sep (Idared and Golden Delicious); or 1 Oct (York).

* Apparent suppressive effect rated on six primary mildew shoots / tree 7 Jul: scale 1-10 (1= none; 10= excellent effect).
Fungicides applied dates: 1 Apr (tight cluster, TC); 12 Apr (full pink-full bloom); 23 Apr (full bloom-fruit set);
1st 6th cover (1C-6C): 7 May, 20 May, 3 Jun, 25 Jun, 15 Jul, 2 Aug.

Table 7. Scab control on Idared, Golden Delicious and York apples, 2010.

	Treatment and rate/A	Timing	Scab % leaves infected Idared	G.Del	York	% fruit infected Idared	G.Del	York
0	No fungicide	---	9 fg	25 g	11 d	47 d	50 d	52 d
1	Rally 40WSP 5 oz + Penncozeb 75DF 3 lb	TC-3C	1 b-d	4 d	3 c	3 ab	1 a	1 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
2	GWN-4617 3.4 fl oz + Penncozeb 75DF 6 lb	TC-3C	3 c-e	2 a-d	3 c	2 ab	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
3	GWN-4617 5.1 fl oz + Penncozeb 75DF 6 lb	TC-3C	2 b-d	4 d	2 bc	1 ab	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
4	GWN-4617 6.8 fl oz + Penncozeb 75DF 6 lb	TC-3C	<1 a-c	2 b-d	2 bc	4 ab	0 a	3 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
5	GWN-4617 8.5 fl oz + Penncozeb 75DF 6 lb	TC-3C	<1 a-c	3 cd	1 bc	7 bc	0 a	2 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
6	GWN-4617 3.4 fl oz + Captan 60 oz	TC-3C	<1 ab	1 a-c	<1 ab	2 ab	2 a	4 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
7	GWN-4617 3.4 fl oz + Penncozeb 3 lb +		<1 ab	1 a-c	<1 ab	3 ab	0 a	2 a
	Captan 80WDG 30 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
8	GWN-4617 3.4 fl oz +GWN-4700 80W 4 oz	TC-3C	4 de	12 e	3 c	5 b	13 b	7 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
9	GWN-4617 3.4 fl oz +GWN-4700 80W 5 oz	TC-3C	5 ef	14 ef	9 d	16 c	19 b	16 bc
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
10	GWN-4617 3.4 fl oz +GWN-4700 80W 6 oz	TC-3C	3 de	14 e	3 c	16 c	20 b	17 bc
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
11	GWN-4617 6.8 fl oz +GWN-4700 80W 4 oz	TC-3C	15 h	20 fg	10 de	41 d	35 c	33 cd
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
12	GWN-4617 6.8 fl oz +GWN-4700 80W 5 oz	TC-3C	12 gh	22 g	16 e	46 d	54 d	49 d
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →						
13	Flint 50WG 2 oz + Penncozeb 75DF 3 lb	TC-3C	0 a	1 a	<1 ab	0 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	4C →						
14	Flint 50WG 2 oz + Rally 40WSP 2.5 oz	TC-3C	<1 a	1 ab	0 a	1 ab	0 a	5 ab
	Captan 80WDG 30 oz + Ziram 3 lb	4C →						
15	Flint 50WG 2 oz	TC-3C	<1 ab	1 a-c	<1 ab	4 b	0 a	1 a
	Captan 80WDG 30 oz + Ziram 3 lb	4C →						

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots/tree rated 22 Jun (Idared), 1 Jul (York) 3 Jul (Golden Delicious). Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 24 Sep (Idared and Golden Delicious); or 1 Oct (York).

Fungicides applied to both sides of the tree on each indicated application date at 100 gal/A as follows: 1 Apr (tight cluster, TC); 12 Apr (full pink-full bloom); 23 Apr (full bloom, York; petal fall, Golden Delicious; 7 mm fruit, Idared); 1st 6th cover (1C-6C): 7 May, 20 May, 3 Jun, 25 Jun, 15 Jul, 2 Aug.

Table 8. Cedar-apple rust and Brooks spot control on Idared, Golden Delicious and York apples.

	Treatment and rate/A	Timing	Cedar-apple rust % leaves infected			Brooks spot % fruit inf.	
			Idared	G.Del	York	Idared	G.Del
0	No fungicide	---	11 f	35 j	41 g	3 a	9 c
1	Rally 40WSP 5 oz + Penncozeb 75DF 3 lb	TC-3C	<1 ab	<1 a-c	1 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
2	GWN-4617 3.4 fl oz + Penncozeb 75DF 6 lb	TC-3C	<1 ab	<1 a	<1 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
3	GWN-4617 5.1 fl oz + Penncozeb 75DF 6 lb	TC-3C	<1 a-c	1 b-d	6 bc	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
4	GWN-4617 6.8 fl oz + Penncozeb 75DF 6 lb	TC-3C	1 b-e	7 ef	14 c-e	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
5	GWN-4617 8.5 fl oz + Penncozeb 75DF 6 lb	TC-3C	<1 ab	2 cd	7 b-d	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
6	GWN-4617 3.4 fl oz + Captan 60 oz	TC-3C	<1 a-d	7 ef	9 cd	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
7	GWN-4617 3.4 fl oz + Penncozeb 3 lb +		3 de	8 f	15 c-e	0 a	0 a
	Captan 80WDG 30 oz	TC-3C					
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
8	GWN-4617 3.4 fl oz +GWN-4700 80W 4 oz	TC-3C	4 e	16 h	15 de	1 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
9	GWN-4617 3.4 fl oz +GWN-4700 80W 5 oz	TC-3C	4 e	10 fg	22 e	1 a	1 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
10	GWN-4617 3.4 fl oz +GWN-4700 80W 6 oz	TC-3C	3 c-e	14 gh	22 e	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
11	GWN-4617 6.8 fl oz +GWN-4700 80W 4 oz	TC-3C	13 f	20 hi	29 ef	0 a	0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
12	GWN-4617 6.8 fl oz +GWN-4700 80W 5 oz	TC-3C	11 f	25 i	38 fg	1 a	3 bc
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →					
13	Flint 50WG 2 oz + Penncozeb 75DF 3 lb	TC-3C	3 c-e	4 de	8 cd	0 a	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	4C →					
14	Flint 50WG 2 oz + Rally 40WSP 2.5 oz	TC-3C	<1 ab	0 a	1 a	0 a	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	4C →					
15	Flint 50WG 2 oz	TC-3C	0 a	<1 ab	2 ab	0 a	0 a
	Captan 80WDG 30 oz + Ziram 3 lb	4C →					

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots/tree rated 22 Jun (Idared), 1 Jul (York) 30 Jul (Golden Delicious). Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 24 Sep (Idared and Golden Delicious); or 1 Oct (York).

Fungicides applied to both sides of the tree on each indicated application date at 100 gal/A as follows: 1 Apr (tight cluster, TC); 12 Apr (full pink-full bloom); 23 Apr (full bloom, York; petal fall, Golden Del.; 7 mm fruit, Idared); 1st-6th cover (1C-6C): 7 May, 20 May, 3 Jun, 25 Jun, 15 Jul, 12 Aug.

Table 9. Sooty blotch and flyspeck control, on Idared, Golden Delicious and York apples, 2010.

	Treatment and rate/A	Timing	% fruit infected: Sooty blotch Idared	Sooty blotch G.Del	Sooty blotch York	Flyspeck Idared	Flyspeck G.Del	Flyspeck York
0	No fungicide	---	10 b	17 b	16 c	11 b	8 b	9 b
1	Rally 40WSP 5 oz + Penncozeb 75DF 3 lb	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	1 ab	0 a	0 a	1 a
2	GWN-4617 3.4 fl oz + Penncozeb 75DF 6 lb	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	0 a
3	GWN-4617 5.1 fl oz + Penncozeb 75DF 6 lb	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	1 a
4	GWN-4617 6.8 fl oz + Penncozeb 75DF 6 lb	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	0 a
5	GWN-4617 8.5 fl oz + Penncozeb 75DF 6 lb	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	1 ab	1 a	0 a	2 a
6	GWN-4617 3.4 fl oz + Captan 60 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	2 a
7	GWN-4617 3.4 fl oz + Penncozeb 3 lb +							
	Captan 80WDG 30 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	0 a
8	GWN-4617 3.4 fl oz +GWN-4700 80W 4 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	3 a	0 a	0 a	1 a	0 a	0 a
9	GWN-4617 3.4 fl oz +GWN-4700 80W 5 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	4 a
10	GWN-4617 3.4 fl oz +GWN-4700 80W 6 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	3 a	0 a	0 a	6 b	0 a	2 a
11	GWN-4617 6.8 fl oz +GWN-4700 80W 4 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	0 a	0 a	0 a	1 a	0 a	0 a
12	GWN-4617 6.8 fl oz +GWN-4700 80W 5 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	1 a	0 a	0 a	2 a	0 a	0 a
13	Flint 50WG 2 oz + Penncozeb 75DF 3 lb	TC-3C						
	Captan 80WDG 30 oz + Ziram 3 lb	4C →	0 a	0 a	2 b	0 a	0 a	2 a
14	Flint 50WG 2 oz + Rally 40WSP 2.5 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	1 a
15	Flint 50WG 2 oz	TC-3C						
	Captan 80WDG 30 oz + Ziram 3 lb	4C →	0 a	0 a	0 a	0 a	0 a	3 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications; Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 24 Sep (Idared and Golden Delicious); or 1 Oct (York).

Fungicides applied to both sides of the tree on each indicated application date at 100 gal/A as follows: 1 Apr (tight cluster, TC); 12 Apr (full pink-full bloom); 23 Apr (full bloom, York; petal fall, Golden Delicious; 7 mm fruit, Idared); 1st-6th cover (1C-6C): 7 May, 20 May, 3 Jun, 25 Jun, 15 Jul, 12 Aug.

Table 10. Postharvest storage rots on York apples, 2010.

	Treatment and rate/A	Timing	Post-incubation rot incidence (%) Any rot	Bitter rot	White rot	Alternaria
0	No fungicide	---	40 f	9 b	9 b	21 b
1	Rally 40WSP 5 oz + Penncozeb 75DF 3 lb	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	6 a-c	0 a	0 a	6 a
2	GWN-4617 3.4 fl oz + Penncozeb 75DF 6 lb	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	1 ab	1 ab	0 ab	1 a
3	GWN-4617 5.1 fl oz + Penncozeb 75DF 6 lb	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	10 b-d	0 a	1 a	10 ab
4	GWN-4617 6.8 fl oz + Penncozeb 75DF 6 lb	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	4 a-c	0 a	0 a	4 a
5	GWN-4617 8.5 fl oz + Penncozeb 75DF 6 lb	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	3 a-c	2 ab	0 ab	1 a
6	GWN-4617 3.4 fl oz + Captan 60 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	7 a-c	0 a	0 a	7 ab
7	GWN-4617 3.4 fl oz + Penncozeb 3 lb + Captan 80WDG 30 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	5 a-c	1 a	1 a	3 a
8	GWN-4617 3.4 fl oz +GWN-4700 80W 4 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	9 c-e	1 ab	0 ab	7 a
9	GWN-4617 3.4 fl oz +GWN-4700 80W 5 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	8 a-c	3 ab	1 ab	5 a
10	GWN-4617 3.4 fl oz +GWN-4700 80W 6 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	8 a-c	1 a	1 a	7 a
11	GWN-4617 6.8 fl oz +GWN-4700 80W 4 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	23 d-f	1 a	0 a	20 b
12	GWN-4617 6.8 fl oz +GWN-4700 80W 5 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →	28 ef	0 a	6 a	23 b
13	Flint 50WG 2 oz + Penncozeb 75DF 3 lb	TC-3C				
	Captan 80WDG 30 oz + Ziram 3 lb	4C →	3 a-c	2 ab	0 ab	2 a
14	Flint 50WG 2 oz + Rally 40WSP 2.5 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 3 lb	4C →	2 ab	0 a	0 a	2 a
15	Flint 50WG 2 oz	TC-3C				
	Captan 80WDG 30 oz + Ziram 3 lb	4C →	1 a	1 a	0 a	1 a

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

Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 1 Oct and evaluated after 24 days storage at ambient temperatures 61-71°F.

Fungicides applied to both sides of the tree on each indicated application date at 100 gal/A as follows: 1 Apr (tight cluster, TC); 12 Apr (full pink-full bloom); 23 Apr (full bloom, York; petal fall, Golden Delicious; 7 mm fruit, Idared); 1st-6th cover (1C-6C): 7 May, 20 May, 3 Jun, 25 Jun, 15 Jul, 12 Aug.

Table 11. Fruit finish on Golden Delicious and York apples, 2010.

	Treatment and rate/A	Timing	Golden Del. russet* russet rating 0-5	Golden Del. russet* % USDA Fcy & X-Fcy	Opalescence rating (0-5)* Idared	Opalescence rating (0-5)* York
0	No fungicide	---	2.5 c-f	79 a-e	1.5 e	1.4 ab
1	Rally 40WSP 5 oz + Penncozeb 75DF 3 lb	TC-3C	1.8 a	95 a	0.9 ab	1.4 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
2	GWN-4617 3.4 fl oz + Penncozeb 75DF 6 lb	TC-3C	1.8 a	91 ab	1.0 a-c	1.4 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
3	GWN-4617 5.1 fl oz + Penncozeb 75DF 6 lb	TC-3C	2.2 a-e	79 a-e	1.0 a-d	1.6 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
4	GWN-4617 6.8 fl oz + Penncozeb 75DF 6 lb	TC-3C	2.0 ab	85 a-c	1.1 b-e	1.4 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
5	GWN-4617 8.5 fl oz + Penncozeb 75DF 6 lb	TC-3C	2.0 a-c	84 b-e	0.7 a	1.6 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
6	GWN-4617 3.4 fl oz + Captan 60 oz	TC-3C	2.3 b-f	75 a-d	1.1 a-d	1.5 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
7	GWN-4617 3.4 fl oz + Penncozeb 3 lb + Captan 80WDG 30 oz	TC-3C	2.2 a-e	85 c-e	1.0 a-c	1.0 a
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
8	GWN-4617 3.4 fl oz +GWN-4700 80W 4 oz	TC-3C	2.6 def	72 c-e	1.1 a-d	1.8 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
9	GWN-4617 3.4 fl oz +GWN-4700 80W 5 oz	TC-3C	2.4 b-f	71 de	1.1 a-d	1.6 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
10	GWN-4617 3.4 fl oz +GWN-4700 80W 6 oz	TC-3C	2.8 f	65 de	1.3 b-e	1.8 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
11	GWN-4617 6.8 fl oz +GWN-4700 80W 4 oz	TC-3C	2.7 ef	64 e	1.4 de	1.4 ab
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
12	GWN-4617 6.8 fl oz +GWN-4700 80W 5 oz	TC-3C	2.8 f	60 a-c	1.3 c-e	1.5 b
	Captan 80WDG 30 oz + Ziram 76DF 3 lb	4C →				
13	Flint 50WG 2 oz + Penncozeb 75DF 3 lb	TC-3C	2.1 a-c	86 b-e	0.9 a-c	1.7 b
	Captan 80WDG 30 oz + Ziram 3 lb	4C →				
14	Flint 50WG 2 oz + Rally 40WSP 2.5 oz	TC-3C	2.2 a-e	74 a-d	1.1 a-d	1.5 b
	Captan 80WDG 30 oz + Ziram 3 lb	4C →				
15	Flint 50WG 2 oz	TC-3C	2.1 a-d	86 a-d	1.0 a-c	1.5 b
	Captan 80WDG 30 oz + Ziram 3 lb	4C →				

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps; 10 shoots/tree rated 22 Jun (Idared), 1 Jul (York) 3 Jul (Golden Delicious). Fruit data represent postharvest counts of 25 fruit per replicate tree sampled: 24 Sep (Idared and Golden Delicious); or 1 Oct (York).

* 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.

Fungicides applied to both sides of the tree on each indicated application date at 100 gal/A as follows: 1 Apr (tight cluster, TC); 12 Apr (full pink-full bloom); 23 Apr (full bloom, York; petal fall, Golden Delicious; 7 mm fruit, Idared); 1st 6th cover (1C-6C): 7 May, 20 May, 3 Jun, 25 Jun, 15 Jul, 2 Aug.

APPLE (*Malus domestica* 'Golden Delicious', 'Red Delicious', and 'Rome Beauty')

Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*

Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Bitter rot; *Colletotrichum* spp.
White (Bot) rot; *Botryosphaeria dothidea*
Alternaria rot; *Alternaria* spp.
Fruit finish

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Early season disease management with combined fungicides on Red Delicious, Golden Delicious, and Rome apples, 2010.

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 2009 to allow powdery mildew inoculum to stabilize in the 2010 test trees. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 550 psi as follows: 1 Apr (TC, tight cluster R. Del and G. Del; Rome ½ in green-TC); 12 Apr (bloom- PF (R. Del.); 23 Apr (petal fall); first- sixth covers (1-6C): 7 May, 21 May, 4 Jun, 18 Jun, 9 Jul, 6 Aug. Maintenance sprays, applied separately to the entire test block with a commercial airblast sprayer, included: Supracide, Assail, Imidan, Provado, Intrepid, Delegate, and Calypso. Inoculum over each Golden Delicious test tree included: cedar rust galls placed 13 Apr and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies placed 12 May. 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 3 Jun (Rome), 19 Jul (Golden Del.), or ten Red Delicious spur cluster leaf sets 17 Aug. Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 23 Sep (Red Delicious and Golden Delicious), or 29 Sep (Rome), placed in cold storage at 4°C and rated after 7 days (Rome), 30 days (Golden Delicious), 34 days cold storage (Red Delicious). Following initial fruit evaluation, fruit were incubated at ambient temperatures 62-76°F for 17-27 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. The first scab infection occurred 29 March just before the first treatment application 1 Apr. Scab lesions appeared on non-treated trees by 12 Apr. Many of the scab infection periods occurred with rather light amounts of rainfall. Under these conditions, Flint-related treatments provided the best scab control on foliage and fruit. Including sulfur with Rally and Penncozeb improved scab control on leaves and fruit (Table 12). Omega gave better scab control than Rally + Penncozeb. The experimental material VA-1 did not give significant scab control at aqny rate. Combinations involving the SI fungicides Rally of Inspire gave the best control of cedar-apple rust. A half rate of Rally, included with Flint, or Inspire included with Omega, significantly improved the weaknesses of those treatments against rust (Table 13). VA-1 gave significant rust control at the lower rates but was less effective at the higher rates. Mildew pressure was high in this test block with conidia available from late March and 45 of the 61 days in April and May were favorable for mildew infection. Under heavy powdery mildew pressure Flint gave the best control on foliage but its control on fruit was improved by mixing a half rate of Rally with it. All treatments gave significant suppression of percent leaf area affected by mildew. Under light disease pressure and slow wetting hour accumulation, all treatments completely controlled or suppressed sooty blotch (Table 14). All treatments gave significant control of one or more rots (Table 15). VA-1 improved the USDA grade for russet, but VA-1, Omega, Flint + Rally and Rally+ Penncozeb + Sulfur significantly increased the amount of opalescence compared to non-treated fruit.

Table 12. Scab control on Rome Beauty, Golden Delicious and Red Delicious apple, 2010.

	Treatment and formulated rate/100 gal	Timing	Scab, % leaves inf.			Scab, lesions/leaf			Scab, % fruit inf.		
			Rome	G Del	R Del	Rome	G. Del.	R. Del.	Rome	G. Del.	R. Del.
0	Non-treated control	---	42 d	30 f	46 de	3.6 b	2.9 ef	4.5 b-d	83 e	77 g	95 e
1	Rally 40WSP 1.25 oz + Penncozeb 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	27 c	26 ef	42 de	2.6 b	1.6 b-d	2.7 a-c	45 c	21 d	39 c
2	Rally 1.25 oz + Penncozeb 12 oz + Sulfur 2 lb Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	15 b	17 cd	28 cd	0.9 a	0.8 a-c	1.3 ab	15 b	8 bc	18 b
3	Flint 50WG 0.5 oz (*+ Rally 0.6 oz, 1C-2C*) Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	3 a	3 a	3 a	0.1 a	0.1 a	0.1 a	3 a	2 a	2 a
4	Flint 50WG 0.5 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	3 a	2 a	2 a	<0.1 a	0.1 a	0.1 a	3 a	5 ab	2 a
5	Omega 4SC 3 fl oz	TC-6C	12 b	13 bc	20 bc	0.6 a	0.5 ab	0.9 ab	22 b	14 cd	32 bc
6	Omega 3 fl oz (+*Inspire 1.5 fl oz, 1C-2C*) Omega 4SC 3 fl oz	TC-3C 4C – 6C	12 b	8 b	12 b	0.8 a	0.4 ab	0.3 a	14 b	8 a-c	18 b
7	VA-1 16.8 ml	TC-6C	39 d	26 ef	47 de	3.1 b	3.5 f	5.5 cd	74 de	61 f	72 d
8	VA-1 23.7 ml	TC-6C	40 d	24 ef	48 e	3.8 b	2.7 d-f	8.3 d	78 de	68 fg	86 e
9	VA-1 30.3 ml	TC-6C	32 c	20 de	41 de	3.0 b	2.0 c-e	3.9 a-c	63 d	39 e	72 d

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on 10 shoots per rep 19 Jul (Golden), 3 Jun (Rome), or 10 Red Delicious cluster spurs 17 Aug. Rome trees in 2010 test were not in test in 2009 to stabilize mildew inoculum pressure for 2010.
Treatments were applied dilute to run-off: 1 Apr (TC, tight cluster R. Del and G. Del; Rome ½ in green-TC); 12 Apr (bloom- PF (R. Del.); 23 Apr (petal fall); first- sixth covers (1-6C): 7 May, 21 May, 4 Jun, 18 Jun, 9 Jul, 6 Aug.
Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 23 Sep (Red Del. and Golden Delicious), or 29 Sep (Rome), placed in cold storage at 4°C and rated after 7 days (Rome), 30 days (Golden Del., 34 days cold storage (Red Del.).

Table 13. Cedar-apple rust and mildew control on Rome Beauty and Golden Delicious apple, 2010. Block #11, 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	Powdery mildew infection % leaves Rome	Powdery mildew infection % leaves G.Del	Powdery mildew infection % leaf area Rome	Powdery mildew infection % leaf area G. Del	Powdery mildew infection % fruit Rome
0	Non-treated control	---	58 g	41 e	5.8 c	3.3 d	5 b	60 c	64 d	34 e	33 e	40 f
1	Rally 40WSP 1.25 oz + Penncozeb 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	2 ab	1 a	<0.1 a	<0.1 a	0 a	56 bc	58 b-d	12 bc	12 b-d	7 ab
2	Rally 1.25 oz + Penncozeb 12 oz + Sulfur 2 lb Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	1 a	<1 a	<0.1 a	<0.1 a	0 a	57 bc	55 b	10 ab	10 a-c	15 b-d
3	Flint 50WG 0.5 oz (*+ Rally 0.6 oz, 1C-2C*) Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	1 ab	<1 a	0.1 a	<0.1 a	0 a	50 ab	44 a	6 a	6 a	5 a
4	Flint 50WG 0.5 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C – 6C	16 d	8 b	0.9 a	0.3 a	0 a	44 a	47 a	9 ab	6 ab	23 c-e
5	Omega 4SC 3 fl oz	TC-6C	8 c	8 b	0.3 a	0.3 a	0 a	57 bc	56 bc	18 cd	15 cd	29 ef
6	Omega 4SC 3 fl oz (+*Inspire 1.5 fl oz, 1C-2C*) Omega 4SC 3 fl oz	TC-3C 4C – 6C	3 b	2 a	0.1 a	<0.1 a	0 a	55 bc	62 cd	23 d	18 d	25 de
7	VA-1 16.8 ml	TC-6C	22 e	12 b	1.0 a	0.4 ab	0 a	59 c	58 b-d	20 d	18 d	31 ef
8	VA-1 23.7 ml	TC-6C	45 f	20 c	3.4 b	0.8 b	1 a	59 c	59 b-d	18 cd	14 cd	12 a-c
9	VA-1 30.3 ml	TC-6C	52 fg	29 d	4.6 bc	1.9 c	4 b	56 bc	61 b-d	17 cd	16 cd	24 c-e

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on 10 shoots per rep 19 Jul (Golden), 3 Jun (Rome), or 10 Red Delicious cluster spurs 17 Aug. Rome trees in 2010 test were not in test in 2009 to stabilize mildew inoculum pressure for 2010. Treatments were applied dilute to run-off: 1 Apr (TC, tight cluster R. Del and G. Del; Rome ½ in green-TC); 12 Apr (bloom- PF (R. Del.); 23 Apr (petal fall); first- sixth covers (1-6C): 7 May, 21 May, 4 Jun, 18 Jun, 9 Jul, 6 Aug.

Postharvest fruit counts of 25-fruit samples picked from each of four single-tree reps 23 Sep (Red Delicious and Golden Delicious), or 29 Sep (Rome), placed in cold storage at 4°C and rated after 7 days (Rome), 30 days (Golden Del., 34 days cold storage (Red Delicious).

Table 14. Sooty blotch, flyspeck and fruit finish on Rome Beauty, Golden Delicious and Red Delicious apple, 2010.

			% fruit infected					Opalescence rating (0-5)*		Golden Del. finish*	
		Timing	Sooty blotch			Flyspeck				% USDA	russet
	Treatment and formulated rate/100 gal		R. Del.	G. Del.	Rome	R. Del.	Rome	R. Del.	Rome	X-fancy	rating (0-5)
0	Non-treated control	---	21 d	24 b	26 c	6 b	4 b	1.0 ab	0.6 a	21 ab	2.8 a
1	Rally 40WSP 1.25 oz + Penncozeb 75DF 12 oz	TC-3C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	4C – 6C	0 a	2 a	0 a	0 a	0 a	0.8 a	0.9 a-c	39 b	2.4 a
2	Rally 1.25 oz + Penncozeb 12 oz + Sulfur 2 lb	TC-3C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	4C – 6C	0 a	0 a	0 a	1 ab	0 a	1.0 ab	1.1 bc	35 ab	2.6 a
3	Flint 50WG 0.5 oz (*+ Rally 0.6 oz, 1C-2C*)	TC-3C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	4C – 6C	0 a	0 a	0 a	0 a	1 ab	1.0 ab	1.2 c	35 ab	2.5 a
4	Flint 50WG 0.5 oz	TC-3C									
	Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	4C – 6C	0 a	3 a	3 a	0 a	0 a	1.1 ab	0.9 a-c	44 b	2.2 a
5	Omega 4SC 3 fl oz	TC-6C	2 ab	1 a	2 a	2 ab	0 a	1.1 ab	1.1 bc	26 ab	2.8 a
6	Omega 4SC 3 fl oz (+*Inspire 1.5 fl oz, 1C-2C*)	TC-3C									
	Omega 4SC 3 fl oz	4C – 6C	3 ab	1 a	1 a	1 ab	1 ab	1.1 ab	0.8 ab	20 ab	2.9 a
7	VA-1 16.8 ml	TC-6C	11 bc	0 a	12 b	2 ab	1 ab	1.3 b	0.9 a-c	31 ab	2.4 a
8	VA-1 23.7 ml	TC-6C	8 cd	0 a	3 a	1 ab	2 ab	1.1 ab	1.0 a-c	38 ab	2.5 a
9	VA-1 30.3 ml	TC-6C	8 bc	2 a	12 b	0 a	4 b	1.2 ab	1.1 bc	15 a	2.9 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps. Harvest counts based on 25 fruit per replication.
Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 23 Sep (Red Delicious and Golden Delicious), or 29 Sep (Rome), placed in cold storage at 4°C and rated after 7 days (Rome), 30 days (Golden Del., 34 days cold storage (Red Delicious).
* 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: 1 Apr (TC, tight cluster R. Del and G. Del; Rome ½ in green-TC); 12 Apr (bloom- PF (R. Del.); 23 Apr (petal fall); first- sixth covers (1-6C): 7 May, 21 May, 4 Jun, 18 Jun, 9 Jul, 6 Aug.

Table 15. Post-storage rot control on Rome Beauty, Golden Delicious, and Red Delicious apple, 2009.

		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	---	20 d	27 c	18 b	9 c	11 b	4 b	8 b	14 e	5 b	3 b	16 b	9 b
1 Rally 40WSP 1.25 oz + Penncozeb 75DF 12 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C-6C	0 a	12 ab	1 a	0 a	1 a	0 a	0 a	6 b-e	1 a	0 a	5 ab	0 a
2 Rally 1.25 oz + Penncozeb 12 oz + Sulfur 2 lb Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C-6C	3 a-c	8 ab	2 a	2 ab	1 a	0 a	1 a	4 a-d	1 a	0 a	1 a	1 a
3 Flint 50WG 0.5 oz (*+ Rally 0.6 oz, 1C-2C*) Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C-6C	0 a	3 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	1 a	0 a
4 Flint 50WG 0.5 oz Captan 80WDG 7.5 oz + Ziram 76DF 12 oz	TC-3C 4C-6C	2 ab	4 ab	0 a	2 ab	1 a	0 a	0 a	2 a-c	0 a	0 a	2 a	0 a
5 Omega 4SC 3 fl oz	TC-6C	4 bc	10 ab	1 a	2 ab	2 a	0 a	2 a	4 a-d	0 a	0 a	3 a	1 a
6 Omega 4SC 3 fl oz (+*Inspire 1.5 fl oz, 1C-2C*) Omega 4SC 3 fl oz	TC-3C 4C-6C	9 bc	14 bc	1 a	6 bc	1 a	0 a	3 a	9 de	0 a	0 a	4 a	0 a
7 VA-1 16.8 ml	TC-6C	6 c	7 ab	1 a	5 bc	1 a	0 a	1 a	3 ab	0 a	0 a	4 ab	1 a
8 VA-1 23.7 ml	TC-6C	6 c	7 ab	0 a	4 bc	1 a	0 a	2 a	1 ab	0 a	0 a	5 ab	0 a
9 VA-1 30.3 ml	TC-6C	9 cd	16 bc	2 a	8 c	3 a	0 a	0 a	9 c-e	0 a	1 a	5 a	1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on 25 fruit per tree.
Postharvest fruit counts are means of 25-fruit samples picked from each of four single-tree reps 23 Sep (Red Delicious and Golden Delicious), or 29 Sep (Rome), placed in cold storage at 4°C and rated after 7 days (Rome), 30 days (Golden Del., 34 days cold storage (Red Delicious). Following cold storage, fruit were incubated at mean 70°F for 27 days (Rome), 23 days (G. Del.) or 17 days (Red Del.) before rot assessment.

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 season disease control by protectant fungicides on Nittany apple, 2010.

Nine treatments involving selected combinations of registered fungicides were compared at Virginia Tech AREC where scab resistance to SI fungicides is well documented and where a shift toward resistance to dodine had been noted in 2004. The test was conducted on 29-yr-old trees with a 28-ft row spacing 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. 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: 25 Mar (GT, greentip), 7 Apr (Pk, pink-early bloom), 15 Apr (B1, 30% bloom) and 29 Apr (B2, late bloom). 12 May (PF, petal fall). First through 7th covers (1C-5C) applied 28 May, 11 Jun, 25 Jun, 15 Jul, 5 Aug 25 Aug and 14 Sep. Inoculum, placed over each test tree, included: wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies 4 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 23 Jul. On-tree fruit scab counts were conducted on 50 fruit per tree 2 Aug. Postharvest fruit data are based on 25-fruit sample per rep harvested 4 Oct and held in cold storage until rating 13 Oct, then evaluated for rot development after 27 days at ambient temperatures 65-73ºF. Maintenance materials applied to the entire test block with the same equipment included Supracide, Assail, FireWall, Calypso, Delegate, Intrepid, Imidan, and Provado. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The first scab infection period occurred 28-29 Mar and lesions appeared as early as 12 Apr with a secondary infection period immediately following 13-14 Apr. Seven additional secondary infection periods occurred through the end of May. Treatments 6 and 7 vs. 2 and 3 showed the benefits of including Sovran rather than Rally at late bloom and first cover, indicating the weakness of the SI fungicide, Rally in this test block. Treatment 4 shows the benefit of Captan rather than Penncozeb in combination with Syllit (Trt. 3) or by Syllit alone (Trt 2). On-tree fruit scab counts were generally higher than postharvest scab counts. Including Sovran in the schedule at late bloom improved on-tree fruit scab control compared to schedule which continued with Rally to first cover (Trts. 7 and 6 vs. 3 and 2). Although Nittany is not particularly susceptible to powdery mildew, inoculum pressure and weather conditions provided a strong mildew test. Treatments that had Sovran at late bloom and first cover (#6-8) gave better mildew control on foliage than the parallel treatments which had at Rally in those applications (#2-4). All treatments gave adequate control of cedar-apple rust which infected in late April and May. Nearly all treatments covered by Captan + Ziram in late season, gave significant control of post-storage rots. Apart from what was judged to be mildew russetting, there was no significant treatment effect on (p=0.05) in fruit finish by any treatment compared to non-treated fruit.

Table 16. Early season disease control by protectant fungicides on Nittany apple, 2010.

			% fruit, leaves, leaf area infected or lesions/leaf							
			Foliar scab		% fruit scab		c. rust	mildew infection, %		
	Treatment and rate per acre	Timing	% lvs	les/leaf	on tree	13 Oct	% lvs	% lvs	lf area	fruit
0	No fungicide	---	42 d	5.6 b	73 d	54 c	13 b	59 e	10 d	23 b
1	Rally 6 oz + Penncozeb 75DF 3 lb	GT-PF	17 c	0.6 a	0 a	1 ab	<1 a	50 de	5 bc	4 a
	Captan 80WDG 5 lb	1C-2C								
	Captan 80WDG 30 oz+ Ziram 3 lb	3C→								
2	Syllit 3.4F 1.5 pt	GT-Pk								
	Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF	18 c	1.1 a	6 bc	3 b	0 a	50 de	6 c	4 a
	Captan 80WDG 5 lb	1C-2C								
	Captan 80WDG 30 oz+ Ziram 3 lb	3C→								
3	Syllit 3.4F 1.5 pt + Penncozeb 3 lb	GT-Pk								
	Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF	17 c	0.6 a	10 c	3 b	0 a	45 cd	5 bc	5 a
	Captan 80WDG 5 lb	1C-2C								
	Captan 80WDG 30 oz+ Ziram 3 lb	3C→								
4	Syllit 3.4F 1.5 pt + Captan 2.5 lb	GT-Pk								
	Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF	9 ab	0.3 a	0 a	0 a	0 a	41 bc	4 a-c	4 a
	Captan 80WDG 5 lb	1C-2C								
	Captan 80WDG 30 oz+ Ziram 3 lb	3C→								
5	Manzate 75DF 3 lb + Captan 2.5 lb	GT-Pk								
	Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF	11 b	0.5 a	0 a	2 ab	0 a	35 ab	4 ab	8 ab
	Captan 80WDG 5 lb	1C-2C								
	Captan 80WDG 30 oz+ Ziram 3 lb	3C→								
6	Syllit 3.4F 1.5 pt	GT-Pk								
	Rally 6 oz + Penncozeb 75DF 3 lb	B1& PF	8 ab	0.2 a	1 a	0 a	<1 a	31 a	3 a	3 a
	Sovran 50DF 4 oz+ Penncozeb 3 lb	B2 & 1C								
	Captan 80WDG 5 lb	2C								
	Captan 80WDG 30 oz+ Ziram 3 lb	3C→								
7	Syllit 3.4F 1.5 pt + Penncozeb 3 lb	GT-Pk								
	Rally 6 oz + Penncozeb 75DF 3 lb	B1& PF	6 ab	0.3 a	0 a	2 ab	<1 a	35 ab	3 a	4 a
	Sovran 50DF 4 oz+ Penncozeb 3 lb	B2 & 1C								
	Captan 80WDG 5 lb	2C								
	Captan 80WDG 30 oz+ Ziram 3 lb	3C→								
8	Syllit 3.4F 1.5 pt + Captan 2.5 lb	GT-Pk								
	Rally 6 oz + Penncozeb 75DF 3 lb	B1& PF	6 a	0.2 a	3 ab	0 a	<1 a	32 ab	3 a	2 a
	Sovran 50DF 4 oz + Penncozeb 3 lb	B2 & 1C								
	Captan 80WDG 5 lb	2C								
	Captan 80WDG 30 oz + Ziram 3 lb	3C→								
9	Kocide 2000 53.8DF 3.5 lb +									
	Penncozeb 75DF 3 lb	GT								
	Penncozeb 3 lb + Captan 2.5 lb	Pink								
	Indar 2F 8 fl oz + Penncozeb 3 lb +		11 b	0.3 a	4 ab	0 a	0 a	34 ab	4 a	5 a
	LI-700 8 fl oz/100 gal	B1-1C								
	Indar 2F 8 fl oz + Captan 2.5 lb +									
	LI-700 8 fl oz/100 gal	2C→								

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications.
Foliar disease ratings on 10 shoots per tree 23 Jul or 50 fruit per tree 2 Aug, or harvest counts of 25 fruit per tree 13 Oct.

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: 25 Mar (GT, greentip), 7 Apr (Pk, pink-early bloom), 15 Apr (B1, 30% bloom) and 29 Apr (B2, late bloom). 12 May (PF, petal fall). First through 7th covers (1C-7C) applied 28 May, 11 Jun, 25 Jun, 15 Jul, 5 Aug 25 Aug and 14 Sep.

Table 17. Summer disease control by protectant fungicides on Nittany apple, 2010.

		% fruit infected		% fruit infected after incubation*			
Treatment and rate per acre	Timing	Sooty blotch	Fly-speck	Any rot	Bitter Rot	White rot	Alter-naria
0 No fungicide	---	4 b	3 b	33 b	18 b	6 b	12 b
1 Rally 6 oz + Penncozeb 75DF 3 lb	GT-PF						
Captan 80WDG 5 lb	1C-2C						
Captan 80WDG 30 oz+ Ziram 3 lb	3C→	0 a	0 a	7 a	1 a	1 a	5 ab
2 Syllit 3.4F 1.5 pt	GT-Pk						
Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF						
Captan 80WDG 5 lb	1C-2C						
Captan 80WDG 30 oz+ Ziram 3 lb	3C→	0 a	1 ab	10 a	3 a	3 ab	5 ab
3 Syllit 3.4F 1.5 pt + Penncozeb 3 lb	GT-Pk						
Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF						
Captan 80WDG 5 lb	1C-2C						
Captan 80WDG 30 oz+ Ziram 3 lb	3C→	0 a	0 a	5 a	0 a	1 a	4 ab
4 Syllit 3.4F 1.5 pt + Captan 2.5 lb	GT-Pk						
Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF						
Captan 80WDG 5 lb	1C-2C						
Captan 80WDG 30 oz+ Ziram 3 lb	3C→	0 a	0 a	5 a	2 a	1 a	3 ab
5 Manzate 75DF 3 lb + Captan 2.5 lb	GT-Pk						
Rally 6 oz + Penncozeb 75DF 3 lb	B1-PF						
Captan 80WDG 5 lb	1C-2C						
Captan 80WDG 30 oz+ Ziram 3 lb	3C→	0 a	1 ab	11 a	2 a	0 a	9 ab
6 Syllit 3.4F 1.5 pt	GT-Pk						
Rally 6 oz + Penncozeb 75DF 3 lb	B1& PF						
Sovran 50DF 4 oz+ Penncozeb 3 lb	B2 & 1C						
Captan 80WDG 5 lb	2C						
Captan 80WDG 30 oz+ Ziram 3 lb	3C→	1 a	0 a	9 a	3 a	0 a	6 ab
7 Syllit 3.4F 1.5 pt + Penncozeb 3 lb	GT-Pk						
Rally 6 oz + Penncozeb 75DF 3 lb	B1& PF						
Sovran 50DF 4 oz+ Penncozeb 3 lb	B2 & 1C						
Captan 80WDG 5 lb	2C						
Captan 80WDG 30 oz+ Ziram 3 lb	3C→	0 a	0 a	2 a	0 a	2 a	0 a
8 Syllit 3.4F 1.5 pt + Captan 2.5 lb	GT-Pk						
Rally 6 oz + Penncozeb 75DF 3 lb	B1& PF						
Sovran 50DF 4 oz + Penncozeb 3 lb	B2 & 1C						
Captan 80WDG 5 lb	2C						
Captan 80WDG 30 oz + Ziram 3 lb	3C→	0 a	0 a	9 a	3 a	1 a	5 ab
9 Kocide 2000 53.8DF 3.5 lb + Penncozeb 75DF 3 lb	GT						
Penncozeb 3 lb + Captan 2.5 lb	Pink						
Indar 2F 8 fl oz + Penncozeb 3 lb + LI-700 8 fl oz/100 gal	B1-1C						
Indar 2F 8 fl oz + Captan 2.5 lb + LI-700 8 fl oz/100 gal	2C→	1 a	0 a	6 a	1 a	1 a	5 ab

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

* Postharvest rots assessed on 25 fruit per tree after 27 days' storage at ambient temperatures 65-73ºF.

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: 25 Mar (GT, greentip), 7 Apr (Pk, pink-early bloom), 15 Apr (B1, 30% bloom) and 29 Apr (B2, late bloom). 12 May (PF, petal fall). First through 5th covers (1C-5C) applied 28 May, 11 Jun, 25 Jun, 15 Jul, 5 Aug and 25 Aug.

APPLE (*Malus domestica* 'Jonagold', 'Ginger Gold')
Scab; *Venturia inaequalis*
White rot (*Botryosphaeria dothidea*)
Alternaria rot (*Alternaria* spp.)
Bitter rot (*Colletotrichum acutatum*)
Fruit finish

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Effects of apple scab "rescue" treatments applied after lesions appeared on Ginger Gold, Jonagold and Red Delicious apples, 2010.

Treatments were applied in two blocks of 19 yr-old trees to test the effectiveness of selected fungicide combinations when delayed until well after lesions had appeared from earlier infection periods. A primary scab infection period occurred 28-29 Mar and lesions were observed in some blocks as early as 12 Apr. Additional infection periods occurred 25-27 Apr and 2-3 May, and the treatments were first applied 10 May (Jonagold) or 11 May (Ginger Gold, Red Delicious). The tests were set up as four randomized blocks with in-row border trees. No fungicides were applied until after scab was present in the trees, then treatments were applied dilute to runoff 10 or 11 May, 26 May, and 10 Jun. No other fungicides were applied to Ginger Gold. Maintenance materials applied airblast to the entire test block included Supracide + oil, FireWall, Assail, NAA + Sevin XLR, Imidan, Provado, Intrepid, Lannate LV, Delegate, and Calypso. Ginger Gold was harvested 29 Jul and first rated 4 Aug, then rated again after 13 days' additional incubation at ambient temperatures (mean 84°F). A single application of cover fungicides (Captan 80WDG 30 oz + Ziram 3 lb/A) was applied airblast to all Jonagold and Red Delicious treatments 5 Aug. The non-treated control did not receive the cover fungicides. A 25 fruit sample was taken and evaluated from Jonagold 9 Sep. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Under heavy post-symptom and secondary pre-symptom scab pressure, all treatments except Indar alone (on Jonagold) gave significant suppression of percent fruit infected, and all treatments except Flint + Rally and Flint + Syllit significantly reduced the number of lesions per fruit. There was no significant difference (p=0.05) among treatments for scab suppression on Ginger Gold (Table 18). On Jonagold (Table 19) the 3-way combination of Flint + Indar + Syllit and Luna Sensation (a package mix of trifloxystrobin and fluopyram) had the fewest scab lesions per fruit. From the time of the last fungicide application 10 Jun to harvest of Ginger Gold fruit 4 Aug there were only four extended wetting periods of 9-14 hours, and none with more than 0.76 in. rainfall, but 65% of non-treated fruit developed rots after the 13-day incubation. Luna Sensation provided the best control of rots with the best or near best suppression of white (Bot) rot, Alternaria, and bitter rot on Ginger Gold. On Red Delicious (Table 20), where 85% of non-treated fruit were infected, Flint + Syllit gave the best fruit scab suppression followed by Inspire + Syllit + Flint and Flint and Inspire Super alone. Syllit alone and Captan + ProPhyt related treatments gave similar significant suppression at 35-38%. There was no significant treatment effect (p=0.05) on fruit finish of any cultivar compared to non-treated fruit.

Table 18. Effect of early cover treatments on scab and post-harvest rot development, Ginger Gold

	Treatment and dilute rate/ 100 gal	Timing	Scab % fruit	Scab lesion / fruit	% fruit with indicated rots after 13-day incubation* Any rot	White rot	Alter-naria	Bitter rot	Russet rating (0-5)**
0	No fungicide	---	79 b	5.6 b	65 c	46 c	22 b	10 b	2.1 a
1	Rally 40WSP 1.5 oz + Syllit 6 fl oz	1C-3C	20 a	0.6 a	32 ab	24 a	8 ab	0 a	1.6 a
2	Flint 50WG 0.5 oz + Syllit 6 fl oz	1C-3C	29 a	1.1 a	51 bc	42 bc	12 ab	3 a	1.9 a
3	Flint 50WG 0.5 oz + Rally 1.5 oz	1C-3C	23 a	0.6 a	50 bc	34 a-c	21 b	0 a	1.9 a
4	Flint 0.5 oz + Rally 1.5 oz + Syllit 6 fl oz	1C-3C	29 a	0.7 a	38 ab	31 ab	10 ab	1 a	1.9 a
5	Luna Sensation 500SC 1.25 fl oz	1C-3C	33 a	0.8 a	29 a	25 a	2 a	1 a	1.6 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps.
No fungicides applied before 10 May. Treatments applied 11 May, 26 May, and 10 Jun; dilute to run-off with a single nozzle handgun at 550 psi. No other fungicide applications.
* Counts of a 25-fruit sample/ rep taken 29 Jul and first rated 4 Aug. Rot counts following 13 days' incubation at ambient temperatures. Mean maximum and minimum temperatures for the 13-day incubation period were 89.1°F and 78.2°F, respectively.
** Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet).

Table 19. Effect of early cover treatments on scab and fruit finish of Jonagold, 2010.

	Treatment and dilute rate/ 100 gal	Timing	Scab infection % fruit	Scab infection lesions / fruit	Finish rating (0-5)* Russet	Finish rating (0-5)* Opale-scence
0	Non-treated control	---	62 b	2.9 e	2.3 a	1.7 a
1	Indar 2F 2 fl oz	1C-3C	47 b	1.4 d	2.2 a	1.7 a
2	Indar 2F 2 fl oz + Syllit 6 fl oz	1C-3C	28 a	1.2 cd	2.1 a	1.5 a
3	Flint 50WG 0.5 oz	1C-3C	23 a	0.9 b-d	2.2 a	1.8 a
4	Flint 50WG 0.5 oz + Syllit 6 fl oz	1C-3C	18 a	0.8 a-c	2.2 a	1.7 a
5	Flint 0.5 oz + Indar 2 fl oz + Syllit 6 fl oz	1C-3C	19 a	0.3 a	2.1 a	1.7 a
6	Luna Sensation 500SC 1.25 fl oz	1C-3C	16 a	0.6 ab	2.1 a	1.5 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps.
No fungicides applied before 10 May. Treatments applied 11 May, 26 May, and 10 Jun; dilute to run-off with a single nozzle handgun at 550 psi.
Cover fungicides (Captan 80WDG 30 oz + Ziram 3 lb/A) applied to treatments #1-6 5 Aug.
Counts of a 25-fruit sample per replication collected and evaluated 9 Sep.
* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet).

Table 20. Effect of fungicides applied to Red Delicious after scab was visible, 2010. Block #12

	Treatment and rate/ 100 gal dilute, applied as first-third cover sprays	Scab infection % fruit	Scab infection lesions / fruit	% fruit infected Sooty blotch	% fruit infected Fly speck	Finish rating (0-5)* Russet	Finish rating (0-5)* Opales-ence
0	Non-treated control	85 d	8.8 b	18 b	15 b	1.0 a	1.3 ab
1	Syllit 3.4F 6 fl oz	38 bc	1.4 a	1 a	1 a	1.0 a	1.1 ab
2	Indar 2F 2 fl oz	50 c	2.0 a	0 a	0 a	1.3 a	1.2 ab
3	Indar 2F 2 fl oz + Syllit 3.4F 6 fl oz	36 bc	1.6 a	1 a	0 a	1.3 a	1.5 b
4	Flint 50WG 0.5 oz	25 ab	1.1 a	0 a	0 a	1.1 a	1.2 ab
5	Flint 50WG 0.5 oz + Syllit 3.4F 6 fl oz	17 a	0.4 a	0 a	0 a	1.0	1.2 ab
6	Inspire Super MP 338SE 3 fl oz	27 ab	1.1 a	0 a	0 a	1.0 a	1.1 ab
7	Inspire Super 338SE 3 fl oz + Syllit 3.4F 6 fl oz	25 ab	0.7 a	0 a	0 a	1.1 a	1.0 ab
8	Captan 80WDG 15 oz + ProPhyt 4.2L 1 pt	35 bc	1.8 a	1 a	0 a	1.0 a	1.0 a
9	Captan 80WDG 15 oz + ProPhyt 4.2L 1 pt + Syllit 3.4F 6 fl oz	37 bc	1.7 a	0 a	0 a	1.1 a	1.1 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps with in-row border trees.
Counts of 25 fruit sample picked from each of four single tree reps 1 Sep and rated 7 Sep.
No fungicides applied until after scab was present in trees.
Treatments applied dilute to runoff with a single nozzle handgun at 550 psi 11 May, 26 May, 10 Jun.
No fungicides applied to in-row border trees.
Cover fungicides (Captan 80WDG 30 oz + Ziram 3 lb/A) applied to all treatments 5 Aug.

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

APPLE (*Malus domestica*

'Stayman Winesap', 'Rome Beauty')
Powdery mildew; *Podosphaera leucotricha*
Fruit finish

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Evaluation of Topguard for mildew control under commercial conditions, 2010

In cooperation with Cheminova, Inc., and in anticipation of Topguard registration on apples, plots were set up in two commercial orchard blocks at Silver Creek Orchards, Tyro, VA. Both test blocks, approximately 20 years old, had a history of heavy mildew pressure. In Stayman, test areas (treatments) 1 and 2 and "Grower schedule" area were adjacent areas in the same block. In Rome, test areas (treatments) 1 and 2 were adjacent areas and the "Grower schedule" area was in a nearby block. All treatments were applied at 100 gal/A to both sides of the tree on each indicated application day: 2 Apr (tight cluster), 12 Apr (petal fall), 23 Apr, and 5 May. To ensure initial uniform disease pressure, infection data were taken from trees in rows adjacent to the border rows between the plot areas. Four trees that appeared to be of comparable vigor in the plot areas were flagged on 18 Mar before the treatment series began, for on-tree counts of primary "strikes" 20 Apr and shoot sampling for secondary infection 18 May. Fruit samples were collected from uniform replicate in-row trees 21 Sep.

Early season weather was favorable for infection and primary mildew inoculum was heavy in the test areas. In both blocks, Topguard gave excellent mildew control on foliage, significantly suppressing the number of primary "strikes" and percent leaves infected compared to the Rally 5 oz/A standard (Tables 21 and 22). In the Stayman block, the "Grower schedule", which included Rally 6 oz/A and an extra sulfur application 7 Apr, also had significantly fewer primary strikes and less area infected than the Rally 5 oz/A standard. This was not the case in the Rome test areas, likely because trees in the adjacent "Grower schedule" area were more vigorous and continued to grow later into the season, thereby increasing the period of susceptibility to secondary infection and offsetting the higher Rally rate and additional sulfur application. There was no significant difference in the amount of mildew russet on Stayman fruit (Table 23). Significantly more Topguard-treated Rome fruit were rated with net-like mildew russet (Table 24). It is not known whether this might be related to reduced abortion of mildewed flowers following the Topguard treatment under heavy primary inoculum conditions. Apart from mildew russet, there were no other significant treatment-related fruit finish effects on Rome. On Stayman, the Rally + mancozeb standard schedule had significantly less russet and opalescence than Topguard and the "Grower schedule". Topguard and the Rally + mancozeb standard had significantly more fruit in the USDA Extra-fancy & Fancy grouping for fruit finish presumed not to be mildew related. Following the rating of fruit, they were further incubated for 34 days; there were no significant differences in the amount of treatment-related postharvest rots that developed after the grower summer cover sprays, similarly applied to all treatments of each cultivar.

Table 21. Stayman Winesap foliar evaluation

	Treatment and rate/A	Application dates:	Mildew infection: primary "strikes" 20 Apr*	Mildew infection: secondary 18 May % leaves	Mildew infection: secondary 18 May % leaf area
1	**Topguard plot:** Topguard 13 fl oz + mancozeb 3 lb + ziram 3 lb	2, 12, and 23 Apr, 5 May	5.5 a	26.0 a	4.3 a
2	**Standard area:** Rally 5 oz + mancozeb 3 lb	2, 12, and 23 Apr, 5 May	29.3 b	48.9 b	15.6 b
3	**Grower schedule area:** Rally 6 oz + mancozeb 3 lb	2, 12, and 23 Apr, 5 May	10.0 a	39.9 b	8.6 a
	Sulfur 10 lb	7 Apr			

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four uniform replicate in-row trees.
* Primary strikes visible up to 7 ft on each of four pre-flagged sample trees 20 Apr.
Secondary infection counts based on 10 shoots per sample tree, collected 18 May.

Table 22. Rome Beauty foliar evaluation

	Treatment and rate/A	Application dates:	Mildew infection: primary "strikes" 20 Apr*	Mildew infection: secondary 18 May % leaves	Mildew infection: secondary 18 May % leaf area
1	**Topguard plot:** Topguard 13 fl oz + mancozeb 3 lb + ziram 3 lb	2, 12, and 23 Apr, 5 May	15.5 a	33.2 a	4.1 a
2	**Standard area:** Rally 5 oz + mancozeb 3 lb	2, 12, and 23 Apr, 5 May	55.3 b	49.8 b	5.2 a
3	**Grower schedule area:** Rally 6 oz + mancozeb 3 lb	2, 12, and 23 Apr, 5 May	48.0 b	56.0 b	9.8 b
	Sulfur 10 lb	7 Apr			

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four uniform replicate in-row trees.
* Primary strikes visible up to 7 ft on each of four pre-flagged sample trees 20 Apr.
Secondary infection counts based on 10 shoots per sample tree, collected 18 May.

Table 23. Stayman Winesap fruit evaluation

	Treatment and rate/A applied 2, 12, and 23 Apr, 5 May	Mildew inf. % fruit	Mildew inf. % fruit area	USDA finish grades * X-fancy	USDA finish grades * X-fancy & Fancy	USDA finish grades * Utility	USDA finish grades * No. 1 & Utility	Finish rating** opal-escence	Finish rating** russet
1	**Topguard plot:** Topguard 13 fl oz + mancozeb 3 lb + ziram 3 lb	10 a	1.3 a	96 a	100 a	0 a	0 a	1.8 b	2.6 b
2	**Standard area:** Rally 5 oz + mancozeb 3 lb	9 a	1.7 a	95 a	98 a	2 a	2 a	1.6 a	2.1 a
3	**Grower schedule area:** Rally 6 oz + mancozeb 3 lb	16 a	2.5 a	91 a	94 b	2 a	6 b	1.9 b	2.8 b
	Sulfur 10 lb (7 Apr)								

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). 25 fruit from each of four uniform replicate in-row trees sampled 21 Sep.
* USDA Extra fancy & fancy and No. 1 & Utility grades after downgrading by russet presumed not to be caused by mildew.
** Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet).

Table 24. Rome Beauty fruit evaluation

Treatment and rate/A applied 2, 12, and 23 Apr, 5 May	Mildew inf. % fruit	Mildew inf. % fruit area	USDA finish grades * X-fancy	USDA finish grades * X-fancy & Fancy	USDA finish grades * Utility	USDA finish grades * No. 1 & Utility	Finish rating** opal-escence	Finish rating** russet
1 **Topguard plot:**								
Topguard 13 fl oz + mancozeb 3 lb + ziram 3 lb	41 b	6.5 b	81 a	86 a	5 a	14 a	1.1 a	1.1 a
2 **Standard area:**								
Rally 5 oz + mancozeb 3 lb	19 a	3.3 ab	88 a	92 a	4 a	8 a	1.2 a	1.2 a
3 **Grower schedule area:**								
Rally 6 oz + mancozeb 3 lb	8 a	1.1 a	96 a	99 a	0 a	1 a	1.2 a	1.2 a
Sulfur 10 lb (7 Apr)								

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). 25 fruit from uniform replicate in-row trees sampled 21 Sep.

* USDA Extra fancy and fancy and No. 1 & Utility grades after downgrading by russet presumed not to be caused by mildew.

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

APPLE (*Malus domestica* 'Golden Delicious', 'Empire'')
Bitter rot; *Colletotrichum acutatum*

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Control of bitter rot by postharvest dip treatments on Golden Delicious and Empire apples, 2010.

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 2010. 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, 68-76°F (mean 72.8°F). Empire fruit were treated 3 hr after inoculation and wounding and incubated as with Golden Delicious. Bitter rot inoculation and treatment date was 28 Oct for both cultivars. Fruit were examined and evaluated periodically as needed for rot development.

Inoculation and incubation conditions provided strong bitter rot tests for both cultivars. Under these conditions, the Scholar and A8574 and combination treatments gave near complete bitter rot control after 5 days incubation, based on percent fruit and percent wounds infected. By the 7th day the single compound treatments had started to decline but the combinations gave complete control through 11 days. Results were similar for both cultivars. A significant rate effect was noted for A8574. The high effectiveness of the Scholar test rate precluded evaluation of any additive of A8574 effect. Penbotec and Mertect gave only slight suppression of bitter rot; Mertect + Captan seemed to give some bitter rot suppression.

Table 25. Control of bitter rot by postharvest dip treatments on Golden Delicious and Empire apples, 2010.

	% fruit or wounds infected with Bitter rot after indicated incubation and lesion radius at 7 days													
	Golden Delicious							Empire						
Treatment and rate	% fruit inf.			% wound inf.			lesion	% fruit inf.			% wound inf.			lesion
/ 100 gal dilute	5 day	7 day	11 day	5 day	7 day	11 day	radius	5 day	7 day	11 day	5 day	7 day	11 day	radius
1 Check – no dip	100 c	100 e	100 e	100 d	100 g	100 f	9.9 f	100 d	100 d	100 e	100 d	100 d	100 f	11.1 g
2 Scholar 1.92SC 8 fl oz	0 a	9 b	11 b	0 a	3 b	4 b	0.1 ab	3 b	3 a	11 b	1 a	1 a	4 b	0.1 ab
3 A8574 16 fl oz	0 a	41 d	76 d	0 a	23 d	45 d	0.7 b	0 a	28 b	94 d	0 b	10 b	68 d	0.4 b
4 A8574 20.0 fl oz	0 a	24 c	65 c	0 a	10 c	30 c	0.3 ab	0 a	28 b	89 c	0 b	10 b	53 c	0.3 ab
5 Scholar 8 fl oz + A8574 16 fl oz	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
6 Scholar 10 fl oz + A8574 20 fl oz	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
7 Penbotec 3.34SC 12.8 fl oz	100 c	100 e	100 e	96 c	98 f	100 f	6.0 c	100 d	100 d	100 e	99 d	100 d	100 f	6.8 d
8 Mertect 1 pt	100 c	100 e	100 e	95 c	96 f	99 f	7.2 d	100 d	100 d	100 e	100 d	100 d	100 f	9.2 e
9 Mertect 340F 1 pt + Captan 50W 1 lb	98 b	99 e	100 e	75 b	85 e	96 e	6.1 c	94 c	100 c	100 e	62 c	83 c	95 e	5.7 c
10 Water dip	100 c	100 e	100 e	100 d	100 g	100 f	8.6 e	100 d	100 d	100 e	100 d	100 d	100 f	9.6 f

Column mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications of 20 fruit per rot and 3 wounds / fruit.

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MANAGEMENT OF APPLE DISEASES WITH FUNGICIDES AT LOW RISK OF RESISTANCE

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EARLY SEASON APPLE SCAB. Performance three reduced or low fungicide resistance risk programs with Manzate, Captan, MicroSulf programs (Trts. 3-4, 7), two organic programs (Trt. 5 with Microthiol/Lime Sulfur (LS)/Cuprofix Ultra and Trt.6 with LS/Microthiol/Kocide 3000 copper, and a conventional Rally + Penncozeb standard (Trt. 2) were evaluated for scab control in an orchard where resistance to the sterol demethylation inhibitor (DMI) fungicides is confirmed. The trial was conducted at the Penn State Fruit Research and Extension Center research orchards on mature Rome Beauty, Golden Delicious, Stayman, Cortland, and Red Delicious trees. Treatments were arranged in a randomized complete block design with four replications. Treatments were applied with a boom sprayer at 400 psi, which delivered 100 gal/A. Spray programs were applied on 7-14 day intervals, until scab primary, and then 8-24 day intervals thereafter, from 1 Apr (half in. green) to 20 Aug (7th cover). A conventional maintenance program for insects was applied 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 Mills apple scab infection model. Rainfall for Apr, May, Jun, Jul, and Aug was 2.0 in., 3.7 in., 1.7 in., 2.3 in., and 3.0 in., respectively. Several scab infection periods occurred during the primary period 16 Mar to 15 Jun. There were 6 moderate and 11 severe infection periods. Apple scab pressure was moderate in the test site. Overall disease pressure in the test site was moderate due to lower than normal temperatures in April and May. Incidence of scab on shoot and fruit was determined on 28 May, 23 Jul and 18 Aug by examining all leaves of 25 arbitrarily selected shoots and fruit. Data obtained from the five apple cultivars Rome Beauty, Golden Delicious, Stayman, Cortland and Red Delicious were analyzed and combined by analysis of variance and significance between means was determined by the Fisher's Protected LSD Test ($P \leq 0.05$).

Scab incidence and severity on untreated shoot leaves on 28 May, 23 Jul, and 18 Aug was 83 and 12, 94 and 12, and 99 and 18%, respectively. On 28 May, 23 Jul, and 18 Aug, programs with Manzate 6 lb early/Captan (Trt. 3), Manzate 3 lb early /Captan/MicroSulf (Trt. 4) and Manzate 5 lb/Captan/Lime Sulfur/MicroSulf (Trt. 7) had the lowest incidence of scab on shoot leaves at 32, 35 and 32%, 35, 25 and 18%, and 39, 51 and 23%, respectively. The organic programs with LS/MicroSulf/Cuprofix (Trt. 5) and LS/Microthiol/Kocide 3000 (Trt. 6) and conventional program Rally/Penncozeb (Trt. 2) had the highest levels of scab on leaves that ranged from 53 to 93%. (Table 1). Scab severity on treated leaves ranged from 1 to 8% with some of the treatments had different levels of scab incidence and were significantly lower than the untreated control. Scab incidence and severity on untreated fruit on 28 May, 23 Jul and 18 Aug was 74 and 3%, 93 and 19%, and 96 and 19%, respectively. Reduced risk Trts. 3, 4 and 7 and conventional Rally/Penncozeb- Trt. 2 provided the best scab control on fruit that ranged from 96 to100% control. Organic Trts. 5 and 6 also provided significant fruit scab control at 85 and 79%, respectively (Table 2). Overall, reduced / low risk programs are effective and outperformed Rally/Penncozeb program especially for scab control on leaves. No treatments caused phytotoxicity to leaves or fruit.

SUMMER DISEASES. Various apple disease management programs, four employing conventional fungicides and three employing organic fungicides or fungicides with a low risk of selecting for pathogen resistance, were compared. The conventional programs incorporated Captan+Topsin, Inspire Super/Captan+Topsin, Luna Sensation and Indar+Captan. The three organic/low resistance risk programs were composed of Lime Sulfur (LS)/Cuprofix Ultra, LS/Kocide 3000 and LS/MicroSulf with Captan+Topsin programs. Results on control of apple scab, sooty blotch, flyspeck, white rot and russet were evaluated. The test was conducted at the Penn State Fruit Research and Extension Center research orchard on mature Golden Delicious trees. 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 at 9 to 26 day intervals from 25 May (2nd cover) to 20 Aug (7th cover). A maintenance program for early season diseases consisting of six sprays from half in. green to 1st cover were applied to all the treatments with a boom sprayer at 100 gal/A at 400 psi. A program for insect management was applied separately 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 Technologies). The growing season environmental conditions were not favorable for summer disease development due to very dry weather from Jun through Aug. Disease incidence was determined on 25 to 50 Golden Delicious fruit on 18 Aug. Data obtained were analyzed by analysis of variance and significance between means was determined by the Fisher's Protected LSD Test ($P \leq 0.05$).

Scab incidence on nontreated fruit was 93%, and scab on treated fruit was significantly lower for all treatments, ranging from 0 to 25%. All conventional programs (Trts. 2-5), one of the organic programs (Trt. 6), and the low risk resistance program (Trt. 8) had the lowest incidence of scab (0 to 6%) and were not significantly different from each other. The other organic program (Trt. 7) had significantly higher scab levels (25%). Incidence of flyspeck, sooty blotch, and Botryosphaeria rot on nontreated fruit was 30, 14, and 0%, respectively. All treatments significantly reduced flyspeck and sooty blotch incidence compared with the nontreated control. There was no significant difference in sooty blotch or flyspeck levels among treatments, and except for Trt. 6 (5% on sooty blotch incidence). All programs provided 100% control on flyspeck. Russet incidence on treated and nontreated fruit ranged from 4.1 to 8%. Except for Trt. 6 with Cuprofix Ultra and Lime Sulfur which had the highest level of russet (8%), russet in treated fruit and nontreated fruit were not different (Table 3). No other type of phytotoxicity was observed.

Table 1. Apple scab incidence on combined 5 apple cultivars, Rome Beauty, Golden Delicious, Stayman, Cortland, and Red Delicious, 2010.

			% Incidence[y]							
			Shoots			%	Fruit			%
Trt.	Fungicide and rate/A	Timing[z]	28 May	23 Jul	18 Aug	Control[x]	28 May	23 Jul	18 Aug	Control[x]
1.	Untreated Check		83.2 g	93.6 e	98.6 f		74.0 e	92.8 d	96.0 d	
2.	Manzate Pro-Stick 75WG 3 lb +									
	Captan 80WDG 2.5 lb	1								
	Rally WF 5 oz +									
	Penncozeb 75DF 3 lb	2-4								
	Captan 80WDG 3.5 lb	5-6, 9								
	Luna Sensation 5 oz..................	7-8, 10-11	60.2 d	52.8 d	76.0 de	23	23.4 d	3.6 ab	4.0 d	96
3.	Manzate Pro-Stick 75WG 6 lb	1-5								
	Captan 80WDG 3.5 lb	6-9								
	Captan 80WDG 2 lb +									
	Topsin M 70WP 1 lb............	10-11	30.6 b	34.8 a	30.8 bc	69	7.4 ab	0.4 a	0.6 a	99
4.	Manzate Pro-Stick 75WG 3 lb +									
	Captan 80WDG 3 lb	1								
	Manzate Pro-Stick 75WG 3 lb +									
	Captan 80WDG 3 lb +									
	MicroSulf WP 3 lb	2-5								
	MicroSulf WP 6 lb +									
	Captan 80WDG 3.5 lb	6-9								
	Captan 80WDG 2 lb +									
	Topsin M 70WP 1 lb............	10-11	24.6 a	38.6 ab	17.6 b	82	3.8 a	1.2 ab	0.0 a	100
5.	Microthiol Disperss 8 lb	1, 3								
	Lime Sulfur 2 gal	2, 4								
	Microthiol Disperss 6 lb	5								
	Cuprofix Ultra 0.5 lb	7-11								
	Lime Sulfur 1 gal.....................	6-11	65.7 de	88.6 e	66.3 d	33	17.5 c	24.4 c	14.5 b	85
6.	Lime Sulfur 2.5 gal	1, 3								
	Microthiol Disperss 6 lb	2, 4								
	Lime Sulfur 1 gal	5-11								
	Kocide 5000 0.5 lb...................	6-11	69.4 def	92.8 e	77.0 de	22	17.6 c	20.0 c	20.4 c	79
7.	Manzate Pro-Stick 75WG 5 lb +									
	Captan 80WDG 2 lb	1-5								
	Lime Sulfur 2 gal rot.									
	MicroSulf WP 6 lb	6-9								
	Captan 80WDG 3.5 lb +									
	Topsin M 70WP 1 lb............	10-11	38.6 bc	51.0 cd	22.8 a	97	7.8 ab	1.0 ab	0.0 a	100

[z] Application timings were: 1= 1 Apr (half-in. green); 2=7 Apr (tight cluster/pink); 3= 19 Apr (pink/bloom); 4= 30 Apr (petal fall); 5= 10 May (1st cover); 6= 25 May (2nd cover); 7= 7 Jun (3rd cover); 8= 21 Jun (4th cover); 9= 15 Jul (5th cover); 10= 2 Aug (6th cover); 11= 20 Aug (7th cover).

[y] All values are scab incidence and the means of at least 25 terminal shoots, leaves and fruit across four replicate trees. Values within columns followed by the same letter are not significantly different ($P < 0.05$) according to Fisher's Protected LSD Test.

[x] Based on the incidence data for 18 Aug.

Table 2. Apple scab severity on combined 5 apple cultivars, Rome Beauty, Golden Delicious, Stayman, Cortland, and Red Delicious, 2010.

			Severity rating[y]					
			Leaves			Fruit		
Trt.	Fungicide and rate/A	Timing[x]	28 May	23 Jul	18 Aug	28 May	23 Jul	18 Aug
1.	Untreated Check		11.6 e	11.6 d	17.6 e	2.9 f	9.8 b	19.3 b
2.	Manzate Pro-Stick 75WG 3 lb +							
	Captan 80WDG 2.5 lb	1						
	Rally WF 5 oz +							
	Penncozeb 75DF 3 lb	2-4						
	Captan 80WDG 3.5 lb	5-6, 9						
	Luna Sensation 5 oz..................	7-8, 10-11	4.4 d	2.1 b	5.9 c	1.1 cde	0.1 a	0.3 a
3.	Manzate Pro-Stick 75WG 6 lb	1-5						
	Captan 80WDG 3.5 lb	6-9						
	Captan 80WDG 2 lb +							
	Topsin M 70WP 1 lb............	10-11	1.7 a	1.0 a	2.0 ab	0.8 ab	0.0 a	0.0 a
4.	Manzate Pro-Stick 75WG 3 lb +							
	Captan 80WDG 3 lb	1						
	Manzate Pro-Stick 75WG 3 lb +							
	Captan 80WDG 3 lb +							
	MicroSulf WP 3 lb	2-5						
	MicroSulf WP 6 lb +							
	Captan 80WDG 3.5 lb	6-9						
	Captan 80WDG 2 lb +							
	Topsin M 70WP 1 lb................	10-11	1.8 a	1.0 a	1.1 a	0.5 a	0.0 a	0.0 a
5.	Microthiol Disperss 8 lb	1, 3						
	Lime Sulfur 2 gal	2, 4						
	Microthiol Disperss 6 lb	5						
	Cuprofix Ultra 0.5 lb	7-11						
	Lime Sulfur 1 gal......................	6-11	4.7 c	5.2 c	7.1 cd	1.3 e	0.6 a	0.9 a
6.	Lime Sulfur 2.5 gal	1, 3						
	Microthiol Disperss 6 lb	2, 4						
	Lime Sulfur 1 gal +	5-11						
	Kocide 5000 0.5 lb....................	6-11	6.5 d	6.4 c	8.2 d	1.2 cd	0.6 a	1.3 a
7.	Manzate Pro-Stick 75WG 5 lb +							
	Captan 80WDG 2 lb	1-5						
	Lime Sulfur 2 gal rot.							
	MicroSulf WP 6 lb	6-9						
	Captan 80WDG 3.5 lb +							
	Topsin M 70WP 1 lb............	10-11	2.5 ab	1.2 ab	1.4 ab	0.8 ab	0.0 a	0.0 a

[x] Application timings were: Application timings were: 1= 1 Apr (half-in. green); 2=7 Apr (tight cluster/pink); 3= 19 Apr (pink/bloom); 4= 30 Apr (petal fall); 5= 10 May (1st cover); 6= 25 May (2nd cover); 7= 7 Jun (3rd cover); 8= 21 Jun (4th cover); 9= 15 Jul (5th cover); 10= 2 Aug (6th cover); 11= 20 Aug (7th cover).

[y] All values are scab incidence and the means of at least 25 terminal shoots, leaves and fruit across four replicate trees. Severity rating is based on scab lesions on leaves and fruit converted to % area leaf or fruit infection: 0=0; 1= 1-3% (1-3 lesions); 2= 3-6% (3-7 lesions); 3= 6-12% (6-15 lesions); 4=12-25% (15-25 lesions); 5= 25-50% (25-50 lesions); 6= 50-75% (50-80 lesions); 7= More than 75% (80 plus lesions). Values within columns followed by the same letter are not significantly different ($P < 0.05$) according to Fisher's Protected LSD Test.

Table 3. Summer disease incidence and severity on 'Golden Delicious apple, 2010.

			% Incidence [y]				% Severity [y]			
Trt.	Fungicide and amount/A	Timing[x]	Scab	Bot. rot	Sooty blotch	Flyspeck	Bot. rot	Sooty blotch	Flyspeck	Russet
1.	Untreated check		93.0 d	0.0 a	14.0 b	30.0 b	0.0 a	1.0 b	1.8 b	6.4 bc
2.	Captan 80WDG 3.5 lb	2C,5C								
	Luna Sensation 5 oz......................	3C-4C,6C-7C	1.0 ab	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	4.69 ab
3.	Inspire Super 9 fl oz +									
	Penncozeb 75DF 3 lb	2C								
	Captan 80WDG 3.5 lb	3C-5C								
	Captan 80WDG 2 lb +									
	Topsin M 70WP 1 lb.................	6C,7C	1.0 ab	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	4.7 ab
4.	Captan 80WDG 3.5 lb	2C-5C								
	Captan 80WDG 2 lb +									
	Topsin M 70WP 1 lb.................	6C,7C	2.0 ab	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	4.1 a
5.	Indar 2F 8 fl oz +									
	LI 700 4 fl oz +									
	Captan 80WDG 2.5 lb...............	2C-7C	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	5.6 ab
	Organic & Low Fungicide Resistance Risk Programs									
6.	Cuprofix Ultra 0.5 lb	3C-7C								
	Lime sulfur 1 gal...........................	2C-7C	6.0 ab	0.0 a	5.0 a	0.0 a	0.0 a	0.3 a	0.0 a	8.0 d
7.	Lime sulfur 1 gal	2C,3C-7C								
	Kocide 3000 0.5 lb........................	3C-7C	25.0 c	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	6.8 cd
8.	Lime sulfur 2 gal rot.									
	MicroSulf WP 6 lb	2C-5C								
	Captan 80 WDG 3.5 lb +									
	Topsin M 70WP 1 lb.................	6C,7C	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	5.6 ab

[x] Application timings were: 25 May (2C, 2[nd] cover); 7 Jun (3C, 3[rd] cover); 21 Jun (4C, 4[th] cover); 15 Jul (5C, 5[th] cover); 2 Aug (6C, 6[th] cover); 20 Aug (7C, 7[th] cover).

[y] All values are incidence and the means of at least 50 fruit across four replicate trees. Rated 18 Aug 2010.
Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables. Values within columns followed by the same letter(s) are not significantly different ($P < 0.05$) according to Fisher's Protected LSD Test.

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CONVENTIONAL FUNGICIDE PROGRAMS FOR APPLE SCAB AND POWDERY MILDEW IN 2010

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Various fungicides for control of apple scab and powdery mildew were evaluated on Rome Beauty and Red Delicious apple trees at the Penn State Fruit Research & Extension Center, Biglerville, PA. The trial was conducted in a randomized complete block design with four replications per treatment. Treatments were applied dilute to both sides of trees with a boom sprayer at 400 psi, which delivered 100 gal/A. Treatment applications were made on 7-14 day intervals from 19 Apr (half-in. green) to 25 May (2nd cover). A maintenance program for insects was applied separately to all the treatments. Weather data was recorded with electronic monitoring systems (Campbell Scientific and Spectrum Weather Systems) and scab infection periods calculated using a modified Mills apple scab infection model. Rainfall for Apr, May, Jun, Jul and Aug was 2.0 in., 3.7 in., 1.7 in., 2.3 in., and 3.0 in., respectively. Overall, powdery mildew pressure was due to dryer than normal weather condition in Biglerville, PA. Apple scab pressure was moderate at the test site although several scab infection periods occurred during the primary period 16 Mar to 15 Jun. There were 6 moderate scab infection events and 11 severe infection events. Moderate scab pressure occurred presumably because the early part of the growing season coincided with days with relatively low temperatures. Incidence of scab on shoot and fruit was determined on 28 May and 24 June by examining all leaves of 25 arbitrarily selected shoots and fruit. Incidence of powdery mildew was also determined on 28 May and 24 Jun by examining all leaves of 25 arbitrarily selected shoots. Severity of powdery mildew was based on a 0 to 4 rating scale: 0 = no visible mildew; 1= 1-25% shoot leaf area; 2= 26-50% shoot leaf area covered; 3= 51-75% shoot leaf area covered; 4=76-100% shoot leaf area covered by powdery mildew. Percentages of shoot leaves with mildew were calculated and data obtained were analyzed by analysis of variance and significance between means was determined by the Fisher's Protected LSD Test ($P \leq 0.05$).

Incidence of scab on nontreated Red Delicious and Rome Beauty shoot leaves on 28 May was 82 and 78%, and increased to 100 and 100%, respectively on 24 Jun. Scab severity on nontreated Red Delicious and Rome Beauty shoot leaves on 28 May was 4.8 and 23%, and 19 and 37%, respectively, on 24 Jun. Incidence of scab on Red Delicious and Rome Beauty treated shoot leaves on 28 May ranged from 3 to 55% and 6 to 75%, respectively, and increased to 3 to 60% and 13 to 86% on 24 Jun. All treatments, except Trt. 2 (Rally/Penncozeb) and Trt. 6 (Topguard/Penncozeb) significantly reduced scab on Red Delicious and Rome Beauty leaves compared to the check. LEM 17 provided the best scab control on leaves followed by Luna Sensation and Topguard /Captan, Inspire Super/Omega and Indar/Penncozeb programs. Rally/Penncozeb and Topguard/Penncozeb programs were not effective in controlling scab on leaves, but significantly reduced scab on fruit, as did the LEM 17, Luna, Inspire Super/Omega and Indar/Penncozeb programs. Scab incidence on nontreated Red Delicious and Rome Beauty fruit (24 Jun) was 100 and 100%, respectively. Incidence of scab on treated Red Delicious and Rome Beauty fruit ranged from 0 to 21% and 3 to 10%, respectively. All treatments significantly reduced scab on fruit. LEM 17 provided the best scab control on Red Delicious and Rome Beauty leaves and fruit. All treatments significantly reduced scab severity on leaves and fruit compared to the check (Tables 1, 2). Incidence of powdery mildew due to infection the previous year (primary infection) was observed on 28 May with 30% infection on nontreated trees. All treatments significantly reduced the levels of primary powdery mildew when compared to nontreated trees. Incidence of secondary powdery mildew on nontreated trees on 28 May was 54% and increased to 61% in 24 Jun. Lowest primary powdery mildew incidence (28 May) was recorded on trees treated with LEM 17, Topguard plus Penncozeb, Luna Sensation and Topguard plus Captan. On 24 Jun, powdery mildew on trees treated with Topguard plus Penncozeb had the lowest incidence and severity of powdery mildew. Trees treated with Luna Sensation, Topguard plus Captan, LEM 17 and Indar plus Penncozeb had powdery mildew levels that were not significantly different from each other, but were significantly lower than the nontreated control. Trees treated with Rally/Penncozeb and Inspire Super/Omega had the highest percentage of powdery mildew among all treatments. No phytotoxicity was observed in any of the treatments.

Table 1. Apple scab incidence and severity on Red Delicious apple, 2010.

Trt.	Fungicide & rate/A	Timing[z]	% Incidence[y] Shoots 28 May	% Contr.[x]	Shoots 24 Jun	% Contr.[w]	Fruit 24 Jun	% Contr.[w]	Severity rating[y] Leaves 28 May	Leaves 24 Jun
1.	Untreated check......................		82.0 h		100.0 h		100.0 d		4.8 ef	23.1 b
2.	Manzate Pro-Stick 75WG 3 lb + Captan 80WDG 2.5 lb	1								
	Rally WF 5 oz + Penncozeb 75DF 3 lb	2-4								
	Captan 80WDG 3.5 lb............	5-6	55.0 fg	32	60.0 fg	40	3.0 ab	97	3.1 c-f	2.5 a
3.	Captan 80WDG 3.5 lb	1								
	Omega 4SC 14 fl oz	2-3								
	Inspire Super 9 fl oz	4-5								
	Omega 4SC 14 fl oz...............	5-6	13.0 a-d	84	27.0 bc	73	0.0 a	100	0.7 ab	2.1 a
4.	Manzate Pro-Stick 75WG 3.5 lb	1, 3								
	Luna Sensation 5 oz	2, 4-5								
	Captan 80WDG 3.5 lb................	6	8.0 abc	90	13.0 ab	87	9.0 ab	91	0.8 ab	0.7 a
5.	Manzate Pro-Stick 75WG 3 lb + Captan 80WDG 2.5 lb	1								
	Indar 2F 8 fl oz + LI 700 4 fl oz + Penncozeb 75DF 3 lb	2-3, 5								
	Indar 2F 8 fl oz + LI 700 4 fl oz + Captan 80WDG 2.5 lb	6	43.0 de	48	39.0 bcd	61	21.0 bc	99	2.8 bcd	1.7 a
6.	Captan 80WDG 3.5 lb	1								
	Topguard 13 fl oz + Penncozeb 75DF 3 lb.............	2-3, 5-6	39.0 cd	52	59.0 ef	41	4.0 ab	96	2.1 abc	2.3 a
7.	Captan 80WDG 3.5 lb	1								
	Topguard 13 fl oz + Captan 80WDG 2.5 lb	2-3, 5-6	7.0 ab	91	11.0 ab	89	0.0 a	100	0.5 ab	0.6 a
8.	LEM 17SC 20 fl oz + JMS Stylet Oil 1 gal	1-5								
	Captan 80WDG 3.5 lb................	6	3.0 a	96	3.0 a	97	0.0 a	100	0.3 a	0.2 a

[z] Application timings were: 1= 1 Apr (half-in. green); 2=7 Apr (tight cluster/pink); 3= 19 Apr (pink/bloom); 4= 30 Apr (petal fall); 5= 10 May (1st cover); 6= 25 May (2nd cover).

[y] All values are scab incidence and the means of at least 25 terminal shoots, leaves and fruit across four replicate trees. Severity rating is based on scab lesions on leaves and fruit converted to % area leaf or fruit infection: 0=0; 1= 1-3% (1-3 lesions); 2= 3-6% (3-7 lesions); 3= 6-12% (6-15 lesions); 4=12-25% (15-25 lesions); 5= 25-50% (25-50 lesions); 6= 50-75% (50-80 lesions); 7= More than 75% (80 plus lesions). Values within columns followed by the same letter(s) are not significantly different ($P < 0.05$) according to Fisher's Protected LSD Test.

[x] Based on incidence data for 28 May.

[w] Based on incidence date for 24 Jun.

Table 2. Apple scab incidence and severity on Rome Beauty apple, 2010.

			% Incidence[y]						Severity rating[y]	
			Shoots	%	Shoots	%	Fruit	%	Leaves	
Trt.	Fungicide and rate/A	Timing[z]	28 May	Contr[x]	24 Jun	Contr[w]	24 Jun	Contr[w]	28 May	24 Jun
1.	Untreated check......................		78.0 f		100.0 e		100.0 c		19.3 d	36.8 c
2.	Manzate Pro-Stick 75WG 3 lb + Captan 80WDG 2.5 lb	1								
	Rally WF 5 oz + Penncozeb 75DF 3 lb	2-3								
	Captan 80WDG 3.5 lb............	5-6	75.0 f	4	69.0 cd	31	10.0 ab	90	6.7 bc	3.6 ab
3.	Captan 80WDG 3.5 lb	1								
	Omega 4SC 14 fl oz	2-3								
	Inspire Super 9 fl oz	4-5								
	Omega 4SC 14 fl oz...............	5-6	32.0 bcd	59	44.0 bc	56	3.0 a	97	1.7 a	2.9 ab
4.	Manzate Pro-Stick 75WG 3.5 lb	1, 3								
	Luna Sensation 5 oz	2, 4-5								
	Captan 80WDG 3.5 lb................	6	6.0 a	92	39.0 ab	61	12.0 ab	88	1.0 a	2.3 ab
5.	Manzate Pro-Stick 75WG 3 lb + Captan 80WDG 2.5 lb	1								
	Indar 2F 8 fl oz + LI 700 4 fl oz + Penncozeb 75DF 3 lb	2-3, 5								
	Indar 2F 8 fl oz + LI 700 4 fl oz + Captan 80WDG 2.5 lb	6	34.0 a-d	56	70.0 cd	30	2.0 a	98	2.1 a	3.0 ab
6.	Captan 80WDG 3.5 lb	1								
	Topguard 13 fl oz + Penncozeb 75DF 3 lb..............	2-3, 5-6	73.0 ef	7	86.0 fg	14	9.0 ab	91	3.3 ab	4.0 ab
7.	Captan 80WDG 3.5 lb	1								
	Topguard 13 fl oz + Captan 80WDG 2.5 lb	2-3, 5-6	23.0 bc	71	32.0 ab	68	5.0 ab	95	2.1 a	1.8 ab
8.	LEM 17SC 20 fl oz + JMS Stylet Oil 1 gal	1-5								
	Captan 80WDG 3.5 lb................	6	16.0 ab	79	13.0 a	87	4.0 a	96	2.3 a	0.7 a

[z] Application timings were: 1= 1 Apr (half-in. green); 2=7 Apr (tight cluster/pink); 3= 19 Apr (pink/bloom); 4= 30 Apr (petal fall); 5= 10 May (1st cover); 6= 25 May (2nd cover).

[y] All values are scab incidence and the means of at least 25 terminal shoots, leaves and fruit across four replicate trees. Severity rating is based on scab lesions on leaves and fruit converted to % area leaf or fruit infection: 0=0; 1= 1-3% (1-3 lesions); 2= 3-6% (3-7 lesions); 3= 6-12% (6-15 lesions); 4=12-25% (15-25 lesions); 5= 25-50% (25-50 lesions); 6= 50-75% (50-80 lesions); 7= More than 75% (80 plus lesions). Values within columns followed by the same letter(s) are not significantly different ($P < 0.05$) according to Fisher's Protected LSD Test.

[x] Based on incidence data for 28 May.

[w] Based on incidence date for 24 Jun.

Table 3. Powdery mildew incidence and severity on Rome Beauty apple, 2010.

	Treatment and rate/A	Timing[x]	% Powdery mildew incidence [y] Primary 28 May	Secondary 28 May	Secondary 24 Jun	% Powdery mildew severity [y] Primary 28 May	Secondary 28 May	Secondary 24 Jun
1.	Untreated check		30.0 e	54.0 def	61.0 c-g	22.0 c	18.3 d	27.3 f
2.	Manzate Pro-stick 75WG 3 lb + Captan 80WDG 2.5 lb	1						
	Rally WF 5 oz + Penncozeb 75DF 3 lb	2-4						
	Captan 80WDG 3.5 lb	5-6	12.0 a-d	63.0 ef	58.0 def	7.5 ab	18.6 d	15.8 b-e
3.	Captan 80WDG 3.5 lb	1						
	Inspire Super 10 fl oz	2-3						
	Omega 4SC 14 fl oz	4-5						
	Inspire Super 9 fl oz + Penncozeb 75DF 3 lb...............	5-6	6.0 ab	34.0 a-d	52.0 de	4.3 ab	6.3 bc	20.6 e
4.	Manzate Pro-Stick 75WG 3.5 lb	1, 3						
	Luna Sensation 5 oz	2, 4-5						
	Captan 80WDG 3.5 lb	6	1.0 ab	19.0 abc	26.0 ab	0.9 ab	2.9 ab	4.3 bc
5.	Manzate Pro-Stick 75WG 3 lb + Captan 80WDG 2.5 lb	1						
	Indar 2F 8 fl oz + LI 700 4 fl oz + Penncozeb 75DF 3 lb	2-3, 5						
	Indar 2F 8 fl oz + LI 700 4 fl oz + Captan 80WDG 2.5 lb	6	8.0 ab	63.0 ef	35.0 abc	5.5 ab	12.1 bcd	5.5 bcd
6.	Captan 80WDG 3.5 lb	1						
	Topguard 13 fl oz + Penncozeb 75DF 3 lb...............	2-3, 5-6	1.0 ab	6.0 a	2.0 a	0.6 ab	1.3 a	0.2 a
7.	Captan 80WDG 3.5 lb	1						
	Topguard 13 fl oz + Captan 80WDG 2.5 lb	2-3,5-6	0.0 a	10.0 ab	31.0 ab	0.0 a	1.3 a	1.3 a
8.	LEM 17SC 20 fl oz + JMS Stylet Oil 1 gal	1-5						
	Captan 80WDG 3.5 lb	6	0.0 a	0.0 a	30.0 ab	0.0 a	0.0 a	1.7 ab

[x] Application timings were: 1= 1 Apr (half-in. green); 2=7 Apr (tight cluster/pink); 3= 19 Apr (pink/bloom); 4= 30 Apr (petal fall); 5= 10 May (1st cover); 6= 25 May (2nd cover).

[y] All values are powdery mildew and the means of at least 25 terminal shoots across four replicate trees. Powdery mildew severity rating is based on % shoot infection: 0=0; 1= 1-25%; 2= 26-50%; 3= 51-75%; 4=76-100% of the shoot covered with powdery mildew. Values within columns followed by the same letter(s) are not significantly different ($P < 0.05$) according to Fisher's Protected LSD Test.

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How Will New Fungicides Fit Into Apple Disease Control Programs?

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Selecting the best fungicide for controlling apple diseases is becoming an increasingly complex process that requires detailed information about orchard history, the past and predicted weather conditions at the time of application, status of pathogen sensitivity to various fungicide chemistries in the orchards in question, and differences in fungicide activity both among the various chemistry groups and among the fungicides within groups. Experience with various fungicides in the DMI group suggest that selecting the best DMI for mildew control may result in suboptimal scab control and selecting the best scab control product may result in suboptimal mildew control (Fig. 1). These differences might not be evident in orchards where both scab and mildew populations are near baseline sensitivity for the DMI chemistry. However, where pathogen populations have already shifted toward resistance, substituting Inspire for Rally to gain improved scab control can result in decreased mildew control. This reportedly happened during the spring of 2010 in some orchards in the Lake Ontario fruit region of New York.

Fig. 1. Schematic indicating relative activity of DMI fungicides registered on apples against three common apple diseases in orchards where scab and mildew populations have shifted toward resistance to the DMI chemistry. This figure is derived from subjective observations and field reports, so exact positions of the various chemistries can be debated, but the general trends are supported by numerous observations.

Fungicide	powdery mildew activity	apple scab activity	SBFS activity
Topguard (flutriafol)	(most)	(least)	(least)
Rally (myclobutanil)			
Procure (triflumazole)			
Vintage (fenarimol)			
Tebuzol (tebuconazole)			
Indar (fenbuconazole)			
Inspire (difenoconazole)	(least)	(most)	(most)

Presumably there are many factors that affected the disease-specific differences among DMI chemistries. However, it is worth noting that the products with greatest activity against mildew are highly water soluble whereas the products with better activity against apple scab and the sooty blotch and flyspeck complex (SBFS) are relatively water-insoluble. Other factors that may contribute to differences are intrinsic toxicity of the various molecules, label rates as they relate to intrinsic activity, and the way the products are formulated. Activity in commercial practice will also depend on spray timing and spray coverage. Ultimately, however, growers may need to select different DMI products for different parts of the season. For example, growers targeting both scab and mildew might benefit from using Inspire Super at tight cluster and pink when scab will be the predominant pathogen, then switching to Topguard or Rally at petal fall and first cover when mildew pressure peaks.

Two field trials conducted at the Hudson Valley Lab in 2010 provided additional insights on some unique aspects of the activity spectra for apple fungicides.

Trial 1: Treatments were replicated four times in a randomized block design in an 11-yr-old orchard containing trees on MM.111 rootstocks with M.9 interstems. Trees in this test block are spaced 25 ft between rows, 10 ft between trees within rows, and 20 feet between plots within rows. Each plot consisted of one Golden Delicious tree and one tree on which the lower scaffolds were McIntosh and the upper portion of the trees had been grafted to Ginger Gold. Plots within rows were separated by 10-ft-tall cedar trees that limited drift from one plot to another. All treatment sprays were applied with a tractor-powered high-pressure handgun at 250 psi and trees were sprayed to drip. Treatment dates and details of the product application schedules are shown in Table 1.

The prebloom period was very dry with no significant scab infection periods until 14-18 April (combined 48 hr wetting, 47 °F, 0.22 in. rain) when trees were at king bloom. Rains that occurred 22 Mar (green tip bud stage) through 31 Mar (half-inch green) qualified as Mill's infection periods but were inconsequential because very few ascospores were mature and ready to discharge. Other major scab infection periods occurred 25-26 Apr (combined 47 hr wetting, 50 °F, and 1.0 in. rain) when trees were at petal fall and 3 May (13 hr wetting, 71 °F, 0.13 in. rain). There were five secondary scab infection periods during the latter half of May, 8 in Jun, 5 in Jul, and 7 in Aug. The months of April and May and the period from mid-June through mid-August were exceptionally dry. The daily maximum temperature reached or exceeded 89 °F on 3 days in May, 3 in Jun, 18 in July, and 9 in August.

Incidence of leaf yellowing from necrotic leaf blotch (NLB) was estimated on 24 Aug when leaf yellowing was evident on many trees but most of the yellowed leaves had not yet fallen (Table 1). Luna Sensation suppressed NLB when applied at tight cluster and pink, but not when applied at petal fall and first cover (trt 3 vs. trt 4). The same pattern was observed for Inspire Super, which suppressed NLB more when applied at pink and bloom (trt 5) than when applied at petal fall and first cover (trt 6). This is the second time that we have found early-season fungicide programs affecting severity of NLB that develops during summer and also the second report showing that Inspire Super (formerly A16001) and Luna Sensation (formerly USF 2016A) can suppress NLB. For the first report, see *Plant Disease Management Reports* 3:PF012, 2009.

Table 1. Effects of fungicides on the estimated incidence of necrotic leaf blotch on Golden Delicious trees at the Hudson Valley Lab in Highland, NY in 2010.

Rates/100 gal of dilute spray; multiply by 3 for equivalent rates/A	Spray dates growth stages [z] 4/7 TC	4/14 PK	4/21 BL	4/30 PF	5/11 1C	5/25 2C	% Golden Del. leaves with NLB [y] 24 Aug
1. Control							41.6 d [x]
2. Dithane Rainshield 75W 16 oz			X	X	X	X	
+ Microthiol Disperss 80W 1 lb				X	X	X	
Flint 50WDG 0.67 oz	**X**	**X**					9.0 ab
3. Dithane Rainshield 75W 16 oz			X	X	X	X	
+ Microthiol Disperss 80W 1 lb				X	X	X	
Luna Sensation 500SC 1.67 fl oz	**X**	**X**					4.4 a
4. Dithane Rainshield 75W 16 oz	X	X	X			X	
+ Scala 600SC 2 oz	X	X	X				
+ Microthiol Disperss 80W 1 lb						X	
Luna Sensation 500SC 1.67 fl oz				**X**	**X**		19.1 bc
5. Dithane Rainshield 75W 16 oz		X	X	X	X		
Inspire Super 338SE 3.97 fl oz		**X**	**X**		X	X	4.6 a
6. Dithane Rainshield 75W 16 oz	X	X	X			X	
+ Vangard 75WDG 1 oz	X	X	X				
+ Microthiol Disperss 80W 1 lb						X	
Inspire Super 338SE 3.97 fl oz				**X**	**X**		10.5 ab

[z] Captec 4L 1.5 qt/A + Topsin M 70W 12 oz/A was applied to all plots including controls using an airblast sprayer on 15 and 30 Jun and 13 Jul, thus accounting for sprays at 3C, 4C, and 5C.

[y] NLB = necrotic leaf blotch. See text for rating methods.

x Numbers within columns followed by the same small letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The angular transformation was used for the analysis of percentage data, with arithmetic means are shown.

In this same block, we compared the effectiveness of a Captan/Topsin M standard treatment throughout summer to Flint and four DMI fungicides that were all applied at tight cluster, pink, 1st cover, 2nd cover, and in two preharvest sprays (Table 2). Due to label limitations, most of the DMI products could not be applied as close to harvest as in this trial, but we wanted to compare the effectiveness of the various chemistries against SBFS. Rally applied alone provided more control of flyspeck than we had expected and Indar and Tebuzol were somewhat disappointing in that we expected them to be more effective than Rally applied alone.

Sooty blotch was more common in fungicide-treated plots in this block than was flyspeck (Table 3). Flyspeck is almost always more severe that sooty blotch in sprayed orchards under New York conditions, so the severity of sooty blotch was somewhat surprising. The second surprise was that Flint performed very poorly against sooty blotch. Inspire Super provided the most consistent control of sooty blotch. The weaknesses of Flint, Rally, and Tebuzol were especially noticeable on incubated Golden Delicious fruit.

Table 2. Effectiveness of fungicides for flyspeck at the Hudson Valley Lab, 2010.

Material and rate of formulated material per 100 gal [z]	**Fruit (%) with flyspeck**			
	McIntosh [y]		**Golden Delicious** [y]	
	3 Sep	**after incubation** [x]	**4 Oct**	**after incubation** [x]
Control	53 d	62 f	29 b	12 d
Dithane// Captan-80 10 oz + Topsin M 4 oz	4 bc	4 abcde	2 a	0 a
Flint 0.67 oz	1 ab	4 abcd	4 a	0 a
Rally 2 oz	8 c	14 e	3 a	2 abc
Indar 2F 2.67 fl oz + LI-700 32 fl oz	6 c	11 de	2 a	5 cd
Tebuzol 45W 2 oz + LI-700 32 fl oz prhvst	6 c	8 cde	5 a	6 bcd
Inspire Super 4 fl oz	1 ab	2 abc	<1 a	2 abc

z Treatments were applied at 14 Apr (pink), 21 Apr (bloom), 11 May (1st cover), 25 May (2nd cover) and in two preharvest sprays (31 & 8 days preharvest for Macs, 39 & 18 days for GD). Dithane 1 lb/100 gal was applied alone on the above-noted early-season spray dates for the Captan/Topsin treatment, was applied alone to all plots except controls on 30 Apr (petal fall), and was combined with all of the other treatments for the 14 Apr through 25 May applications. Captec 4L 1.5 qt/A + Topsin M 70W 12 oz/A was applied to all plots including the controls using an airblast sprayer on 15 and 30 Jun and 13 Jul, thus accounting for sprays at 3C, 4C, and 5C.

y Based on evaluation of 65 (McIntosh) or 70 (Golden Delicious) fruit/tree, or all fruit available for trees with less than the indicated numbers.

x Fruit were incubated at 70° F and 100% relative humidity for 10-18 days after harvest (duration varied with cultivar) to encourage development of latent infections.

w Numbers within columns followed by the same small letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The angular transformation was used for the analysis of percentage data, with arithmetic means being reported.

Table 3. Effectiveness of fungicides for sooty blotch at the Hudson Valley Lab, 2010.

Material and rate of formulated material per 100 gal[z]	Fruit (%) with sooty blotch: McIntosh[y] 3 Sep	McIntosh[y] after incubation[x]	Golden Delicious[y] 4 Oct	Golden Delicious[y] after incubation[x]
Control	47 e[w]	66 f	53 d	84 ef
Dithane// Captan-80 10 oz + Topsin M 4 oz	5 bc	14 abc	11 abc	32 bc
Flint 0.67 oz	16 d	47 e	30 cd	85 f
Rally 2 oz	15 d	30 de	26 bc	60 de
Indar 2F 2.67 fl oz + LI-700 32 fl oz	7 cd	12 bc	10 ab	41 cd
Tebuzol 45W 2 oz + LI-700 32 fl oz prhvst	3 abc	12 abc	25 bc	74 ef
Inspire Super 4 fl oz	<1 a	2 a	1 a	21 abc

[z,y,x,w] See footnotes for Table 2.

Trial 2: The objective of this trial was to compare effectiveness of Captan and Ziram applied with various tank-mix partners to control summer diseases on apples. Treatments were applied in an orchard planted in 2001 wherein each plot contained one Cameo tree on Bud.9 rootstock and one Royal Court tree on EMLA.111 rootstock with an M.9 interstem. Prior to the start of this experiment, the following fungicides were applied to the entire block using an airblast sprayer: COCS (copper) 2 lb/A plus Damoil 2 qt/A on 3 Apr (half-in. green); Nova 40W 4.5 oz/A + Dithane 75W 2.7 lb/A on 6 Apr (tight cluster) and 14 Apr (pink); Nova 4 oz/A + Penncozeb 75W 3 lb/A on 24 Apr (full bloom); Sovran 50W 4.6 oz/A plus Penncozeb 3 lb/A on 2 May (petal fall); and Nova 5 oz/A plus Penncozeb 3 lb/A on 13 May (first cover). The summer fungicides tested in this trial were applied on 11 June, 2 and 27 July, 16 and 28 Aug. These treatments were applied to four replications using a handgun and a tractor-driven high-pressure sprayer (270 psi) to spray trees to drip.

The accumulated leaf-wetting hours counting from petal fall (awhr-PF) as measured on a DeWitt string recorder and the accumulated rainfall for the preceding interval between sprays were 155 hr/2.66 in., 97 hr/1.42 in., 110 hr/1.18 in., 71 hr/1.14 in., and 79 hr/4.67 in. for sprays applied on 11 June, 2 July, 27 July, 16 Aug, and 28 Aug, respectively. Awhr-PF and rainfall for the interval from the last spray on 28 Aug to Royal Court harvest on 9 Sep were 48 hr with no rainfall and from 28 Aug to Cameo harvest on 8 Oct were 403 hr and 4.55 in. rainfall. However, for the latter period, 194 hr of wetting and 3.4 in. rain occurred during the last 10 days before harvest. The 540 awhr-PF threshold for the time when SBFS should appear in unsprayed trees occurred on 22 Aug. Development of flyspeck in Royal Court control plots was monitored by observing 25 fruit per tree in each of three replicates. Incidence of flyspeck on control fruit was 0, 16, 76, and 97% on 26 July, 9, 19 Aug, and 3 Sep, respectively. Thus, SBFS appearance on control fruit increased very rapidly between 9 and 19 Aug, somewhat earlier than expected because cumulative wetting from petal fall for 9 and 19 Aug was only 466 and 526 hr, respectively. In previous years when observing SBFS development on Golden Delicious, we found that flyspeck appearance usually spiked shortly after 540 awhr-PF.

Effects of treatments on disease incidence at harvest was determined by harvesting 75 Royal Court fruit per tree on 9 Sep and 70 Cameo fruit per tree on 8 Oct. Fruit were evaluated immediately after harvest, fruit with decays were discarded, and the remaining fruit were then incubated at 70°F and 100 percent relative humidity for either 19 (Royal Court) or 14 (Cameo) days before they were evaluated a second time. The incubation period allowed recent infections that were not yet visible at harvest to develop visible signs or symptoms on fruit.

Data was collected for a total of 19 parameters in this trial. For each parameter, a two way analysis was used to compare the main effects of Captan and Ziram while also looking at the main effects from combining these fungicides with either Tactic (an adjuvant used as a "spreader sticker"), ProPhyt, or Topsin M. All analyses were performed with arcsine-transformed data. Analyses were performed using the SuperANOVA software package (Abacus Concepts) for the Macintosh computer.

Grand means and simple means for one of the 19 parameters evaluated are shown in Table 4, and results from other similar analyses are summarized in Table 5. For each parameter, we also conducted a second analysis that included the unsprayed control treatment and Ziram applied alone, two treatments that did not fit within the two-way analyses. This second set of analyses allowed us to determine if Ziram applied alone was less effective than when it was combined with Tactic, ProPhyt, or Topsin M. Results from a single comparison from those simple ANOVAs is shown in the right-hand column on Table 5.

At the rates tested, and considering results across all three of the combination products, Ziram provided disease control either better than or equivalent to that of Captan for all of the parameters evaluated. Ziram treatments resulted in significantly more visible residue on fruit at harvest than Captan treatments (data not shown), but the visible residues from Ziram were reduced where Tactic was included in the Ziram sprays (Fig. 2). In comparisons of simple means from the two-way analyses, the combinations involving ProPhyt plus either Captan or Ziram were nearly always more effective for controlling flyspeck and sooty blotch than were comparable combinations with Tactic (Table 5). However, the addition of ProPhyt did not provide any advantage for controlling black rot. ProPhyt combined with either Ziram or Captan was usually just as effective as those fungicides combined with Topsin M, but the combination with Topsin M proved stronger for several parameters on incubated Cameo fruit where the residual effectiveness of ProPhyt had apparently begun to wane.

Figure 2: Typical residues on Royal Court fruit as photographed on 21 September. A total of 0.4 in. of rain occurred between the last application on 28 Aug and the time that this photograph was taken. Treatments represented are Ziram applied alone (upper left), Ziram plus Topsin M (lower left), Ziram plus ProPhyt (upper right), and Ziram plus Tactic (lower left).

Table 4: Effects of fungicides on incidence of flyspeck on **Royal Court fruit following incubation.**

Products and rates per 100 gal [z] partner products (below) \ main fungicide (right)	Percent fruit with flyspeck Captan-80 16 oz	Ziram-76 21.3 oz	grand means
Prophyt 4.2E 21.3 fl oz	23.6 a*	7.2 a	15.4 a[x]
Tactic 8 fl oz	53.5 b*	29.8 b	41.7 b
Topsin M 70 WDG 4 oz	27.6 a	13.3 a	20.4 a
Grand means for fungicides	34.9 B	16.8 A[x]	

[z] Treatments were applied 11 Jun, 2 and 27 Jul, 16 and 28 Aug.

[y] Arithmetic means are shown in the table, but means separations were determined by applying Fisher's Protected LSD to results from two-way analyses of arcsine-transformed data. Simple means within columns followed by the same lower-case letter or grand means followed by the same upper case letter do not differ significantly ($P \leq 0.05$). Asterisks indicate comparisons where simple means for Captan and Ziram treatments are significantly different ($P \leq 0.05$).

[x] Two treatments, an unsprayed control and Ziram used alone at 21.3 oz/100 gal, were also evaluated in this trial but did not fit into the two-way analyses. Flyspeck incidence for the unsprayed control and for Ziram used alone were 100% and 25.2%, respectively.

Table 5. Summary of significant differences from analyses for 19 different parameters.

Variable	Comparing means from two-way analyses [z]: *P*-values: grand means: Ziram b.t.[x] Captan	effects of mix partners	interaction	results from comparing grand means for partners: Topsin b.t. Tactic	ProPhyt b.t. Tactic	Topsin b.t. ProPhyt	from simple means: Captan+ ProPhyt bet.than C+Tactic	Ziram+ ProPhyt bet.than Z+Tactic	1-way ANOVA:[y] Ziram+ Prophyt b.t. Ziram
Flyspeck, RC, harvest	**0.007**	**0.008**	0.899	Y	Y	N	Y	Y	Y
Flyspeck, RC incubated	**0.001**	**<0.001**	0.840	Y	Y	N	Y	Y	Y
Flyspeck, Cameo harvest	**0.087**	**<0.001**	0.130	Y	Y	N	Y	Y	N
Flyspeck, Cameo incubated	0.111	**<0.001**	0.521	Y	Y	Y	Y	Y	N
Sooty blotch, RC harvest	0.118	**0.005**	0.478	Y	Y	N	Y	N	N
Sooty blotch, RC incubated	**<0.001**	**<0.001**	0.840	Y	Y	N	Y	Y	Y
Sooty blotch, Cameo, harvest	0.216	**0.001**	0.578	Y	Y	N	N	Y	N
Sooty blotch, Cameo, incubated	0.363	**<0.001**	0.879	Y	Y	N	Y	Y	N
Downgraded SBFS, RC incubated	**<0.001**	**0.001**	0.083	Y	Y	N	Y	Y	Y
Downgraded SBFS, Cameo harvest	0.222	**0.083**	0.785	N	N	N	N	N	N
Downgraded SBFS, Cameo incub'd	0.320	**0.001**	0.415	Y	Y	N	Y	N	N
No SBFS or rots, RC harvest	**0.017**	**0.011**	0.656	Y	Y	N	Y	N	N
No SBFS, RC incubated	**0.001**	**0.001**	0.821	Y	Y	N	Y	Y	Y
No SBFS, Cameo harvest	0.112	**<0.001**	0.402	Y	Y	N	Y	Y	N
No SBFS, Cameo incubated	0.278	**<0.001**	0.934	Y	Y	Y	Y	Y	N
Black rot, RC harvest	0.431	0.756	0.312	N	N	N	N	N	N
Black rot, RC incubated	0.625	**0.002**	0.217	N	N	N	N	N	N
Black rot, Cameo, harvest	0.427	0.535	0.933	N	N	N	N	N	N
Black rot, Cameo, incubated	0.312	0.849	0.565	N	N	N	N	N	N

[z] Summary of results for 19 parameters that were compared using two-way analyses similar that shown in Table 4.

[y] This column summarizes results from separate one-way analyses of the six treatments used in the two-way analyses plus the control and the treatment involving ziram alone.

[x] b.t. means "better than" at a statistically significant level ($P \leq 0.05$).

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EFFECT OF MICROCLIMATE AND CANOPY LOCATION ON SI FUNGICIDE RESISTANCE IN APPLE SCAB

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Venturia inaequalis is the causal organism of apple scab, an economically devastating disease of apples that occurs wherever apples are grown (1). Management has predominantly relied on chemical applications, and fruit tree training and orchard layout have paralleled this trend. However, studies have found that in more conventional plantings (less than 150 trees/A), the concentration of airborne *V. inaequalis* ascospores is not uniformly distributed within an orchard, within a block of the same cultivar, or within an individual tree (2,3). Ascospore deposition decreases with increasing tree height but is significantly higher in the center and at the western edge of the tree (3). This differs for leaf moisture, in which the upper, eastern portion of the tree canopy has the longest leaf wetness duration -- up to 3 hours more per day than the lower, western portion (4). The impact this may have on secondary infections (caused by *V. inaequalis* conidia) and resistance in scab has not been studied. The objectives of this study were to monitor the microclimate within trees in more conventional plantings and to characterize the spatial dynamics of SI fungicide resistance in *V. inaequalis* populations in Virginia.

Mature Stayman trees were selected from a more conventionally-planted test block. Fifty-six EL-USB-1 data loggers (temperature and relative humidity) were positioned at three canopy heights (<1.5m from the ground, 1.5-3m or >3m) and facing in three directions (East, West or by the trunk) within four treated and four non-treated trees. Four WatchDog A-series data loggers (temperature and leaf wetness) were positioned in the middle (1.5-3m from the ground) by the trunk of two treated and two non-treated trees already outfitted with the EL-USB-1 data loggers (Figure 1). Weather data was recorded from 15 June until 13 October 2010. Data corresponding to apple scab infection periods or secondary wetting were analyzed using PROC MIX (α=0.05) in SAS® (Windows®, release 9.2, SAS Institute Inc., Cary, NC).

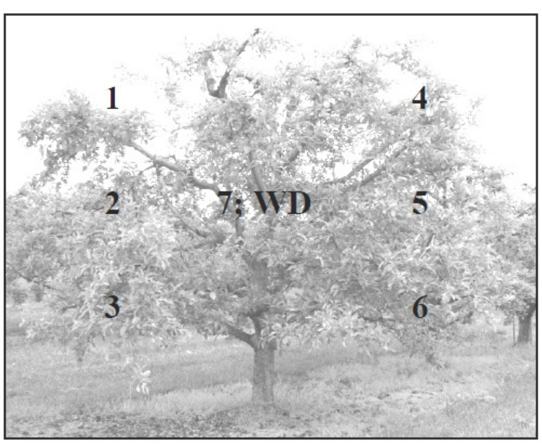

Figure 1. Placement of weather sensors within a tree. EL-USB-1 data loggers (1-7) and WatchDog A-series data logger (WD).

Myclobutanil (Nova/Rally 40W) was applied airblast at a rate of 5 oz/100 gal. Shoot growth on treated and non-treated trees within each replication was monitored using neon-colored rubber bands to ensure the most recently infected leaves were collected at each sampling interval. Six to ten leaves containing at least one scab lesion were collected from five sampling zones (lower interior, lower exterior, middle interior, middle exterior or upper) of individual trees. The lower zone is <1.5m from the ground, the middle zone is 1.5-3m and the upper is >3m. The interior zone of the canopy radiates out from the trunk 1.5m, and the exterior zone extends from the periphery of the canopy into the tree 1.5m. Monoconidial isolates were cultured on PDA. Fungicide resistance was assessed using plate assays with formula grade myclobutanil at concentrations of 0, 0.1, 0.5 and 1 ppm. Radial colony growth was measured weekly for four weeks, and the entire assay was conducted in triplicate. Data were analyzed using PROC GLM (α=0.05) in SAS® (Windows®, release 9.2, SAS Institute Inc., Cary, NC).

Three infection periods and/or secondary wetting were recorded by the weather sensors in 2010: 9-10 July (12.5 hrs), 13-14 July (14 hrs) and 31 July-1 August (9.5 hrs). Generally, temperature, relative humidity and leaf wetness were not significant among the various factors (height, direction, the interaction of height and direction or replication) (Table 1). During infection period 3, leaf wetness was significantly different among WatchDog replications ($P<0.001$), but this may be due to differences in canopy coverage (i.e. amount of foliage). When analyzed concurrently, infection period was a significant factor ($P<0.001$) for both EL-USB-1 and WatchDog data loggers, but temperature and relative humidity or leaf wetness among the various factors were not.

Table 1. ANOVA for differences between factors when accounting for infection period in 2010.

EL-USB-1 loggers (56)		P-value							
		Inf Per 1 [a]		Inf Per 2 [b]		Inf Per 3 [c]		All Inf Per	
Factor	df	Temp	RH	Temp	RH	Temp	RH	Temp	RH
Canopy Height [d]	2	0.050	0.366	0.558	0.292	0.622	0.527	0.110	0.071
Direction [e]	2	0.334	0.937	0.981	0.738	0.829	0.505	0.866	0.620
Height x Direction	2	0.305	0.688	0.971	0.556	0.802	0.715	0.604	0.318
Infection Period	2	-	-	-	-	-	-	<0.001	<0.001

WatchDog loggers (4)		P-value							
		Inf Per 1 [a]		Inf Per 2 [b]		Inf Per 3 [c]		All Inf Per	
Factor	df	Temp	LW	Temp	LW	Temp	LW	Temp	LW
Replication [f]	3	0.212	0.147	0.953	0.917	0.965	<0.001	0.791	0.062
Infection Period	2	-	-	-	-	-	-	<0.001	<0.001

[a] Infection period 1: July 9-10 (12.5hr)
[b] Infection period 2: July 13-14 (14 hr)
[c] Infection period 3: July 31-August 1 (9.5hr)
[d] Lower (>1.5m from the ground), middle (1.5-3m) or upper (<3m)
[e] East, West or by trunk
[f] Four replications with 1 WatchDog/replication

Within a sample year, the mean colony growth of *V. inaequalis* isolates was significantly different (P<0.001) among replications (A, B, C or D), assay treatments (0, 0.1, 0.5 or 1 ppm myclobutanil) and assay times (7, 14, 21 or 28 days) (Table 2). We suspect the statistical difference in replications was due to elevation fluctuations within the test block. Whether the *V. inaequalis* isolate came from a treated or non-treated tree was significant (P<0.001) in 2009, but not in 2010 (P=0.787). Canopy height and canopy zone were significant (P<0.001) in 2009, with the lower interior portion of the canopy having the greatest range of resistance as well as most sensitive and most resistant *V. inaequalis* isolates, in terms of percent growth reduction (the difference in colony growth on 0 and 1 ppm myclobutanil at 28 days). Canopy height and canopy zone were not significant in 2010 (P=0.144 and P=0.286, respectively). Sampling interval was significant (P<0.001) in 2009, and Tukey's HSD test indicated May X July and June X July were significant at the 0.05 level. This was not a factor in 2010 as only one sample was taken due to unfavorable weather and lack of shoot growth. When analyzed concurrently, all factors were significant (P<α) including collection year.

Table 2. ANOVA for differences between factors when accounting for collection year.

	Type III SS, P-value		
Factor	**2009 (N=18)**	**2010 (N=22)**	**All Years (N=40)**
Replication	<0.001	<0.001	0.003
NT or T	<0.001	0.787	0.028
Canopy Height	<0.001	0.144	0.023
Canopy Zone	<0.001	0.286	0.032
Sampling Interval	<0.001	-	<0.001
Assay Treatment	<0.001	<0.001	<0.001
Assay Time	<0.001	<0.001	<0.001
Collection Year	-	-	<0.001

The results of this experiment were inconclusive. The microclimate (temperature, relative humidity and leaf wetness) was not significant among canopy height or direction. But canopy height and canopy zone were significant for the 2009 *V. inaequalis* isolates, in terms of the spatial dynamics of fungicide resistance. Since the hot and dry conditions of 2010 were not favorable for *V. inaequalis*, and the data loggers were put out later than originally planned due to a backorder with the supplier, we will be repeating this experiment in 2011.

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APPLES AND FRUIT PATHOLOGY IN SHAANXI PROVINCE, CHINA

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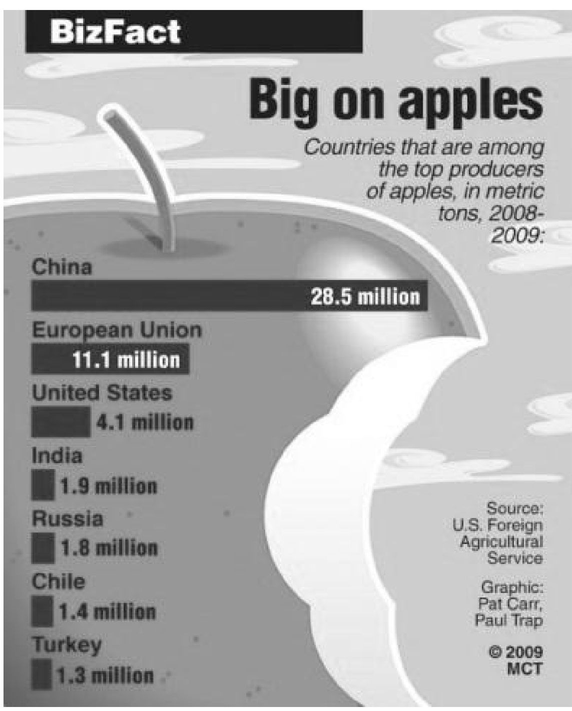
The People's Republic of China produces an estimated 28 million metric tons of apples annually, making it, by far, the country with the world's largest apple industry (Table 1, Fig. 1). Almost half of that production is in Shaanxi Province in the central part of China. The province is diverse in its agriculture, producing many valuable crops including grain, cotton, oil plants, rapeseed, tobacco, vegetables, garden fruits and other fruits, in addition to apples. The landscape and soils are diverse, with extensive loess formations, a long growing season with minimal rainfall, warm days and cool nights, and lower levels of pollution (relative to the metropolitan areas).

My visit in October, 2010, was facilitated by Dr. Sun Guangyu, Professor of Plant Pathology at Northwest A&F University in Yangling, about 90 minutes' drive west of Xi'an, the largest city in Shaanxi Province. The university matriculates approximately 30,000 students and consists of an older campus situated on a hillside overlooking the city of Yangling, as well as a more modern campus located in the city.

I visited two of the university's apple research stations. The first was the Northwest A&F University Apple Experiment Station in Baishui, about 2.5 hours (by automobile) east of Xi'an. This is a very modern and state of the art university research facility. Demonstration plantings at the station provided examples of many kinds of high density systems on M.9 and M.26 rootstock, as well as rootstock/interstem combinations. Systems were observed that consisted of pyramidal spindle, slender spindle, super spindle, top spindle, V-trellis, and organic plantings that utilized composted organic waste (the Chinese used the term "caca" and my host professed to be not familiar with *E. coli*). Fuji on M.26 in a super spindle training system is the preferred system according to the research horticulturist there. Fire blight and the causal organism, *Erwinia amylovora*, have not been reported in China, but I suspect if or when it occurs, it will be potentially devastating.



The production unit is based on 1/5-acre privately-owned orchard blocks, each called a mu. In Shaanxi, there are about 1 million mu planted with Fuji on a variety of Malling rootstocks, predominantly M.7 but very variable in appearance (planting density, pruning style, etc.). I visited several mu and conversed with farmers about their production practices. I observed fruit being harvested, graded, and sorted by hand in the orchard. From the orchard, fruit are stored at home or taken on (all kinds of) vehicles to packinghouses for preparation for the export market. Many sales are private and are made by direct market (with lots of haggling over the price, but at about $0.50 per pound for the transactions I witnessed) or wholesale to a distributor. Many people prefer to purchase directly from farmers because the price is about half of that in the grocery store and the quality is about twice as good. Distributors will take the presorted fruit (no defects allowed apparently, as I didn't see any grading facilities for handling tree-run fruit) where they are then placed in a protective netting/Styrofoam sheath and placed individually and gently on a grader where they are sorted by size. From there, they are boxed and shipped.

Growing high quality Fuji apples for export incorporates the double bag system to protect the fruit from solar radiation, chemical deposits, and insect and disease injury. Fruit are hand thinned and then bagged at about the 15-cm-diam stage. Following removal of the outer opaque bag about 2 weeks prior to harvest, fruit are finished up (brought to the desired pink/yellow coloration) with reflective mulch during the pre-harvest fruit coloring period. The second bag, which is red and translucent, is removed at harvest. Hail netting is used extensively.

The major apple diseases in Shaanxi include Valsa canker (*V. ceratosperma*), Marssonina blotch (*M. coronaria*), SB&FS (fungal complex), Bitter rot (*Colletotrichum* spp.), Moldy core (fungal complex), White rot and Black rot (*Botryosphaeria* spp.), and European canker (*Nectria galligena*). We are fortunate to not have the first two in the USA, for they seem to require intensive management practices. Valsa canker has caused the removal of entire blocks of trees because of its lethal bark-killing symptoms. Marssonina blotch is more similar to apple scab, with extensive fruit and foliar spotting and premature leaf abscission if not controlled with fungicide sprays. No one could or would tell me exactly what sprays were being used and how often they were being applied.

I also visited Fengxiang Apple Research Station, located about 1 hour west of Xi'an. This station is a demonstration orchard for producing high quality Fuji apples for export. Some apples are prepared with the SOD logo applied as a color variation due to an opaque reverse sticker that is placed on the fruit during the coloring stage (resulting in a yellow "SOD" imprint on the pink fruit surface). SOD is the acronym for superoxide dismutase, an antioxidant enzyme that many consumers believe promotes health and longevity. When I asked what makes an apple and SOD apple, I was told that it is sprayed four times starting in July with a bacterium that promotes enzyme production in the plant. I could not find any literature on this. SOD apples fetch a price premium.

Why have Chinese farmers switched over to apple growing in such a massive way? Their central government offers financial incentives for developing new orchards, and has also created a network of trained advisers to provide technical support, the Chinese version of the Cooperative Extension Service.

I believe the Chinese government had two main motives for this gigantic apple expansion experiment: develop a new, high-value export crop, and help farmers make enough money to stay on their tiny farms instead of migrating to over-crowded and polluted metropolitan areas. Previous crops, such wheat and tobacco, weren't profitable enough to keep farmers on the land.

About seventy percent of Chinese still live in rural areas in this complicated country, and the government would like to keep them there. With fast-growing populations nearing 20 million each, Shanghai and Beijing are already among the world's largest and most densely populated cities. One thing Chinese farmers share with American farmers is the need to make a living. In Shaanxi Province, the change-over to apples seems, for the time being, to be a successful step in that direction.

Table 1. World apple production; top ten producers in 2008 (Source: FAO).

Country	Production (Metric tons)
People's Republic of China	27 507 000
United States	4 237 730
Iran	2 660 000
Turkey	2 266 437
Russia	2 211 000
Italy	2 072 500
India	2 001 400
France	1 800 000
Chile	1 390 000
Argentina	1 300 000
World	64 255 520

Is Glyphosate Compromising Apple Tree Health?

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Glyphosate (Round-Up and generics) is an important tool for managing ground cover beneath apple trees. According to the last available data from the USDA's National Agricultural Statistics Service, 54% of New York apple acreage was treated with glyphosate at least once in 2007, and 10 percent of that acreage received two applications (Anonymous, 2008). However, there are increasing concerns that glyphosate may sometimes damage fruit trees in subtle ways that may be largely unrecognized.

Glyphosate kills plants by blocking a critical enzyme pathway known as the shikimic acid pathway. The blocked enzyme is essential for respiration in plants, so plants that receive a full dose of glyphosate cannot survive unless they are bioengineered to be glyphosate-resistant or have evolved to be resistant as is the case with some weed species in the Midwest. At lower concentrations, however, glyphosate can adversely affect plants without producing any immediately visible effects.

In other crops, glyphosate exposure has been shown to reduce root growth and seed production and affect seed quality and plant nutrient balances. In soils, the affinity of glyphosate for cations can reduce availability of calcium, magnesium, manganese, copper, iron, nickel, and zinc either by direct chemical interactions or by negative effects on soil microbes involved in making these minerals available to plants. Glyphosate taken up by roots can also interfere with movement and availability of some of these minerals inside plant tissue (Cakmak et al., 2009). Glyphosate tends to accumulate in meristematic tissue and storage organs. No one knows how much of the glyphosate taken up by apple trees is transported to apple fruit, but it seems possible that glyphosate may influence apple fruit physiology either by partially blocking the shikimic acid pathway or by affecting nutrient balances within fruit. Observations and results of initial trials on apples in New York have recently been published (Rosenberger et al., 2010a, 2010b).

Trunk cankers: Six years ago in an article in *Scaffolds Fruit Journal*, Rosenberger and Fargione (2004) hypothesized than an interaction between glyphosate and *Botryosphaeria dothidea* was causing basal trunk cankers and tree decline in some apple orchards in eastern NY and Connecticut. Injury was especially common on Macoun trees. Since then, Macoun trees throughout eastern New York and New England have continued to develop basal trunk cankers, decline, and die. However, the link between glyphosate and basal cankers on Macoun is still hypothetical. No one has proven that glyphosate is at fault.

Varying levels of trunk injury (presumably glyphosate-related) have been noted in other cultivars on farms where Macoun trees have been killed, but tree losses from trunk cankers have been mostly limited to Macoun plantings. Cortland is probably the second most commonly affected variety. More recently, however, some of the older Honeycrisp plantings in the Hudson Valley have begun to show trunk cankers somewhat like those previously reported on Macoun. It is not yet clear whether these cankers on Honeycrisp will eventually result in tree death or loss of productivity.

Decreased winter hardiness: At The Ohio State University, Hannah Mathers and her graduate students have shown that one springtime, low-dose application of glyphosate to trunks of field grown ornamentals can reduce winter hardiness and cause bark cracking in several ornamental species including crab apples (Daniel et al., 2009; also see http://www.ag.ohio-state.edu/~news/story.php?id=4685). The research from Mathers' group helped to explain why we have occasionally seen blocks of apples in New York where scaffold limbs were killed during winter following improper application of glyphosate the previous season. The link between glyphosate and increased susceptibility to cold injury may also help to explain several cases in New York and in other states where young apple trees developed nondescript trunk cankers and/or dieback in patterns that seemed inconsistent with any known disease or weather-related phenomenon. Given the recent results from Mathers' lab, it seems possible that glyphosate-induced cold injury might be involved in causing the unusual damage to young trees in locations where glyphosate has been applied anytime over the past two years, either in the orchard or in the nursery.

Internal browning is a disorder that can appear during controlled atmosphere (CA) storage. Even mild cases of internal browning are unacceptable for fruit used in fresh-cut slices. Incidence and severity of internal browning vary from block to block, but the underlying factors that contribute to differences among blocks have not yet been determined. In a recent article in *New York Fruit Quarterly*, James *et al.* (2010) reported that the risk of browning in Empire apples could be minimized by harvesting fruit during the early part of the harvest window. Other factors that have been evaluated for their effects on browning have not produced consistent results.

In late summer of 2009, we initiated a trial to determine if exposure of Empire apple trees to glyphosate might influence the incidence and severity of internal browning that develops in apples that are held in long-term CA storage.

Experimental design: The trial was replicated on three farms in western New York in 'Empire' blocks known to produce fruit that developed internal browning during CA storage. On each farm, three treatments were replicated four times using single trees as the experimental unit. Thus, the experiment encompassed 12 trees on each farm. Details for each farm are outlined in Table 1. Treatments included an untreated control, glyphosate applied to one or several terminal shoots on lower fruiting limbs, and glyphosate applied to fruit and leaves on one or several lower fruiting limbs on each tree. Because we wanted to collect 25 fruit for each sample, limbs that were treated were selected to ensure that we could collect at least 25 fruit from the treated limbs at harvest. Treatments never involved more than 30% of the leaf area on lower scaffold limbs, and no glyphosate was applied to leaves or fruit above the lowest tier of scaffold limbs.

The glyphosate formulation used in this trial was Monsanto's Roundup PowerMax®, which contains 5.5 pounds per gallon of the active ingredient (glyphosate) in the form of its potassium salt. This product is labeled for use on tree fruits at rates of 11 fl oz to 3.3 qt/acre per application with a maximum yearly rate of 5.3 quarts/acre and a 1-day preharvest interval. A rate of 44 fl oz/A is recommended for controlling weeds greater that 12 inches high or vines greater than 6 inches long. At 44 fl oz/A, a grower would be mixing approximately 1.5 fl oz of Roundup Powermax per gallon of water in an herbicide sprayer calibrated to deliver 30 gallons of spray per sprayed acre.

To simulate what might occur if glyphosate sprays drift into the lower limbs of treated trees, Roundup Powermax was mixed with water at the rate of only 0.034 fl oz/gal (i.e., 1 ml/gal) for this experiment. This solution was applied to treated limbs using a hand-pumped "Solo" type of sprayer, and the solution was misted over the marked limbs. Applications were done on dry days with no rainfall predicted for the next 24 hours.

In early October when fruit were mature, 25 fruit were collected from the treated lower limb(s) and another 25 were collected from the upper canopy on each of the 12 test trees in each orchard. Thus, samples collected from each farm represented the treatments shown in Table 2.

At Farm C, we were unable to get harvest samples from all of the trees because some trees had been harvested before samples could be collected. For this farm, we recovered fruit samples for only two of four replicates for treatments 1a, 1b, and 2a, and for only three of the four replicates for treatments 2b, 3a, and 3b.

Fruit were harvested in the morning and then transported to Ithaca for storage later that same day. In Ithaca, fruit were cooled overnight and were then placed into a CA storage that was held at 36° F with 2% oxygen and 2% carbon dioxide for 8 months. Fruit were not treated with 1-MCP. On 9 June 2010, fruit were removed from storage and held at 68° F for 7 days before they were evaluated for internal browning.

Core browning was assessed by cutting through the equator of the apple to hit the center of the core. Slight, moderate and severe categories would indicate the severity of the browning at that location, with slight being just barely noticeable and severe being dark brown and obvious throughout the core area. Flesh browning was assessed by cross-sectioning the apple with the first cut targeted to the plane where the stem is attached to the apple, the second through the core as for assessing core browning, and then a third slightly above the calyx. On many fruit, additional cuts were made between these three main cross-sections if no browning was noted in the first few cuts. If there was evidence of flesh browning by the stem but not as far down as the core, it was rated as slight and given a rating of 1. If the browning was also evident at the core but not near the calyx, it was rated as moderate (rating = 2). When the flesh browning extended from the stem area, through the core area, and all the way down to the calyx, it was rated severe (rating = 3). The firm flesh browning in Empire always starts up in the stem area. Mean severity for each treatment was calculated by taking the average severity rating for all fruit in the treatment, including fruit that were rated as having no internal browning.

Data was analyzed using the SuperAnova Statistical package for Macintosh computers. We used a two-way or factorial analysis for effects of the 3 treatments across 3 different farms. For each variable, we analyzed the trees as a whole using fruit from the upper and lower limbs as subsamples, and we then conducted separate analyses to evaluate effects of treatments on fruit from the lower limbs and from fruit on the upper limbs. Where samples were missing for the Farm C, we entered the data as missing and allowed the software package to adjust for the missing data.

Results: Glyphosate treatments applied to trees increased the incidence and severity of both flesh browning and core browning (Table 3) when grand means for incidence and severity were compared across all three farms in statistical analyses that included apple samples from both upper and lower limbs on each tree. When treatments were compared within farms, the fruit from Farm B showed the same pattern and statistical effects as noted for the grand means. However, treatments produced more variable results on the other two farms, and effects of treatments usually were not statistically significant when means within each of those farms were compared (Fig. 1). The percentage increase in browning incidence for glyphosate-treated compared to control fruit varied from 0 to more than 130% (Fig. 2).

When we analyzed only data for fruit harvested from the tops of trees and looked at the grand means across all three farms, glyphosate treatments caused significant increases in both the incidence and severity of flesh browning and in the incidence but not the severity of core browning (data not shown). The trends for treatment effects within farms, based on data from only upper branches, were similar to those noted in Figure 1 and Table 3, but there were fewer significant effects due to the reduced sample size. Surprisingly, comparisons of grand means for fruit harvested from the bottom limbs of trees showed no significant differences due to glyphosate treatment, and that was true both for fruit sprayed directly and for fruit from lower limbs where only terminal leaves were sprayed. However, the data trends were similar to those noted for fruit from the tops of the trees, and we might have detected treatment effects if we had used a larger sample size.

Discussion: Results from this trial provide initial evidence (from only one year of data!) that glyphosate uptake by Empire trees can affect the incidence and severity of internal browning during long-term CA storage. For the samples from Farm C, fruit from glyphosate-exposed trees always had more browning than fruit from non-exposed trees even though the numerical differences often were not statistically significant. The same was true at Farm A for the treatment where glyphosate was sprayed over fruit, but not where it was applied only to terminal shoots. In the latter case, the leaf surface area exposed to glyphosate may have been too low to allow uptake of enough glyphosate to affect the whole-tree physiology. Presumably more leaf area was exposed to glyphosate on trees where fruit and leaves were treated than on trees where only terminal shoots were treated.

Treatment effects were more evident for fruit in the tops of exposed trees than for fruit taken directly from the lower limbs subjected to glyphosate exposure. This result may reflect the way glyphosate is transported within trees after uptake, or it may relate to other differences in fruit physiology between fruit growing on lower limbs and fruit growing on upper limbs.

For all three farms, there was a significant "background" level of internal browning in the control trees. It is not clear whether this background of internal browning represents fruit that develop internal browning for reasons unrelated to glyphosate exposure or whether the browning in control trees is attributable to glyphosate exposure that occurred when the cooperating growers applied glyphosate to these orchards. The latter possibility is supported by the fact that on Farm B, which had the lowest background in the controls and the largest and most consistent glyphosate-stimulated increases in browning (Fig. 2), the grower had not applied glyphosate in the test orchard in either 2008 or 2009. The other two growers routinely applied glyphosate in early summer, and trees on Farm C, which had the highest level of browning in the controls (Fig. 1), usually received a second application in early August. Other factors that presumably affect how much glyphosate is absorbed into apple trees from herbicide applications include the type of equipment, the number of root suckers that are exposed to glyphosate, the weather conditions at the time of application, and whether or not the growers use drift-inhibitors to minimize the number of small droplets produced by their herbicide sprayers. Thus, there is no way to account for all of the variables that may have affected glyphosate exposure from grower-applied sprays in these orchards.

The glyphosate exposure that we introduced in this trial might be considered extreme because we directly sprayed branches in a way that commercial growers would never do intentionally. However, we used a very low rate of glyphosate and the limbs that were sprayed showed no evidence of glyphosate injury in spring or summer of 2010. Thus, it is conceivable that trees in orchards where glyphosate is used as an herbicide could have glyphosate exposures equal to what we introduced in this trial without showing any foliar evidence of glyphosate damage.

The results reported here were derived from only one year of data, one application timing, and one cultivar, so it would be premature to conclude that glyphosate exposure is the major contributing factor for internal browning problems in apples. Nevertheless, the data from this trial suggests that glyphosate may exacerbate this storage problem. Growers may wish to minimize glyphosate exposure at least for Empire apples that will be placed into long-term CA storage. Rosenberger *et al.* (2010) have listed various approaches for minimizing exposure of trees to glyphosate where this herbicide is being used.

Results from this trial raise numerous questions that can be resolved only via additional research. Factors such as timing of glyphosate exposure (spring versus summer), exposure route (via spray drift, through root suckers, or through bark), and glyphosate formulation may all impact the glyphosate-browning interaction. We do not know if storage life of cultivars other than Empire can be affected by glyphosate exposure. Many additional experiments will be required to discern all of the potential interactions that may be occurring when apple trees are exposed to glyphosate.

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Table 1. Descriptions of Empire apple orchards used for glyphosate-browning trials in 2009.

Farm	Root-stock	Year planted	Glyphosate treatment date	Harvest date
A*	M.26	1991	12 Aug 2009	6 Oct 2009
B**	M.9	1990	28 July 2009	7 Oct 2009
C***	M.9	1993	22 July 2009	8 Oct 2009

* Grower sprayed glyphosate (Makaze) on the block in May 2009.
** No glyphosate sprayed by grower for the past two years (2008 and 2009).
*** Glyphosate applied twice per year, once in spring and once in summer, at 2 qt/treated acre.

Table 2. Treatments from which fruit samples were collected on each of the three farms.

Treatment 1: Controls with no glyphosate exposure other than via grower applications to the block:
- 1-a. Fruit from lower limbs
- 1-b. Fruit from upper limbs

Treatment 2: Glyphosate applied to lower terminal shoot(s)
- 2-a. Fruit from lower limbs on which the terminal shoots received glyphosate
- 2-b. Fruit from upper limbs not directly exposed to glyphosate

Treatment 3: Glyphosate applied to fruit and leaves on lower limb(s)
- 3-a. Fruit from lower limbs that where both leaves and fruit had been sprayed with glyphosate
- 3-b. Fruit from upper limbs not directly exposed to glyphosate

Table 3. Results from statistical analyses of four different parameters used to evaluate effects of glyphosate treatments and farm of origin on incidence and severity of firm flesh browning and core browning that developed after eight months of controlled atmosphere storage on Empire apples harvested from trees exposed to glyphosate during July-August.

Main effects	degrees of freedom	*P*-values from statistical analyses* flesh browning incidence	flesh browning severity	core browning incidence	core browning severity
Rep (tree)	3	0.991	0.920	0.663	0.204
Treatment (A)	2	0.004**	0.002**	0.006**	0.021**
Farm (B)	2	<0.001**	<0.001**	0.078	0.029**
Interaction: (A*B)	4	0.066	0.044**	0.024**	0.008**

* A separate two-way analysis was performed for each of the four browning parameters shown in the table. Each analysis included three treatments, three different farms, and four replicates with two sub-samples of 25 fruit from each replicate.

** Double asterisks indicate effects where significant differences existed among the grand means ($P \leq 0.05$). Glyphosate exposure had a significant effect on all four measures of internal browning. Differences in the incidence of flesh and core browning for the three glyphosate treatments are shown in Figure 1.

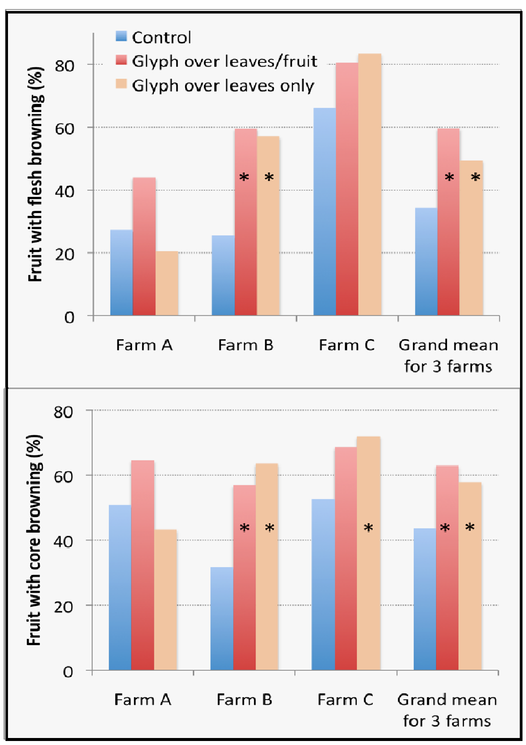

Figure 1. Effects of glyphosate on the incidence of firm flesh browning (upper graph) and on core browning (lower graph) on three different farms. A low rate of glyphosate was applied to either leaves and fruit or to terminal leaves only on one or more lower limbs on each tree.

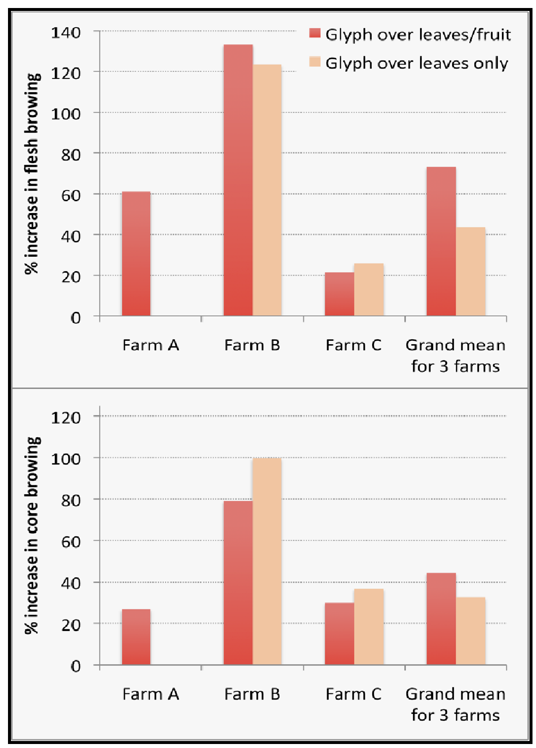

Figure 2. Percentage increases (as compared to non-treated controls) in the incidence of firm flesh browning (top) and core browning (bottom) caused by glyphosate treatments applied to Empire trees on three different farms.

EFFICACY OF DIFENOCONAZOLE MIXTURES ON PEACH SCAB DEVELOPMENT

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Fungicide mixtures Inspire Super (A16001; difenoconazole + cyprodinil), Inspire XT (A8122; difenoconazole + propiconazole), and A16976 (difenoconazole + chlorothalonil) were tested in alternation with Gem (trifloxystrobin) for efficacy against peach scab. In addition, KFD-64-01 (tebuconazole + sulfur) was examined for efficacy against blossom blight and brown rot.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2010 growing season. The test block consisted of a 15-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 Ziram at 4 lb/A on 18 Mar for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing are shown in table 1.

Assessment. Blossom blight canker development (*Monilinia fructicola*) was evaluated on 8 Jul by examining 20 twigs per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 23 Jun by examining 40 fruit per tree. Scab (*Fusicladium carpophilum*) was evaluated on 9 Aug by examining 40 fruit per tree. Trees sprayed during the preharvest ripening period were evaluated for brown rot (*M. fructicola*) and Rhizopus rot (*Rhizopus* spp.) at harvest on 12 Aug. All fruit 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) were examined. For post harvest evaluations, 40 asymptomatic fruit were harvested from each tree and placed on benches in a greenhouse (ave. air temp. = 78.6ºF). Brown rot, Rhizopus rot, and anthracnose rots were evaluated at 4 and 6 days postharvest (DPH).

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. The growing season (April through early August) had temperatures far above average with little rainfall (Table 1). July was the only month to receive rainfall close to the 30 year average; rainfall for all other months was 1.02-1.22 inches below average. Every month during the growing season, except August, had temperatures well above average. April, May, June, and July had temperatures 4.1º, 2.7º, 4.1º, and 1.8ºF above average, respectively. August temperatures were 0.2ºF above average. Average monthly temperatures this growing season were: Apr, 56.2ºF, May 64.9ºF, Jun 75.4ºF, Jul 78.1ºF, and Aug 75.0ºF.

Blossom Blight. Several days with rain and above normal temperatures during the susceptible period from P through PF were conducive for blossom blight development. Non-treated control trees had 30% shoots with cankers with an average of 0.46 cankers per shoot (Table 2).

All treatments provided significant control of blossom blight incidence and severity. Canker incidence was reduced by 62%-96% and cankers per shoot by 67-98%; no differences were observed between fungicide treatments. Note that blossom blight programs only differed in their PF spray; all treatments received Vangard at pink and bloom.

Rusty Spot. Low rainfall and unseasonably warm weather from PF-SS created favorable conditions for rusty spot development. Non-treated control trees had 35% fruit infection and 0.45 lesions per fruit, a high amount of disease for this cultivar (Table 3).

Gem sprayed from PF through 2C provided a 75% reduction in rusty spot incidence and an 80% reduction in severity. All treatments alternating Gem with a test fungicide were equivalent to Gem alone with the exception of A16976 at the lower 24 fl oz rate. The KFD-64-01 programs were targeted at blossom blight and brown rot control. Hence fungicides effective against rusty spot were not included in these treatments, resulting in higher disease levels.

Scab. Below average rainfall from SS (mid-April) to 40 dph (3 Jul) was unfavorable for the development of scab. The excessive heat may also have had a detrimental effect on scab development. Twig lesions provided some inoculum, but disease was very low compared to past years. Non-treated control trees had 33.1% scab incidence with an average of 7.89 lesions per fruit (Table 4). In 2009, when conditions were favorable for scab, non treated control trees had 100% fruit infection with 97.1% of fruit having more than 10 lesions.

The standard treatments of Bravo/Microthiol provided 83%-94% control of scab incidence. All Gem alternations provided 62%-91% control and were equivalent to the standard and one another. Gem alone was the only treatment that did not significantly reduce scab incidence, although it did effectively reduce severity.

All treatments significantly reduced the number of lesions per fruit from that of the non-treated control by 87%-100% with no significant differences among them.

Brown Rot. Pressure for brown rot at harvest was fairly light. Rainfall during the pre-harvest period only occurred after the 1 dph spray and on the day of harvest. On 5-Aug, overhead irrigation was applied to this block. The irrigation and two days of rainfall within a week of harvest most likely resulted in the very high postharvest disease pressure.

Non-treated control trees had 9.8% fruit rot at harvest (Table 5). KFD-64-01 at 2 and 3 lb reduced brown rot by 78% and 76% respectively, a significant reduction from the non-treated control.

Postharvest brown rot reached 74.4% on non-treated fruit by 4-DPH and 87.5% by 6-DPH. Regardless of disease pressure, both rates of KFD-64-01 provided excellent control of brown rot during the postharvest period. At 4-DPH, KFD-64-01 reduced brown rot 87%-89% and at 6 DPH, KFD-64-01 reduced brown rot by 82%-90%. There were no significant differences between the 2 and 3 lb rates of KFD-64-01.

CONCLUSIONS

- Alternation of Gem with Procure, **Inspire Super, Inspire XT**, and **A16976** provided scab control equivalent to Gem alone and to the Bravo/Microthiol programs. Overall, given that disease pressure was low, the level of scab control was considered good.

- **KFD-64-01** provided excellent brown rot control when disease pressure was high. While there were no significant rate effects, brown rot levels were numerically lower for the 3 lb rate throughout postharvest period. KFD-64-01 will need to be applied at all three spray timings during bloom (P, B, PF) in order to determine its efficacy against blossom blight.

TABLE 1. Daily average air temperature and rainfall accumulation during the 2010 season at the Rutgers Agricultural Research and Extension Center, Bridgeton NJ. Phenological stages indicate date of fungicide treatment application.

Date	Temp ºF	Rain (in)
29-Mar	53.84	1.33
30-Mar	44.61	0.77
31-Mar	50.41	0.11
1-Apr	54.33	0
2-Apr	**Pink (P)**	
2-Apr	54.64	0
3-Apr	53.2	0
4-Apr	60.31	0
5-Apr	62.58	0
6-Apr	69.38	0.01
7-Apr	76.03	0
8-Apr	**Bloom (B)**	
8-Apr	72.28	0
9-Apr	54.32	0.6
10-Apr	49.03	0
11-Apr	59.28	0
12-Apr	59.28	0
13-Apr	46.28	0.08
14-Apr	49.11	0
15-Apr	57.35	0
16-Apr	**Petal Fall (PF)**	
16-Apr	60.14	0.29
17-Apr	54.42	0.08
18-Apr	47.3	0
19-Apr	52.82	0
20-Apr	52.92	0
21-Apr	53.24	0.16
22-Apr	58.32	0.02
22-Apr	**Shuck Split (SS)**	
23-Apr	56.32	0
24-Apr	52.8	0
25-Apr	51.07	0.82
26-Apr	51.87	0.47
27-Apr	52.69	0.02
28-Apr	47.47	0
29-Apr	55.11	0
30-Apr	62.35	0
1-May	72.93	0

Date	Temp ºF	Rain (in)
2-May	76.38	0
3-May	75.29	0.06
4-May	**1st Cover (1C)**	
4-May	71.58	0
5-May	66.27	0
6-May	70.76	0
7-May	61.15	0
8-May	67.43	0
9-May	51.72	0
10-May	50.01	0
11-May	47.5	0.03
12-May	50.87	0.38
13-May	**2nd Cover (2C)**	
13-May	54.46	0
14-May	66.36	0.78
15-May	66.98	0
16-May	62	0
17-May	58.25	0
18-May	51.47	1.63
19-May	57.4	0
20-May	65.01	0
21-May	70.79	0
22-May	66.38	0
23-May	65.25	0.09
24-May	65.37	0
25-May	**3rd Cover (3C)**	
25-May	68.65	0
26-May	72.86	0
27-May	73.14	0
28-May	63.3	0
29-May	69.15	0.01
30-May	74.86	0
31-May	77.36	0
1-Jun	77.45	0
2-Jun	76.69	0
3-Jun	78.53	0
4-Jun	77.74	0
5-Jun	79.46	0

Table 1. –Continued-

Date	Temperature	Rain
6-Jun	79.72	0.01
7-Jun	66.49	0
8-Jun	**4th Cover (4C)**	
8-Jun	65.38	0
9-Jun	61.84	0.35
10-Jun	72.12	0.07
11-Jun	69.67	0
12-Jun	71.48	0
13-Jun	77.38	0.45
14-Jun	74.16	0.03
15-Jun	71.97	0
16-Jun	70.24	0.01
17-Jun	75.58	0.01
18-Jun	70.24	0
19-Jun	73.16	0
20-Jun	80.82	0
21-Jun	79.35	0
22-Jun	**5th Cover (5C)**	
22-Jun	77.52	0.41
23-Jun	80.4	0.01
24-Jun	81.85	0.22
25-Jun	77.29	0
26-Jun	78.09	0
27-Jun	83.26	0
28-Jun	83.92	0.78
29-Jun	80.26	0
30-Jun	70.32	0
1-Jul	67.44	0
2-Jul	67.46	0
3-Jul	72.1	0
4-Jul	78.07	0
5-Jul	81.13	0
6-Jul	85.7	0
7-Jul	**6th Cover (6C)**	
7-Jul	86	0
8-Jul	78.88	0
9-Jul	77.9	0.03
10-Jul	73.41	0.67
11-Jul	77.42	0

Date	Temperature	Rain
12-Jul	76.28	0
13-Jul	77.4	0.39
14-Jul	74.22	1.83
15-Jul	77.4	0
16-Jul	82.1	0
17-Jul	80.6	0.05
18-Jul	82.3	0
19-Jul	81.5	0.01
20-Jul	**7th Cover (7C)**	
20-Jul	78.73	0.17
21-Jul	79.8	0.01
22-Jul	79.35	0
23-Jul	82.63	0
24-Jul	86.76	0
25-Jul	81.7	0.89
26-Jul	**17-dph**	
26-Jul	74.09	0
27-Jul	75.37	0
28-Jul	78.25	0.08
29-Jul	80.96	0
30-Jul	73.41	0
31-Jul	72.27	0
1-Aug	73.92	0
2-Aug	71.18	0
3-Aug	**9-dph**	
3-Aug	76.04	0
4-Aug	80.37	0
5-Aug	82.15	0
6-Aug	78.51	0
7-Aug	74.37	0
8-Aug	76.89	0
9-Aug	78.46	0
10-Aug	82.86	0
11-Aug	**1-dph**	
11-Aug	81.94	0.2
12-Aug	76.1	0.27
12-Aug	**Harvest**	

dph = days preharvest

TABLE 2. Blossom Blight Canker Incidence and Severity[1]				
Treatment	**Rate / A**	**Timing**	**% Shoots w. Canker[2]**	**# Cankers per shoot[2]**
Nontreated Control	----------------	----------------	30.0 a	0.46 a
Vangard 75WG **KFD-64-01** Bravo Ultrex 82.5WDG Microthiol Disperss 80DF KFD-64-01	**5.0 oz** **2.0 lb** 3.3 lb 12.0 lb 2.0 lb	**P, B** **PF** SS 1C-7C 17, 9, 1 dph	7.5 b	0.08 b
Vangard 75WG **KFD-64-01** Bravo Ultrex 82.5WDG Microthiol Disperss 80DF KFD-64-01	**5.0 oz** **3.0 lb** 3.3 lb 12.0 lb 3.0 lb	**P, B** **PF** SS 1C-7C 17, 9, 1 dph	3.8 b	0.05 b
Vangard 75WG **Gem 500SC**	**5.0 oz** **2.0 fl oz**	**P, B** **PF**, SS, 1C-7C	1.3 b	0.01 b
Vangard 75WG **Procure 480SC** Gem 500SC	**5.0 oz** **12.0 fl oz** 2.0 fl oz	**P, B** **PF**, 1C, 3C, 5C, 7C SS, 2C, 4C, 6C	5.0 b	0.05 b
Vangard 75WG **Inspire Super 2.82EW** Gem 500SC	**5.0 oz** **12.0 fl oz** 2.0 fl oz	**P, B** **PF**, 1C, 3C, 5C, 7C SS, 2C, 4C, 6C	11.3 b	0.15 b
Vangard 75WG **Inspire XT 4.17EC** Gem 500SC	**5.0 oz** **5.0 fl oz** 2.0 fl oz	**P, B** **PF**, 1C, 3C, 5C, 7C SS, 2C, 4C, 6C	5.0 b	0.05 b
Vangard 75WG **A16976 550SC** Gem 500SC	**5.0 oz** **24.0 fl oz** 2.0 fl oz	**P, B** **PF**, 1C, 3C, 5C, 7C SS, 2C, 4C, 6C	3.8 b	0.04 b
Vangard 75WG **A16976 550SC** Gem 500SC	**5.0 oz** **32.0 fl oz** 2.0 fl oz	**P, B** **PF**, 1C, 3C, 5C, 7C SS, 2C, 4C, 6C	8.8 b	0.09 b

[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. Rusty Spot Incidence and Severity[1]				
Treatment	**Rate / A**	**Timing**	**% Infected fruit[2]**	**# Lesions/fruit[2]**
Nontreated Control	-----------------	-----------------	35.0 a	0.45 a
Vangard 75WG **KFD-64-01** **Bravo Ultrex 82.5WDG** **Microthiol Disperss 80DF** KFD-64-01	5.0 oz **2.0 lb** **3.3 lb** **12.0 lb** 2.0 lb	P, B **PF** **SS** **1C, 2C**, 3C-7C 17, 9, 1 dph	27.7 b	0.35 b
Vangard 75WG **KFD-64-01** **Bravo Ultrex 82.5WDG** **Microthiol Disperss 80DF** KFD-64-01	5.0 oz **3.0 lb** **3.3 lb** **12.0 lb** 3.0 lb	P, B **PF** **SS** **1C, 2C**, 3C-7C 17, 9, 1 dph	29.4 ab	0.35 b
Vangard 75WG **Gem 500SC**	5.0 oz **2.0 fl oz**	P, B **PF, SS, 1C, 2C**, 3C-7C	8.8 de	0.09 d
Vangard 75WG **Procure 480SC** **Gem 500SC**	5.0 oz **12.0 fl oz** **2.0 fl oz**	P, B **PF, 1C**, 3C, 5C, 7C **SS, 2C**, 4C, 6C	11.3 d	0.13 cd
Vangard 75WG **Inspire Super 2.82EW** **Gem 500SC**	5.0 oz **12.0 fl oz** **2.0 fl oz**	P, B **PF, 1C**, 3C, 5C, 7C **SS, 2C**, 4C, 6C	10.0 de	0.12 d
Vangard 75WG **Inspire XT 4.17EC** **Gem 500SC**	5.0 oz **5.0 fl oz** **2.0 fl oz**	P, B **PF, 1C**, 3C, 5C, 7C **SS, 2C**, 4C, 6C	5.0 e	0.06 d
Vangard 75WG **A16976 550SC** **Gem 500SC**	5.0 oz **24.0 fl oz** **2.0 fl oz**	P, B **PF, 1C**, 3C, 5C, 7C **SS, 2C**, 4C, 6C	17.6 c	0.22 c
Vangard 75WG **A16976 550SC** **Gem 500SC**	5.0 oz **32.0 fl oz** **2.0 fl oz**	P, B **PF, 1C**, 3C, 5C, 7C **SS, 2C**, 4C, 6C	8.8 de	0.11 d

[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]				
Treatment	**Rate / A**	**Timing**	**% Infected Fruit**[2]	**# Lesions/fruit**[2]
Nontreated Control	----------------	----------------	33.1 a	7.89 a
Vangard 75WG KFD-64-01 **Bravo Ultrex 82.5WDG** **Microthiol Disperss 80DF** KFD-64-01	5.0 oz 2.0 lb **3.3 lb** **12.0 lb** 2.0 lb	P, B PF **SS** **1C-5C**, 6C, 7C 17, 9, 1 dph	5.6 b	0.22 b
Vangard 75WG KFD-64-01 **Bravo Ultrex 82.5WDG** **Microthiol Disperss 80DF** KFD-64-01	5.0 oz 3.0 lb **3.3 lb** **12.0 lb** 3.0 lb	P, B PF **SS** **1C-5C**, 6C, 7C 17, 9, 1 dph	1.9 b	0.04 b
Vangard 75WG **Gem 500SC**	5.0 oz **2.0 fl oz**	P, B PF, **SS, 1C-5C**, 6C, 7C	18.1 ab	0.60 b
Vangard 75WG **Procure 480SC** **Gem 500SC**	5.0 oz **12.0 fl oz** **2.0 fl oz**	P, B PF, **1C, 3C, 5C**, 7C **SS, 2C, 4C**, 6C	12.5 b	0.21 b
Vangard 75WG **Inspire Super 2.82EW** **Gem 500SC**	5.0 oz **12.0 fl oz** **2.0 fl oz**	P, B PF, **1C, 3C, 5C**, 7C **SS, 2C, 4C**, 6C	8.1 b	1.01 b
Vangard 75WG **Inspire XT 4.17EC** **Gem 500SC**	5.0 oz **5.0 fl oz** **2.0 fl oz**	P, B PF, **1C, 3C, 5C**, 7C **SS, 2C, 4C**, 6C	8.1 b	0.09 b
Vangard 75WG **A16976 550SC** **Gem 500SC**	5.0 oz **24.0 fl oz** **2.0 fl oz**	P, B PF, **1C, 3C, 5C**, 7C **SS, 2C, 4C**, 6C	3.8 b	0.07 b
Vangard 75WG **A16976 550SC** **Gem 500SC**	5.0 oz **32.0 fl oz** **2.0 fl oz**	P, B PF, **1C, 3C, 5C**, 7C **SS, 2C, 4C**, 6C	3.1 b	0.03 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**	**4-DPH**	**6-DPH**
Nontreated Control	-----------------	-----------------	9.8 a	74.4 a	87.5 a
Vangard 75WG KFD-64-01 Bravo Ultrex 82.5WDG Microthiol Disperss 80DF **KFD-64-01**	5.0 oz 2.0 lb 3.3 lb 12.0 lb **2.0 lb**	P, B PF SS 1C-7C **17, 9, 1 dph**	2.2 b	9.4 b	15.6 b
Vangard 75WG KFD-64-01 Bravo Ultrex 82.5WDG Microthiol Disperss 80DF **KFD-64-01**	5.0 oz 3.0 lb 3.3 lb 12.0 lb **3.0 lb**	P, B PF SS 1C-7C **17, 9, 1 dph**	2.4 b	8.1 b	9.2 b

[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 PEACH BLOSSOM BLIGHT AND BROWN ROT DEVELOPMENT

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The pre-mix experimental fungicides Inspire Super (A16001, difenoconazole + cyprodinil) and Inspire XT (A8122, difenoconazole + propiconazole) were tested and compared to standard materials for efficacy against blossom blight and brown rot.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2010 growing season. The test block consisted of a 15-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 Ziram at 4 lb/A on 18 Mar for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer. Treatment application dates and phenological timing are shown in Table 1.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 7 Jul by examining 20 twigs per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 11 Jun by examining 40 fruit per tree. Scab (*Fusicladium carpophilum*) was evaluated 24 Aug by examining 40 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 6 Sep by examining all fruit 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, uninjured fruit were harvested from each tree and placed on benches in the greenhouse (ave. air temp. = 77.6ºF). Brown rot was evaluated at 3 and 6 days postharvest (DPH).

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 the 30-year means or sums, respectively, for Bridgeton, NJ.

RESULTS AND DISCUSSION

Environment. Overall, the growing season (April through early September) was dry with very warm temperatures (Table 1). July was the only month to receive rainfall close to the 30 year average; rainfall for all other months was 1.02-1.22 inches below average. Every month except August had temperatures well above average. April, May, June, and July had temperatures 4.1º, 2.7º, 4.1º, and 1.8ºF above average, respectively. The temperature for August was 0.2ºF above average. Average monthly temperatures this growing season were: Apr, 56.2ºF, May 64.9ºF, Jun 75.4ºF, Jul 78.1ºF, and Aug 75.0ºF.

Blossom Blight. Warm temperatures and several days with rainfall during the bloom period (P, B, PF), when blossoms were susceptible, resulted in favorable conditions for blossom blight development. Blossom blight canker incidence was moderately high with 20% shoot infection on non-treated trees (Table 2). All treatments provided significant blossom blight control. The three Inspire treatments provided 100% control and had significantly lower incidence than the standard Vangard treatment which provided 84% control. There were no significant differences between treatments for number of cankers per shoot.

Rusty Spot. The warm, dry weather between PF and 2C was very conducive for the development of rusty spot. Disease pressure was very high because of the favorable conditions and the very high susceptibility of Autumnglo to rusty spot. The non-sprayed control had 82.4% fruit infection with an average of 3.38 lesions per fruit (Table 3).

Since this experiment was not designed for evaluation of rusty spot, rusty spot effective fungicides were not applied during the PF through 2C timings. Neither Bravo nor Captan, applied for scab control, provide any rusty spot control. Hence, there were no significant differences in rusty spot incidence between any of the treatments. However, significantly fewer lesions per fruit were observed for the Inspire XT treatment, presumably due to its application at PF.

Scab. Weather conditions were very unfavorable for scab; rainfall was well below average throughout the susceptibility period from SS (late April) to 40-dph (late July). Extremely high temperatures may have been unfavorable for scab development. Twig lesions provided some inoculum, but infection was very low compared to past years. Non-sprayed trees had 22.5% fruit infection and 6.3% fruit with over 10 lesions (Table 4). In 2009, a favorable year for scab, non-sprayed trees in this block had 100% fruit infection with over 99% of fruit having 10 or more lesions.

All treatments significantly reduced scab incidence and severity from the non-treated control and were equivalent to one another. Although there were no significant differences, Bravo cover sprays appeared to provide more control than Captan cover sprays. All three Bravo treatments had consistently lower disease levels than the Captan treatment in all three disease assessment categories. The three Bravo treatments provided 80%-92% control of scab while Bravo/Captan provided 63% control.

Brown Rot. Conditions were moderately favorable for brown rot development. Rainfall occurred on several days during the early stage of the ripening period. Four days with rainfall (> 0.10 in) occurred between 8C and 18 dph, one day with 1.37 in rainfall occurred after the 18 dph spray, and one day with 0.22 in rainfall accumulation occurred following the 10-dph spray (Table 1).

Insect control was a problem in this block and some fruit had worm damage. Therefore, separate brown rot assessments were performed on fruit with and without insect injury. At harvest, 1.0-4.6% of fruit from all treatments had brown rot with insect injury with no significant differences between them (Table 5).

Non-treated control trees had 51.8% non-insect injured, brown rotted fruit at harvest. All treatments significantly reduced brown rot, providing 79-83% control.

Post harvest brown rot pressure was very high. Non sprayed fruit reached 68.0% infection at 3-DPH and 90.8% infection at 6-DPH. All treatments significantly reduced brown rot at both post harvest assessments. Percent control ranged from 55-72% at 3-DPH and 26-35% at 6-DPH; no significant differences were observed among fungicide treatments.

CONCLUSIONS

- **Inspire XT** and **Inspire Super** provided excellent control of blossom blight. Although the standard Vangard provided very good blight control under moderate disease pressure, the difenoconazole mixtures were superior under these conditions.

- **Inspire XT** and **Inspire Super** provided excellent harvest and postharvest control of brown rot. Both difenoconazole mixtures yielded equivalent control to the Elite/Pristine/Indar standard.

- A rate effect was not observed between the two **Inspire Super** treatments for either blossom blight or brown rot control.

- **Inspire XT** applied at PF significantly reduced rusty spot severity. Both Inspire XT and Inspire Super have shown potential to be effective for rusty spot control in a 2009 experiment. In that study, Inspire XT and Inspire Super both significantly reduced rusty spot incidence when applied at SS and 1C (materials that don’t control rusty spot were applied at PF and 2C). To fully understand the efficacy of Inspire XT and Inspire Super on rusty spot, these materials will need to be applied for the duration of the rusty spot susceptibility period (PF-2C).

Table 1. Weather and spray timings for 2010 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
2-Apr	54.64	0
3-Apr	53.2	0
4-Apr	60.31	0
5-Apr	**Pink (P)**	
5-Apr	62.58	0
6-Apr	69.38	0.01
7-Apr	76.03	0
8-Apr	72.28	0
9-Apr	54.32	0.60
10-Apr	49.03	0
11-Apr	59.28	0
12-Apr	**Bloom (B)**	
12-Apr	59.28	0
13-Apr	46.28	0.08
14-Apr	49.11	0
15-Apr	57.35	0
16-Apr	60.14	0.29
17-Apr	54.42	0.08
18-Apr	47.3	0
19-Apr	52.82	0
20-Apr	**Petal Fall (PF)**	
20-Apr	52.92	0
21-Apr	53.24	0.16
22-Apr	58.32	0.02
23-Apr	56.32	0
24-Apr	52.8	0
25-Apr	51.07	0.82
26-Apr	51.87	0.47
27-Apr	52.69	0.02

Date	Temp	Rain
28-Apr	47.47	0
29-Apr	55.11	0
30-Apr	**Shuck Split (SS)**	
30-Apr	62.35	0
1-May	72.93	0
2-May	76.38	0
3-May	75.29	0.06
4-May	71.58	0
5-May	66.27	0
6-May	70.76	0
7-May	61.15	0
8-May	67.43	0
9-May	51.72	0
10-May	50.01	0
11-May	**1st Cover (1C)**	
11-May	47.5	0.03
12-May	50.87	0.38
13-May	54.46	0
14-May	66.36	0.78
15-May	66.98	0
16-May	62	0
17-May	58.25	0
18-May	51.47	1.63
19-May	57.4	0
20-May	**2nd Cover (2C)**	
20-May	65.01	0
21-May	70.79	0
22-May	66.38	0

Date	Temp	Rain
23-May	65.25	0.09
24-May	65.37	0
25-May	68.65	0
26-May	72.86	0
27-May	73.14	0
28-May	63.3	0
29-May	69.15	0.01
30-May	74.86	0
31-May	77.36	0
1-Jun	77.45	0
2-Jun	76.69	0
3-Jun	**3rd Cover (3C)**	
3-Jun	78.53	0
4-Jun	77.74	0
5-Jun	79.46	0
6-Jun	79.72	0.01
7-Jun	66.49	0
8-Jun	65.38	0
9-Jun	61.84	0.35
10-Jun	72.12	0.07
11-Jun	69.67	0
12-Jun	71.48	0
13-Jun	77.38	0.45
14-Jun	74.16	0.03
15-Jun	71.97	0
16-Jun	**4th Cover (4C)**	
16-Jun	70.24	0.01
17-Jun	75.58	0.01

Table 1 – continued -

Date	Temp	Rain
18-Jun	70.24	0
19-Jun	73.16	0
20-Jun	80.82	0
21-Jun	79.35	0
22-Jun	77.52	0.41
23-Jun	80.4	0.01
24-Jun	81.85	0.22
25-Jun	77.29	0
26-Jun	78.09	0
27-Jun	83.26	0
28-Jun	83.92	0.78
29-Jun	80.26	0
30-Jun	70.32	0
1-Jul	**5th Cover (5C)**	
1-Jul	67.44	0
2-Jul	67.46	0
3-Jul	72.1	0
4-Jul	78.07	0
5-Jul	81.13	0
6-Jul	85.7	0
7-Jul	86	0
8-Jul	78.88	0
9-Jul	77.9	0.03
10-Jul	73.41	0.67
11-Jul	77.42	0
12-Jul	76.28	0
13-Jul	77.4	0.39
13-Jul	**6th Cover (6C)**	
14-Jul	74.22	1.83
15-Jul	77.4	0

Date	Temp	Rain
16-Jul	82.1	0
17-Jul	80.6	0.05
18-Jul	82.3	0
19-Jul	81.5	0.01
20-Jul	78.73	0.17
21-Jul	79.8	0.01
22-Jul	79.35	0
23-Jul	82.63	0
24-Jul	86.76	0
25-Jul	81.7	0.89
26-Jul	74.09	0
27-Jul	**7th Cover (7C)**	
27-Jul	75.37	0
28-Jul	78.25	0.08
29-Jul	80.96	0
30-Jul	73.41	0
31-Jul	72.27	0
1-Aug	73.92	0
2-Aug	71.18	0
3-Aug	76.04	0
4-Aug	80.37	0
5-Aug	82.15	0
6-Aug	78.51	0
7-Aug	74.37	0
8-Aug	76.89	0
9-Aug	78.46	0
10-Aug	**8th Cover (8C)**	
10-Aug	82.86	0
11-Aug	81.94	0.20
12-Aug	76.1	0.27

Date	Temp	Rain
13-Aug	74.04	0
14-Aug	71.96	0
15-Aug	71.47	0.57
16-Aug	80.05	0
17-Aug	80.83	0
18-Aug	70.7	0.55
19-Aug	**18-dph**	
19-Aug	75.72	0
20-Aug	77.02	0
21-Aug	75.01	0
22-Aug	75.74	1.37
23-Aug	71.28	0
24-Aug	66.02	0
25-Aug	68.96	0
26-Aug	71.77	0
27-Aug	**10-dph**	
27-Aug	66.93	0
28-Aug	67.77	0
29-Aug	73.7	0
30-Aug	76.35	0
31-Aug	77.82	0
1-Sep	78.16	0.22
2-Sep	79.64	0
3-Sep	75.23	0
4-Sep	73.56	0
5-Sep	**1-dph**	
5-Sep	64.19	0
6-Sep	65.62	0
6-Sep	**Harvest**	

dph = days preharvest

TABLE 2. Blossom Blight Incidence and Severity[1]				
Treatment	**Rate / A**	**Timing**	**% Shoots w. canker**[2]	**#Cankers per shoot**[2]
Non-treated Control	--------	--------	20.0 a	0.24 a
Vangard 75WG Bravo Ultrex 82.5WDG Captan 80WDG Elite 45WP Pristine 38WG Indar 2F	**5.0 oz** 3.3 lb 3.75 lb 6.0 oz 12.5 oz 6.0 fl oz	**P, B, PF** SS 1C-8C 18 dph 10 dph 1 dph	3.3 b	0.03 b
Inspire Super 2.8EW Bravo Ultrex 82.5WDG Inspire Super 2.8EW	**10.0 fl oz** 3.3 lb 10.0 fl oz	**P, B, PF** SS, 1C-8C 18, 10, 1 dph	0.0 c	0.0 b
Inspire Super 2.8EW Bravo Ultrex 82.5WDG Inspire Super 2.8EW	**12.0 fl oz** 3.3 lb 12.0 fl oz	**P, B, PF** SS, 1C-8C 18, 10, 1 dph	0.0 c	0.0 b
Inspire XT 4.17EC Bravo Ultrex 82.5WDG Inspire XT 4.17EC	**7.0 fl oz** 3.3 lb 7.0 fl oz	**P, B, PF** SS, 1C-8C 18, 10, 1 dph	0.0 c	0.0 b

[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 ($\alpha=0.05$, $K=100$).

TABLE 3. Rusty Spot Incidence and Severity[1]				
Treatment	**Rate / A**	**Timing**	**% Infected Fruit** [2]	**# Lesions/fruit** [2]
Non-treated Control	--------	--------	82.4 a	3.38 a
Vangard 75WG **Bravo Ultrex 82.5WDG** **Captan 80WDG** Elite 45WP Pristine 38WG Indar 2F	**5.0 oz** **3.3 lb** **3.75 lb** 6.0 oz 12.5 oz 6.0 fl oz	P, B, **PF** **SS** **1C, 2C**, 3C-8C 18 dph 10 dph 1 dph	88.3 a	3.10 a
Inspire Super 2.8EW **Bravo Ultrex 82.5WDG** Inspire Super 2.8EW	**10.0 fl oz** **3.3 lb** 10.0 fl oz	P, B, **PF** **SS, 1C, 2C**, 3C-8C 18, 10, 1 dph	81.9 a	2.84 a
Inspire Super 2.8EW **Bravo Ultrex 82.5WDG** Inspire Super 2.8EW	**12.0 fl oz** **3.3 lb** 12.0 fl oz	P, B, **PF** **SS, 1C, 2C**, 3C-8C 18, 10, 1 dph	82.5 a	2.44 ab
Inspire XT 4.17EC **Bravo Ultrex 82.5WDG** Inspire XT 4.17EC	**7.0 fl oz** **3.3 lb** 7.0 fl oz	P, B, **PF** **SS, 1C, 2C**, 3C-8C 18, 10, 1 dph	73.8 a	1.87 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**
Non-treated control	-----	-----	22.5 a	16.3 a	6.3 a
Vangard 75WG **Bravo Ultrex 82.5WDG** **Captan 80WDG** Elite 45WP Pristine 38WG Indar 2F	5.0 oz **3.3 lb** **3.75 lb** 6.0 oz 12.5 oz 6.0 fl oz	P, B, PF **SS** **1C-7C**, 8C 18 dph 10 dph 1 dph	8.3 b	5.8 b	2.5 b
Inspire Super 2.8EW **Bravo Ultrex 82.5WDG** Inspire Super 2.8EW	10.0 fl oz **3.3 lb** 10.0 fl oz	P, B, PF **SS, 1C-7C**, 8C 18, 10, 1 dph	4.4 b	3.1 b	1.3 b
Inspire Super 2.8EW **Bravo Ultrex 82.5WDG** Inspire Super 2.8EW	12.0 fl oz **3.3 lb** 12.0 fl oz	P, B, PF **SS, 1C-7C**, 8C 18, 10, 1 dph	1.9 b	1.9 b	0.0 b
Inspire XT 4.17EC **Bravo Ultrex 82.5WDG** Inspire XT 4.17EC	7.0 fl oz **3.3 lb** 7.0 fl oz	P, B, PF **SS, 1C-7C**, 8C 18, 10, 1 dph	4.4 b	3.8 b	0.6 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 Postharvest Incidence[1]			**% Fruit Infected** [2]			
			Harvest [3]			
Treatment	**Rate / A**	**Timing**	**Not Injured**	**Insect Injured**	**3-DPH**	**6-DPH**
Non-treated control	-----	-----	51.8 a	4.6 a	68.0 a	90.8 a
Vangard 75WG Bravo Ultrex 82.5WDG Captan 80WDG **Elite 45WP** **Pristine 38WG** **Indar 2F**	5.0 oz 3.3 lb 3.75 lb **6.0 oz** **12.5 oz** **6.0 fl oz**	P, B, PF SS 1C-8C **18 dph** **10 dph** **1 dph**	9.7 b	1.9 a	30.0 b	67.5 b
Inspire Super 2.8EW Bravo Ultrex 82.5WDG **Inspire Super 2.8EW**	10.0 fl oz 3.3 lb **10.0 fl oz**	P, B, PF SS, 1C-8C **18, 10, 1 dph**	10.9 b	1.7 a	29.4 b	61.3 b
Inspire Super 2.8EW Bravo Ultrex 82.5WDG **Inspire Super 2.8EW**	12.0 fl oz 3.3 lb **12.0 fl oz**	P, B, PF SS, 1C-8C **18, 10, 1 dph**	9.6 b	1.5 a	30.6 b	65.6 b
Inspire XT 4.17EC Bravo Ultrex 82.5WDG **Inspire XT 4.17EC**	7.0 fl oz 3.3 lb **7.0 fl oz**	P, B, PF SS, 1C-8C **18, 10, 1 dph**	9.0 b	1.0 a	18.9 b	59.2 b

[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).
[3] Due to the occurrence of insect injury in this block, fruit with and without injury were assessed separately for brown rot.

MANAGEMENT OF PEACH DISEASE WITH EXPERIMENTAL FUNGICIDES

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The fungicides DPX-LEM17 (penthiopyrad) and Luna Sensation (fluopyram + trifloxystrobin) were tested for their ability to provide control of blossom blight and brown rot. Adament (trifloxystrobin + tebuconazole) was used as the standard. The experimental fungicides YT669 (picoxystrobin) and Q8Y78 were applied full season at two rates to test their efficacy against the full spectrum of peach diseases.

MATERIALS AND METHODS

Orchard Site. The experiment was conducted during the spring and summer of the 2010 growing season. The test block consisted of a mixed-cultivar orchard of 15-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 study.

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. Treatment application dates and phenological timings are shown in Table 1. All trees in the block received Ziram at 4 lb/A on 18 Mar for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Assessment. Blossom blight canker development (*Monilinia fructicola*) was evaluated on 28 Jun by examining 20 twigs per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 14 Jun by examining 40 fruit per tree. Scab (*Fusicladium carpophilum*) was evaluated on 26 Aug by examining 40 fruit per tree. Brown rot (*M. fructicola*) and Rhizopus rot (*Rhizopus* spp.) were evaluated at harvest on 8 Sep by examining all fruit on four or more branches per replicate tree (either a minimum of 100 fruit per tree or all fruit on the tree for trees with less than 100 fruit). For postharvest evaluations, 40 asymptomatic, uninjured fruit were harvested from each tree and placed on benches in a greenhouse (ave. air temp. = 74.9ºF). Brown rot and Rhizopus rots were evaluated at 3- and 6-days postharvest (DPH).

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. The growing season (April through early September) had above average temperature and below average rainfall (Table 1). July was the only month to receive rainfall close to the 30 year average; rainfall for all other months was 1.02-1.22 inches below average. The temperature was well above average for every month of the growing season except August. Temperatures in April, May, June, and July were 4.1º, 2.7º, 4.1º, and 1.8ºF above average, respectively. August was 0.2ºF above average. Average monthly temperatures this growing season were: Apr, 56.2ºF, May 64.9ºF, Jun 75.4ºF, Jul 78.1ºF, and Aug 75.0ºF.

Blossom Blight. Blossom blight canker incidence was moderate with 11.3% shoot infection on non-treated trees (Table 2). Unseasonably warm temperatures in early April caused the buds to quickly progress through the susceptible stages of pink, bloom, and petal fall. One rainfall event (>0.10 in) occurred during full bloom when blossoms were most susceptible, while the other rainfall events occurred towards the end of the susceptible period during petal fall. The warm weather was advantageous for disease development. All treatments reduced blossom blight incidence by 89-100%, a significant reduction from the non-treated control, and did not differ significantly from one another.

Rusty Spot. Warm temperatures and very little rainfall from PF through 2C were extremely favorable for rusty spot development. Non-sprayed control trees had 73.1% fruit infection with an average of 1.65 lesions per fruit (Table 2).

All treatments provided significant control of rusty spot incidence and severity. The five standard Rally treatments provided 76-86% control. YT669 at 12 fl oz and Q8Y78 at 18 fl oz provided equivalent control to Rally and significantly more control than the other treatments. The Rally treatments reduced the number of lesions per fruit by 84-90%. YT669 at 8 and 12 fl oz and Q8Y78 at 20 fl oz reduced the number of lesions per fruit by 79%, 84%, and 88%, respectively, and were equivalent to Rally. Pristine was the least effective fungicide.

Scab. Weather conditions were less favorable for scab development than in previous years. Rainfall was well below average during the susceptible period from SS (late April) to 40 days pre-harvest (late July). Extremely high temperatures may have also been detrimental for scab development. Nevertheless, non-sprayed control trees had nearly 100% infected fruit and 70% of fruit had 10 or more lesions (Table 3). High inoculum levels in the form of twig lesions were the most likely reason for high incidence and severity of scab. In years when weather conditions were also favorable for scab, non-sprayed fruit in this block were often covered by large areas of coalescing lesions; this symptom was not observed this year.

All treatments provided significant control of scab incidence and severity. The five Bravo/Captan standard treatments provided 85-90% control. The remaining treatments were equivalent to Bravo/Captan. All treatments reduced the amount of fruit with greater than 10 lesions by 87-100% with no significant differences among them.

Brown Rot. Conditions were somewhat favorable for brown rot development. Several days with rainfall occurred in the early stage of the ripening process. Four rain days (> 0.10 in) occurred between 8C and 19-dph, 1.37 in of rain fell two days after the 19-dph spray, and 0.22 in of rain occurred two days after the 9-dph spray (Table 1).

Insect control was a problem in this block and many fruit had obvious worm damage. The brown marmorated stink bug was also present in the orchard. Therefore, fruit with and without insect injury were separately assessed for brown rot. The amount of brown rotted fruit at harvest with insect injury ranged from 2.0%-7.3% for all the treatments with no significant differences (Table 4).

Non-treated control trees had 54.7% fruit with brown rot at harvest that did not show any evidence of insect predisposition. For these fruit, all treatments provided significant control. Pristine provided the most control with an 85% reduction in brown rot. All remaining treatments, with the exception of DPX-LEM17 at 20 fl oz + Induce, provided statistically equivalent control to Pristine.

The non-treated control had 31.5% rotted fruit at 3-DPH and 85.5% rotted fruit at 6-DPH. At 3-DPH, all treatments significantly reduced brown rot with no significant differences between them despite a wide range in control (from 25% for DPX-LEM17 at 14 fl oz to 74% for YT669 at 12 fl oz). This lack of separation was mostly likely due to within-treatment variation. At 6-DPH, Q8Y78 at 18 fl oz provided the most control and reduced brown rot by 57% from the non-sprayed control. All other treatments, with the exception of Adament and DPX-LEM17 at 20 fl oz + Induce, provided equivalent control to Q8Y78 at 18 fl oz.

Rhizopus Rot. Rhizopus rot at harvest was negligible. At 3-DPH, levels of Rhizopus remained low with the majority of treatments uninfected. Fruit treated with DPX-LEM17 at 14 fl oz + Induce had the highest amount of rot with 2.7% infection which was significantly higher than all other treatments with the exception of DPX-LEM17 at 20 fl oz + Induce (Table 5). By 6-DPH all treatments had 2.0-14.7% fruit with Rhizopus rot; no significant differences were observed between the treatments.

CONCLUSIONS

- **Luna Sensation (USF 2016)** provided control equivalent to the standard (Adament) for blossom blight and brown rot.

- **DPX-LEM17** provided equivalent control to the standard Adament for blossom blight management. For rusty spot control, DPX-LEM17 applied at PF followed by Rally from SS-2C yielded the same results as the standard Rally applied at all four spray timings. There were no significant differences between all three DPX-LEM17 treatments for either blossom blight or brown rot; however, DPX-LEM17 at 20 fl oz + Induce is the only treatment that provided significantly less control than the most effective treatment at harvest and 6-DPH.

- **YT669** at 12 fl oz provided control equivalent to the standard for all diseases. YT669 at 8 fl oz provided equivalent control to the standard for all diseases except rusty spot incidence. Both the 8 and 12 fl oz rates of YT669 were equivalent to each other for the control of all diseases except rusty spot incidence; thus, for most diseases, a rate effect was not observed.

- **Q8Y78** at 18 fl oz was equivalent to the standard for the control of all diseases. Q8Y78 at 12 fl oz provided control equivalent to the standard for all diseases with the exception of rusty spot incidence and severity. With the exception of rusty spot, the 18 fl oz rate of Q8Y78 did not provide significantly more control of any disease than the 12 fl oz rate. Nevertheless, the 18 fl oz rate had consistently lower levels of brown rot than the 12 fl oz rate in each of the four assessment categories.

- **Pristine** provided equivalent control to the standard materials for all diseases with the exception of rusty spot incidence and severity.

Table 1. Weather and Spray Schedules for 2010 growing season at Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. Sprays are indicated by bolded phenological stage. Units for daily average temperature and rainfall are ºF and inches, respectively.

Date	Temp	Rain	Date	Temp	Rain	Date	Temp	Rain
2-Apr	54.64	0	28-Apr	47.47	0	23-May	65.25	0.09
3-Apr	53.2	0	29-Apr	55.11	0	24-May	65.37	0
4-Apr	60.31	0	30-Apr	**Shuck Split (SS)**		25-May	68.65	0
5-Apr	62.58	0	30-Apr	62.35	0	26-May	72.86	0
6-Apr	**Pink (P)**		1-May	72.93	0	27-May	73.14	0
6-Apr	69.38	0.01	2-May	76.38	0	28-May	63.3	0
7-Apr	76.03	0	3-May	75.29	0.06	29-May	69.15	0.01
8-Apr	72.28	0	4-May	71.58	0	30-May	74.86	0
9-Apr	54.32	0.60	5-May	66.27	0	31-May	77.36	0
10-Apr	49.03	0	6-May	70.76	0	1-Jun	77.45	0
11-Apr	59.28	0	7-May	61.15	0	2-Jun	76.69	0
12-Apr	59.28	0	8-May	67.43	0	3-Jun	**3rd Cover (3C)**	
13-Apr	**Bloom (B)**		9-May	51.72	0	3-Jun	78.53	0
13-Apr	46.28	0.08	10-May	50.01	0	4-Jun	77.74	0
14-Apr	49.11	0	11-May	**1st Cover (1C)**		5-Jun	79.46	0
15-Apr	57.35	0	11-May	47.5	0.03	6-Jun	79.72	0.01
16-Apr	60.14	0.29	12-May	50.87	0.38	7-Jun	66.49	0
17-Apr	54.42	0.08	13-May	54.46	0	8-Jun	65.38	0
18-Apr	47.3	0	14-May	66.36	0.78	9-Jun	61.84	0.35
19-Apr	52.82	0	15-May	66.98	0	10-Jun	72.12	0.07
20-Apr	52.92	0	16-May	62	0	11-Jun	69.67	0
21-Apr	**Petal Fall (PF)**		17-May	58.25	0	12-Jun	71.48	0
21-Apr	53.24	0.16	18-May	51.47	1.63	13-Jun	77.38	0.45
22-Apr	58.32	0.02	19-May	57.4	0	14-Jun	74.16	0.03
23-Apr	56.32	0	20-May	**2nd Cover (2C)**		15-Jun	71.97	0
24-Apr	52.8	0	20-May	65.01	0	16-Jun	**4th Cover (4C)**	
25-Apr	51.07	0.82	21-May	70.79	0	16-Jun	70.24	0.01
26-Apr	51.87	0.47	22-May	66.38	0	17-Jun	75.58	0.01
27-Apr	52.69	0.02						

Table 1 - continued

Date	Temp	Rain
18-Jun	70.24	0
19-Jun	73.16	0
20-Jun	80.82	0
21-Jun	79.35	0
22-Jun	77.52	0.41
23-Jun	80.4	0.01
24-Jun	81.85	0.22
25-Jun	77.29	0
26-Jun	78.09	0
27-Jun	83.26	0
28-Jun	83.92	0.78
29-Jun	80.26	0
30-Jun	70.32	0
1-Jul	**5th Cover (5C)**	
1-Jul	67.44	0
2-Jul	67.46	0
3-Jul	72.1	0
4-Jul	78.07	0
5-Jul	81.13	0
6-Jul	85.7	0
7-Jul	86	0
8-Jul	78.88	0
9-Jul	77.9	0.03
10-Jul	73.41	0.67
11-Jul	77.42	0
12-Jul	76.28	0
13-Jul	77.4	0.39
14-Jul	74.22	1.39
14-Jul	**6th Cover (6C)**	
14-Jul	74.22	0.44
15-Jul	77.4	0

Date	Temp	Rain
16-Jul	82.1	0
17-Jul	80.6	0.05
18-Jul	82.3	0
19-Jul	81.5	0.01
20-Jul	78.73	0.17
21-Jul	79.8	0.01
22-Jul	79.35	0
23-Jul	82.63	0
24-Jul	86.76	0
25-Jul	81.7	0.89
26-Jul	74.09	0
27-Jul	75.37	0
28-Jul	78.25	0.08
29-Jul	**7th Cover (7C)**	
29-Jul	80.96	0
30-Jul	73.41	0
31-Jul	72.27	0
1-Aug	73.92	0
2-Aug	71.18	0
3-Aug	76.04	0
4-Aug	80.37	0
5-Aug	82.15	0
6-Aug	78.51	0
7-Aug	74.37	0
8-Aug	76.89	0
9-Aug	78.46	0
10-Aug	**8th Cover (8C)**	
10-Aug	82.86	0
11-Aug	81.94	0.20
12-Aug	76.1	0.27
13-Aug	74.04	0

Date	Temp	Rain
14-Aug	71.96	0
15-Aug	71.47	0.57
16-Aug	80.05	0
17-Aug	80.83	0
18-Aug	70.7	0.55
19-Aug	75.72	0
20 Aug	**19-dph**	
20-Aug	77.02	0
21-Aug	75.01	0
22-Aug	75.74	1.37
23-Aug	71.28	0
24-Aug	66.02	0
25-Aug	68.96	0
26-Aug	71.77	0
27-Aug	66.93	0
28-Aug	67.77	0
29-Aug	73.7	0
30-Aug	**9-dph**	
30-Aug	76.35	0
31-Aug	77.82	0
1-Sep	78.16	0.22
2-Sep	79.64	0
3-Sep	75.23	0
4-Sep	73.56	0
5-Sep	64.19	0
6-Sep	65.62	0
7-Sep	**1-dph**	
7-Sep	75.2	0
8-Sep	78.78	0
8-Sep	**Harvest**	

dph = days preharvest

TABLE 2. Blossom Blight Canker Incidence Rusty Spot Incidence and Severity [1]			**Blossom Blight** [2]	**Rusty Spot** [2]	
Treatment	**Rate / A**	**Timing**	**% Shoots w. Cankers**	**% Inf. Fruit**	**# Lesions /Fruit**
Nontreated	------	------	11.3 a	73.1 a	1.65 a
Adament 50WG ***Rally 40WSP*** *Rally 40WSP* + Bravo Ultrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Adament 50WG	**6.0 oz** ***5.0 oz*** *5.0 oz* + 3.8 lb *5.0 oz* + 3.75 lb 3.75 lb 6.0 oz	**P, B** ***PF*** *SS* *1C, 2C* 3C-8C 19, 9, 1 dph	0.0 b	12.5 e	0.16 d
Luna Sensation 4.17SC ***Rally 40WSP*** *Rally 40WSP* + Bravo Ultrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG Luna Sensation 4.17SC	**5.0 fl oz** ***5.0 oz*** *5.0 oz* + 3.8 lb *5.0 oz* + 3.75 lb 3.75 lb 5.0 fl oz	**P, B** ***PF*** *SS* *1C, 2C* 3C-8C 19, 9, 1 dph	0.0 b	15.6 de	0.23 d
DPX-LEM17 1.67SC *Rally 40WSP* + Bravo Ultrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC	***14.0 fl oz*** *5.0 oz* + 3.8 lb *5.0 oz* + 3.75 lb 3.75 lb 14.0 fl oz	**P, B, *PF*** *SS* *1C, 2C* 3C-8C 19, 9, 1 dph	0.0 b	10.6 e	0.18 d
DPX-LEM17 1.67SC + Induce *Rally 40WSP* + Bravo Ultrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC + Induce	***14.0 fl oz + 32 fl oz*** *5.0 oz* + 3.8 lb *5.0 oz* + 3.75 lb 3.75 lb 14.0 fl oz + 32 fl oz	**P, B, *PF*** *SS* *1C, 2C* 3C-8C 19, 9, 1 dph	1.3 b	17.5 de	0.26 d
DPX-LEM17 1.67SC + Induce *Rally 40WSP* + Bravo Ultrex 82.5WDG *Rally 40WSP* + Captan 80WDG Captan 80WDG DPX-LEM17 1.67SC + Induce	***20.0 fl oz + 32 fl oz*** *5.0 oz* + 3.8 lb *5.0 oz* + 3.75 lb 3.75 lb 20.0 fl oz + 32 fl oz	**P, B, *PF*** *SS* *1C, 2C* 3C-8C 19, 9, 1 dph	1.3 b	12.5 e	0.16 d
YT669 2.08SC + Induce	***8.0 fl oz + 32 fl oz***	**P, B, *PF***, *SS, 1C, 2C*, 3C-8C, 19, 9, 1 dph	0.0 b	24.4 cd	0.34 cd
YT669 2.08SC + Induce	***12.0 fl oz + 32 fl oz***	**P, B, *PF***, *SS, 1C, 2C*, 3C-8C, 19, 9, 1 dph	0.0 b	13.8 e	0.26 d
Q8Y78 2.0SC + Induce	***12.0 fl oz + 32 fl oz***	**P, B, *PF***, *SS, 1C, 2C*, 3C-8C, 19, 9, 1 dph	0.0 b	31.3 c	0.52 bc
Q8Y78 2.0SC + Induce	***18.0 fl oz + 32 fl oz***	**P, B, *PF***, *SS, 1C, 2C*, 3C-8C, 19, 9, 1 dph	0.0 b	14.4 e	0.20 d
Pristine 38WG	***12.0 oz***	**P, B, *PF***, *SS, 1C, 2C*, 3C-8C, 19, 9, 1 dph	1.3 b	45.6 b	0.74 b

[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	------	------	98.1 a	28.1 a	70.0 a
Adament 50WG Rally 40WSP Rally 40WSP + **Bravo Ultrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Adament 50WG	6.0 oz 5.0 oz 5.0 oz + **3.8 lb** 5.0 oz + **3.75 lb** **3.75 lb** 6.0 oz	P, B PF **SS** **1C, 2C** **3C-7C**, 8C 19, 9, 1 dph	10.6 bc	10.0 a	0.6 b
Luna Sensation 4.17SC Rally 40WSP Rally 40WSP + **Bravo Ultrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** Luna Sensation 4.17SC	5.0 fl oz 5.0 oz 5.0 oz + **3.8 lb** 5.0 oz + **3.75 lb** **3.75 lb** 5.0 fl oz	P, B PF **SS** **1C, 2C** **3C-7C**, 8C 19, 9, 1 dph	15.0 bc	11.3 a	3.8 b
DPX-LEM17 1.67SC Rally 40WSP + **Bravo Ultrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** DPX-LEM17 1.67SC	14.0 fl oz 5.0 oz + **3.8 lb** 5.0 oz + **3.75 lb** **3.75 lb** 14.0 fl oz	P, B, PF **SS** **1C, 2C** **3C-7C**, 8C 19, 9, 1 dph	11.9 bc	10.6 a	1.3 b
DPX-LEM17 1.67SC + Induce Rally 40WSP + **Bravo Ultrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** DPX-LEM17 1.67SC + Induce	14.0 fl oz + 32 fl oz 5.0 oz + **3.8 lb** 5.0 oz + **3.75 lb** **3.75 lb** 14.0 fl oz + 32 fl oz	P, B, PF **SS** **1C, 2C** **3C-7C**, 8C 19, 9, 1 dph	14.4 bc	9.4 a	5.0 b
DPX-LEM17 1.67SC + Induce Rally 40WSP + **Bravo Ultrex 82.5WDG** Rally 40WSP + **Captan 80WDG** **Captan 80WDG** DPX-LEM17 1.67SC + Induce	20.0 fl oz + 32 fl oz 5.0 oz + **3.8 lb** 5.0 oz + **3.75 lb** **3.75 lb** 20.0 fl oz + 32 fl oz	P, B, PF **SS** **1C, 2C** **3C-7C**, 8C 19, 9, 1 dph	9.4 c	9.4 a	0.0 b
YT669 2.08SC + Induce	**8.0 fl oz + 32 fl oz**	P, B, PF**, SS, 1C, 2C** **3C-7C**, 8C, 19, 9, 1 dph	23.8 bc	16.9 a	6.9 b
YT669 2.08SC + Induce	**12.0 fl oz + 32 fl oz**	P, B, PF, **SS, 1C, 2C** **3C-7C**, 8C, 19, 9, 1 dph	19.4 bc	16.9 a	2.5 b
Q8Y78 2.0SC + Induce	**12.0 fl oz + 32 fl oz**	P, B, PF, **SS, 1C, 2C** **3C-7C**, 8C, 19, 9, 1 dph	28.8 b	19.4 a	9.4 b
Q8Y78 2.0SC + Induce	**18.0 fl oz + 32 fl oz**	P, B, PF, **SS, 1C, 2C** **3C-7C**, 8C, 19, 9, 1 dph	25.0 bc	21.9 a	3.1 b
Pristine 38WG	**12.0 oz**	P, B, PF**, SS, 1C, 2C** **3C-7C**, 8C, 19, 9, 1 dph	24.4 bc	18.1 a	6.3 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]			
			Harvest[3]			
Treatment	**Rate / A**	**Timing**	**Not Injured**	**Insect Injured**	**3-DPH**	**6-DPH**
Nontreated	------	------	54.7 a	4.5 a	31.5 a	85.5 a
Adament 50WG Rally 40WSP Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Adament 50WG**	6.0 oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **6.0 oz**	P, B PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	18.3 bc	5.9 a	19.7 b	59.5 bc
Luna Sensation 4.17SC Rally 40WSP Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Luna Sensation 4.17SC**	5.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **5.0 fl oz**	P, B PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	17.3 bc	3.0 a	10.7 b	49.1 bcd
DPX-LEM17 1.67SC Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	14.0 fl oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **14.0 fl oz**	P, B, PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	17.1 bc	5.9 a	23.5 b	53.2 bcd
DPX-LEM17 1.67SC + Induce Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC + Induce**	14.0 fl oz + 32 fl oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **14.0 fl oz + 32 fl oz**	P, B, PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	17.9 bc	5.0 a	12.7 b	47.1 bcd
DPX-LEM17 1.67SC + Induce Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC + Induce**	20.0 fl oz + 32 fl oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **20.0 fl oz + 32 fl oz**	P, B, PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	34.4 b	7.3 a	18.5 b	65.3 b
YT669 2.08SC + Induce	**8.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	16.8 bc	4.0 a	11.6 b	49.5 bcd
YT669 2.08SC + Induce	**12.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	20.6 bc	4.1 a	8.1 b	41.8 cd
Q8Y78 2.0SC + Induce	**12.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	17.7 bc	4.2 a	14.0 b	54.3 bcd
Q8Y78 2.0SC + Induce	**18.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	10.1 c	2.0 a	10.8 b	37.2 d
Pristine 38WG	**12.0 oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	8.4 c	2.1 a	12.1 b	44.3 bcd

[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).
[3] Due to the occurrence of insect injury in this block, fruit with and without insect injurywere assessed separately for brown rot.

TABLE 5. Rhizopus Harvest and Post-harvest Incidence[1]			% Fruit Infected [2]	
Treatment	**Rate / A**	**Timing**	**3-DPH**	**6-DPH**
Nontreated	------	------	0.0 b	5.8 a
Adament 50WG Rally 40WSP Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Adament 50WG**	6.0 oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **6.0 oz**	P, B PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	0.0 b	8.5 a
Luna Sensation 4.17SC Rally 40WSP Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **Luna Sensation 4.17SC**	5.0 fl oz 5.0 oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **5.0 fl oz**	P, B PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	0.0 b	6.3 a
DPX-LEM17 1.67SC Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC**	14.0 fl oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **14.0 fl oz**	P, B, PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	0.0 b	9.6 a
DPX-LEM17 1.67SC + Induce Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC + Induce**	14.0 fl oz + 32 fl oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **14.0 fl oz + 32 fl oz**	P, B, PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	2.7 a	14.7 a
DPX-LEM17 1.67SC + Induce Rally 40WSP + Bravo Ultrex 82.5WDG Rally 40WSP + Captan 80WDG Captan 80WDG **DPX-LEM17 1.67SC + Induce**	20.0 fl oz + 32 fl oz 5.0 oz + 3.8 lb 5.0 oz + 3.75 lb 3.75 lb **20.0 fl oz + 32 fl oz**	P, B, PF SS 1C, 2C 3C-8C **19, 9, 1 dph**	1.3 ab	11.0 a
YT669 2.08SC + Induce	**8.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	0.6 b	5.8 a
YT669 2.08SC + Induce	**12.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	0.0 b	3.2 a
Q8Y78 2.0SC + Induce	**12.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	0.0 b	7.1 a
Q8Y78 2.0SC + Induce	**18.0 fl oz + 32 fl oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	0.0 b	1.9 a
Pristine 38WG	**12.0 oz**	P, B, PF, SS, 1C-8C, **19, 9, 1 dph**	0.6 b	4.6 a

[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).

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HIGHLIGHTS OF FUNGICIDE TRIALS ON WINE GRAPES, 2010

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1. POWDERY MILDEW. A combination of five synthetic fungicide programs and one organic / bio-fungicide (Regalia SC) as a rotational material, for management of grape powdery mildew was evaluated. Fungicide applications were made to Chardonnay and White Riesling grape vines located at the Penn State Fruit Research & Extension Center vinifera vineyard, Biglerville, PA. The experiment was arranged in a randomized complete block design, with four replications. Each replication contained two vines of each cultivar per treatment plot. A standard insecticide maintenance program was separately applied using an airblast sprayer delivering 100 gal/A at 400 psi. A standard fungicide maintenance program provided season long control of the common grapevine diseases other than powdery mildew. Treatments were applied using a Bean covered-boom dilute sprayer delivering 50-100 gal/A at 100 psi. Treatment applications were made from 5 May (pre-bloom) to 25 July (5th post bloom) as follows: Pre-bloom/stage 17 just before cap come-off (5 May); BLM (17 May); 1st post-bloom 10-14 days (28 May); 2nd post-bloom 10-14 days (14 Jun); 3rd post-bloom 10-14 days (25 Jun) (PC); 4th post-bloom 10-14 days (10 Jul); 5th post-bloom 10-14 days (25 Jul). Rainfall for Apr, May, Jun, Jul, and Aug was 2.0 in., 3.7 in., 1.7 in., 2.3 in., and 3.0 in., respectively. Incidence of powdery mildew were rated on shoots and fruit clusters by visually determining the percent shoot/cluster area infected on 52 arbitrarily selected shoots and clusters per plot (52 shoots and fruit clusters /two vines of each cultivar per plot). Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables. Data were analyzed using analysis of variance and mean separation was determined by the Fisher's Protected LSD test ($P < 0.05$).

Powdery mildew pressure was high, with incidence and severity on nontreated Chardonnay leaves and fruit of 100 and 98%, 100 and 97%, respectively. Incidence and severity on nontreated W. Riesling leaves and fruit clusters was 100 and 72% and 96 and 33%, respectively. All treatments significantly reduced powdery mildew incidence and severity on leaves and fruit compared to the non-treated control. Incidence on treated Chardonnay and W. Riesling leaves and fruit clusters ranged from 3 to 30% and 2 to 50%, and 0.5 to 13% and 0 to 29%, respectively. Rotating Regalia with Quintec significantly reduced the levels of powdery mildew on leaves and fruit. Vintage / MicroSulf program was the least effective in reducing powdery mildew on both grape cultivars (Table 1).

2. DOWNY MILDEW. Various fungicide programs were evaluated to control downy mildew on Chancellor at the Penn State Fruit Research & Extension Center hybrid vineyard, Biglerville, PA. Vines were spaced at 6 x 10 ft and were cordon trained and hand pruned. The treatments were arranged in a randomized complete block design with four replications. Each replication contained two vines of each cultivar. The vineyard received an insecticide maintenance program throughout the season using an airblast sprayer (100 gal/A at 400 psi). All treatment plots received a fungicide maintenance program applied at 10-14 day intervals to control powdery mildew and other diseases. Treatment applications were made using a Bean covered-boom dilute sprayer delivering 50-100 gal/A at 100 psi. Incidence of downy mildew were rated on shoots and fruit clusters by visually determining the percent shoot/cluster area infected on 52 arbitrarily selected shoots and clusters per plot. Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables. Data were analyzed using analysis of variance and mean separation was determined by the Fisher's Protected LSD test ($P < 0.05$).

Downy mildew pressure was moderate due to unfavorable dry weather condition from bloom throughout the growing season. Downy mildew incidence and severity on treated shoot leaves on 6 Jul and 20 Jul was 14 and 4%, and 96 and 17%, respectively. Downy mildew incidence and severity on nontreated fruit on 20 Jul was 21 and 2%, respectively.   Incidence of downy mildew on treated leaves and fruit ranged from 0 to 5% and 0 to 6%, respectively, with all the treatments being similar to each other and significantly different from the nontreated control. Although not significant, the addition of Phostrol (2 pt) in Ranman and Phostrol (4 pt) in Zampro schedules showed better downy mildew control. Solo Gavel, Phostrol and Revus programs provided the same level of activity in controlling downy mildew (Table 2).

3. BOTRYTIS AND SOUR ROTS. The test was conducted to evaluate the efficacy of fungicide programs to control Botrytis bunch and sour rots. Fungicide applications were made to 'Pinot Noir' vines located at the Penn State Fruit Research & Extension Center vinifera vineyard, Biglerville, PA. Vines were spaced at 6 x 12 ft and were Scott Henry trained and hand pruned. The experiment was arranged in a randomized complete block design, with four replications. Each replication contained two vines per treatment plot. A standard insecticide maintenance program was separately applied using an airblast sprayer delivering 100 gal/A at 400 psi. A standard fungicide maintenance program provided season long control of the common grapevine diseases other than Botrytis rot. Treatments were applied using a Bean covered-boom dilute sprayer delivering 50-100 gal/A at 100 psi, depending on the canopy growth. On 2-3 Sep, bunch rot incidence (percent cluster infected) and severity (% area cluster infected) were rated on fruit clusters by visually determining the percent cluster area infected on 52 arbitrarily clusters per plot were determined. Severity was rated using the Barratt-Horsfall scale and was converted to % area infected using Elanco conversion tables. Data were analyzed using analysis of variance and mean separation was determined by the Fisher's Protected LSD test ($P < 0.05$).

Botrytis bunch rot pressure was moderate in the test site. Incidence and severity of Botrytis and sour rots on non treated fruit clusters was 73 and 2%, and 20 and 1%, respectively. Botrytis and sour rot on treated vines ranged from 7 to 23% and 5 to 12%, respectively. All treatments significantly reduced the incidence and severity of Botrytis rots. All treatments significantly reduced the incidence and severity of Botrytis and sour rots. Inspire Super; Luna Experience (fluopyram+tebuconazole) and Elevate/Regalia programs had the lowest levels of Botrytis and sour rots. Elevate/ Scala rotation program had the highest incidence of Botrytis and sour rots. Botrytis and sour rot was significantly reduced when Regalia was rotated with Elevate. Luna Sensation and Elevate/Regalia programs provided the best sour rot control (Table 3).

Table 1. Powdery mildew incidence and severity on Chardonnay and White Riesling grapes, 2010.

Programs and rate/acre	Timing[z]	Chardonnay % Incidence[y] Leaves	Chardonnay % Incidence[y] Fruit	Chardonnay % Severity[y,x] Leaves	Chardonnay % Severity[y,x] Fruit	W. Riesling % Incidence[y] Leaves	W. Riesling % Incidence[y] Fruit	W. Riesling % Severity[y,x] Leaves	W. Riesling % Severity[y,x] Fruit
Untreated check		100.0 e	100.0 f	98.3 c	95.6 c	99.5 d	96.2 d	72.0 b	32.8 b
Quintec 4 oz rot.	4,6,8,10								
Regalia 2 qt +									
CoHere 4 oz	5,7,8	3.4 a	21.2 cd	0.1 a	0.5 ab	1.0 a	5.3 a	0.0 a	0.1
Luna Experience 8 oz +									
Silwet L-77 4 fl oz	4-10	2.9 a	2.4 a	0.1 a	0.1 a	3.9 a	0.0 a	0.1 a	0.0 a
Vivando 15 fl oz +									
Silwet L-77 4 fl oz.................	4-10	5.3 ab	4.8 ab	0.1 a	0.1 a	0.5 a	0.0 a	0.0 a	0.0 a
Torino 3.4 fl oz +									
R-56 Spreader 0.5 qt	4-10	3.9 a	15.4 bcd	0.1 a	0.4 a	2.4 a	1.9 a	0.1 a	0.1 a
Vintage SC 6 fl oz +									
Silwet L-77 4 fl oz rot.									
MicroSulf 5 lb...........................	4-10	27.9 d	50.0 e	1.6 b	1.7 b	12.5 bc	28.9 c	0.3 a	0.7 a
Revus Top 7 fl oz +									
Silwet L-77 4 fl oz.................	4-10	11.5 bc	16.8 cd	0.4 a	0.6 ab	7.2 ab	17.8 b	0.2 a	0.4 a

[z] Application timings: 1= 1-3" shoot growth (9 Apr); 2= 3-4" shoot growth (20 Apr); 3= 8-12" shoot growth (28 Apr); 4= Pre-bloom/stage 17 just before cap come-off (5 May); 5= M-L BLM (17 May); 6= 1st post-bloom 10-14 days (28 May); 7= 2nd post-bloom 10-14 days (14 Jun); 8= 3rd post-bloom 10-14 days (25 Jun) (PC); 9= 4th post-bloom 10-14 days (10 Jul); 10= 5th post-bloom 10-14 days (25 Jul (V); 11= 6th post-bloom 14-21 days before harvest (13 Aug)

[y] All values are powdery mildew incidence and severity and the means of at least 52 (26 + 26 clusters from top + bottom cordons) terminal shoots and fruit clusters per 2 vines across four replicate plots (28 Jul)

[x] Severity ratings are based on Horsfall-Barratt system.

Values within columns followed by the same letter(s) are not significantly different (P<0.05) according to Fisher's Protected LSD test.

Table 2. Downy mildew incidence and severity on Chancellor grapes, 2010.

		Shoot leaves[y]					Fruit Cluster[y]		
		% Incidence		%	% Severity[x]		% Incidence		% Sever.
Treatments and rate/acre	Timing[z]	6 Jul	20 Jul	Control[w]	6 Jul	20 Jul	20 Jul	Control[w]	20 Jul
Untreated check		14.0 b	96.0 c		3.7 b	15.6 b	20.5 b		1.5 b
Ranman 2.1 fl oz.............	3-10	1.0 a	2.0 ab	98	0.0 a	0.1 a	0.5 a	98	0.0 a
Ranman 2.75 fl oz...........	3-10	1.5 a	4.5 b	95	0.0 a	0.1 a	1.0 a	95	0.0 a
Ranman 2.75 fl oz + Phostrol 2 pt	3-10	1.0 a	1.0 ab	99	0.0 a	0.0 a	0.0 a	100	0.0 a
Ranman 2.75 fl oz + Phostrol 4 pt	3-10	1.0 a	1.0 ab	99	0.0 a	0.0 a	5.5 a	73	0.2 a
Ranman 2.1 fl oz + Phostrol 2 pt	3-10	1.0 a	2.0 ab	98	0.0 a	0.0 a	2.0 a	90	0.1 a
Phostrol 4 pt....................	3-10	1.0 a	0.0 a	100	0.0 a	0.0 a	0.0 a	100	0.0 a
Zampro 14 fl oz	3-10	0.0 a	3.0 ab	97	0.0 a	0.2 a	3.5 a	83	0.1 a
Zampro 14 fl oz rot. Phostrol 4 pt....................	3,5,7,9,10 4,6,8	1.0 a	0.0 a	100	0.0 a	0.0 a	1.5 a	93	0.0 a
Gavel 75DF	3-10	1.0 a	1.0 ab	99	0.0 a	0.0 a	0.0 a	100	0.0 a
Gavel 75DF 2.5 lb rot. Phostrol 4.0 pt.................	3,5,6,8 4,7,9,10	0.0 a	2.0 ab	98	0.0 a	0.0 a	0.0 a	100	0.0 a
Revus SC 8 fl oz	3-10	0.0 a	1.0 ab	99	0.0 a	0.0 a	0.8 a	95	0.0 a
Penncozeb 75DF 3 lb Captan 80WG 2.5 lb Ziram 76DF 4 lb	3,5,7 4.6,7 9,10	0.0 a	1.0 ab	99	0.0 a	0.0 a	0.5 a	98	0.0 a

[z] Application timings: 1= 0-2" shoot growth (9 Apr); 2= 1/4-3" shoot growth (20 Apr); 3= 8-12" shoot growth (5-6 expanded leaves) (30 Apr); 4= Pre-bloom (10 May); 5= Post-bloom (21 May); 6= 2nd post-bloom 10-14 days (5 Jun); 7= 3rd post-bloom 10-14 days (17 Jun); 8 (PC) = 4th post-bloom 10-14 days (30 Jun); 9= 5th post-bloom 10-14 days (12 Jul); 10= 6th post-bloom (22 Jul).

[y] All values are downy mildew incidence and severity and the means of at least 52 shoots and fruit clusters per 2 vines across four replicates

[x] Severity ratings are based on Horsfall-Barratt system. Values within columns followed by the same letter(s) are not significantly different (P<0.05)

[w] Based from 20 Jul rating

Table 3. Disease incidence and severity on Pinot Noir grapes, 2010.

Treatment and rate/acre	Timing[z]	Botrytis rot[y] % Incidence	Botrytis rot[y] % Severity[x]	Sour rot[y] % Incidence	Sour rot[y] % Severity[x]
Untreated check		42.8 c	1.6 c	19.7 e	0.6 c
Elevate 1.5 lb	B,V				
Scala 18 fl oz	PC,PH	22.6 b	0.6 ab	12.5 cde	0.3 ab
Elevate 1.5 lb rot.	B,V				
Regalia 2 qt	PC,PH	8.7 a	0.2 ab	5.3 a	0.1 a
Inspire Super 20 fl oz................	B,PC,V,PH	6.7 a	0.2 a	9.1 abc	0.2 ab
Inspire Super 20 fl oz	B,V				
Pristine 23 oz	PC,PH	11.2 a	0.4 ab	12.1 cd	0.3 ab
Luna Experience 8 oz	B,PC,V,PH	8.2 a	0.2 ab	5.3 a	0.2 ab

[z] Timings: B= Bloom (28 May); PC or BT= Preclosure/Berry Touch (25 Jun); V- Veraison (26 Jul); PH=Preharvest (13 Aug).

[y] All values are Botrytis bunch and sour rots incidence and severity and the means of at least 52 (26 + 26 clusters from top + bottom cordons) fruit clusters per 2 vines across four replicate plots (2-3 Sep)

[x] Severity ratings are based on Horsfall-Barratt system. Values within columns followed by the same letter(s) are not significantly different (P<0.05) according to Fisher's Protected LSD test.

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Fungicide performance trial for powdery and downy mildew of grape, 2010

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Grape (*Vitis vinifera* 'Chardonnay')
Powdery mildew; *Erysiphe necator* (synonym: *Uncinula necator*)

This trial was conducted with 'Chardonnay' grapes planted in 1990, trained to a Lyre divided canopy, with a spacing of 7 ft between vines and 12 ft between rows. Each row contained 45 vines including a border panel (3 vines). Plots consisted of a single vine, and were arranged in a completely randomized design with four replications. Every other vine in the row received treatment; border vines received only insecticides. Treatments were applied with a 4-gal backpack air sprayer, regulated to 21 psi by a CFValve system (GATE LLC) through a single boom with a flat fan nozzle (TeeJet 8003VS). Treatments were started 6 d after bloom and repeated three times every 14 d. Treatments were tank-mixed with Penncozeb 75DF (3 lb/A) in order to suppress downy mildew infection. All treatments are also tank-mixed with the adjuvant Sylgard 309 at 0.03% by volume. Prior to the experimental treatment regime, all vines were treated with Penncozeb 75DF (3 lb/A) and Microthiol Disperss (3 lb/A). Diseases were assessed four times during the season. Sixty leaves and ten clusters per vine were randomly selected (a total of 240 leaves per treatment), and the estimated percentage of infected area (disease severity) was recorded. The linear mixed model was used to conduct the analysis of variance (JMP 7.0.1, SAS institute, Cary NC). Treatment was considered as a fixed effect, and replication was considered as a random effect. Raw data without transformation were analyzed.

The warm temperatures early in the season promoted both rapid growth of grapevines and also the development of powdery mildew. Bud break at Winchester was 8 April, and 50% bloom was 24 May. The weather was very conducive for powdery mildew development for most of the season. Rain events between bud break and bloom occurred regularly and probably promoted ascospore release. However, the total amount of precipitation was low (the trial location received ~1.1 inches). Some of vines at the research plot were damaged by night frost on 10 May. The first observation of powdery mildew at the plots was 24 May. The disease assessment of 7 July taken 8 days after the termination of the treatments is presented. Mean disease incidence of powdery mildew ranged from 18% to 99%, and disease severity ranged from 1% to 38%. Treatment effects were highly significant ($P < 0.001$) for disease incidence and severity on leaves, and disease severity on bunches, and a good separation of treatment means was found. Disease incidence ranged from around 20% (~80% disease control) to around 40% (~60% disease control). However, disease severity was below 5% on all treatments, reflecting the very small size of many colonies observed. Also, it should be noted that most of the infected leaves were found in the upper part of the canopy where younger leaves tend to be present which may have developed after the previous spray. Compared to severe infection on untreated vines, all treatments presented excellent control.

Although there were a few potential infection events, the environmental conditions were not favorable for downy mildew development. At the time of the assessment, disease incidence and severity of downy mildew were zero for all treatments, including unsprayed check.

Powdery Mildew 7 July, 2010								
trt	Treatment[z]	Days after first application[y]	Disease Incidence[x]		% Control[w]	Disease Severity[v]		% Control[w]
5	Rally 40WSP 4 oz	42, 56, 60	27.9%	DE	71.7%	1.1%	C	97.2%
6	Vivando 300SC 10 oz	42, 56, 60	36.7%	CD	62.9%	1.9%	C	95.0%
7	Vivando 300SC 15 oz	42, 56, 60	21.3%	E	78.5%	0.5%	C	98.6%
8	Luna Experience SC400 8 oz	42, 56, 60	17.9%	E	81.9%	0.8%	C	98.0%
9	Torino (GWN-4617) 3.4 oz	42, 56, 60	36.7%	CD	62.9%	2.6%	C	93.1%
10	Vintage SC 4 oz then Torino 3.4 oz	20, 25, 36 42, 56, 60	46.3%	C	53.2%	4.3%	C	88.7%
11	Inspire Super 2.82SC 14 oz	42, 56, 60	40.4%	CD	59.1%	3.9%	C	89.8%
12	Inspire Super 2.82SC 20 oz	42, 56, 60	37.9%	CD	61.6%	2.8%	C	92.6%
13	Quintec 4 oz	42, 56, 60	42.1%	C	57.4%	2.4%	C	93.7%
14	PM Check (Penncozeb 75DF, 3 lb)		79.6%	B	19.4%	17.3%	B	54.2%
15	Unsprayed		98.8%	A	0.0%	37.8%	A	0.0%

Downy Mildew 7 July, 2010						
trt	Treatment[z]	Days after first application[y]	Disease Incidence[x]	%Control[w]	Disease Severity[v]	%Control[w]
1	Zampro 11 oz	37, 42, 56, 60, 74	0%	0%	0%	0%
2	Zampro 14 oz	37, 42, 56, 60, 74	0%	0%	0%	0%
3	Revus Top 7 oz	37, 42, 56, 60, 74	0%	0%	0%	0%
4	DM check	37, 42, 56, 60, 74	0%	0%	0%	0%
5	Standard	37, 42, 56, 60, 74	0%	0%	0%	0%

[z] All rates are calculated based on per acre bases using 100 gal of water, PM Check received mancozeb (Penncozeb 75DF at 3 lb/A) during the experiment to prevent downy mildew and black rot.

[y] Unless noted otherwise, three sprays of sulfur at 3 lb/A were applied prior to day 42 (days 20, 25, 36).

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

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

[w] %Control = the percentage of disease controlled, compared with unsprayed check

THE INTEGRATION OF NON-CHEMICAL STRATEGIES FOR ADOPTION INTO BUNCH ROT MANAGEMENT PROGRAMS IN PENNSYLVANIA

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Weather patterns in Pennsylvania typically provide favorable conditions for the development of harvest bunch rots of wine grapes, particularly in varieties that produce compact bunches (Pinot Noir, Riesling, Chardonnay, and Vignoles). The production of healthy grapes *regardless of the weather* is a formidable challenge in many years but is essential to the production of high quality wines from Pennsylvania grapes. Bunch rot management programs that rely primarily on chemical control are more apt to fail than more integrated approaches that reduce disease susceptibility and minimize reliance on pesticides.

Harvest bunch rot development in a grape cluster is largely determined by the compactness of that cluster; as clusters become more compact, they become more susceptible to bunch rot. Research has identified new strategies for bunch rot and sour rot control that modify cluster compactness to achieve significant reductions in harvest rot development (1-5). Early cluster zone leaf removal (applied before bloom) and gibberellic acid (at full bloom) have the effect of reducing fruit set by 20-30 % over untreated vines (2-4). This reduces the compactness of clusters, reducing their susceptibility to bunch rots and improving the penetration of pesticides into the cluster (4).

In 2010, these strategies were evaluated in six commercial and two Penn State University vineyards in Northwestern (vineyards 1-3 in figures below) and Southern (vineyards 4-7; vineyard 8 is not shown) Pennsylvania. Treatments were applied as amendments to commercial grower programs for bunch rot management on *Vitis vinifera* 'Chardonnay', 'Pinot Noir/Gris', and 'Riesling', and *Vitis* interspecific hybrid 'Vignoles' grapevines. Treatments were generally applied to 3 to 4-vine plots in a randomized complete block design with 4 replications. For each vineyard trial, effects on bunch rot and cluster architecture (fruit set, cluster weight, cluster compactness) were determined and included in this report. Effects on juice quality are currently being evaluated, and effects on return bloom ('year after' effects of the treatments) will be determined in the spring of 2011. Trials compared a 'grower standard' or GS (without leaf removal = GS1; with post bloom leaf removal = GS2) to GS + early (trace bloom) leaf removal (trace LR) and GS + gibberellin (GA at bloom at 25 ppm). Rainfall was recorded at each vineyard with portable data-loggers to track disease pressure during the ripening period.

Results

<u>Harvest bunch rots:</u> Relatively dry weather during ripening (August) minimized rot development at most southern PA vineyard sites and this is reflected in the figures below. Vineyards 5 and 7 were the most intensively managed commercial vineyards, where the 'grower standard' included leaf removal after fruit set (GS2); these sites showed the least bunch rot development. Nevertheless, on Chardonnay (Figure 1), trace bloom leaf removal (trace LR) and gibberellin (GA 25ppm) significantly improved bunch rot control over the grower standard at vineyard 5 (one of the driest sites). Conversely, at vineyard 7 (the wettest site in southern PA), there was no effect on bunch rot from the treatments on Chardonnay (Figure 1), but rots were reduced on Pinot Noir by trace LR and GA by 76 and 67 %, respectively (Figure 2). The reason for this discrepancy at vineyard 7 may relate to the timing of leaf

removal applied by the grower in the grower standard; in Chardonnay, leaf removal was applied near fruit set (not long after trace bloom leaf removal), whereas in Pinot Noir, leaves were removed later, close to veraison.

At most of the other sites, the effects of the treatments were confounded by factors that caused injury to berries: i) a late generation of grape berry moth provided abundant wounding of berries at vineyards 2, 3, and 4, ii) bird damage wounded many Chardonnay clusters at vineyard 4, iii) Phomopsis fruit rot (from infections probably acquired during June) played a major role in harvest rot at vineyard 8 (the driest site during August), and iiii) heavy powdery mildew fruit infection (from infections acquired during June) confounded results at vineyard 1. Despite these factors, in almost all vineyards both trace bloom leaf removal and gibberellin reduced the incidence (percent infected) and severity (percent area infected, shown below) of harvest bunch rot when compared to the grower's standard treatment program (GS1 or 2). However, the figures below show that the rot reductions on Chardonnay, Pinot Noir, and Pinot Gris were not always statistically significant (different letters denote significant differences).

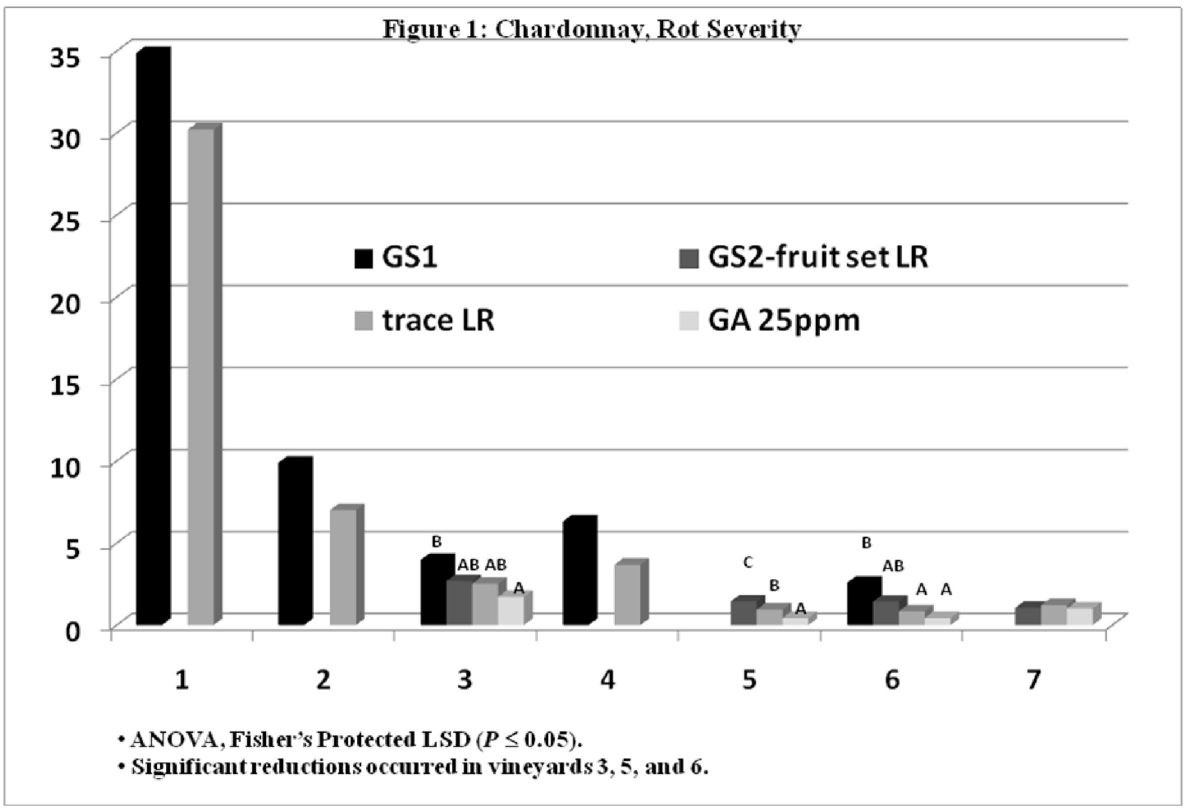
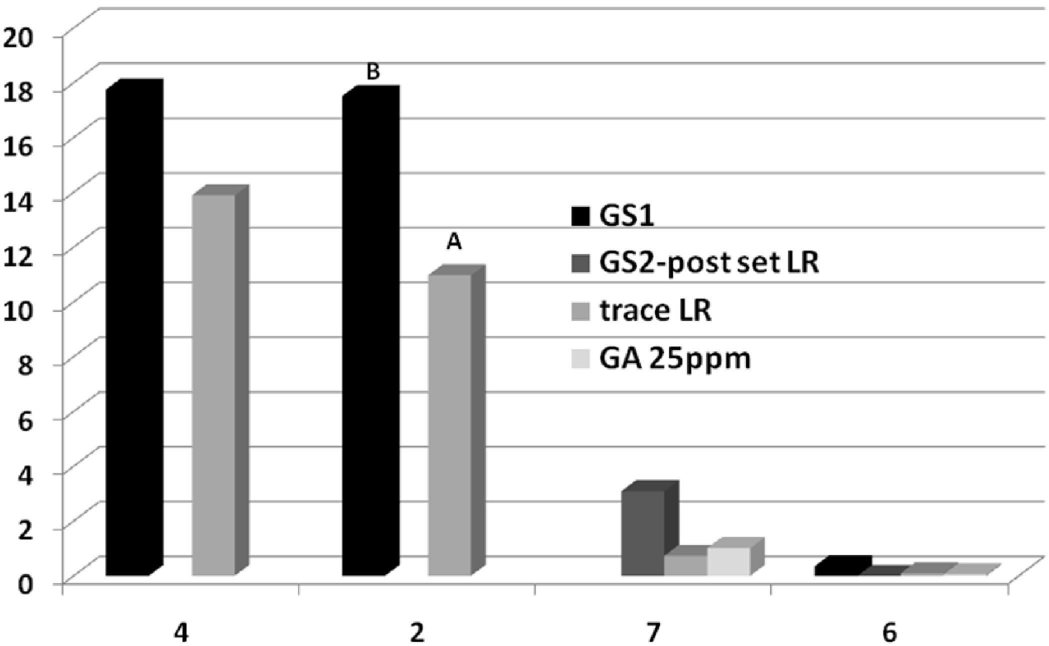


Figure 2: Pinot Gris Noir, Rot Severity



- ANOVA, Fisher's Protected LSD ($P \leq 0.05$).
- **Significant reductions occurred only in vineyard 2.**

Treatment effects on Riesling were mixed (data not shown); at vineyard 3, trace LR and GA improved rot control over GS1 (no leaf removal), but neither treatment was significantly more effective than GS2 (leaf removal after fruit set). However, trace LR and GA provided little or no reduction in rots on Riesling at vineyard 6. Rot reductions were also evident at vineyard 8 (Vignoles), but were complicated by Phomopsis fruit rot that developed by harvest. Nevertheless, the severity of the rot on Vignoles was reduced by 50 % over the grower standard alone, but this difference was not statistically significant.

Effects on cluster architecture: In general, leaf removal at trace bloom and GA at bloom, reduced the compactness and weight of clusters, and reduced fruit set (number of berries per cluster). These were all intended effects well documented in earlier experiments in Penn State vineyard trials (2-4), and it is these effects that are responsible for the added reductions in rot. Other effects such as the length of clusters and weight of individual berries were also measured but treatment differences are not as consistently defined by the data.

In summary, trace bloom leaf removal and gibberellin (applied at bloom) reduced the susceptibility of compact clusters by reducing fruit set and cluster compactness. The result was less bunch rot development in most vineyard trials, even in a dry year. In general, gibberellin was more successful than trace bloom leaf removal, at reducing compactness and bunch rots on Chardonnay, whereas on other varieties, such as Pinot Noir, Pinot Gris, and Riesling, this trend was less consistent in 2010. There were several sources of variation in rot in 2010 that may have affected rot development, somewhat independent of the efficacy of cluster loosening treatments. For example, i) injury to clusters from insect feeding, powdery mildew, and Phomopsis fruit rot increased susceptibility to bunch rots, regardless of treatment, and ii) loss of flowers by cold injury in some vineyards, increased the set of remaining flowers, diluting the effects of treatments aimed at reducing fruit set and compactness.

A major consideration is the cost of these treatments. Material for the gibberellin treatment, at 25 ppm, is estimated at about $10-15 per acre, far less than the price of a single Botrytis fungicide application. Applying the trace bloom leaf removal treatment is much more labor intensive and may cost up to $250 per acre (applied by hand), depending on the trellis system, skill of the workers, and vigor of the vines. However, research has indicated that the cost of hand leaf removal decreases with earlier timing; in university trials, trace bloom leaf removal was 15% less costly to apply than leaf removal at fruit set, and 34 % less costly than leaf removal applied at veraison. Data gathered over additional seasons will provide more insights into the factors that affect the consistency of cluster loosening treatments on different varieties, potential 'year after' effects of the treatments, and the overall value of these treatments in bunch rot management programs.

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CONTROL OF APPLE DISEASES WITH INSPIRE SUPER, OMEGA, TOPGUARD, AND FONTELIS, 2010

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Different schedules of Inspire Super, Topguard, Fontelis, and a Nova + Dithane standard were evaluated for early-season disease control in an 11-yr-old research orchard spaced 4.3 m x 7.3 m on M.111 rootstock. The test was conducted in a randomized block design with four single-tree replications per treatment. Treatments were applied from both sides of the row with a Swanson model DA-500 airblast sprayer (935 L/ha, 100 gal/A) as follows: 31 March (half-inch green, HG), 7 Apr (pink, P), 15 April (bloom, B), 28 April (petal fall, PF), 10 May (first cover, 1C), 25 May (second cover, 2C), 11 June (third cover, 3C), 23 June (fourth cover, 4C), 7 July (fifth cover, 5C), 23 July, (sixth cover, 6C), and 11 August (seventh cover, 7C) (Table 1). Maintenance insecticide sprays were applied separately with the same equipment. Control of summer diseases was accomplished with Captan 80WDG + Ziram 76DF applied at approximately 14-day intervals at 6th and 7th cover. The 2010 growing season was atypical in that we recorded the second-earliest bloom date on record (since we began recording in1934, only 1945 was earlier); Jun, Jul, and Aug were warmer than normal; and we had an official drought declaration. Days with maximum temperature exceeding 90°F totaled 5, 19, and 14 for Jun, Jul, and Aug, respectively. Temperatures from the period Mar through Jul were 4.5 to 6.2°F above normal. Total precipitation in Mar, Apr, May, Jun, Jul, and Aug was 4.5, 3.4, 5.2, 1.2, 2.0, and 1.6 in, respectively. Ten early season infection periods (prior to 1 June) were followed by 15 additional infection periods from the period 1 Jun through 30 Aug. Fifteen infection periods occurred during the test period (HG through 5C). Generally warm temperatures and abundant rainfall in May were very favorable for early season disease development. Incidence on leaves was determined on 14 Jun from 10 terminal shoots per tree from single-tree plots in each of the four replications. Incidence of diseases on fruit was determined on 14 Jun and 17 Sep from 100 and 25 fruit from each treatment and block, respectively. Percent data were transformed (arcsin transformation) and subjected to analysis of variance and means separation with the Waller-Duncan k-ratio t-test.

Non-sprayed foliage in June showed 78% of leaves with scab and 46% of leaves with cedar-apple rust. In the treatments for leaf scab, all treatments were significantly better than the nonsprayed control (Table 1). The Topguard + Dithane treatment was not significantly different from the Rally + Dithane standard, and these two treatments were less effective for leaf scab than the other fungicide treatments. All treatments were significantly better than the nonsprayed control for leaf rust incidence; although there were significant differences among treatments over a range of rust incidence from 0 to 10% (Table 1). Fruit from nonsprayed trees showed 68% and 80% of the fruit with scab in June and September, respectively. All treatments were significantly better than the nonsprayed control (Table 1). The Topguard + Dithane treatment was not significantly different from the Rally + Dithane standard, and these two treatments were less effective for fruit scab than the other fungicide treatments. Topguard + Captan gave better leaf and fruit scab control than Topguard + Dithane, likely due to the higher rate of captan relative to mancozeb. No phytotoxicity was observed in any of the treatments.

				Leaves and fruit – 14 June				Fruit diseases – 16 Sept [x]			
No.	Treatment Fungicide	Rate/A	Timing[z]	Leaf scab (%)[y]	Fruit scab (%)[x]	Leaf CAR (%)[y]	Leaf FELS (%)[y]	Scab (%)	Cedar-apple rust (%)	Fly speck (%)	Rots (%)
1.	Manzate 75DF + Vangard 75WG	4 lb + 4 oz	HG								
	Fontelis 200SC + Damoil	20 fl oz + 1 gal	P,B,PF								
	Manzate 75DF	6 lb	1C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	2C-7C	4.6 c[w]	6.8 c	4.8 bc	1.8 b	7.0 c	0.0 c	0.0 c	3.0 a
2.	Fontelis 200SC + Damoil	20 fl oz + 1 gal	HG,P,B,PF,1C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	2C-7C	5.4 c	4.8 c	3.3 bcd	2.5 b	9.0 c	0.0 c	0.0 c	3.0 a
3.	Manzate 75DF + Vangard 75WG	4 lb + 4 oz	HG								
	Manzate 75 + Fontelis 200SC + Damoil	3 lb + 14 oz +	P,B,PF								
	Manzate 75DF	1 gal									
	Captan 80WDG + Topsin-M 70W	6 lb	1C								
		2 lb + 8 oz	2C-7C	7.2 c	4.5 c	1.7 cd	5.4 ab	4.0 c	0.0 c	0.0 c	12.0 a
4.	Manzate 75DF + Vangard 75WG	4 lb + 4 oz	HG								
	Fontelis 200SC + Damoil	14 oz + 1 gal	P,B,PF								
	Manzate 75DF	6 lb	1C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	2C-7C	3.5 c	3.3 c	5.2 bc	5.0 ab	4.0 c	4.0 ab	1.0 c	4.0 a
5.	Manzate 75DF	6 lb	HG,P,B,PF,1C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	2C-7C	9.2 c	7.2 c	10.0 b	4.2 b	6.0 c	1.0 bc	1.0 c	3.0 a
6.	Topguard SC + Dithane 75DF	13 fl oz + 3 lb	P,B,PF,1C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	2C-7C	29.9 b	26.5 b	0.0 d	6.6 ab	30.0 b	0.0 c	0.0 c	4.0 a
7.	Topguard SC + Captan 80WDG	13 fl oz + 2.5 lb	P,B,PF,1C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	2C-7C	7.9 c	6.3 c	0.0 d	2.9 b	5.0 c	0.0 c	4.0 b	2.0 a
8.	Manzate 75DF	3 lb	HG								
	Flint 50WDG + Manzate 75DF	2 oz + 3 lb	P,B								
	Captan 80WDG	3.125 lb	PF,3C								
	Omega 4SC	13.8 fl oz	1C,4C								
	Inspire Super 2.82EW	12 fl oz	2C,5C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	6C-7C	1.9 c	1.0 c	6.0 b	3.5 b	5.0 c	0.0 c	0.0 c	4.0 a
9.	Manzate 75DF	3 lb	HG								
	Flint 50WG + Manzate 75WG	2 oz + 3 lb	P,B								
	Inspire Super 2.82EW	12 fl oz	PF,3C								
	Omega 4SC	13.8 fl oz	1C,4C								
	Captan 80WDG	3.125 lb	2C,5C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	6C-7C	8.3 c	3.3 c	0.0 d	0.8 b	6.0 c	0.0 c	0.0 c	4.0 a
10.	Manzate 75DF	3 lb	HG								
	Rally 40WSP + Dithane 75DF	5 oz + 3 lb	P,B,PF,1C								
	Captan 80WDG + Topsin-M 70W	2 lb + 8 oz	3C-7C	25.5 b	40.8 b	0.0 d	2.5 b	47.0 b	1.0 bc	13.0 a	4.0 a
11.	Untreated………………………..	---	---	77.8 a	68.0 a	46.2 a	19.9 a	80.0 a	5.0 a	6.0 b	12.0 a

[z] Application timings: HG = 31 Mar, P = 7 Apr, B = 15 Apr, PF = 28 April, 1C = 10 May, 2C = 25 May, 3C = 11 Jun, 4C = 23 Jun, 5C = 7 Jul, 6C = 23 Jul, and 7C = 11 Aug.
[y] Data are mean percent incidence from 10 terminal shoots per tree from each of four single-tree replicates arranged in randomized blocks. Different letters within columns denote significant differences among arcsine-transformed percentage values. Percentages reported in columns. FELS = frogeye leaf spot.
[x] On 14 Jun, data are the means of 100 hand-thinned fruit per tree, whereas on 16 Sep, data are mean percent incidence from 25 fruit per tree from each of four single-tree replicates arranged in randomized blocks. Different letters within columns denote significant differences among arcsine-transformed percentage values. Percentages reported in columns.
[w] Means marked with the same letter are not significantly different within columns among arcsine-transformed percentage values according to the Waller Duncan *K*-ratio *t*-test (K=100; α=0.05). Actual percentages reported in columns.

Effect of Calcium Sprays on Bitter Pit in 'Honeycrisp' Apples

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This paper and work is dedicated to the memory of Dr. Rongcai Yuan who initiated these studies in 2009.

'Honeycrisp' is high quality apple that commands a high price in the market place. Plantings of 'Honeycrisp' have increased throughout the mid-Atlantic and in Virginia in recent years despite the difficulties associated with producing high quality 'Honeycrisp' fruit. 'Honeycrisp is susceptible to a number of maladies including the physiological disorder, bitter pit. Low fruit calcium has long been associated with the appearance of bitter pit in apple. Growers are encouraged to add calcium chloride to their regular cover sprays to reduce the incidence of bitter pit. A number of calcium related spray materials are now available, many in convenient liquid formulations and growers are interested in how these various products perform in relation to the standard flake formulation of calcium chloride for the control of bitter pit. The objective of this study was to compare several sources of Ca for effective reduction in bitter pit in 'Honeycrisp' apples.

Studies were conducted in 2009 and 2010. Results in 2009 were similar to those observed in 2010. Only the results from 2010 are reported here. Materials were applied to mature 'Honeycrisp' trees at rates recommended by the manufacturer. Sprays were applied dilute to first drip with a handgun sprayer beginning 20 Apr. repeated on 24 Apr. and continued thereafter at approximately 2-week intervals with the last spray applied 10 Aug. A total of 10 sprays were applied during the growing season. The following calcium sources served as treatments: Dow Flake Xtra (83-87% calcium chloride, Dow Chemical Co.), Nutriphite-Ultra [0-28-26 (as potassium chloride), Biagro Western Sales, Inc.], Calciphite [5% soluble potash and 8% calcium (from potassium phosphate and calcium carbonate), Biagro Western Sales, Inc.], and InCal (5% calcium and 1% Zn, Miller Chemical Co.). On 25 Aug 20 fruit were harvested at random from each of six replicate trees per treatment. Sixty fruit per treatment were evaluated for signs of bitter pit at harvest and 60 fruit were placed in refrigerated cold storage at 4.4°C (40° F) and evaluated on 29 Sept. Bitter pit was rated on a 0 to 3 scale with 0 being no bitter pit evident, 1 = less than 15% of the apple's surface affected (light), 2 = 15 to 35% of the surface with bitter pit (moderate), and more than 35% of the surface affected with bitter pit (severe). Fruit size, percent surface red color flesh firmness, soluble solids concentration, and starch index rating were determined on the fruit collected at harvest.

Compared to the control, calcium treatments had no effect on the percent of fruit showing bitter pit at harvest (Table 1). Overall, the incidence of bitter pit was very low at harvest. Following five weeks in storage, however, the incidence of bitter pit had increased in all treatments. When removed from storage fruit treated with calcium chloride showed less bitter pit than all other treatments. Calcium chloride treated fruit had less than 15% of their surface affected with bitter pit on 29 Sept. while all other treatments had between 15% and 35% of their surface showing bitter pit. There were no differences in the level of bitter pit observed between the control and the remaining four calcium treatments. Calcium treatments had no effect on fruit size, percent red color, fruit firmness, or soluble solids concentration (SSC) at harvest (Table 2). Fruit treated with Calciphite + Nutriphite-Ultra had lower SSC than fruit treated with calcium chloride, but neither treatment was different from the untreated control. Fruit treated with calcium chloride or Nutriphite-Ultra and Calciphite showed advanced maturity compared to control fruit.

In this study and at the rates used, only calcium chloride applied in 10 season long sprays effectively reduced the incidence of bitter pit in 'Honeycrisp' apples and only after five weeks in refrigerated storage.

Table 1. Effect of calcium sprays on bitter pit in 'Honeycrisp'/M.111 apples at harvest and after 5-wks storage (2010)[Z].

No	Field ID	Treatment[Y]	Rate	Time of Application	Bitter pit rating [X] (0-3)	
			Rate/Acre	Date	Aug. 25	Sept. 29
1	W	Control	-	-	0.19 ab[W]	1.48 a
2	B	Calcium chloride	2 lb	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26, 8-10	0.03 b	0.53 b
3	FO	Nutriphite-Ultra + Calciphite*	1 qt 2 qt	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26, 8-10	0.27 ab	1.39 a
4	HP	Calciphite + Nutriphite-Ultra**	2 qt 1 qt	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26	0.33 a	1.63 a
5	LG	Calciphite***	2 qt	4-20 4-24, 5-4, 5-16, 6-29, 7-12, 7-26, 8-10	0.28 ab	1.07 ab
6	RBKD	InCal	1 qt	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26, 8-10	0.23 ab	1.54 a

[Z] Full bloom on May 14, 2010. Trees planted in 2007.
[Y] 6 replications. Rates in amount of formulated product.
[X] Fruit were harvested and examined on August 25, 2010 and again after 5-wks storage at 40° F.
Bitter pit rating:
0 means – No bitter pit
1 means – Light amount of bitter pit, less than 15% surface area affected
2 means – Moderate amount of bitter pit, over 15% surface area affected
3 means – Severe (heavy) amount of bitter pit, over 35% surface area affected
[W] Mean separation within column by Duncan's new Multiple Range Test.

* From bloom – 3 applications of (Nutriphite-Ultra 1qt + Calciphite 1qt) at 10-14 days intervals. Then 2 qts Calciphite every 2 weeks to harvest.
** At bloom and petal fall – 1 qt Nutriphite-Ultra +2 qts Calciphite. Then Calciphite at 10-14 days intervals until end of July.
*** 2 qts Calciphite every 14 days from bloom to 30 days post petal fall. Then Calciphite beginning 2 months from harvest at 14 days intervals.

Table 2. Effect of calcium sprays on fruit quality in ‘Honeycrisp’/M.111 apples (2010)[Z].

Treatment[Y]	Rate	Time of Application	Fruit diam (cm)	Fruit wt. (grams)	Percent red color (0-100)		Fruit firmness (lb)	Soluble solids concn. (%)	Starch index rating (1-8)
	Rate/Acre	Date			Aug. 25	Sept. 29			
Control	-	-	8.54 a[X]	248.5 a	69.6 a	74.8 a	14.1 a	15.8 ab	6.00 c
Calcium chloride	2 lb	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26, 8-10	8.92 a	258.9 a	62.1 a	71.0 a	14.3 a	16.0 a	6.83 ab
Nutriphite-Ultra + Calciphite*	1 qt 2 qt	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26, 8-10	8.53 a	260.9 a	71.1 a	72.8 a	14.1 a	15.8 ab	7.11 a
Calciphite + Nutriphite-Ultra**	2 qt 1 qt	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26	8.78 a	267.9 a	61.7 a	74.0 a	14.0 a	15.4 b	6.87 ab
Calciphite***	2 qt	4-20 4-24, 5-4, 5-16, 6-29, 7-12, 7-26, 8-10	8.77 a	268.8 a	63.4 a	71.9 a	14.3 a	15.6 ab	6.39 abc
InCal	1 qt	4-20 4-24, 5-4, 5-16, 5-31, 6-14, 6-29, 7-12, 7-26, 8-10	8.74 a	268.0 a	66.8 a	66.3 a	14.4 a	15.7 ab	6.17 bc

[Z] Full bloom on May 14, 2010. Trees planted in 2007.
[Y] 6 replications. Rates in amount of formulated product. Fruit quality was determined on August 25, 2010. Color also recorded after 5-wks storage at 40°F.
[X] Mean separation within column by Duncan’s new Multiple Range Test.

* From bloom – 3 applications of (Nutriphite-Ultra 1qt + Calciphite 1qt) at 10-14 days intervals. Then 2 qts Calciphite every 2 weeks to harvest.
** At bloom and petal fall – 1 qt Nutriphite-Ultra +2 qts Calciphite. Then Calciphite at 10-14 days intervals until end of July.
*** 2 qts Calciphite every 14 days from bloom to 30 days post petal fall. Then Calciphite beginning 2 months from harvest at 14 days intervals.

Not for Citation or Publication
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Update on a state-wide survey of grape leaf roll disease, 2010

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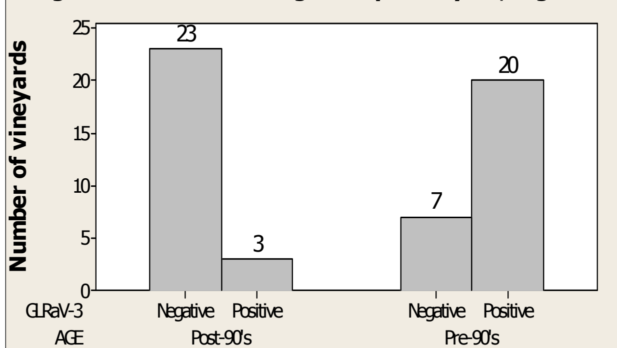
OBJECTIVES:

1) Document the prevalence and spatio-temporal pattern of grapevine leafroll disease and associated viruses in Virginia *V. vinifera* and inter-specific hybrids.
2) Determine whether native *Vitis* species serve as asymptomatic hosts and therefore reservoirs of leafroll viruses for newly established and replanted vineyards.
3) Develop observational data as to the presence of mealybugs as a potential vector.
4) Determine the movement of GLRaVs from infected vines to newly planted clean vine within the same row, and examine a potential management tool to restrict the movement of the vector.

Grape leaf roll disease has been reported in VA commercial vineyards in the past few years, and there are increasing concerns on the disease. This disease is caused by a group of viruses (GLRaVs). Each one of viruses can cause disease symptom; however, there are some evidence that mixed infection of two or more viruses are common (GLRaVs group 2 and 3). This disease causes leaf to curl and become red (especially in red colored varieties) and it can cause uneven ripening and reduction in Brix, probably by disrupting photosynthesis processes.

In order to estimate the distribution of the GLRaVs among VA vineyards, we have been conducting a disease survey. Samples are collected from seemingly infected vineyards and sent to Washington State University for a molecular detection and identification of viruses. In some vineyards, samples are collected systematically so that we can further analyze for the temporal and spatial movement of the disease. Also, as noted in the objectives, we have been collecting samples from wild grapes to see whether this virus can be found in these vines.

Fig. 1 GLRaV-3 infection and age of sampled vineyards, Virgina 2009



Another experiment is conducted in Winchester AREC to determine the effect of insecticide treatments on the movement of the disease. New vines (not infected) are inter-planted in infected Cabernet sauvignon vineyards. Since the vectors (mealybugs and scales) are only known mean of spread, neonicotinoid insecticide treatments should limit the movement of the disease.

Results and future work

- More than 700 samples from 45 vineyards in different regions of Virginia were tested using single tube-one step RT-PCR to detect GLRaVs, with emphasis on GLRaV-2 and -3 and Grapevine fleck virus (GFkV) in 2009.
- The results indicated that about 70% of total samples collected from nearly 50% of vineyards were tested positive for one or both GLRaVs and GFkV.
- Many of the positive samples were from vines planted before 1990's (Fig. 1).
- Samples from eight wild grapevines tested were found negative for the two GLRaVs and GFkV.
- Field experiment showed that some of the first year vines are already infected with GLRaV-3, indicating the rapid rate of transmission of the disease by mealybugs.
- The survey is being continued during 2010 season to collect samples from more vineyards planted both pre- and post-1990's plantings (>300 samples from 105 locations), plus more wild grape vines (9 locations), to assess the presence of the three viruses.
- The samples from both 2009 and 2010 will be tested for other grapevine viruses in order to assess association among different viruses.

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Development of a map-based apple and grape disease risk assessment system

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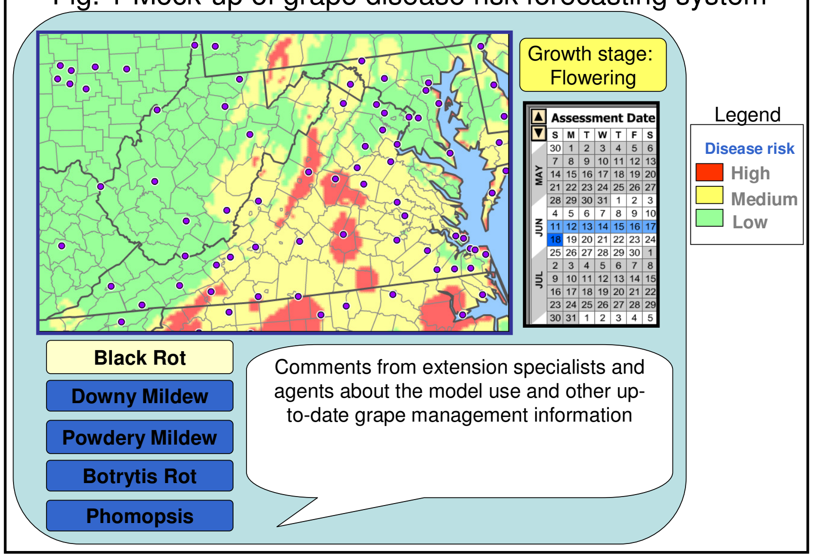
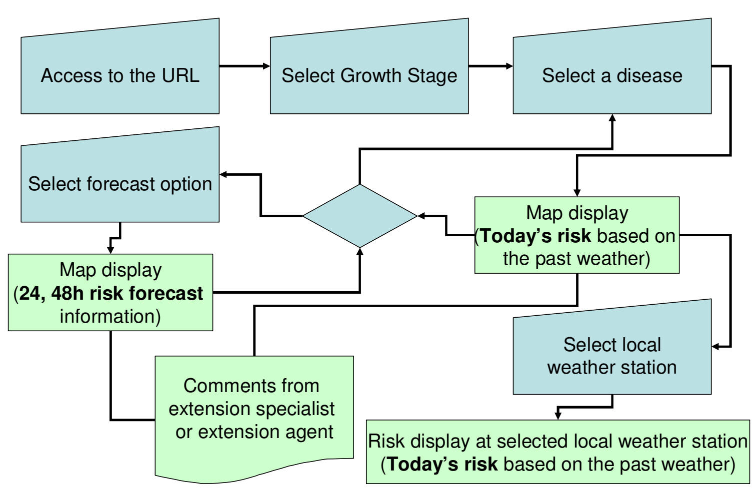
Fig. 1 Mock-up of grape disease risk forecasting system



What we envision as a goal of our project is the establishment of a web-based information center for grape and apple diseases for Virginia growers. One of the major components of the system is a disease risk assessment system that provides up-to-date map-based information on the risk of five major grape fungal diseases (Table 1) and several fugal and bacterial diseases for apple. The proposed risk assessment system will have two layers of spatial hierarchy. The top layer shows large scale (state-wide) information based on climate models. The similar system has been used for a wheat disease risk assessment system, and the developers of the system Dr. Erick De Wolf from Kansas State University and certified consultant climatologist Mr. Paul Knight from Penn State University are our collaborators. The website will deliver disease risk analysis based on disease prediction models, and the result of these models will be displayed as a map (Fig. 1). Once a user (a grower) accesses the site, he/she pick the growth stage of grape, a target disease, and target time window (current or forecast), and a risk map will be generated based on the input (Fig. 2). The display will be an easy to understand,

Fig. 2 User experience of grape disease forecasting system



color-coded map with green, yellow, and red areas for low, moderate, and high risk of the disease, respectively (Fig. 1). The map display will be updated daily so that growers can visit the site in the morning prior to make a decision. Also, up to 3-day weather forecast information will be used for future risk assessment, which will give growers "heads-up" for upcoming events.

Table 1. Examples of disease prediction models for major grape fungal diseases in Virginia

Disease	Pathogen	Selected references
Black rot	*Guignardia bidwellii*	Ellis, M. A., et. al. (1986), Funt, R. C., et al. (1990)
Downy mildew	*Plasmopara viticola*	Tarr S. A. J. (1972), Strizyk, S. (1983), Madden, L. V. et al. (2000), Lalancette, N., et al. (1988)
Powdery mildew	*Erysiphe necator*	Correiar, B. R. (1999), Sall , M. A.,(1979)
Botrytis gray mold	*Botrytis cinerea*	Broome, J. C., et al. (1995), Bulit, J, et al. (1970), Nair, N. G., and Allen, R. N. (1993), Shtienberg, D., and Elad, Y. (1997)
Phomopsis cane and leaf spot	*Phomopsis viticola*	Erincik, O., et al. (2003), Nita, M., et al. (2007)

WITHIN SEASON AND CONCURRENT SEASON DISTRIBUTION OF SI FUNGICIDE RESISTANCE IN APPLE SCAB

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Venturia inaequalis is the casual organism of apple scab, an economically devastating disease of apples that occurs wherever apples are grown (1). Management has predominantly relied on chemical applications with sterol inhibitor (SI) fungicides being one of the dominant systemic fungicides used in commercial apple production (2). Unfortunately, some *V. inaequalis* populations are developing resistance to this class of fungicides (3,4). Knowledge about the frequency, timing and mechanisms of fungicide resistance is necessary to improve existing and/or develop alternative management strategies. The objective of this study was to characterize the relative frequency and temporal dynamics of SI fungicide resistance in *V. inaequalis* populations in Virginia.

Mature trees were selected from three test blocks, each represented by a single apple cultivar: Ramey York, Fuji and Gala. Myclobutanil (Nova/Rally 40W) was applied dilute to runoff at a rate of 1.25 oz/100 gal. An extended spray schedule from late spring through summer applied selective pressure to the *V. inaequalis* populations. Starting in 2007, shoot growth on treated and non-treated trees within each test block was monitored using neon-colored rubber bands to ensure the most recently infected leaves were collected at each sampling interval. Five to six leaves containing at least one scab lesion were collected from individual trees, and monoconidial isolates were cultured on PDA. Fungicide resistance was assessed using plate assays with formula grade myclobutanil at concentrations of 0, 0.1, 0.5 and 1 ppm. Radial colony growth was measured weekly for four weeks, and the entire assay was conducted in triplicate. Data were analyzed using PROC GLM (α=0.05) in SAS® (Windows®, release 9.2, SAS Institute Inc., Cary, NC).

Within a given season, the mean colony growth of *V. inaequalis* isolates was significantly different ($P<0.001$) among assay treatments (0, 0.1, 0.5 or 1 ppm myclobutanil) and assay times (7, 14, 21 or 28 days) (Table 1). Which cultivar the *V. inaequalis* isolate came from was a significant factor in 2006 ($P=0.016$), 2007 ($P<0.001$) and 2009 ($P=0.010$), but we suspect this has more to do with the physical location of the test blocks. The Ramey York and Fuji test blocks are across from one another, whereas the Gala trees are located 500m to the South. Whether the *V. inaequalis* isolate came from a treated or non-treated tree was significant ($P<0.001$) in 2006, but this was before we began monitoring shoot growth and is likely an artifact of having older and younger lesions in the assay. Sampling interval was significant ($P<0.001$) in 2007, and Tukey's HSD test indicated May X July, June X July, and May X August were significant at the 0.05 level. When analyzed concurrently, all factors were significant ($P<0.001$) including collection year.

Table 1. ANOVA for differences between factors when accounting for collection year.

Factor	2006 (N=87)	2007 (N=76)	2009 (N=7)	2010 (N=33)	All Years (N=203)
	Type III SS, P-value				
Cultivar	0.016	<0.001	0.010	0.966	<0.001
NT or T	<0.001	0.122	0.710	0.073	<0.001
Sampling Interval	0.255	<0.001	0.770	0.250	<0.001
Assay Treatment	<0.001	<0.001	<0.001	<0.001	<0.001
Assay Time	<0.001	<0.001	<0.001	<0.001	<0.001
Collection Year	-	-	-	-	<0.001

Percent growth reduction – the difference in colony growth on 0 and 1 ppm myclobutanil at 28 days – was used to assess fungicide resistance. Generally, a range of resistance was seen at each sampling interval, and the average percent growth reduction was similar for treated and non-treated trees of the same cultivar (Figure 1). In the May and June sampling intervals, the average percent growth reduction for *V. inaequalis* isolates hovered around 60% regardless of cultivar or tree treatment. In contrast, the average percent growth reduction for *V. inaequalis* in the July sampling interval was around 30% (i.e. more resistant to myclobutanil). This may be due to less favorable environmental conditions for *V. inaequalis* and/or the reduction in chemical applications. However, the average percent growth reduction in August (around 50%) was similar to that of May and June.

The results of this four-year study provide useful information about the frequency and timing of SI fungicide resistance in *V. inaequalis* populations in Virginia, and may aid in a better understanding of the mechanisms employed by this pathogen. The unexpected shift in resistance in the July sampling interval merits further exploration. This study is on-going.

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Figure 1. Concurrent season distribution of SI fungicide resistance by cultivar and tree treatment. Cultivars: Fuji (red), Gala (green) and Ramey York (blue). Tree treatment: treated (hatched bar) and non-treated (solid bar).