PROCEEDINGS

80th

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE

December 2 & 3, 2004

WINCHESTER, VIRGINIA

(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE

80TH ANNUAL MEETING

December 2 and 3, 2004
Winchester Holiday Inn
Winchester, Virginia

Conference Chair
James F. Walgenbach
NC State University
Mountain Horticultural Crops Research & Extension Center

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Horticulture

LIST OF PARTICIPANTS

First name	Last name	Organization
Art	Agnello	NYS-AES
Atanas	Atanassov	Rutgers
Tara	Baugher	Penn State Ext
Chris	Bergh	VA Tech
Alan	Biggs	WVU-KTIREC
Deborah	Breth	Cornell CES
Dan	Bullock	AFRS-ARS-USDA
Jim	Chevalier	Bayer
David	Combs	NYS-AES
Daniel	Cooley	UMass
Rob	Crassweller	Penn State
Larry	Crim	USDA-ARS-AFRS
Anne	DeMarsay	Rutgers - Marucci Ctr
Nic	Ellis	PSU-FREC
Mary Anne	Erickson	Certis Co
Kathy	Foster	Rutgers
Don	Ganske	DuPont
Mike	Glenn	AFRS-ARS-USDA
Patricia	Gundrun	AFRS-ARS-USDA
Larry	Gut	Mich State Univ
Bill	Hanlin	NCSU
Lisa	Hopkins	USDA-ARS-AFRS
Chris	Hott	AFRS-ARS-USDA
Jeff	Huether	CerexAgri
Larry	Hull	Penn State FREC
Peter	Jentsch	Cornell Hudson Valley Lab
Greg	Krawczyk	Penn State
Michael	Lachance	VA Tech
Norman	Lalancette	Rutgers
Kathleen	Leahy	UMass
Tracy	Leskey	USDA-ARS
Gail	Lokaj	Rutgers
Steve	McArtney	NCSU
Stephen	Miller	USDA-ARS-AFRS

LIST OF PARTICIPANTS (cont)

First name	Last name	Organization
Clayton	Myer	Penn State
Michael	Newell	Univ of MD WREC
Brian	Olson	Dow AgroSciences
Mike	Parker	NCSU
Douglas	Pfeiffer	VA Tech
Dean	Polk	Rutgers
Harvey	Reissig	NYS-AES
Dave	Rosenberger	Cornell Hudson Valley Lab
Bob	Rouse	Univ of MD
Ann	Rucker	Rutgers
Rick	Schmenk	Syngenta
Patti	Schurr	
Peter	Shearer	Rutgers AREC
Brent	Short	USDA-ARS
Greg	Stamm	CBC America
Jim	Steffel	Labservices
Valen	Straub	Labservices
Dick	Straub	Cornell Hudson Valley Lab
George	Sundin	Mich State Univ
Turner	Sutton	NCSU
Torri	Thomas	USDA-ARS
Gar	Thomas	BASF
Bill	Turechek	USDA-ARS-FL
Tom	Tworkoski	AFRS-ARS-USDA
Raul	Villanueva	NCSU
Jim	Walgenbach	NCSU
Tony	Wolf	VA Tech
Starker	Wright	AFRS-ARS-USDA
Keith	Yoder	VA Tech
Xing	Zhang	VA Tech
Richard	Zimmerman	

80th Cumberland-Shenandoah Fruit Workers Conference

December 2 & 3, 2004
Winchester, VA

Thursday, December 2

8:30 – 9:00	**Registration**
9:00 – 9:30	**Call of the States**
	General Session
9:30 – 10:00	**What's so Different about the New Zealand Apple Industry?** Steve McArtney, Dept. Hort. Sciences, NC State Univ., Fletcher, NC.
10:00 – 10:15	BREAK
	NE-180 Project Summary
10:15 – 10:35	Horticultural Aspects. Steve Miller, USDA-ARS AFRS, Kearneysville, WV
10:35 – 10:55	Plant Pathology Aspects. Keith Yoder, VPI&SU, Winchester, VA
10:55 – 11:15	Entomological Aspects. Henry Hogmire, West Virginia Univ., Kearneysville, WV
	Cross-Discipline Paper Submissions
11:15 – 11:30	Cultural Factors Promoting Dogwood Borer Infestation in Newly Planted Apple Orchards. Tracy Leskey USDA-ARS, Kearneysville, WV, and Chris Bergh, VPI&SU, Winchester, VA.
11:30 – 11:45	What is Causing Basal Cankers on Apple Trees? Dave Rosenberger.
11:45 – 12:00	A Survey of Potential Pierce's Disease Vectors in NC Vineyards. Bill Hanlin. NC State Univ., Wilkes Co. Coop. Ext. Serv., Wilkesboro, NC.
1:00-5:00	**Concurrent Sessions (Entomology, Horticulture, Plant Pathology)**
5:30 – 7:30	**Mixer**

Friday, December 3

8:30 – 9:30	**Business Meeting**
9:30-12:00	**Concurrent Sessions**

Concurrent Sessions – Horticulture

Thursday, December 2, 2004

1:00 PM	**Yield, Fruit Size and Leaf Nutrient Content of Three Peach Tree Growth Habits Grown at Various Spacings and With Several Training Systems** Stephen Miller and Ralph Scorza, USDA Appalachian Fruit Research Station, Kearneysville, WV
1:20	**Genetic and Environmental Effects on Water Use Efficiency in Peach** Michael Glenn, R Scorza, and W.R. Okie*, USDA Appalachian Fruit Research Station, Kearneysville, WV, *USDA Fruit and Nut Laboratory, Byron, GA
1:40	**Autumn Strawberry Production in the Mid-Atlantic Coast Region with Short Day Cultivars** Fumiono Takeda, USDA Appalachian Fruit Research Station, Kearneysville, WV
2:00	**Response of Nittany/M.9 to Repeat Apogee Treatments - The Second Year** Stephen Miller, USDA Appalachian Fruit Research Station, Kearneysville, WV
2:20	**Morphology an Control of Flowering in Apple** Steven McArtney and Emily Hoover, NCSU, Fletcher, NC and University of Minnesota, St. Paul, MN
2:40	**Evaluating the Graft Union Strength of Gala on 12 Apple Rootstocks** Michael Parker and Peter Mente, NCSU, Department of Horticulture and Department of Biomedical Engineering, respectively, Raleigh, NC
3:00	**Chemical Regulation of Timing and Synchrony of Bud Break and Flowering in Different Wood Types of Apple** Steve McArtney, Department of Horticultural Science, NCSU and John Palmer, Robert Diack and Shayna Ward, HortResearch, New Zealand
3:20	**Interaction of Cultivar on Apple Training Systems.** R.M. Crassweller and D.E. Smith. Department of Horticulture, Penn State Univ., University Park, PA.
3:40	**Break**
3:50	**Late Submissions and Discussion**

Concurrent Sessions – Plant Pathology

Thursday afternoon

1:00-1:15	**Preview of Maryblyt for Windows.** Alan Biggs[1], W. W. Turechek[2], Gary Lightner[3], West Virginia University, KTFREC, Kearneysville, WVA[1], USDA ARS FL, Beltsville, MD[2], and consultant, Charles Town, WVA[3]
1:15-1:30	**Fire Blight Studies, 2004.** Keith Yoder, VPI&SU, Ag. Research and Extension Center, Winchester, VA.
1:30-1:45	**Highlights of Fungicide Testing on Apples, 2004.** Keith Yoder, VPI&SU, Ag. Research and Extension Center, Winchester, VA.
1:45-2:00	**Postharvest Apple Disease Control, 2003-04.** Keith Yoder, VPI&SU, Ag. Research and Extension Center, Winchester, VA.
2:00-2:15	**Timing Summer Fungicides for Apples in the NE.** David Rosenberger, Cornell University, Hudson Valley Lab., Highland, NY
2:15-2:30	**New Fungicides for Postharvest Disease Control on Apples.** David Rosenberger, Cornell University, Hudson Valley Lab., Highland, NY
2:30-2:45	**Management of Alternaria Blotch and Other Summer Diseases of Apples.** Turner Sutton, North Carolina State University, Raleigh, NC
2:45-3:00	**Break**
3:00-3:15	**Management of Peach Leaf Curl and Scab: Influence of Fungicide Applications at Bud Swell on Disease Incidence and Sporulation.** Norman Lalancette, Elspeth Murday, Kathleen Foster, Rutgers University, R&E Center, Bridgeton, NJ
3:15-3:30	**Management of Brown Rot, Scab, and Rusty Spot of Peach using DMI, QoI, and Biorational Fungicides.** Norman Lalancette, Kathleen Foster, Elspeth Murday, Rutgers University, R&E Center, Bridgeton, NJ
3:30-3:45	**Examination of Biorational Fungicides for Pre-harvest Peach Brown Rot Control.** Norman Lalancette, Kathleen Foster, Elspeth Murday, Rutgers University, R&E Center, Bridgeton, NJ
3:45-4:00	**Analysis and Attempted Management of Bacterial Canker of Sweet Cherry in Michigan.** George Sundin, Lisa Renick, Andrea Cogal, Michigan State University, E. Lansing, MI
4:00-4:15	**Development of DMI-fungicide Resistance in the Cherry Leaf Spot Pathogen *Blumeriella jaapii*.** George Sundin, Tyre Proffer, Gale Ehret, Raeffele Berardi, James Nugent, Patricia McManus[1], Michigan State University, East Lansing and University of Wisconsin, Madison WI[1]
4:15-4:30	**New Approaches to Managing Blueberry Anthracnose. Anne DeMarsay, Peter Oudemans.** Rutgers University, Blueberry and Cranberry Research Center, Chatsworth, NJ

Friday morning

9:30-12:00	**Additional papers, discussion**

Concurrent Sessions – Entomology

Thursday afternoon

1-1:15	**Refinement of Bio-Based Approaches to Reducing Insecticide Use Against PC and AM.** Art Agnello, Cornell Univ., Geneva, NY
1:15-1:30	**Small-plot and On-Farm Evaluation of New Controls for Rhagoletis Fruit Flies.** Larry Gut, Kirsten Pelz, Rufus Isaacs and John Wise. Mich. State Univ., East Lansing, MI.
1:30-1:45	**Insecticidal Effects of Sevin XLR When Applied as an Apple Thinning Agent.** Peter Jentsch and Dick Straub. Cornell Univ., Hudson Valley, NY
1:45-2:00	**Residual Activity of Newly Registered Reduced Risk Compounds.** Greg Krawczyk and Larry Hull. Penn State Univ., Biglerville, PA
2:00-2:15	**Comparison of Different Spray Schedules for Control of OFM in Apples in New York, 2004.** Harvey Reissig and David Combs. Cornell Univ., Geneva, NY
2:15-2:30	**Effective and Economic Alternatives to Azinphosmethyl: Field Evaluation of Phosmet and Pyrethroid Schedules.** Dick Straub and Peter Jentsch. Cornell Univ., Hudson Valley, NY
2:30-2:45	**Results from 2004 Peach Entomology Studies.** Peter Shearer, Atanas Atanassov and Ann Rucker. Rutgers University, Bridgeton, NJ.
2:45-3:00	**An Evaluation of Cyd-X Virus/Mating Disruption for Codling Moth Control on Apple.** Larry Hull and Greg Krawczyk. Penn State Univ., Biglerville, PA
3:00-3:15	Break
3:15-3:30	**LRFA Applications for OFM and CM on Apple in Pennsylvania.** Larry Hull. Penn State Univ., Biglerville, PA
3:30-3:45	**Management of Key Arthropod Pests in NJ Peach Orchards with Mating Disruption and Reduced-Risk Insecticides.** Atanas Atanassov, Peter Shearer and Ann Rucker. Rutgers Univ., Bridgeton, NJ.
3:45-4:00	**Bin Mating Disruption; Does it Work?** Jim Walgenbach and Steve Schoof. NC State Univ., Fletcher, NC.
4:00-4:15	**New Technology in Hand-Applied Pheromone Dispensers for OFM Disruption.** Art Agnello. Cornell Univ., Geneva, NY.
4:15-4:30	**Female-equivalent mating disruption formulations.** Larry Gut, Lukasz Stelinski, David Epstein and James Miller. Mich. State Univ., East Lansing, MI.
4:30-4:45	**More on *Heringia calcarata*, the Specialized Hover Fly Predator of Woolly Apple Aphid:** Chris Bergh, VPI&SU, Winchester, VA.
4:45-5:00	**Progress in Developing More Compatible Management Systems for OFM in Apples in Western NY.** Harvey Reissig, Art Agnello and Jan Nyrop. Cornell Univ., Geneva, NY.

Concurrent Session – Entomology (continued)

5:00-5:15 **Effects of Host Plants on the Developmental Rate of OFM Larvae: Possible Implications for Modeling and Management.** Clayton Myers and Larry Hull. Penn State Univ., Biglerville, PA.

Friday morning

9:30-9:45 **Effects of Surround on Apple Maggot Behavior.** Raul Villanueva and Jim Walgenbach, NC State Univ., Fletcher, NC.

9:45-10:00 **Using Time Series Analysis for Interpretation of Seasonal Trap Counts.** Nic Ellis and Larry Hull, Penn State Univ., Biglerville, PA.

10:00-10:15 ***T. pyri* in Pennsylvania Apple Orchards & Controlling 17-Year Cicada in Reduced Risk Orchards.** Dave Biddinger and Larry Hull. Penn State Univ., Biglerville, PA.

10:15-10:30 **Relative Cultivar Susceptibility to Stink Bug Injury.** Mark Brown and Stephen Miller, USDA-ARS, Kearneysville, WV; and Keith Yoder, VPI&SU, Winchester, VA.

10:30-10:45 **Whole-Orchard Monitoring of OFM Adults: Investigating Questions of Diapause and Movement at the Peach/Apple Interface.** Clayton Meyers, Nic Ellis and Larry Hull, Penn State Univ., Biglerville, PA.

10:45-11:00 **Analysis of *Wolbachia* strains associated with plum curculio using the *wsp* g in the eastern North America.** Xing Zhang, Shirley Luckhart and Douglas G. Pfeiffer. VPI&SU, Blacksburg, VA.

11:00-12:00 **Late Submissions**

Business and Financial

80th Cumberland-Shenandoah Fruit Workers Conference

Program Highlights and Business Meeting

North Carolina State University hosted that 80th Cumberland-Shenandoah Fruit Workers Conference at the Holiday Inn in Winchester, VA, on December 2-3. There were 70 registered participants and 50 papers presented. Registration was $50 and covered the cost of the Proceedings, breaks and lunch on Thursday. Jim Walgenbach served as general chair and secretary, while Steve Miller continued his role as treasurer. Turner Sutton, Mike Parker and Raul Villanueva served as session moderators for Plant Pathology, Horticulture and Entomology sessions, respectively.

The meeting began at 9:00 am on Thursday with a "Call of the States" that included a brief report of the crop, weather and pest conditions for each state during the 2004 season. This was followed by a General Session that included a description of the New Zealand apple industry by Steve McArtney (NC State University), and presentations on Horticultural (Steve Miller, USDA-ARS) and Plant Pathology (Keith Yoder, VPI&SU) aspects of the NE-183 Project "Multidisciplinary Evaluation of New Apple Cultivars." Three cross-discipline papers followed the General Session. The remainder of the papers were presented during concurrent sessions (Entomology, Horticulture and Plant Pathology) that started after lunch and Thursday and continued through Friday morning. A Social was held on Thursday evening, which was sponsored by DuPont, Syngenta, Bayer, Cerexagri, Dow and Gowan.

The business meeting was called to order by Jim Walgenbach at Friday at 8:30 am. It was decided that papers for the Proceedings should be submit via email to Jim Walgenbach by January 7. There was a short discussion on switching from printing of a hard copy of the Proceedings to production on a CD. In view of concerns about the longevity of CD technology, it was decided that hard copy production was still preferred. Steve Miller gave the treasurer's report. Total income in 2003 was $2,550, and together with a carry over of $1,539.12, left a balance of $4,089.30. Expenses associated with the 2003 meeting were $2,841.22. The CSFWC account balance prior to the 2004 meeting was $1,250.13, which included $2.05 interest payment. Receipts for registration of the 2004 meeting totaled $3,500; which left an account balance of $4,750.13 as of December 3, 2004. Information was also presented on the cost of meetings from 1997-2003. On behalf of the members, Jim Walgenbach expressed appreciation to Steve Miller for continuing to serve as treasure.

The 2005 CSFWC will move to its traditional date (Thursday and Friday before Thanksgiving), and will be held on November 17-18 at the Holiday Inn in Winchester, VA. The USDA will host the 2005 meeting, with Tracy Leskey serving as General Chair.

Respectfully submitted,

James F. Walgenbach, General Chair, Secretary Stephen S. Miller, Treasurer

Financial Report

2003/2004 Cumberland-Shenandoah Fruit Workers Conference

Balance Preceding the 2003 Meeting (Nov.19)	$1,539.12
Income (2003/2004) –	
Receipts from registration (51)	2,550.00
Interest on Account, Dec 2003	0.18
Total Assets (Dec. 1, 2003)	**$4,089.30**
Expenses (2003-2004)–	
Room rental, luncheon, etc. for 2003 meeting, Jimmy's Holiday Inn	$1,876.73
Proceedings, 2003 (copy, bind, etc.)	701.04
Laminate covers	103.60
Postage and meeting costs	159.85
Total Expenses (2003-'04)	**$2,841.22**
Additional Income (2004)	
Interest on Account	2.05
Balance as of 12/01/04	**$1,250.13**
Paid Registrations, '04 (70)	$3,500.00
Balance as of 12/03/04	**$4,750.13**

Historical Figures for Cumberland-Shenandoah Fruit Workers Conference

Facilities & Food Costs:

Year	Amount	Cost/attendee
1997	1,617.15	$23.43
1998	1,624.40	28.00
1999	1,916.78	26.25
2000	2,134.64	31.86
2001	2,453.93	28.53
2002	2,055.61	28.95
2003	1,876.73	36.80

Proceeding Publication Costs:

Year	Amount
1997	946.58
1998	867.55
1999	772.74 + 116.03 = 888.77
2000	1,358.07 + 103.60 = 1,461.67
2001	1,365.00 + 116.17 = 1,481.17
2002	896.00 + 103.60 = 999.60
2003	701.04 + 103.60 = 804.64

CSFWC Registrations – Meeting Hosts

2004 - 70	2005 - USDA
2003 - 50	2006 - Pennsylvania
2002 - 71	2007 - West Virginia
2001 - 86	2008 - NewJersey/SC
2000 - 67	2009 - Virginia
1999 - 73	2010 - Maryland
1998 - 58	2011 - North Carolina
1997 - 69(?)	2012 - USDA

Total Meeting Costs

1997 - 2,563.73
1998 - 2,491.95
1999 - 2,805.55
2000 - 3,596.31
2001 - 3,935.10
2002 - 3,055.21
2003 - 2,841.22

Call of the States

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE
Call of the States Report – New York 2004
Art Agnello - NYS Agric. Expt. Sta., Geneva

The weather was a major factor, as usual, in this year's fruit production and pest events. Early cold spells in January claimed over 15,000 younger trees in the Champlain Valley, as well as many vinifera grapevines in the Finger Lakes; the peach and cherry crop also was eliminated in some parts of the northern Finger Lakes region. A cool and rainy spring moderated just long enough to accommodate the bloom (and pollination to fruit set) period, before regressing into rainy and cool weather patterns that resembled early fall for much of the summer. A good-sized apple crop was set, but the unfavorable weather made thinning difficult, so some definite overcropping resulted. Nevertheless, the apple harvest was above average, with many varieties showing larger than normal fruit size.

The poor weather made disease management a challenge this year; heavy apple scab pressure was noted across the state, and some definite resistance problems are evident, especially to the DMI fungicides. Several fire blight infection periods were recorded, and summer diseases, especially fly speck, were common. Cool temperatures had the positive effect, however, of not only obstructing the early season pests such as European red mite, spotted tentiform leafminer, and rosy apple aphid, along with pear psylla, but the bloom period warmup also gave plum curculio the chance to progress through its oviposition period in short order, so that most locations could get by with just the petal fall and 1st cover applications for sufficient protection.

Seemingly unaffected by climatic conditions, obliquebanded leafroller appeared pretty much on schedule again this year, but still at lower than crisis levels, and evidently still susceptible to timely intervention using the newer selective materials labeled recently. The internal worm (oriental fruit moth, codling moth, etc.) populations were once again detectable, but evidently were not much more problematic than in 2003, except in a few high pressure orchards. Among other factors, some credit can certainly be given to increased grower attention to monitoring and timing, as well as to new chemistry available for treatment decisions.

Apple maggot occurrence was fairly normal this year — some high populations evident in eastern NY, particularly in the Hudson Valley, and rather spotty in western NY locations — on the whole, about what we would expect in a wet season. Woolly apple aphid was an early and widespread concern in many orchards again this year, and promises to continue its ascendance to the level of an annual problem since we are lacking any very effective tactics to use against it. Other sometimes sporadic summer pests were similarly troublesome, depending on the specific locality: green aphids and potato leafhopper, stink bugs, European apple sawfly, late season dock sawfly, mirid bugs and San Jose scale all generated their share of attention in one area of the state or another.

Finally, a few pests were apparently not around in any noticeable number, or else we haven't yet heard from all quarters: Comstock mealybug, white apple leafhopper and tarnished plant bug. As always, some of these won't be known entirely until after the fruit starts to be inspected and packed for distribution.

Pennsylvania State Report for CSFWC, 2004.

Krawczyk, G., J. R. Schupp , R. C Crasweller*, and L. A. Hull.
Penn State University
Fruit Research and Extension Center, Biglerville, PA
* Department of Horticulture, State College, PA

Horticulture:

Last year was the second wettest on record in PA, making 2004 a most challenging season for disease management. Many apple orchards had high levels of over-wintering scab inoculum, due to the severe infections in 2003. There were also severe fire blight outbreaks in some apple and pear blocks.

Apple bloom was light to moderate and initial set followed a similar pattern. High temperatures in May contributed to a strong response to chemical thinners in apple. Apple yields were about 10% lower than average, but fruit size was larger than average, with good quality and finish. Apple fruit maturity ran ahead of normal throughout the entire harvest season. Peach fruit also matured 10-14 days earlier than normal, but fruit size and quality were variable.

Entomology:

From entomological perspective the 2004 season was not typical for Pennsylvania fruit growers. Although, it started normally with the biofix for OFM established on April 17, for CM on May 02, for TABM on May 08, and for OBLR on May 19, the colder than normal weather during late May and early June generated a situation where the temperature driven developmental models did not predict accurately moth activities. Extended period of temperatures higher than developmental thresholds but lower than temperatures required for adult activity caused the models to inaccurately predict moths behavior. In consequence, models for OFM and CM needed to be restarted at the beginning of the second generation flight.

At the harvest time 840 fruit loads were rejected due to the presence of live worms (OFM 631 loads, CM 187 loads, 5 TABM and 17 other insects) in fruit delivered to our local PA fruit processors (Knouse and Mott's).

Despite relatively mild and very wet summer the above threshold **European red mite** populations were observed in most grower' orchards. Partially it can be attributed to plentiful of pyrethroids applications directed to control the Brood X of **periodical cicada,** which in some orchards caused significant injury to young wood.

The **obliquebanded leafroller** outbreaks were again observed in some isolated orchards, mostly when spray coverage was not adequate. The **tufted apple bud moth** fruit injuries were again at low to average levels when compared to previous years. Also, some increased populations of **European apple sawfly** and **apple maggot** were reported form isolated orchards

Call of States – West Virginia
2004

Alan Biggs, Henry Hogmire, Steve Miller and Richard Zimmerman

HORTICULTURE

Temperatures were below normal during January and February with average snowfall while March was near normal in temperatures but below normal in precipitation. Monthly temperatures during the growing season (April * October) were all below normal, except for May. A brief warm spell in mid-April advanced bud development on tree fruits slightly and bloom on most tree crops was several days ahead of normal (but behind bloom dates in 2003). Temperatures during early May at the 10 mm fruitlet stage for apples were well above normal with nights in the low 70s. Apple growers who used an aggressive thinning program over thinned. While temperatures were below normal for the growing season, precipitation was above normal for all months except August and October. Many growers noted the high humidity conditions contributing to brown rot and cracking in sweet cherries, and cracking in Stayman and GoldRush apples. Despite the near normal bloom dates, most tree crops matured well ahead of normal dates with sweet cherries and some peaches being harvested up to two weeks ahead of normal. Early and mid-season apples also matured a week to 10 days ahead of their normal maturity dates. The peach crop was above the 2003 crop, but prices were terrible and some growers dumped packed peaches. One local grower has bulldozed 90% of his 300 acres of peach trees. Preharvest drop in apples was above normal for a number of varieties. The apple crop was slightly below the 2003 crop and estimated to be between 1.8 and 2 million boxes. Size was variable with a few growers reporting above average size but most indicating that size was poor. West Virginia's 2004 apple production represents a 200% drop since the 1960s. Orchard land for development is bringing $20,000 or more per acre. Prices for processing apples were very poor again and are not keeping pace with production costs. Another previously very successful processing grower has decided to leave the apple growing business (about 200 acres).

PLANT PATHOLOGY

The 2004 growing season was one of the wettest in recent history and followed 2003, which was also one of the wettest years on record. Accordingly, plant disease management played an important role for most fruit producers in West Virginia. Apple scab was the disease with the most widespread incidence and severity in 2004, despite intense management efforts. High scab levels occurred because of ideal overwintering conditions for the fungus, combined with frequent extended wetting periods from April through mid-June, as well as above normal temperatures in March and May. Also, many growers have been trying to cut costs by relying exclusively on protectant-type fungicides. This type of management is not efficacious under the weather conditions experienced in 2004. Fire blight was generally sporadic in its occurrence, but was severe in some locations. Apple rusts and mildew were light to moderate. Growers were well-prepared for summer disease control, after having experienced the relentless wetting earlier, and were thus able to manage more effectively the rots and fruit blemish fungi.

ENTOMOLOGY

The insect of the year award in area orchards for 2004 goes to periodical cicada. Brood X, which was active from mid-May until the third week of June. Damage was most abundant in Berkeley and Hampshire Counties, with generally much lower levels throughout most of Jefferson County. Injury was most severe on non-bearing trees. On bearing trees the greatest impact was observed on peaches where numerous branches bearing fruit were broken, resulting in fruit loss.

Rosy apple aphid, which was the most troublesome insect in 2003, was much less abundant in 2004, as were most foliage pests including spirea aphids, white apple leafhopper, rose leafhopper and spotted tentiform leafminer. Potato leafhopper was quite abundant in some orchards, as was European red mite where pyrethroids were used for cicada control in the absence of preventative measures. Japanese beetles were very abundant over a prolonged period in 2004.

Biofix (first trap capture) of oriental fruit moth, codling moth and tufted apple bud moth was almost identical to 2003. However, because of warmer temperatures in 2004, development based on degree days was 15-17 days earlier by June 1 and 12-14 days earlier by July 1 and for the remainder of the season.

Populations of oriental fruit moth and codling moth and the fruit injury they cause were higher than in 2003, resulting in a significant number of fruit loads that were rejected by processors.

Call of the States: Maryland
2004-CSFWC

Eastern half of State

Climate

A cool March and early April held back bloom and reports of frost damage to blossoms was nominal. A warmer May and June accelerated things, with three of the reported six days that exceeded 90 F occurring in June. The Eastern part of Maryland did not receive the high rainfall and wind damage experienced in Western Maryland and neighboring states from the three tropical systems that passed. Monthly rainfall totals were typical during the growing season. However, on many occasions the rainfall event lasted for several days. August and September were cooler than usual with many cloudy damp days.

Horticulture

Full Peach bloom (4/19) was several days later this season than in 2003. The first Redhaven was picked on July 13. Generally, fruit quality was good and acceptable insect and disease suppression was achieved using the recommendations in the Tri-state guide.

Apple bloom was on April 30th. Maryblight successfully predicted several infection periods and strikes were observed at the station and areas around the Eastern Shore. Apple and Asian pear harvest was advanced.

Chandler strawberry on plastic was first harvested on May 9 and was completed on June 2. This was a somewhat compressed season due to the warm May temperatures. Yields at the station were higher than the farm average. Disease incidence was low if on a seven-day spray schedule. Problems with *anthracnose* infected propagation material was encountered by some nurseries and growers

Grape yields were acceptable if sprayed regularly. Downey mildew was early and the last to go. Grape quality was low due to cooler and cloudy August and September.

Michael J. Newell
Wye Research and Education Center

NC State of the State - 2004

After bloom and fruit set in 2004 the apple crop in NC promised to be a very good crop. However, two tropical storms a week apart with excessive rain, in excess of 20 inches in some areas, and heavy winds (45-75 mph) in September was devastating in many orchards in western NC. Approximately 20% of the current seasons= crop was lost and tens of thousands of trees were damaged with some orchards needing to be removed.

In general, apple insect pests were not particularly troublesome in 2004. Codling moth and oriental fruit moth populations were somewhat lower than in previous years. Where problems did occur with these insects, the source was usually nearby storage bins. A few growers did experience some late-season tufted apple bud moth damage, but this was attributed to these few growers not applying either Intrepid or SpinTor, but instead relied on Ops. Plant bugs and stink bug populations were more problematic in 2004 compared to previous years. While damage to apples was somewhat higher than normal, damage to peaches was considerably higher. Early season diseases were generally light with little scab, powdery mildew or fire blight problems. Wet weather, especially late in the season, was very favorable for sooty blotch and flyspeck and some growers suffered significant losses from these diseases. Glomerella leaf spot, which had been found in only one orchard in NC prior to 2004, was observed several Gala orchards in Henderson County causing up to 90% defoliation after harvest.

The peach crop in NC in 2004 was very good with few problems with spring frost/freeze conditions. Frequent rains during the summer resulted in large fruit size with excellent quality. Bacterial canker was seen in several areas in the spring resulting from ideal conditions in late winter-early spring. Bacterial spot was also observed in some cultivars due to wet conditions. Scale continues to be a problem with the reduction in broad-spectrum organophosphate insecticides being used in addition to the presence of plant bugs and stink bugs. However, overall insect and disease pressure was light.

General Session

The NE-183 Regional Project

Multidisciplinary Evaluation of New Apple Cultivars
Horticultural Aspects[1]

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Interest in new apple cultivars has risen significantly among U.S. apple growers and consumers over the past 10 to 15 years. While a number of reasons have been cited for this heightened interest, a few are worth repeating including: higher prices received by the grower for unique cultivars, enhanced pest resistance requiring fewer pesticide inputs, demand by niche markets, more distinct apple flavors available to consumers, and better fruit quality (specifically crispness and texture) (Greene, 1998; Greene and Weis, 2003; Harker, 2002; Miller, 1991; Stebbins, 1994). It could be said that among apple growers, consumers, processors, and apple breeders the search for that "perfect" apple continues. Between the late 1950s and the early 1980s apple production in the U.S. centered on a limited number of cultivars, primarily 'Delicious' and 'Golden Delicious', which comprised over 50% of total production, and to a lesser extent 'Rome' and 'McIntosh' with about 16% of U.S. production. Entering 2004, 'Delicious' and 'Golden Delicious' make up a smaller share of the total U.S. production (about 40%) with several newer cultivars, such as 'Gala', 'Fuji', 'Granny Smith' and 'Idared', being added to the list of significant cultivars. The U.S. Apple Association's recent production analysis (2003) listed 15 cultivars that comprised 90% of total U.S. production. Clearly growers and consumers are interested in a wider selection of apple cultivars.

Systematic evaluation of apple cultivars across a broad range of soil and climatic conditions has been quite limited. Evaluations of performance of new cultivars and selections are often limited to those of the plant breeder at a few test sites or observations by growers and/or nursery personnel in the field. In 1994, Regional Project NE-183 titled "Multidisciplinary Evaluation of New Apple Cultivars", was initiated to systematically evaluate the performance of new apple cultivars in replicated trials under a wide range of climatic and edaphic conditions. Unique to this project was the integration of pathologists and entomologists along with horticulturists/pomologists providing for the concurrent evaluation of both horticultural characteristics and the pest susceptibility of new apple cultivars and selections. Greene et al. (2004) have provided background information on the NE-183 Regional Project. Additional information and results may be found in Biggs and Miller (2001, 2003), Brown and Maloney (2003), Ferree and Schmid (2004), Greene and Weis (2003), Hampson et al. (2004), and Miller et al. (2004) or on

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[1] The author acknowledges the assistance of Dr. Ronald McNew, Professor, Agricultural Statistics Laboratory, Agricultural Experiment Station, Division of Agriculture, University of Arkansas, Fayetteville, AR for his statistical analysis of the data. Also, thanks are extended to cooperators listed in Table 1 who provided data.

the Virtual Orchard website http://www.virtualorchard.net/NE183/. The purpose of this report is to provide members of the Cumberland-Shenandoah Fruit Workers Conference with an update on findings from the NE-183 project as they relate to horticultural performance. Cooperators at 18 locations (Table 1) representing 19 planting sites provided data for this paper.

Materials and methods

Details regarding the planting, cultural maintenance, and data collection for the NE-183 Project plantings were presented by Crassweller et al. (2005), Hampson et al. (2004), and Miller et al. (2004, 2005). Briefly, trees representing 22 apple cultivars (Table 2) were propagated on virus free Malling.9 (M.9) T337 rootstock by Adams County Nursery (Aspers, PA) in 1993. The 1-year-old trees were dug in the fall of 1994 and planted at 18 states and 2 Canadian provinces in the spring of 1995. The experimental design was a randomized complete block with five blocks and a single tree of each cultivar per block. Trees were planted in north-south rows, where possible, at a spacing of 2.5 x 4.3 m. Plantings had the primary designation of either horticulture or pest susceptibility. Horticultural (H) plantings were dedicated to answering questions of horticultural characteristics such as growth, yield, flowering, or fruit and sensory quality. Pest (P) plantings were dedicated to examining the disease and insect susceptibilities of the various cultivars. Data from both the H and P plantings at the WV site are included in this report; data for all other sites represent only H plantings. Five replicated blocks of 23 additional cultivars or advanced selections (Table 2) were added to the project in 1999. 'Golden Delicious' (Gibson strain) was included in both the 1995 and 1999 plantings as a standard of comparison. Four cultivars in the 1995 planting and eight cultivars in the 1999 planting possessed the V_f gene for apple scab resistance.

A standard protocol for cultural management was developed for cooperators in the project. Trees were staked and trained to a pyramid-shaped canopy with minimal pruning during the first few years in the orchard. All flowers were removed in the year of planting with a local option to remove or retain fruit in the second year. Full bloom was defined as the date when 90% of spur flowers were open. In 1998 and thereafter cooperators were instructed to harvest each cultivar when the average starch index [SI (rated on a 1 to 8 scale)] rating fell within the range of 4 to 6 (considered optimum maturity for fresh consumption) based on the Cornell Generic Starch-Iodine Index Chart (Blanpied and Silsby, 1992). Yield was recorded on a per tree basis. Preharvest fruit drop was also recorded for each tree. Fruit quality traits [size, soluble solids concentration (SSC) firmness, SI, titratable acidity, red overcolor, and surface russet] was determined from a 10-apple sample selected at random from each tree. Sensory (attractiveness, crispness, juiciness, sweetness, acidity, flavor, and desirability) evaluation was performed on 5-fruit per tree and rated on either a unipolar or bipolar scale or a hedonic scale as appropriate. The local spray schedule and cultural recommendations for commercial apple orchards was followed throughout.

Because of the large volume of data and the size of some of the individual data sets in this project, only selected quality attributes and in some instances only a portion of the data set for a given attribute will be used to illustrate the horticultural findings. Because of a shortage of trees of 'Senshu', only plantings designated for the "pest susceptibility" studies received this cultivar. The cultivar 'Sansa' was also deleted from the study due to a virus infection detected in the scion of all budded trees after planting. In addition, data from the 1999 planting will not be presented at this time as this information has not been summarized and is not available from all cooperating locations.

The factors in the statistical analysis of quality and sensory data are cultivar, location, block of the statistical design, tree, and year (when yearly data rather than averages or totals over years were analyzed). The analysis of each attribute was done using the MIXED procedure of SAS statistical software (Ver. 8, SAS Institute Inc., Cary, NC). The main effects and interaction effects of location and cultivar were the fixed effects in the model. The random effects, which were all nested within location, were the effects of block, year, block x cultivar, block x year, and block x cultivar x year. Mean separation was done using the LSMEANS feature of MIXED, which involves multiple t tests, each at the 5% probability level.

Results and discussion

Tree survival was generally very good and averaged 93% over the 19 planting locations. Tree survival ranged from 100%, recorded at three locations (NYH, PAR, and WI), to 61% at the WV location (Crasweller et al., 2005). A hail storm that resulted in fire blight in the year of planting was responsible for nearly all of the tree losses reported at the WV location.

Full bloom date is an important selection criterion for new apple cultivars when planting in areas subject to frequent spring frosts. The mean full bloom date for 20 cultivars in the 1995 planting over 15 locations is presented in Table 3. 'Arlet' was the earliest blooming cultivar followed one day later by 'Orin', 'Sunrise', 'Pristine', and NY75414-1. 'Gala Supreme', 'Honeycrisp', 'Suncrisp', and 'Golden Supreme' shared the latest bloom date, which was 5 days later than 'Arlet'.

Scion vigor plays an important role in planting density and the ability to manage a given cultivar within the allotted orchard space. Trunk cross-sectional area (TCSA) is a good indicator of tree vigor and canopy size. The 20 cultivars evaluated in the 1995 NE-183 planting differed significantly in vigor (Crassweller et al., 2005) (Fig.1). 'Shizuka' had the largest mean TCSA after 5 growing seasons, but was not significantly larger than 'Pristine', 'Arlet', or 'Enterprise'. 'Braeburn' and 'Honeycrisp' had the smallest TCSA, significantly smaller than all other cultivars evaluated and about 60% less than the TCSA of 'Shizuka'.

Among 20 of the cultivars in the 1995 planting 'Shizuka' had the highest cumulative yield after six growing seasons (a five-year-old tree) (Fig. 2). Eight other cultivars ('Arlet', 'Cameo', 'Enterprise', 'Fuji', 'Ginger Gold', 'Golden Delicious', 'GoldRush', and 'Suncrisp') also had high cumulative yields which did not differ from 'Shizuka'. 'Honeycrisp' had the lowest cumulative yield, but not lower than 'Braeburn', 'Gala Supreme', NY75414-1, or 'Pristine' (Fig. 2). While yield is important, yield efficiency may be of greater interest in characterizing the potential of a tree over a period of time. Mean cumulative yield efficiency for the 20 cultivars in the sixth leaf are illustrated in Fig. 3 (data from Crassweller et al., 2005). 'GoldRush' was the most efficient cultivar based on cumulative yield, followed closely by 'Suncrisp', 'Ginger Gold', and

'Braeburn'. The least efficient cultivars in terms of cumulative yield were 'Pristine', 'Golden Supreme', and 'Gala Supreme'. A low cumulative yield efficiency might be associated with alternate bearing. Crassweller et al. (2005) indicated that 'Golden Supreme' and 'Pristine' had a strong tendency toward alternate bearing, but his data also indicated a strong alternate bearing tendency for 'GoldRush' and 'Suncrisp', the two cultivars that exhibited the highest cumulative yield efficiency (Fig. 3). Cultivars that Crassweller et al. (2005) found to have a low biennial bearing index ('Arlet', 'Enterprise', and NY75414-1), indicating they tend to have a crop each year, had somewhat moderate cumulative yield efficiency compared to other cultivars in this study.

Preharvest drop can result in significant crop loss and is not easy to control. Among the 20 apple cultivars evaluated at 15 locations in the 1995 NE-183 project, 'Golden Supreme' and 'Pristine' were equally susceptible to preharvest drop (Crassweller et al., 2005). These two cultivars had an average drop of 23%. Several cultivars averaged more than 10% drop but less than 20% drop including: 'Fortune' (15%), 'NY75414-1 (14%), 'Arlet' (13%), 'Honeycrisp' (13%), 'Shizuka' (12%), and 'Braeburn' (11%). 'GoldRush' had the least preharvest fruit drop at 3 percent.

Among fruit quality characteristics, fruit size is of primary interest. Large fruit size often brings a premium price and growers strive for large fruit size. When Hampson et al. (2004) compared 'Braeburn' and 'Golden Delicious' from the 1995 NE-183 project across 14 of the planting locations they found a significant effect of location on fruit weight (Fig. 4). 'Braeburn' and 'Golden Delicious' grown at the BC location were significantly larger (by weight) than for any other location reporting fruit weight; the PAR location reported the lowest weight. There was a significant cultivar x planting site interaction ($P \leq 0.001$) when the mean fruit weight for the 20 cultivars was compared across 19 planting sites (Miller and McNew, 2005). The interaction is illustrated in Fig. 5 using eight selected cultivars at eight of the 19 planting sites. Among the 20 cultivars evaluated the BC planting site produced the largest fruit for 11 of the cultivars; the WA site had the largest fruit for six of the 20 cultivars (data not shown). The average difference in fruit weight between the largest and smallest fruit among the 20 cultivars was 122 g. The greatest range in fruit weight was 195 g for 'Honeycrisp' which occurred between the BC and AR planting sites. The smallest range in fruit weight difference was 60 g for 'Pristine' and occurred between the WA and PAB planting sites. Why many of the apple cultivars in this study were consistently larger when grown at the BC site cannot be determined, but it may be suggested that length of growing season, temperatures during the critical cell division stage, and/or light quantity and quality are more ideal in the BC region than at other locations in this study.

Soluble solids content and acidity play significant roles in the taste and flavor perceived in eating an apple, and as such help characterize an apple's quality. In the NE-183 Regional Project, SSC and TA were affected by the cultivar main effect ($P \leq 0.001$) (Miller and McNew, 2005). 'Golden Delicious', 'Gala Supreme', and 'GoldRush' had significantly higher SSC than the 16 other cultivars tested across 14 planting sites (Table 4). 'GoldRush' is the latest maturing cultivar among the 19 cultivars evaluated (Miller et al., 2004). 'Pristine', 'Sunrise', and 'Ginger Gold', the earliest maturing cultivars (Miller et al., 2004), produced the lowest SSC across all sites. 'GoldRush' had the highest TA (Table 4) and was significantly higher in TA than all other cultivars evaluated. 'Orin', a cultivar characterized as sweet and of low acid (Greene et al., 1997; Miller et al., 2004), had the lowest TA, however, it was not significantly lower than 'Fuji' or 'Ginger Gold' (Table 4). Titratable acidity ($P = 0.060$), but not SSC ($P = 0.788$) was affected by the planting site main effect. Among the six planting sites that measured TA, BC had the highest mean TA, although it was not significantly higher than the mean TA for the same cultivars grown at the NYI site (Fig. 6). The two WV sites reported the lowest TA, but not significantly lower than the NYG, NYI, or PAB sites (Fig. 6). The cultivar x planting site interaction for SSC and TA was not significant.

Crispness is one of the major traits consumers desire in apples (Stebbins, 1994) and to be labeled as a high quality apple it must have crispness (Barritt, 2001). Crispness of the apple cultivars in the NE-183 Regional Project, as rated by project cooperators, was affected by planting site and cultivar (Fig. 7). Among the seven planting sites rating crispness, apples grown at the MA, PAR, and VT sites were rated higher for crispness than the same cultivars grown at the NYG, PAB, and the two WV sites (Fig. 7A). 'GoldRush' and 'Creston' were rated crisper than all other cultivars evaluated except 'Braeburn', 'Ginger Gold', and 'Honeycrisp' (Fig. 7B). 'Enterprise' along with ''NY 75414' and 'Pristine' were rated significantly less crisp than all other cultivars.

Time and space do not permit further description or discussion of additional horticultural characteristics for the cultivars evaluated in the NE-183 Regional Project. It can be concluded however, that no one cultivar stood out as superior in all horticultural or fruit quality characteristics measured when averaged across all locations. The project does demonstrate the significant effect that the interaction of cultivar and location can have on apple cultivar performance. In addition, the results support the need for widespread systematic testing of new apple cultivars across many locations in order to ascertain performance under different soil and climatic conditions. Cultivars that have received high ratings by cooperators attending the annual NE-183 meetings when all characteristics have been considered include: 'GoldRush', 'Golden Supreme', 'Shizuka', 'Cameo', and 'Honeycrisp' in the 1995 planting and 'September Wonder Fuji', 'Ambrosia', 'Crimson Crisp' (Co-op 39), and 'Hampshire' in the 1999 planting.

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Table 1. Locations and cooperators in the NE-183 Regional Project "Multidisciplinary Evaluation of New Apple Cultivars" with plantings who supplied data for this report. All plantings were designated horticultural plantings except the WVP site (see text).

Location		Cooperator	Planting Location
(AR)	Arkansas	C. Rom	Fayetteville
(BC)	British Columbia	C. Hampson	Summerland, Canada
(MA)	Massachusetts	D. Greene, J. Clements	Belchertown
(ME)	Maine	R. Moran, J. Schupp	Monmouth
(NJ)	New Jersey	W. Cowgill, R. Belding, B. Tietjen	Pittstown
(NYG)	New York	S. Brown	Geneva
(NYH)	New York	J. Schupp, E. Stover	Highland
(NYI)	New York	I. Merwin	Ithaca
(NC)	North Carolina	J.D. Obermiller, M. Parker, C.R. Unrath	Fletcher
(OH)	Ohio	D. Miller, D.Ferree	Wooster
(ONT)	Ontario	J. Cline	Simcoe, Canada
(OR)	Oregon	A. Azarenko	Corvallis
(PAB)	Pennsylvania	G. Greene	Biglerville
(PAR)	Pennsylvania	R. Crassweller	Rock Springs
(VT)	Vermont	E. Garcia, L. Burkett	Burlington
(WA)	Washington	B. Barritt	Wentachee
(WI)	Wisconsin	T. Roper	Sturgeon Bay
(WV)	West Virginia	S. Miller	Kearneysville
(WVP)	West Virginia, Pest	S. Miller, A. Biggs, H. Hogmire	Kearneysville

Table 2. Apple cultivars and selections evaluated for horticultural quality and selected sensory characteristics in the NE-183 "Multidisciplinary Evaluation of New Apple Cultivars" Regional Project.

1995 Planting	
Arlet (Swiss Gourmet)	GoldRush (originally Co-op 38)[z]
Braeburn	Honeycrisp
Cameo (originally Carousel)	NY75414-1[z]
Creston (originally BC8M15-10)	Orin
Enterprise (originally Co-op 30)[z]	Pristine (originally Co-op 32)[z]
Fortune (originally NY 429)	Sansa
Fuji Red Sport #2	Senshu
Gala Supreme	Shizuka
Ginger Gold	Suncrisp (originally NJ 55)
Golden Delicious, Gibson strain	Sunrise
Golden Supreme	Yataka Fuji
1999 Planting	
Ambrosia	September Wonder Fuji
Autumn Gold	NJ 109
BC 8S-26-50	NJ 90
Chinook	NY65707-19[z]
Corail (Pinova)	NY79507-49[z]
Crimson Crisp (originally Co-op 39)[z]	NY79507-72[z]
Cripps Pink (Pink Lady®)	Runkel
CQR10T17[z]	Scarlet O'Hara (originally Co-op 25)[z]
CQR12T50 (Princess)[z]	Silken
Delblush	Sundance (originally Co-op 29)[z]
Golden Delicious	Zestar™
Hampshire	

[z] Scab resistant cultivar or selection

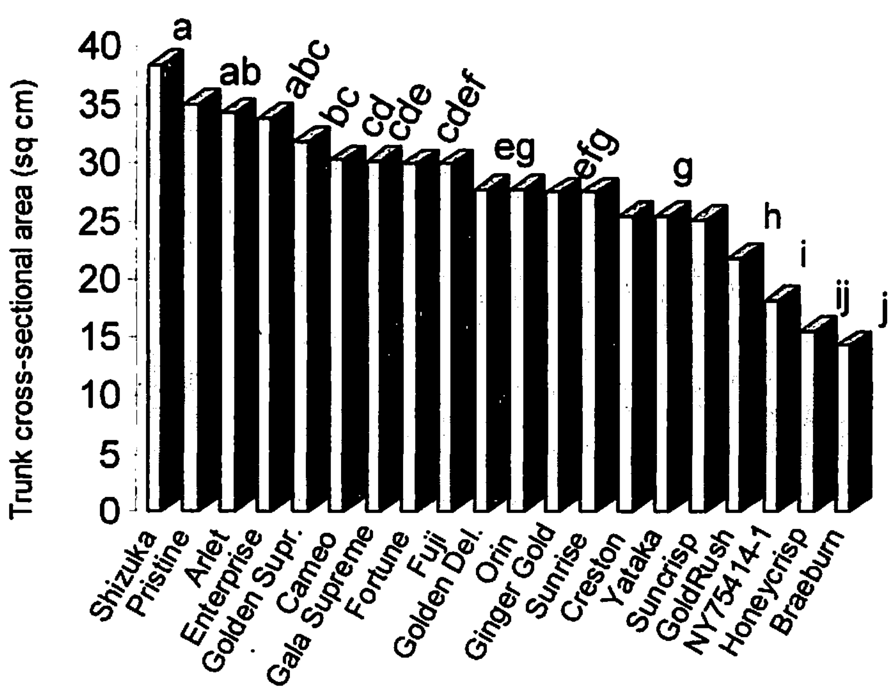
Table 3. Mean full bloom date for 20 apple cultivars or selections across 15 locations in the 1995 NE-183 Regional Project planting[z].

Mean Full Bloom Date[y]	Cultivar(s)
27 April	Arlet
28 April	Orin, Sunrise, Pristine, NY75414-1
29 April	Braeburn, Ginger Gold, Yataka, Creston
30 April	GoldRush, Shizuka, Fuji
1 May	Fortune, Enterprise, Golden Delicious, Cameo
2 May	Gala Supreme, Honeycrisp, Suncrisp, Golden Supreme

[z] Data for table obtained from Crassweller et al., 2005

[y] Date when 90% of spur blossoms are open.

Fig. 1. Trunk cross-sectional area for 20 five-year-old apple cultivars across 15 planting sites in the 1995 NE-183 Regional Project planting. Vertical bars followed by the same letter(s) are not significantly different by t test at the 5% level. Some bars in the middle range are not labeled simply for clarity of the graph.



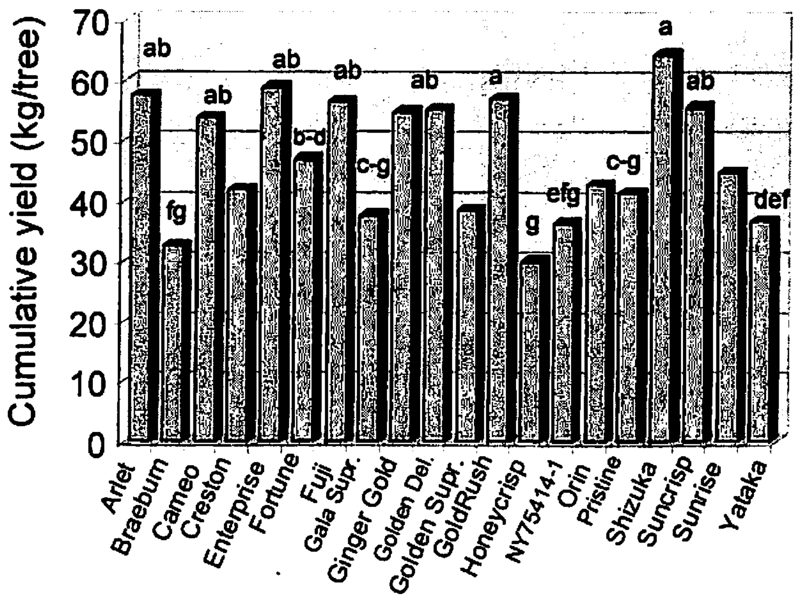


Fig. 2. Cumulative yield of 20 five-year-old apple cultivars planted across 15 locations in the NE-183 Regional Project. Vertical bars with the same letter(s) are not significantly different by t test at the 5% level. Letters omitted from some bars for clarity of the graph.

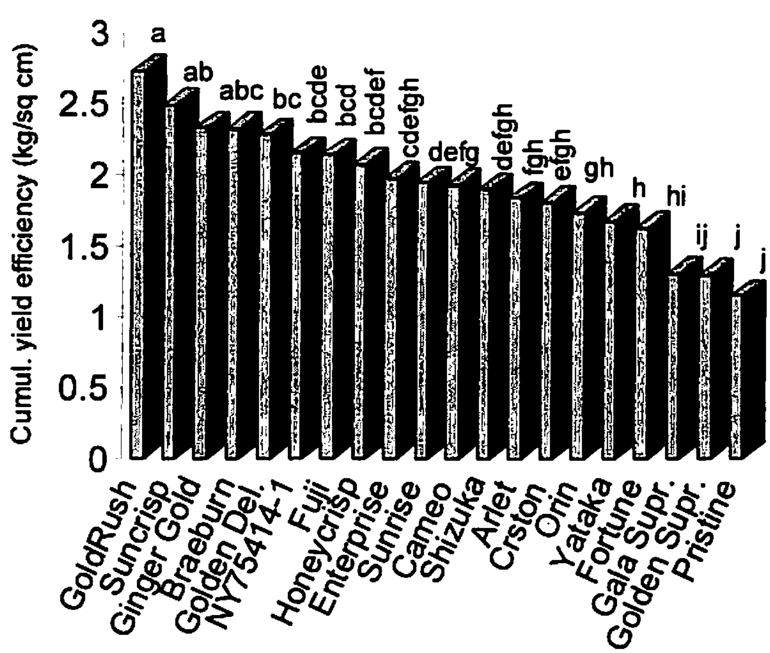


Fig. 3. Cumulative yield efficiency for 20 five-year-old apple cultivars planted across 15 locations in the NE-183 Regional Project. Vertical bars with the same letter(s) are not significantly different by t test at the 5% level.

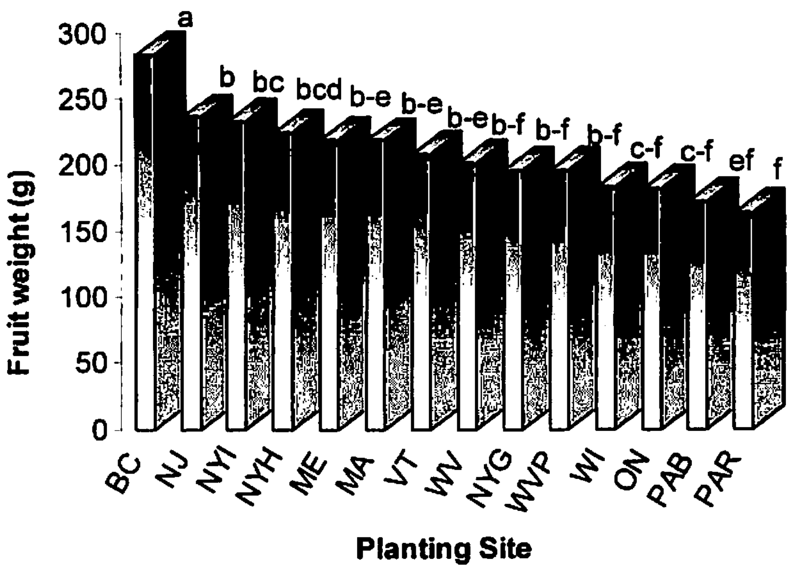


Fig. 4. Effect of planting location on the average fruit weight of 'Braeburn' and 'Golden Delicious' apples across 14 locations in the NE-183 Regional project. Vertical bars with the same letter(s) are not significantly different by t test at the 5% level. After C. Hampson et al., 2004.

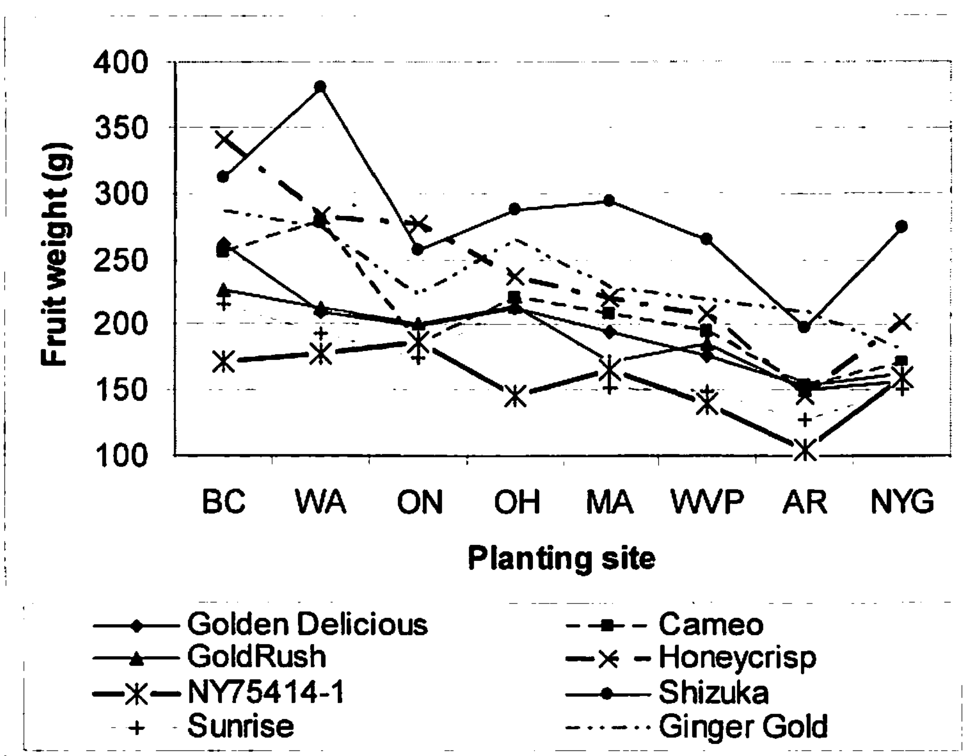


Fig. 5. Interaction of cultivar and planting location for fruit weight for eight Cultivars among eight locations within the 1995 NE-183 Regional Project plantings. For clarity only a portion of the 20 cultivars and 19 locations is presented. From, Miller and McNew, 2005.

Table 4. Generalized least-squares means for 19 apple cultivars for average soluble solids concentration across 14 planting sites and titratable acidity at six planting sites in the NE-183 Regional Project.

Cultivar	Soluble solids (%)	Titratable acidity (%)
Braeburn	13.4 gh[z]	0.75 cd
Golden Delicious	15.2 a	0.63 fghi
Arlet	14.1 cde	0.73 cde
Creston	13.6 efgh	0.58 ghij
Cameo	14.2 cde	0.61 ghij
Enterprise	14.6 b	0.73 cde
Fuji	14.5 bc	0.46 kl
Gala Supreme	15.6 a	0.67 defg
Ginger Gold	13.0 hi	0.51 ijkl
Golden Supreme	13.5 fgh	0.53 jk
GoldRush	15.5 a	0.99 a
Honeycrisp	13.3 h	0.78 c
Fortune	13.9 defg	0.72 cdef
NY 75414-1	14.0 cdef	0.80 c
Orin	14.4 bcd	0.41 l
Pristine	12.4 i	0.91 b
Shizuka	14.0 cdef	0.57 hij
Suncrisp	14.7 b	0.79 c
Sunrise	12.6 i	0.65 efgh
Mean	14.0	0.67

[z] Means followed by the same letter(s) are not significantly different by t-test at the 5% level.

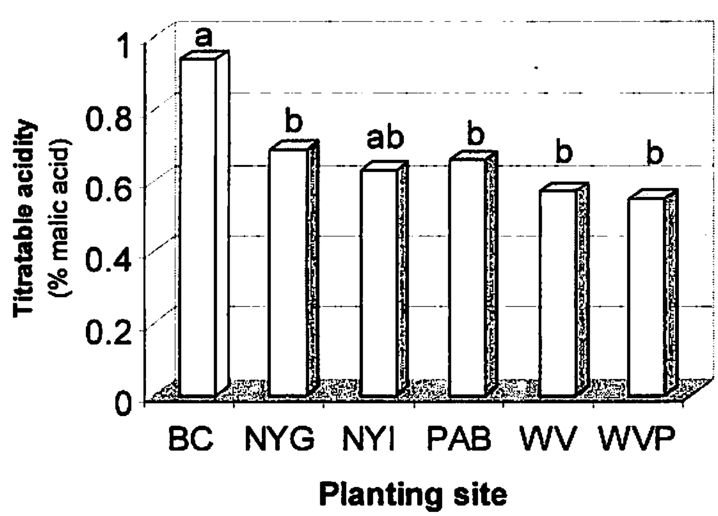
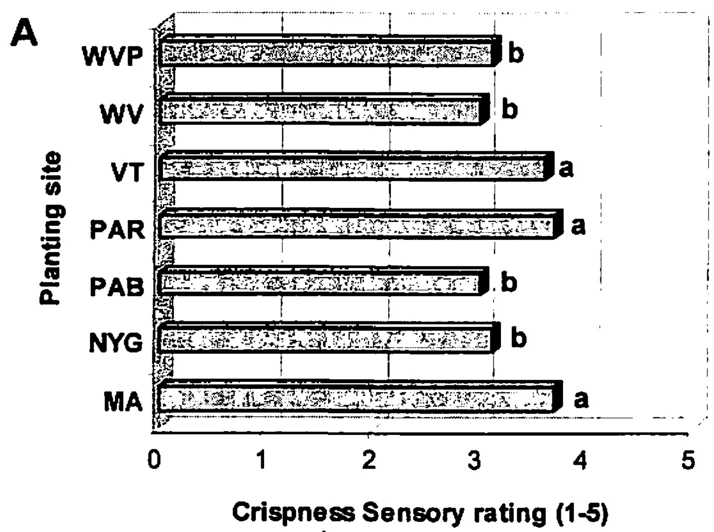
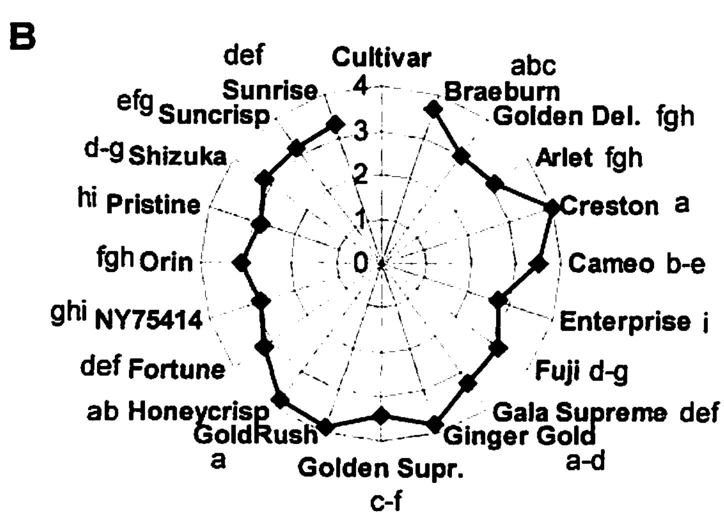


Fig. 6. Effect of planting site on mean titratable acidity for 19 apple cultivars in the NE-183 Regional Apple Evaluation Project. Vertical bars with the same letters are not significantly different at the 5% level by t-test.

Fig. 7. Effect of planting site (A) and cultivar (B) on apple flesh crispness rating for 19 cultivars and seven planting sites in the NE-183 Regional Project. Sensory rating on a 5-point unipolar intensity scale where 1 = not crisp, 3 = crisp, and 5 = extremely crisp. Horizontal bars or cultivar names with the same associated letters are not significantly different by t test at the 5% level. From Miller and McNew, 2005.





Disease Resistance and Susceptibility of Apple Cultivars in the NE-183 planting

(The good, the bad, and the ugly)

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My interest in apple disease resistance began when I was working on scab in graduate school at Michigan State. At that time I was aware that there had been a 20-year effort to breed scab-resistant varieties but that the available resistant varieties really didn't have very good horticultural quality. I had heard that better varieties were coming available that would have resistance to several diseases which should allow more reduction in fungicide use. At Winchester in 1991, with Ross Byers, we established a planting of scab resistant varieties specifically to test for ones that also resist mildew and rusts and might have processing potential (5, 6). We became interested in the new Regional Project NE-183, Multidisciplinary Evaluation of New Apple Cultivars when it was in the planning stages in 1993.

The NE-183 project is composed of 28 plantings located in 21 states from Georgia to Maine and Washington State and Ontario and British Columbia, Canada. The first project planting was established in 1995. Ours is one of eight '95 plantings directed at disease evaluation. A varietal selection committee chaired by Duane Greene selected the cultivars for the 1995 NE-183 planting which includes Cultivars in the 1995 NE-183 Planting: Arlet, , Cameo, Creston, Enterprise, Fortune, Fuji Red Sport #2, Gala Supreme, Ginger Gold, GoldRush, Honeycrisp,* NY 75414-1, Pristine Orin, Sansa, Senshu, *Shizuka, *Suncrisp. *Sunrise, and Yataka. Standards for disease susceptibility and horticultural qualities included Pioneer Mac, Braeburn and Golden Delicious. The group includes ones representing a range of ripening from early August to late October. Trees were custom bud grafted by ACN, Inc. in 1993. Four of the varieties were known to be scab resistant: Enterprise, Goldrush, Pristine, and NY 75414-1. All trees were grafted onto M.9 rootstock; Golden Delicious, Braeburn and Yataka were also planted on Mark rootstock. Our planting includes four rows with complete replications and a fifth replication across the south end of the four rows. To help stabilize scab pressure we included a Fuji tree between all test trees.

A second planting, established in 1999, included these cultivars, eight of which were known to be *scab resistant: Ambrosia, Autumn Gold, BC 8S-26-50, Chinook *Crimson Crisp, (Coop 39), *CQR10T17, *CQR12T50 (Princess) Delblush, Golden Delicious, Hampshire, September Wonder Fuji (Jubilee Fuji), NJ 109, NJ 90, *NY 79507-49, *NY 79507-72, Cripps Pink (Pink Lady ®), Runkel, Silken, *Sundance (Coop 29), Zestar!™, NY 428, Corail (Pinova), *NY 65707-19, *Scarlet O'Hara (Coop 25). We included the cultivars of local interest, Red Yorking and Ramey York. To help stabilize scab pressure we planted a Ramey York tree between all test trees.

A general protocol was established to be followed for all of the NE-183 disease plantings. Minimal early pruning was done to allow the natural tree structure to be expressed. We also used a minimal spray program as needed to maintain tree growth. This included a light fungicide application either very early in the season or in mid-season after scab started to appear in the trees. We have used insecticides as needed to avoid serious pest problems that would have reduced tree growth. At Winchester, we protected the trees from fireblight with streptomycin and have not lost a single tree in the '95 planting, although we frequently inoculate adjacent fire blight test blocks.

Basis for disease rankings: The discussion of disease susceptibility presented here is based on individual rankings mostly from field data collected at Winchester. Some data were included from other sites (eg. Dave Rosenberger's, '01-02 cedar-apple rust data from plots in the Hudson Valley). Fruit disease data were taken near harvest. To establish rankings we used equal weighting for early season and late season diseases. Early season included scab, mildew and rusts and late season were Brooks spot, sooty blotch, flyspeck and rots. Thus, for the '99 planting rankings, the scab ranking is mean of rankings for % leaves infected in 2000-03 and % fruit infected '01-03; mildew is based on % leaves infected '00-03. Rust rankings were based on per cent leaves (cedar-apple rust) or fruit infected (quince rust) with equal weighting of '00-03 data from Winchester, and '01-02 data from Hudson Valley. All '99 planting summer disease rankings based on disease incidence at Winchester '01-03.

Table 1. Top ten mean rank order, early season or summer diseases NE-183 '95 planting, Winchester, VA

	Top 10 mean rank order, early season diseases						Top 10 mean ranking order, summer diseases				
	Scab	Mildew	C-apple rust	Quince rust	Mean ranking		Brooks spot	sooty blotch	fly speck	rots	Mean ranking
NY 75414-1	1	1	1	5	2.0	Pristine	1	1	2	1	1.3
Gala Supreme	4	2	1	8	3.8	Sansa	5	3	1	2	2.8
Enterprise	1	3	1	13	4.5	Sunrise	6	2	4	4	4.0
Pristine	1	5	15	1	5.5	Honeycrisp	1	6	6	6	4.8
Sunrise	14	6	1	6	6.8	Arlet	7	4	5	5	5.3
Sansa	1	4	8	19	8.0	NY 75414-1	1	5	12	8	6.5
Suncrisp	11.5	22	1	3	9.4	Pioneer Mac	1	10	15	2	7.0
Orin	11.5	16	10	2	9.9	Golden Supreme	9	7	9	16	10.3
Pioneer Mac	14.5	21	1	6	10.6	Fortune	6	9	17	9	10.3
Yataka	19.5	7	11	8	11.4	Ginger Gold	10	8	8	17	10.8

Means weighted equally for early season or all summer disease rankings.

Table 2. Top ten mean rank order, early season or summer diseases NE-183 1999 planting, Winchester, VA

	Top 10 mean rank order, early season diseases						Top 10 mean rank order, summer diseases				
	scab	mildew	VA / NY c-a rust	quince rust	Mean ranking		Brooks spot	sooty blotch	fly speck	rots	Mean ranking
NY 79507-72	1	7	1	16	6.3	September Wonder Fuji	1	9	10	1	5.3
Sundance (Coop 29)	1	23	1	1	6.5	NY 79507-72	15	2	5	4	6.5
NY 65707-19	1	4	5	18	7.0	NJ 90	1	6	14	6	6.8
NY 79507-49	1	10	3	14	7.0	NY 79507-49	1	12	6	8	6.8
BC-8S-26-50	9	5	12	13	9.8	CQR10T17	1	7	13	13	8.5
Scarlet O'Hara (Coop 25)	1	8	23	7	9.8	McIntosh	1	14	18	1	8.5
Hampshire	24	6	7	4	10.3	NJ 109	21	3	2	12	9.5
Runkel	14	16	8	5	10.8	Crimson Crisp Coop 39	23	5	4	7	9.8
Red Yorking	17	14	14	1	11.5	Zestar (MN 1824)	18	1	1	19	9.8
Corail (Pinova)	11	20	11	6	12.0	BC-8S-26-50	1	4	23	23	10.0

Mean rankings weighted equally for early season or all summer disease rankings.

Table 3. Top ten overall mean disease ranking order, for cultivars in the NE-183, 1995 and 1999 plantings, Winchester, VA

	1995 NE-183 planting				1999 NE-183 planting		
	Early season	Summer disease	Overall mean		Early season	Summer disease	Overall mean
Pristine	5.5	1.3	3.4	NY 79507-72	6.3	6.5	6.4
NY 75414-1	2.0	6.5	4.3	NY 79507-49	7.0	6.8	6.9
Sunrise	6.8	4.0	5.4	September Wonder Fuji	12.3	5.3	8.8
Enterprise	4.5	11.0	7.8	NY 65707-19..................	7.0	12.5	9.8
Honeycrisp	11.5	4.8	8.2	BC-8S-26-50	9.8	10.0	9.9
Arlet	11.6	5.3	8.5	NJ 90	13.0	6.8	9.9
Pioneer Mac	10.6	7.0	8.8	Hampshire	10.3	11.0	10.7
Gala Supreme ...	3.8	16.0	9.9	Scarlet O'Hara (Coop 25)	9.8	11.8	10.8
Golden Supreme	12.5	10.3	11.4	McIntosh	14.3	8.5	11.4
Fortune	13.3	10.3	11.8	Zestar (MN 1824)	13.0	9.8	11.4

Early season and summer disease rankings equally weighted to give overall mean ranking for each planting.

Table 4. Summer disease incidence on NE-183 cultivars in relation to harvest date and accumulated wetting hours*, Winchester, VA

1999						2000						2001					
Cultivar	harv. date	wet hours	sooty blotch	fly speck	rots	Cultivar	harv. date	wet hours	sooty blotch	fly speck	rots	Cultivar	harv. date	wet hours	sooty blotch	fly speck	rots
Pristine	7/29	290	0	0	0	Pristine	7/17	489	26	12	0	Pristine	7/24	462	0	0	0
Sunrise	8/12	307	0	0	0	Sunrise	8/3	646	54	12	2	Sunrise	8/7	572	1	0	0
Ginger Gold	8/16	321	0	0	0	Ginger Gold	8/11	721	100	18	34	Ginger Gold	8/29	718	43	31	2
Sansa	8/18	325	0	0	0	Sansa	8/11	721	20	1	1	Sansa	8/29	718	13	3	0
Arlet	8/30	419	0	0	0	Arlet	8/21	768	37	1	0	Arlet	8/29	718	16	7	0
Honeycrisp	8/30	419	0	0	0	Honeycrisp	8/21	768	71	17	15	Honeycrisp	8/29	718	58	11	2
Golden Sup.	9/8	489	8	2	0	Golden Sup.	8/21	768	83	12	12	Golden Supreme	8/29	718	14	18	6
NY 75414-1	9/9	498	0	0	0	Fortune	9/5	912	100	98	30	NY 75414-1	9/12	796	22	38	0
Pioneer Mac	9/9	498	6	2	0	NY 75414-1	9/5	912	93	73	12	Pioneer Mac	9/12	796	66	52	0
Senshu	9/15	533	48	30	0	Senshu	9/5	912	100	81	13	G. Delicious	9/19	830	99	48	38
Yataka	9/27	609	24	14	0	Pioneer Mac	9/5	912	100	76	1	Senshu	9/19	830	98	85	15
Creston	9/27	609	38	20	0	G. Delicious	9/8	936	100	78	46	Yataka	9/26	878	100	77	18
Fortune	9/27	609	20	0	2	Braeburn	9/29	1088	100	34	12	Creston	9/26	878	90	25	36
G. Delicious	10/1	653	52	10	26	Yataka	9/29	1088	100	39	31	Gala Supreme	9/26	878	93	63	2

Averages of five replications. * Accumulated wetting hours as rainfall or dew recorded by maximum humidity readings on a hygrothermograph with accumulation starting ten days after petal fall 10 May (1991), 29 Apr (2000), and 8 May (2001).

1995 planting, top ten mean ranking order
Several cultivars stand out as highlights in the mean rankings from the 1995 planting (Table 1). Some cultivars ranked high because of their resistance to scab but were highly susceptible to others. Examples are Pristine's #15 ranking for cedar-apple rust, meaning it would require protection from rust if grown in rust-prone areas, although it is resistant to scab, mildew and quince rust. Similarly, Enterprise ranked high from its resistance to scab, mildew, and cedar-apple rust, but would require special protection (or after-infection control) for its #13 ranking for quince rust. Although Suncrisp ranked 7th overall for early season diseases, it has a weakness for powdery mildew. Pristine and Sunrise ranked high for many summer diseases, benefiting from their early ripening (mid to late July, Table 4) which often allowed them to escape many of the summer diseases before enough wetting hours accumulated to permit infection by sooty blotch, flyspeck and rots. It is no surprise that the combination of Pristine's immunity to scab and strong resistance to mildew and quince rust, combined with this early ripening escape from summer diseases would rank it at the top of the list overall for the 1995 planting (Table 3). In spite of Honeycrisp's drawbacks as a cultivar for the mid-Atlantic region and farther south, we must credit with some surprising resistance features to scab and Brooks spot, although it is quite susceptible to rots. It is interesting to note that in the dry year in 1999 (Table 4), the first ripening eight or ten cultivars escaped sooty blotch, flyspeck and many also the rots; however the following wetter year, with earlier accumulation of wetting hours, none escaped sooty blotch and few escaped flyspeck or rots.

1999 planting, top ten mean ranking order
Scab resistance cultivars again pulled several cultivars to the top of the list in the rankings of the 1999 planting (Table 2). However, several of these showed weaknesses that would require fungicide control in problem areas: Sundance (Coop 29) for mildew (which could likely be handled with sulfur in an organic production effort), quince rust susceptibility by BC 8S-26-50, NY 79507-72, NY 65707-19, and NY 79507-49, and cedar-apple rust susceptibility by Scarlet O'Hara (Coop 25). In spite of these several susceptibilities, NY 79507-72, NY 79507-49, NY 65707-19, BC-8S-26-50, gained high overall rankings because of their scab resistance and one or more summer diseases. An interesting surprise among the thigh overall rankings for the 1999 planting cultivars is September Wonder Fuji which headed the summer disease list because of interesting resistance to Brooks spot and rots (although ripening rather late in the season). This resistance to rots could be a real benefit that should be further explored.

Unusual disease susceptibilities
One purpose for our involvement in this project was to look for unusual problems in new cultivars. An example of this is with Brooks spot which infects fruit at about second cover, a month after petal fall. Cameo had 51% fruit infected with Brooks spot in 1997 while than standard cultivar Golden Delicious had 21%. The following culitvars were not infected: Pristine, Sunrise, Ginger Gold, Honeycrisp, Sansa, Fortune, Pioneer Mac, NY 75414 and Enterprise. In the 1999 planting, the scab-resistant NY 79507-72 and Crimson Crisp (Coop 39) would have otherwise ranked rather high for summer diseases, but showed susceptibility to Brooks spot which is not controlled by sulfur if these cultivars were to be grown in organic production.

Yield characteristics
Dr. Steve Miller, USDA, Bardane, WV, contributed information regarding yield characteristics of the top disease ranking cultivars. While disease resistance may be a useful consideration, horticultural qualities are of primary importance. Among the top cultivators in disease rankings in the '95 planting, Dr. Miller found that Enterprise raked first in 7-year yield totals, 1996-2002. This is particularly important for a potential processing cultivar. Enterprise has turned out to be a relatively grower-friendly tree with good yield and tree structure. One problem that has surfaced with Enterprise is an apparent proneness to how calcium deficiency as a skin spot when growing in low pH soils. This can be corrected by liming and supplemental calcium sprays.
Among the more interesting disease-resistant cultivars in the 1999 planting, Dr. Miller found that NY 79507-49, second in overall disease ranking, ranked fourth in 3-year yield totals (2001-03). September Wonder Fuji, which ranked third in overall disease rankings, chiefly because of reduced rot incidence, was 7th in 3-year yield totals and had only 1.9% fruit drop.

Enterprise and September Wonder Fuji
Dr. Miller describes Enterprise as "large, highly colored; firm and juicy, but not crisp; tart to subacid that improves at late SI, but high soluble solids; tough, chewy skin. The tree is vigorous and spreading,

subject to low soil pH problems; with excellent resistance to fireblight. He describes September Wonder Fuji "as medium sweet and juicy; fine texture; color better than standard Fuji but does not store as well as standard Fuji; vigorous tree.

Other experimental uses for the NE-183 plantings

After completing our fruit disease evaluations in the 1995 planting in 2001, we had opportunity to use this variety planting for several other valuable varietal comparisons. In 2002 we compared the copper sensitivity using the new formulation, Cuprofix. In 2003 we duplicated thinning demonstration of the activity of some new combinations with Ross Byers. In 2004 Mark Brown compared stink bug damage among the five replicates of cultivars in the planting.

Considerations for Utilizing Disease Resistance in New Apple Plantings

As the potential values of some of these new cultivars being recognized, here are some considerations for utilizing disease resistance in new apple plantings:

1. Cultivars must have market potential to be of commercial value.
2. Plantings of cultivars with matched resistance to allow a reduction in the fungicide program for the whole block.
3. Planting a cultivar that is highly susceptible to a disease (such as mildew), with a similarly susceptible cultivar in the planting gives more economic incentive to manage that disease better, thereby reducing potential yield losses.
4. Matched plantings of early ripening cultivars may escape some of the summer diseases in drier years.
5. Disease resistance should be utilized to its fullest potential in any effort in organic production.

Expected publications

Early in the diseases evaluation process (1995-97) we had four group publications showing foliar disease susceptibility in Biological &Cultural Tests reports. Numerous other are now as we have completed fruit evaluations for the 1999 planting. Our intention is to have separate publications for both the '95 and '99 plantings for each of these diseases: scab, mildew, rusts / leafspots, sooty blotch / flyspeck, and rots. We hope to publish most of these in *Plant Disease*.

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Cross-Discipline

WHAT IS CAUSING BASAL CANKERS ON APPLE TREES?

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Over the past five years, we have noted with increasing frequency a kind of trunk injury on apples trees that does not fit the description of any known disease. The injury usually occurs at or near ground level and extends 2-8 inches up the trunk from the graft union. Frequently the injury is confined to one side of the trunk (Fig. 1), but in some orchards large numbers of trees are killed after trees become girdled. Bark on roots below the soil line and on the trunk above the cankered area remains healthy. The canker margin is usually rather distinct. In some orchards, cankers are most prevalent on the southwest side of trees, suggesting that winter injury may be involved. However, in other orchards the injury may be more prevalent on the northern side of the trees. In eastern New York, tree losses from this trunk canker are becoming more common than tree losses from fire blight.

Most affected orchards have the following characteristics:

- The orchards are well-managed with a very clean herbicide strip.
- Trees affected are generally more than five years old with trunks at least three inches in diameter.
- Severity of damage is often variety-dependent, with especially severe injury noted on Cortland and Macoun trees.
- Affected orchards have received glyphosate (Roundup or generic equivalents) at least once per year.

We are only now initiating research to determine the causes of this potentially lethal trunk canker. However, we are sharing our observations and our hypothesis concerning the possible cause in order to elicit information about the geographical distribution of this phenomenon and also to promote discussion of factors that might contribute to the development of the basal cankers.

Hypothesis for explaining herbicide-induced trunk cankers: We suspect that basal trunk cankers are caused by *Botryosphaeria dothidea* invading bark that was injured when glyphosate was applied to water-stressed trees.

The following observations explain the basis for this hypothesis. First, the patterns of injury on individual tree trunks and on adjacent trunks within plantings is often consistent with the exposure pattern that would be expected from an herbicide sprayer where the boom is adjusted to provide overlapping coverage across the tree line within the tree row. Second, the injury has been observed in orchards where only glyphosate and gramoxone were applied, so we can rule out residual herbicides as a potential cause. Gramoxone has a longer history of usage than glyphosate, and the trunk canker problem emerged relatively recently and at about the same time that the pricing for glyphosate was dropping and glyphosate usage in New York orchards was increasing. The extremely clean herbicide strips in many of the affected orchards suggest that either multiple applications each year or late-summer applications of glyphosate may be common in the affected blocks.

B. dothidea is known to become aggressively pathogenic in drought stressed trees. Whereas *B. dothidea* is endemic in most older apple orchards where it commonly occurs in superficial bark cankers (Fig. 2A), this fungus also causes necrosis that extends into the inner bark in apple trees that are under drought stress (Fig. 2B). Perhaps glyphosate applied under certain conditions can cause localized desiccation of the bark, thereby predisposing the tissue to subsequent invasion of *B. dothidea*. Finally, if *B. dothidea* is a critical component in canker development, then young trees may escape injury because *B. dothidea* inoculum is less prevalent in young trees and/or because the outer bark may become more susceptible to infection as the tree ages. The observed prevalence of basal trunk cankers on Cortland and Macoun trees might be related to the susceptibility of these cultivars to glyphosate injury and/or to invasion by *B. dothidea.*

Management implications: Drastic changes in ground cover management are not warranted at this time because we still have no experimental evidence proving that glyphosate injury is at the root of the problem. However, if our hypothesis is correct, then the following precautions are worth considering:

1. Glyphosate applications made after July 1st may be more likely to cause injury than those made during May and June because trees are more likely to be under drought stress conditions during summer and fall.
2. If glyphosate is applied during late summer or fall, the lowest effective rate of glyphosate should be used, contact with the tree trunks should be minimized, and sprays should not be applied during periods when trees may be under water stress (i.e., during drought periods or on very hot days).
3. Read glyphosate labels carefully! Many different formulations are currently available, so anyone using 10-yr-old notes when adding glyphosate to their spray tank may be drastically overdosing their trees.
4. When applying glyphosate, always include a drift inhibitor in the spray tank to minimize the potential for unwanted drift of small spray droplets.
5. Glyphosate should never be applied in orchards using controlled droplet applicators (CDA sprayers) because these applicators by definition generate small droplets that are prone to drift.

Summary: Although the cause/effect relationship between trunk cankers and herbicide injury remains to be proven, we suggest that growers avoid applying glyphosate to trees that are under water stress until further investigations can be completed.

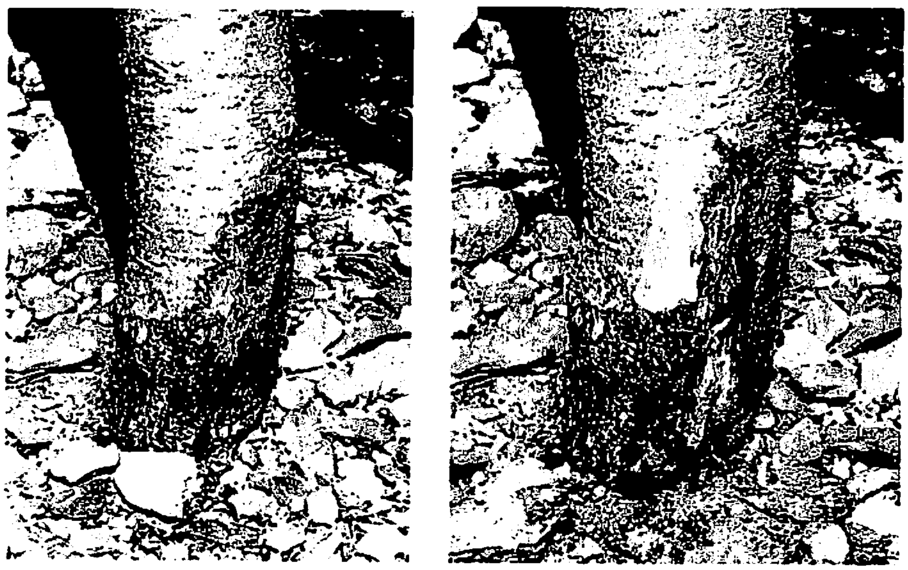

Fig. 1. Example of a basal canker that may be associated with injury initiated by herbicide sprays that contacted the lower part of the tree trunk (left). The same canker with bark removed to show necrosis (right).

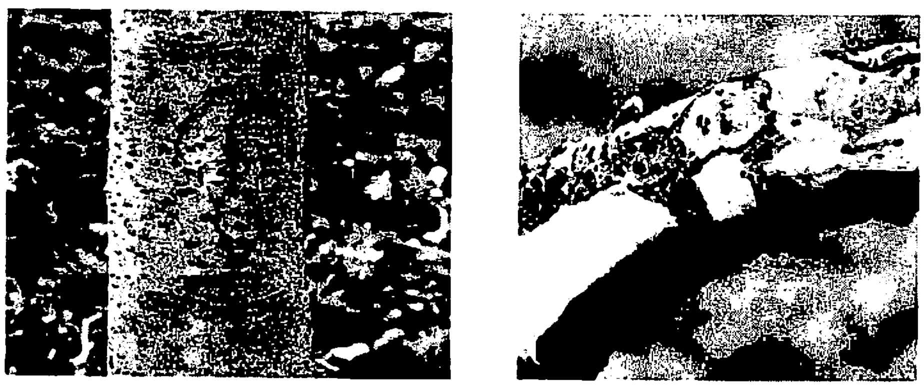

Fig. 2: Superficial cankers caused by *Botryosphaeria dothidea* on trunk (A) and on limb (B), with the latter cut to show necrosis that extends into inner bark.

SURVEY OF POTENTIAL PIERCE'S DISEASE VECTORS IN NORTH CAROLINA VINEYARDS

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Introduction

Pierce's disease is caused by the bacterium *Xylella fastidiosa*. The *X. fastidiosa* bacteria are xylem limited in grape vines and are vectored mainly by insects in the Homopteran family, Cicadellidae, otherwise know as sharpshooters. Since temperatures below 5° C cause *X. fastidiosa* populations to decline in grape vines, the geographic range of Pierce's disease (P.D.) appears to be limited to the most southern states and parts of southern California (Feil and Purcell, 2001). Southeastern sections of North Carolina were considered to be the northern most range of this disease, with most of North Carolina to be considered at low risk for Pierce's disease infections (Hoddle 2004).

A survey conducted by Turner Sutton in 2000 of North Carolina vineyards indicated that the geographic range of P.D. was more northern then previously thought (Harrison et al, 2002). Vineyards located in counties next to the Virginia boarder had vines that tested positive for *X. fastidiosa* and showed the typical symptoms of P.D. infections. The only vineyards not testing positive for PD were the higher elevation orchards in the northwest area of the state. Since no research had been conducted on potential PD vectors in North Carolina vineyards, a study was undertaken in 2002 and 2003 to determine which sharpshooter vectors were present in and around vineyards.

Methods and Materials

Three vineyards were monitored in 2002 and 2003. All of the vineyards, except one, had vines that tested positive for Pierces disease. Survey methods included 15.24 x 30.48 centimeter yellow sticky traps placed in the vineyard. Sweep net samples were also taken from vegetation on the vineyard floor and vegetation surrounding the vineyard. Vegetation samples around the vineyard were divided into understory (honeysuckle, seedlings, wild grape), mature trees, blackberries, pine trees, annual weeds, and ditch banks.

Monitoring vineyards began in May in 2002 and April in 2003. Traps were collected approximately every 2 weeks. Traps were covered with cellophane wrap prior to transport to prevent contamination. Sweep net samples were taken on the same days traps were replaced

Results.

Numerous sharpshooters were captured in sweep net samples but very few were also found on sticky traps. One sharpshooter, *Graphocephala versuta,* was consistently captured in higher numbers in sweep net and sticky trap samples (Figure 1). Overwintering adult *G. versuta* sharpshooters were detected as early as April in all of the vineyards. The decline in May/June indicates the end of one generation while the increase in July is the emergence of the next adult generation.

Paraphlepsius irroratus was another sharpshooter that was commonly found on sticky traps, although in much lower numbers then *G. versuta. P. irroratus* populations appeared to peak in June when *G. versuta* populations were at their lowest. *P. irroratus* were the only sharpshooter on the sticky traps that was also commonly found in sweep net samples of the vineyard floor.

A sweep net survey of the vegetation in and around the vineyard yielded some interesting data (Figure 2). *G. versuta* were found primarily on blackberries, however significant populations were also found on understory vegetation, including hardwood seedlings, honeysuckle, and wild grape. To a lesser extent, *G. versuta* were also found on taller weeds like horseweed and ragweed. *G. versuta* were rarely found along mowed ditch banks even though several broadleaf weed species were present, and were also rarely found on the vineyard floor and mature trees. No sharpshooters were ever found on pines.

Both *G. versuta* and *P. irroratus* are known disease vectors, although neither sharpshooter has been a confirmed vector of Pierce's disease (Pooler 1997, Chiykowski 1988). *G. versuta* is known to transmit the *X. fastidiosa* bacteria to peach trees, causing phony peach disease (Ball 1979). Research conducted in Washington D.C. found almost 25% of *G. versuta* captured carried X. fastidiosa bacteria (Pooler 1997).

The importance of *G. versuta* as a P.D. vector is two fold. If *G. versuta* is like other known vectors of P.D., then once the adult has acquired the *Xyllela fastidiosa* bacteria, the insect retains the bacteria for the rest of its life (Hill 1995). Second, *G. versuta* adults are active in the spring of the year when buds break dormancy. It has been shown that early season infections lead to more dramatic symptoms and higher percentages of vine loss than late season infections (Goodwin and Purcell 1992). Since we are not finding glassy winged sharpshooters, an important late season vector, early season vector control may be critical to prevent the spread of *X. fastidiosa* in North Carolina vineyards.

According to research, vegetation surrounding these vineyards, such as blackberries, are wild hosts for *Xylella fastidiosa* (Hopkins 1988). Elimination of these wild hosts around the vineyard may be an important factor in reducing Xylella inoculum while eliminating alternative hosts for its vectors.

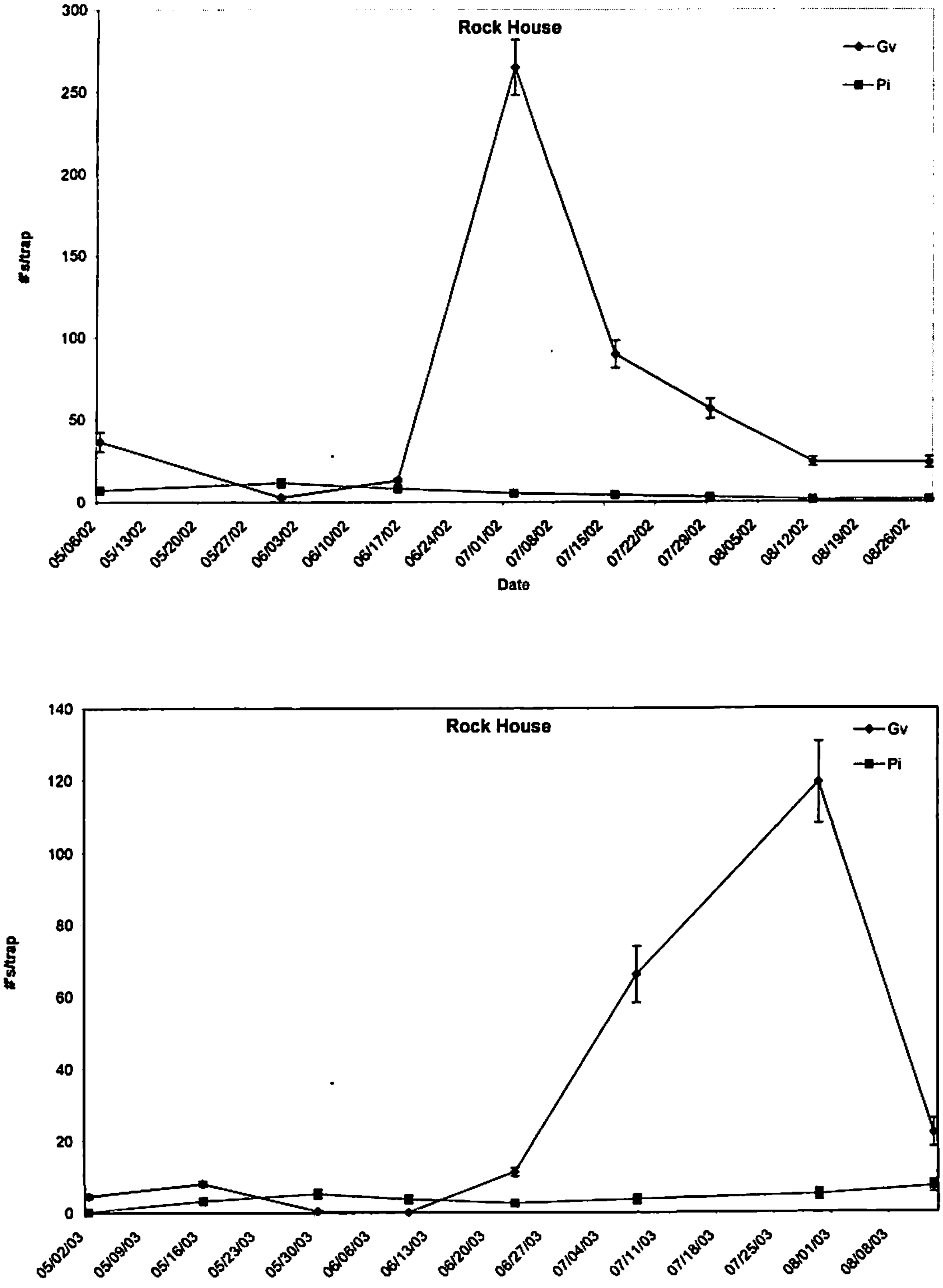

Figure 1. Typical population trends for Graphocephala versuta and Paraphlepsius irroratus in one vineyard in 2002 and 2003.

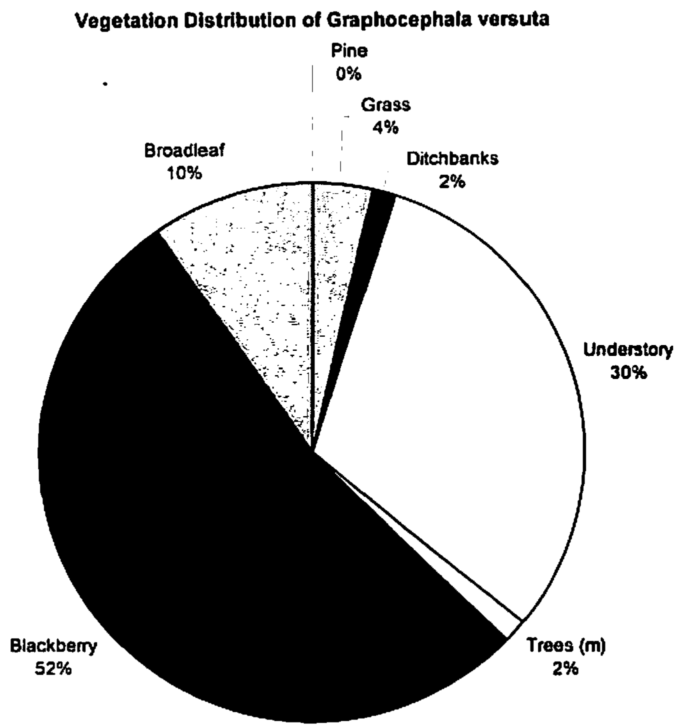

Figure 2: Percentages of *Graphocephala versuta* found in sweep net samples base upon type of vegetation.

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Entomology

REFINEMENT OF BIO-BASED APPROACHES TO REDUCING INSECTICIDE USE AGAINST PLUM CURCULIO AND APPLE MAGGOT - 2004

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This trial was conducted in mixed plantings of fresh and processing apples on two commercial farms in Wayne County, NY, in cooperation with researchers overseeing and additional 22 similar plots in the six New England states as part of a Univ. of Massachusetts USDA NE Regional IPM project initiated by Ron Prokopy in 2003. The field trials conducted in 2004 constituted the first year of a 2-year validation and demonstration of the effectiveness of the following advanced-level IPM tactics in commercial orchards:

1 - For plum curculio (PC), an optimal trap tree approach to determine need and timing of insecticide use against PC in comparison with existing approaches based on calendar-driven sprays or heat-unit accumulation models.

2 - For apple maggot (AM), an orchard-architecture-based ranking system for deploying odor-baited pesticide-treated spheres for direct control of AM in comparison with existing approaches to AM control based on calendar-driven sprays or monitoring-trap-capture-driven sprays.

Materials & Methods

Three non-replicated treatments were set up in plots 1.3–1.9 A in size at each of two commercial farms in the following varieties: Rome and Ida Red (Peters, Williamson); and Empire (Perkins, N. Rose). Plots were chosen so as to be adjacent or in proximity to a woods or hedgerow along at least one border. Plot A was designated as the "Conventional" treatment, Plot B as "1st-Level IPM", and Plot C as "Advanced-Level IPM". Treatment protocols were as follows:

Plot A: For PC, a petal fall plus two cover sprays of phosmet to the entire plot on a 10–14-day schedule. For AM, 3 applications of phosmet to the entire plot at mid-July, early August and mid-August.

Plot B: For PC, a petal fall application of phosmet to the entire plot followed by 2 more applications, the first 10–14 days after petal fall; and the second based on the heat-unit accumulation model of Reissig et al. (1998) requiring insecticide protection until 340 DD (base 50°F) after petal fall.

Plot C: For PC, a petal fall application of phosmet to the entire plot followed by subsequent applications of phosmet only to perimeter-row trees, contingent on incidence of fresh PC oviposition injury on an odor-baited "trap tree" located in the middle of the perimeter row closest to the woods or hedgerow area adjacent to the plot. For AM, deployment of odor-baited pesticide-treated spheres on perimeter trees of all four sides of the plot, as a substitute for insecticide sprays. Distance between the pesticide-treated spheres on the perimeter rows was determined for each orchard based on an 'AM damage potential' index that ranks 4 environmental factors: tree size, quality of pruning, varietal susceptibility, and nature of bordering habitat.

All insecticide sprays were applied by the grower cooperators. Each of the PC trap trees was baited by hanging 4 vials containing benzaldehyde (a component of ripening fruit shown to be attractive to PC) and one membrane dispenser containing grandisoic acid (a component of the boll weevil mating pheromone shown to be attractive to PC) within 30" of the center of the tree canopy, within 3 days of petal fall. On the same date, 25 fruit clusters on each trap tree containing a king and 4 lateral fruits were tagged with flagging tape and numbered so as to facilitate repeated inspections of the same fruits for evidence of fresh PC oviposition injury. These inspections were conducted twice per week for 5 weeks until 23 June, or slightly past the 340 DD cutoff date. On 8 July, final midsummer PC injury was assessed in all plots by inspection of 10 fruits on each of 10 trees in each of the first 9 rows of each plot from the woods edge.

For AM, pesticide-treated spheres (PTS) were hung in the perimeter rows of Plot C at each farm on 7–8 July. Each PTS consisted of an apple-red hollow plastic sphere approximately 8.2 cm (3 1/4") in diameter with a contoured compressed top cap paraffin wax and wire mesh matrix containing sugar (as a feeding stimulant) and spinosad as the toxicant. This was designed so that any significant rain or dew would produce a coating of the sphere by the sugar+spinosad mixture, to lure and kill any AM flies entering the orchard from outside sources. To determine the inter-sphere distance along the perimeter, the following index was calculated by summing the values (1, 2, or 3, respectively) for each of the following parameters: tree size (large, medium, small); quality of pruning (poor, fair, good); varietal susceptibility to AM damage (high, moderate, low); and bordering habitat (woods, hedgerow, open field or adjacent sprayed orchard). For each site in this study, the index resulted in a total value of:

2 ('medium' tree size) + **2** ('fair' pruning) + **3** ('low' susceptibility) + **1** (woods border) = **8**

According to the guidelines previously established by field research of these parameters, this value when applied to the protocol would thus require a distance of 11 m (36 ft) between spheres. The number of PTS used in the individual Plot C's was 37 at Peters and 32 at Perkins; each was deployed together with a vial containing a standard 5-component blend of fruit odor volatiles, affixed to the same hanger wire and above the sphere.

To monitor AM flight progress into the center of the plots, 4 unbaited red sphere traps were hung in trees along a transect through the middle 2 rows of each of the 3 plots at both sites; these were inspected twice weekly and cleaned of any AM and non-target flies, from 20 July to 16 Sept.

Immediately before the respective harvest dates at the two sites (23 Sept., Perkins; 11 Oct., Peters), final fruit damage was assessed by randomly picking 100 fruits per row (10 fruits from each of 10 trees) in each of the first 9 rows of each plot, and visually inspecting them for damage caused by plum curculio, apple maggot, obliquebanded leafroller, and tarnished plant bug. Mean percent damage levels were transformed by arcsine square root and treatment means separated using ANOVA and Fisher's lsd test ($P = 0.05$).

Results

Plum Curculio: No PC oviposition damage was found on any of the tagged fruits on the trap trees at either farm for the entire 5 weeks of fruit inspection after petal fall; therefore, no additional insecticide sprays were advised beyond the petal fall application. The 8 July assessment of PC damage gave the following values:

Peters	Plot A, 0.1% ab	Plot B, 0.0% a	Plot C, 0.8% b
Perkins	Plot A, 0.7% ab	Plot B, 0.6% a	Plot C, 1.6% b

Apple Maggot: Adult trap captures on the unbaited red sphere traps hung inside each of the plots were extremely low during the summer. Only one AM adult was caught on one of the traps at the Perkins site during the entire trapping period, on 11 August (in Plot C). At the Peters site, single adult catches were recorded on the following dates: 30 July (Plot B), 6 August (one each in Plots A and C), and 13 August (Plot C).

Harvest Evaluations: Insect damage was very low in all plots at both sites (Table 1). Apple maggot injury was only nominal overall, and there were no significant differences across any of the treatments. For Plum Curculio, no damage was found at the Peters site, and a small amount at Perkins; in this case, the damage in Plot B (using the DD oviposition model) was significantly higher than in the other two plots. Tarnished plant bug and late-feeding obliquebanded leafroller damage was uniformly low across all treatments at Peters. At Perkins, TPB was significantly higher in the Conventional plot, and late OBLR was higher in the 1st-Level IPM plot. Overall levels of clean fruit were statistically comparable at Peters, and slightly lower in the 1st-Level IPM plot at Perkins.

Table 1. Fruit Harvest Damage Evaluations

	Peters					Perkins				
	Avg. % damaged fruits*					Avg. % damaged fruits*				
Treatment	**AM**	**PC**	**TPB**	**Late**	**Clean**	**AM**	**PC**	**TPB**	**Late**	**Clean**
A (Conventional)	0.0 a	0.0 a	0.0 a	2.0 a	98.0 a	0.1 a	0.1 a	2.2 a	0.0 a	97.7 ab
B (1st-Level IPM)	0.0 a	0.0 a	0.1 a	1.1 a	98.8 a	0.0 a	2.6 b	0.4 b	0.7 b	96.3 a
C (Advanced IPM)	0.7 a	0.0 a	0.0 a	2.1 a	97.2 a	0.0 a	0.0 a	0.8 ab	0.6 ab	98.7 b

(*Values within a column followed by the same letter not significantly different; P=0.05 [Fisher's Protected lsd]).

New England Locations: Population pressure for both AM and PC was substantially greater in the New England field sites than was observed in NY, although there was high variability from one site to the next (Fig. 1). Among the trends noted in these locations were the following:

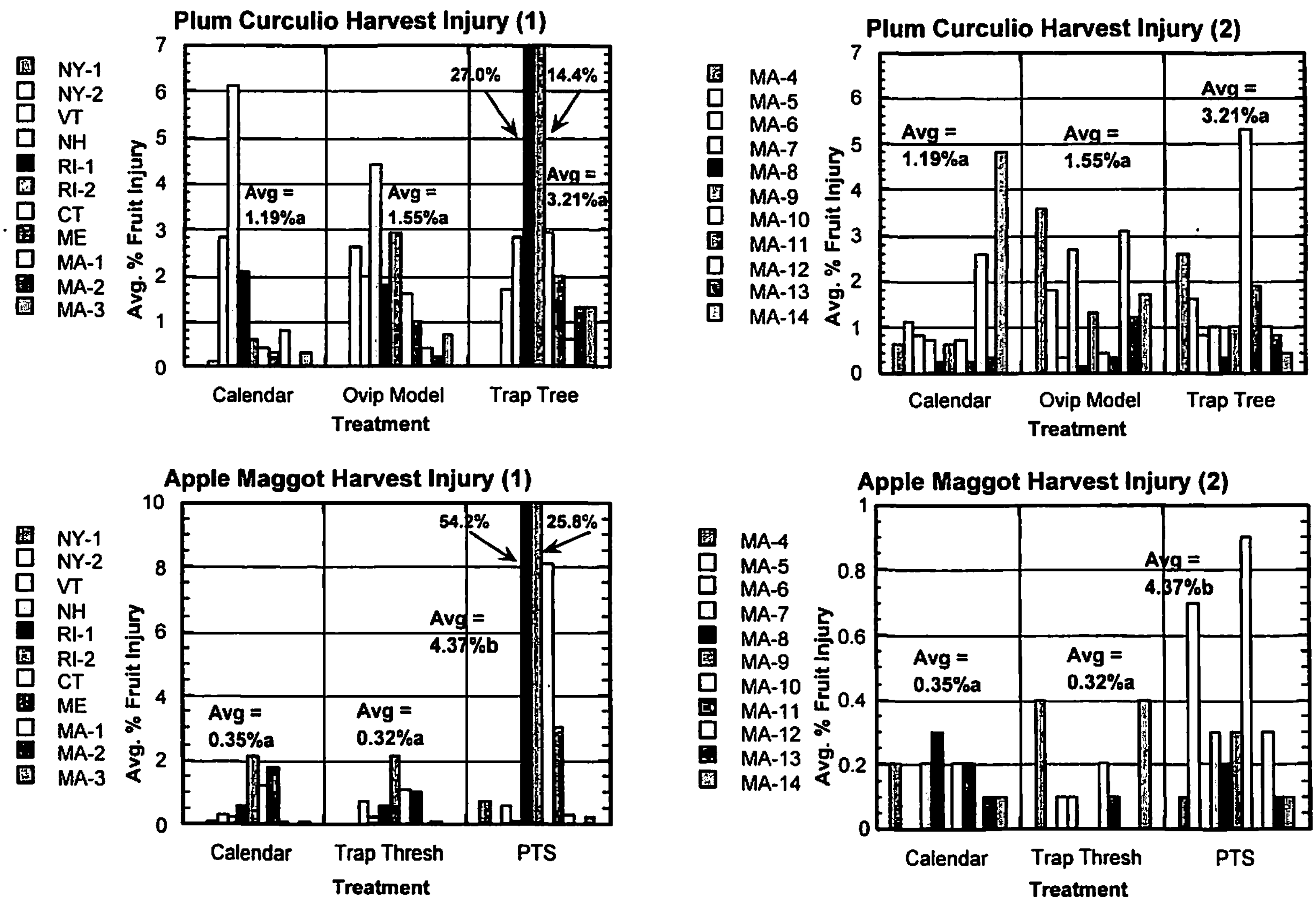
- The "Advanced-Level IPM" plots usually exhibited the higher fruit damage readings at harvest.
- A definite edge effect was noted in the incidence of pest injury, with worse damage occurring generally nearer to the non-orchard habitats adjacent to the plots.
- Because it was not always possible to set up all the plots in plantings of the same variety, a varietal effect was also apparent in several cases; increasing pest susceptibility was seen in the progression from: McIntosh, Red Mac, Cortland, Jonamac, Mutsu, Liberty, to Redfree.

In at least two cases, the Plot C (Advanced-Level IPM) was set up in plantings where there was evidently an indigenous apple maggot population in the orchard. This would explain the poor performance of the pesticide treated spheres in controlling this pest, as a behavioral tactic of this nature would not be expected to be effective in such a case.

Acknowledgments

Thanks are due to Jim Peters and Robert Perkins for the use of their farms; Gowan Co. and Dow AgroSciences for the donation of insecticide products; Starker Wright for providing the pesticide treated spheres; and Jaime Piñero, Kathleen Leahy, Glen Koehler, Heather Faubert, Lorraine Los and Glenn Morin for all of their collaborative advice and guidance.

Fig. 1. Mean fruit damage levels caused by plum curculio and apple maggot in conventional (Calendar), 1st-Level IPM (Oviposition Model or Trap Threshold), and Advanced-Level IPM (Trap Tree or Pesticide Treated Spheres) plots in 22 commercial farms in New England and New York, 2004. Experiment-wise averages are given for each treatment across all sites.



NEW TECHNOLOGY IN HAND-APPLIED PHEROMONE DISPENSERS
FOR ORIENTAL FRUIT MOTH DISRUPTION
2004

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This trial was conducted in mixed plantings of fresh and processing apples on six commercial farms in Wayne and Ontario Counties, NY. A low-density pheromone "bag" dispenser was compared against two types of "twist-tie" dispensers for efficacy in suppressing pheromone trap catches of oriental fruit moth (OFM), *Grapholita molesta*, when applied against the 2nd and 3rd generations of this pest. Apple varieties included Gala, R.I. Greening, Golden Delicious, Red Delicious, Monroe, Ida Red, Empire, and McIntosh.

Materials & Methods

The pheromone bag treatment, termed "MSTRS" technology (Metered Semiochemical Timed Release System, AgBio Inc., Westminster, CO) consisted of food-grade plastic enclosing a 6.4 x 6.4 cm natural fiber pad containing 65.8 g of OFM pheromone (85.4 : 5.5 : 0.9% of Z:E8-12:OAc : Z8-12:OH), which was deployed in a grid pattern at a spacing of 22.9 m (75 ft) between dispensers, resulting in densities between 11–20 per ha (5.2–8.0 per acre). A pole+hoop applicator was used to position the dispensers in the top one-third of the tree canopy; deployment took place from 9–13 July.

The MSTRS dispensers were compared against the following treatments in single-plot replicates ranging in size from 1.2–2 ha (3–5.0 acres):

1 – Isomate M-100 ties (CBC America), applied 16–18 June at a rate of 250/ha (100/acre) at two of the sites: Furber and Trammel (Fig. 1).

2 – Isomate M Rosso ties (CBC America Corp., Commack, NY), applied 16–22 April at a rate of 500/ha (200/acre) at four of the sites: Bartleson, Beckens, Datthyn, and DeBadts (Fig. 2).

Grower standard blocks were used as check plots at each site, and had no pheromone treatments, but received pesticide sprays according to conventional practice. Treatment efficacy in depressing adult male trap catch was monitored by using 3–4 Pherocon IIB traps per plot, each baited with a standard Scentry oriental fruit moth lure, and checked weekly from 9 July to 16 September.

Results

As ease of use and labor requirements are considerations in deciding the type of pheromone dispenser to be used in a particular situation, data were taken on the time and number of people required to deploy the MSTRS dispensers in each plot. This product is used at a certain inter-dispenser spacing rather than a specific per-acre rate, so plot geometry as well as area dictate the total number of dispensers needed per block; density decreases as area increases. The following specifics pertain to the six sites where the MSTRS were deployed in this trial:

Site	Area, A (ha)	Dimensions, ft (m)	No. Applied Total	No. Applied per A (ha)	Time req'd. (worker-min) Total	Time req'd. (worker-min) per A (ha)
Bartleson	5.0 (2.0)	360 x 450 (110 x 137)	26	5.2 (12.8)	40	8.0 (20.0)
Beckens	5.0 (2.0)	216 x 920 (66 x 280)	33	6.6 (16.3)	60	12.0 (30.0)
Datthyn	3.5 (1.4)	294 x 504 (90 x 154)	28	8.0 (20.0)	30	8.6 (21.5)
DeBadts	3.5 (1.4)	273 x 425 (83 x 130)	24	6.9 (17.3)	25	7.1 (17.8)
Furber	5.0 (2.0)	312 x 1512 (95 x 461)	36	7.2 (18.0)	40	8.0 (20.0)
Trammel	3.0 (1.2)	180 x 760 (55 x 232)	22	7.3 (18.3)	25	8.3 (20.8)

Time measurements for hand-applied deployment of the twist-tie OFM dispensers taken in parallel studies have averaged approximately 240 ties/hr/person, or 25 min per A (62.5 min per ha) for the Isomate M-100 dispenser, and 50 min per A (125 min per ha) for Isomate Rosso. The MSTRS time requirements correspond to a ~50–70% reduction over the M-100 ties, and ~75–85% over the Rosso ties.

Pheromone trap catches of OFM adult males in the test sites were lower than they might normally have been, owing to unfavorable cool and rainy weather during July and August. Nevertheless, sufficient numbers of moths were caught in the non-disrupted check plots to indicate the degree of effectiveness of the pheromone treatments in the adjacent plantings. Both the Isomate M-100 and Rosso treatments completely suppressed OFM trap catches in their respective plots for the duration of the study; in 4 of the 6 sites, traps in the MSTRS plots caught 1–2 moths on one or two occasions (Fig. 3).

Because of time constraints resulting from a shipping error at the production facility, the MSTRS dispensers were received without the proper tree-attaching clips, so an arrangement was improvised using rubber bands. Unfortunately, these degraded with the prolonged exposure to sunlight, so a certain proportion (10–20%) of the bags ended up on the ground in most plots by late August or early September, possibly detracting from the degree of pheromone saturation attained in the tree canopy space. Nonetheless, overall treatment efficacy and efficiency of this type of dispenser appears to be high enough to encourage further investigation of opportunities to integrate this type of product into future demonstration-research plots involving OFM mating disruption as one management component.

The principle of using a low-density, high-yield dispenser to disrupt chemical communication between the sexes incorporates elements of both mechanisms of mating disruption as currently proposed—false trail following by the males as they are attracted up the plumes from the bags, coupled with sex pheromone habituation from exposure to the strong doses—which would serve to arrest them in mid-flight. While this approach may be suitable for a species such as OFM, which is relatively easy to disrupt, other studies have shown that species such as codling moth tend to respond better to higher numbers of pheromone point sources, with perhaps greater concentrations on the block edges. Therefore, the utility of the MSTRS design may be best realized against a selected smaller number of pest species.

Acknowledgments
Thanks are due to D. Bartleson, B. Beckens, D. Datthyn, R. DeBadts, T. Furber and K. Trammel for allowing these trials to be conducted on their farms; to Dorothy and Dianne

Mitchell, Rachel Mussack and Rachel Falkey for field assistance in setting up and maintaining the plots, and for T. Baker and J. Meneley (AgBio, Inc.) for arranging to provide the dispensers.

Fig. 1. Plot details of two of the six sites where the MSTRS dispensers were assessed in Ontario and (Trammel) Wayne Counties (Furber), NY. 2004

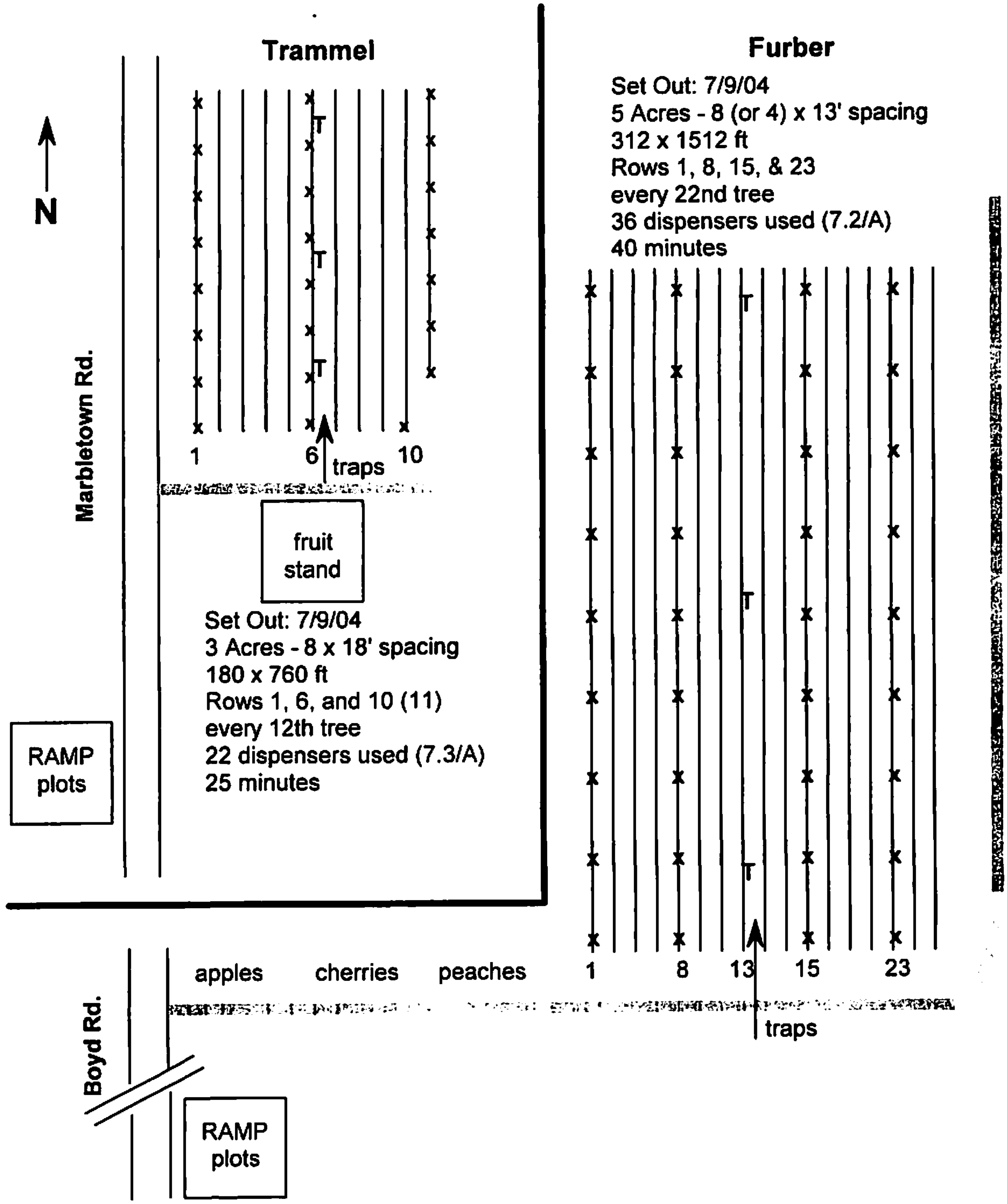


Fig. 2. Plot details of four of the six sites where the MSTRS dispensers were assessed in Wayne Co., NY. 2004

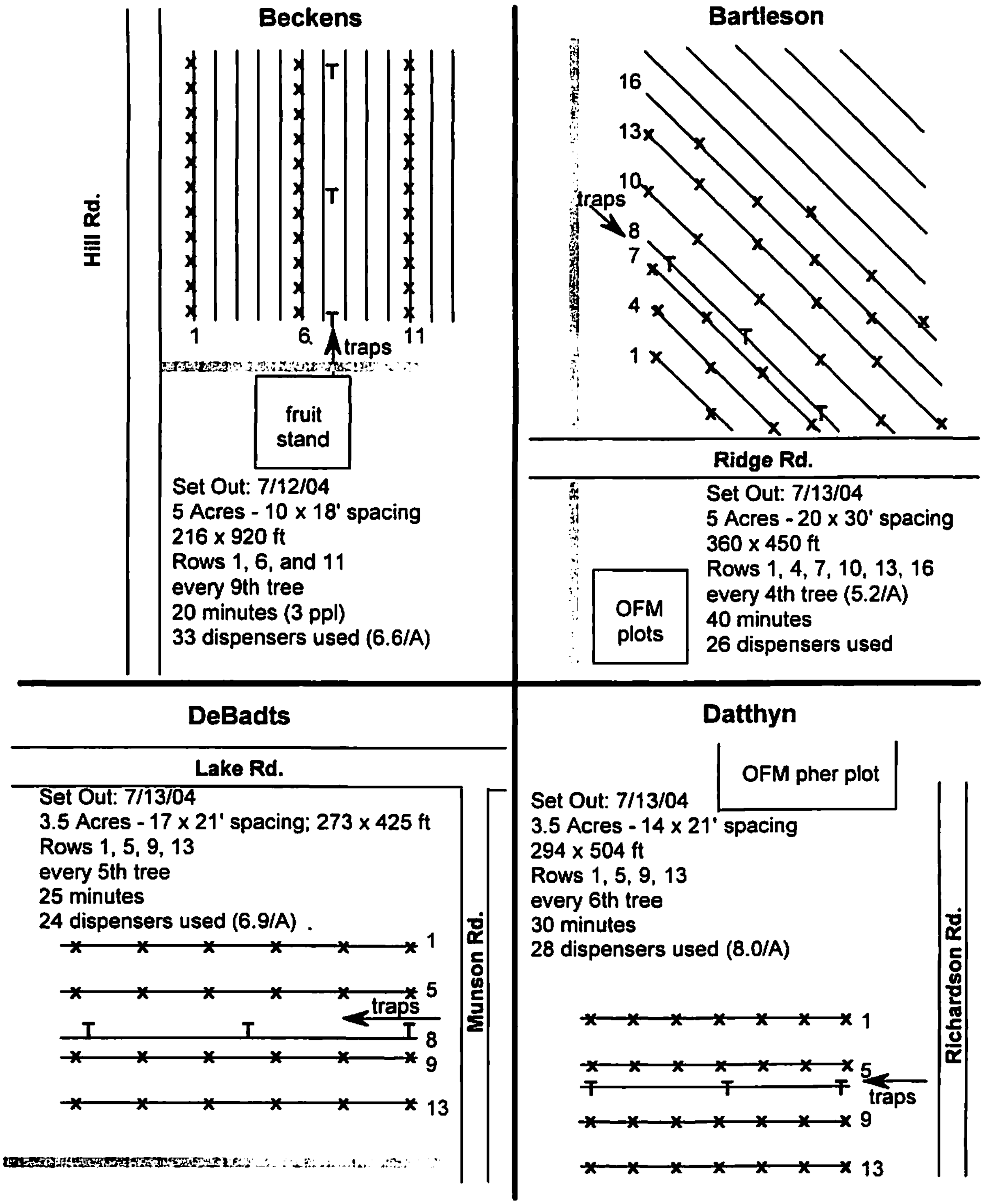
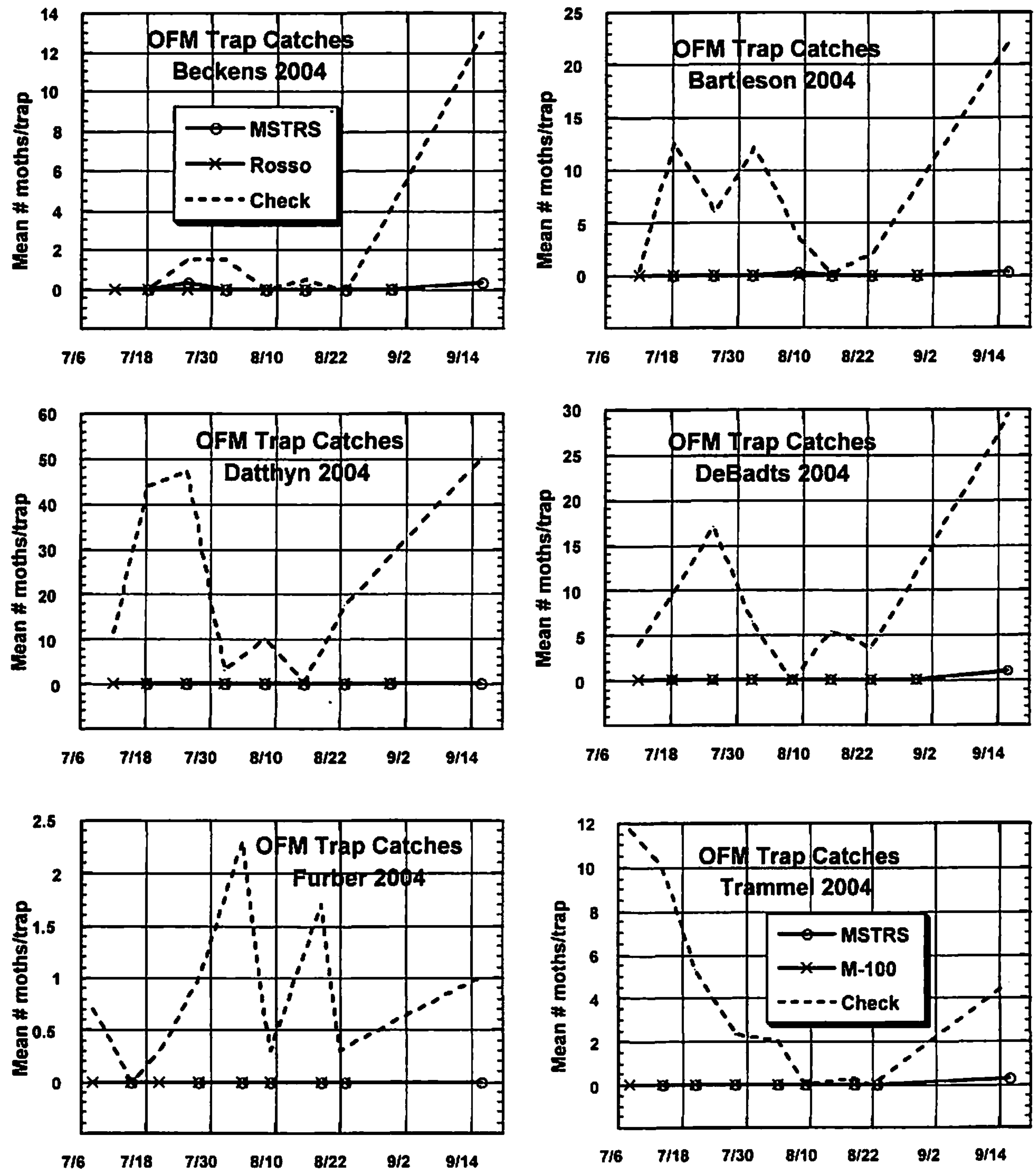


Fig. 3. Pheromone trap catches of oriental fruit moths in apple orchards treated with MSTRS pheromone dispensers vs. Isomate Rosso (Beckens, Bartleson, Datthyn, DeBadts) or M-100 (Furber, Trammel) twist-ties. Wayne and Ontario Counties, NY. 2004



Not for Citation or Publication
Without Consent of the Authors

MANAGEMENT OF KEY ARTHROPOD PESTS IN NEW JERSEY PEACH ORCHARDS WITH MATING DISRUPTION AND REDUCED RISK INSECTICIDES

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Introduction

Our peach Risk Avoidance and Mitigation Program (RAMP) integrates mating disruption to control Oriental fruit moth, *Grapholita molesta* (Busck) (OFM); greater peach tree borer, *Synanthedon exitiosa* (Say) (PTB); and lesser peach tree borer, *Synanthedon pictipes* (Grote & Robinson) (LPTB) with reduced risk insecticides to control various pests including plum curculio, *Conotrachelus nenuphar* (Herbs) (PC); tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) (TPB); various stink bugs (*Euschistus tristigmus* (Say), (*Acrosternum hilare* (Say), (*Euschistus servus* (Say) (CF); tufted apple bud moth, *Platynota idaeusalis* (Walker) (TAPM); and San Jose scale, *Quadraspidiotus perniciosus* (Comstock) (SJS). Changes in pest abundance and levels of fruit damage were evaluated and compared with levels in adjacent orchards sprayed predominantly with organophosphorus, carbamates, and pyrethroid insecticides. Levels of beneficial fauna abundance were also compared.

Materials and Methods

This study was conducted in eight commercial orchards in Cumberland County (sites 1 - 4) and Camden County (sites 5 - 8), New Jersey in 2004 (Table 1). The study sites were approximately 10–40 acres in size (Table 1). Each study site was divided into 2 blocks and

Table 1. Study sites

Site	Variety	Approximate acreage	
		Conventional	RAMP
1	Cresthaven	1.0	9.0
2	Sentry	9.4	9.4
3	Harcrest	7.4	7.4
4	Flaming Raymond	15.7	15.7
5	PF 17	5.5	5.5
6	PF 23	6.5	6.5
7	Buddy's Pride	7.5	7.5
8	Encore	9.5	9.5

assigned one of two treatments; 1) RAMP, in which pests were managed with reduced risk chemicals and mating disruption and without OP, carbamate, and pyrethroid insecticides, when possible (Table 2), and 2) conventional, in which pests were managed with "conventional" management practices and products. Comparisons were then made between treatments. The approximate total acreage used in this study was 140 acres.

Table 2. Product used in RAMP orchards: 2004

Product	Rate / Acre	Unit
3M-MEC-OFM	0.5	Oz
Isomate M 100	100	Ties
Isomate M Rosso	200	Ties
PTB 3M Sprayable	2.0, 4.0	Oz
Isomate – P	100	Ties
Isomate – L	100	Ties
Avaunt 30 WG	6.0	Oz
Intrepid 2F	8.0, 10.0, 12.0	Oz
Actara	4.0	Oz
Warrior	4.0, 5.0	Oz

Arthropod abundance and fruit damage were monitored at regular intervals. Male OFM, TABM, PTB, and LPTB moths were monitored weekly with delta traps baited with standard pheromone lures. Two traps per block were used. Lures were changed approximately every 4 weeks; trap bottoms were replaced when needed. Levels of shoot infestations were determined for each of the 4 OFM generations by counting the number of injured shoots per tree on 10 interior and 10 border trees in each block. TPB and SB numbers were assessed weekly using 4 x 25 sweeps of the ground cover per block until harvest of each variety. GPA infestations were determined by counting the number of active colonies per tree on 10 trees per block during the active period on weekly basis. PTB and LPTB numbers were monitored by counting the number of exuviae per tree on 50 trees per block. PTB exuviae were counted two times and LPTB exuviae were counted three times during the season. Beneficial insects were monitored at approximately 15 day intervals by counting the numbers of observed individuals during three-minute-observations of peach canopies (10 trees per block). Weekly on-site assessments were conducted on randomly chosen interior and border trees to monitor fruit damage from arthropod pests. Detailed midseason and harvest fruit injury evaluations were conducted. Midseason fruit damage from arthropod pests was assessed once for each variety by checking 200 fruit per block (10 fruit per 10 interior and 10 border trees). Damage to fruit at harvest was evaluated by checking 600 fruit per block (20 fruit / 10 interior and 20 border trees). All midseason and harvest fruit samples were collected and examined in the laboratory.

All the RAMP blocks were managed without using any organophosphorus or carbamate insecticides with an exception of one late Lorsban spray for borers in one block. RAMP blocks used Isomate M 100 dispensers, Isomate M Rosso dispensers, or 3M-MEC-OFM sprayable pheromone for mating disruption of OFM and reduced risk insecticides (indoxacarb, thiamethoham, methoxyfenozide, lambda-cyhalothrin) to control other pests. Isomate PTB dispensers, Isomate LPTB dispensers, or 3M Sprayable PTB pheromone were applied to disrupt LPTB and PTB. Most pesticides and sprayable pheromones were applied as alternate-row-middle sprays with air blast sprayers except for a few complete sprays. Comparison of the RAMP program to the conventional program was based on captures of male OFM, PTB, LPTB in pheromone traps, abundance of CF and beneficial insects, and shoot, trunk, and fruit injury caused by the target pests.

Results

Mating disruption for OFM using 3M-MEC-OFM sprayable pheromone, Isomate M 100, or Isomate M Rosso dispensers applied in five of the eight blocks suppressed capture of male OFM in pheromone traps in the RAMP program orchards. More male OFM were trapped in conventional orchards compared with RAMP orchards treated with OFM mating disruption ($F_{1,4} = 30.75$, $P = 0.005$) (Table 3).

Table 3. Average number of male OFM captured: 2004

Program	Average number ± se males per trap
RAMP	10.1 ± 4.0b
Conventional	216.3 ± 38.0a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

No OFM mating disruption products were applied in the other three RAMP orchards that had low OFM pressure in previous years. In 2004, OFM pressure in the RAMP and conventional blocks remained low. No differences in the number of captured OFM males between either treatments were found ($F_{1,2} = 0.72$, $P = 0.486$) (Table 4).

Table 4. Average number of male OFM captured: 2004

Program	Average number ± se males per trap
RAMP (no OFM mating disruption)	22.0 ± 7.6a
Conventional	18.7 ± 6.7a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

Trace amounts of damaged shoots were detected during the season. There were no differences in the number of damaged shoots between the programs during each OFM generation ($F_{1,7} \leq 1.0$, $P \geq 0.351$) (Table 5).

Table 5. OFM shoot injury: 2004

	Mean ± se number per tree	
Generation	Conventional	RAMP
First	0.02 ± 0.01a	0.04 ± 0.02a
Second	0.06 ± 0.02a	0.05 ± 0.02a
Third	0.12 ± 0.05a	0.15 ± 0.05a
Fourth	0.18 ± 0.05a	0.24 ± 0.07a

Means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

The amount of OFM damaged fruit was low in both programs (Table 6). There was no difference in the amount of OFM fruit injury between treatments in midseason ($F_{1,7} = 1.0$, $P = 0.351$) or harvest assessment ($F_{1,7} = 0.44$, $P = 0.528$).

Table 6. OFM fruit injury: 2004

	Mean ± se percent damaged fruit	
Assessment	Conventional	RAMP
Midseason	0.00 ± 0.0a	0.02 ± 0.02a
Harvest	0.06 ± 0.03a	0.13 ± 0.08a

Means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

There were more CF insects in the conventional ground cover than in RAMP ground cover ($F_{1,7} = 5.83$, $P = 0.046$) (Table 7).

Table 7. Mean seasonal number of CF insects: 2004

Program	Mean number ± se per 100 sweeps
RAMP	4.3 ± 1.4b
Conventional	5.6 ± 1.1a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

CF insect control was satisfactory in both programs (Table 8). There were more CF damaged fruit in the conventional blocks than the RAMP blocks in the midseason assessment ($F_{1,7} = 9.42$, $P = 0.018$) and no differences were found in the harvest evaluation ($F_{1,7} = 0.86$, $P = 0.384$).

Table 8. CF fruit injury: 2004

	Mean ± se percent damaged fruit	
Assessment	Conventional	RAMP
Midseason	1.4 ± 0.2a	1.2 ± 0.2b
Harvest	1.9 ± 0.3a	1.6 ± 0.3a

Means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

Early season control of PC with Avaunt and Actara in RAMP orchards was satisfactory (Table 9). A few PC scars and larvae infested fruit were detected in the RAMP and conventional orchards. PC control was equivalent for both pest management programs (midseason: $F_{1,7} = 1.5$, $P = 0.26$; harvest: $F_{1,7} = 4.51$, $P = 0.071$).

Table 9. PC fruit injury: 2004

	Mean ± se percent damaged fruit	
Assessment	Conventional	RAMP
Midseason	0.7 ± 0.5a	0.2 ± 0.1a
Harvest	0.5 ± 0.3a	0.8 ± 0.4a

Means within a row followed by the same letter are not different (Anova; $P > 0.05$).

Male TABM pheromone trap captures indicated high pressure in both program orchards. There were no differences in male TABM abundance between treatments ($F_{1,7} = 2.55$, $P = 0.155$) (Table 10).

Table 10. Average number of male TABM captured: 2004

Program	Average number ± se males per trap
RAMP	89.9 ± 25.4a
Conventional	138.6 ± 21.2a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

There were no TABM damaged fruit found during the midseason assessment (Table 11). Some TABM damaged fruit and live larvae were observed in RAMP and conventional orchards during the harvest assessment. However, there were no differences in damage levels between treatments ($F_{1,7} = 0.28$, $P = 0.611$) (Table 11).

Table 11. TABM fruit injury: 2004

	Mean ± se percent damaged fruit	
Assessment	Conventional	RAMP
Midseason	0.0 ± 0.0a	0.0 ± 0.0a
Harvest	0.4 ± 0.1a	0.3 ± 0.2a

Means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

SJS damaged fruit were detected in both programs blocks at harvest assessment. Even though damage was high in one RAMP block, there were no differences between treatments ($F_{1,7}$ = 1.60, P = 0.246) (Table 12).

Table 12. SJS fruit injury: 2004

	Mean ± se percent damaged fruit	
Assessment	Conventional	RAMP
Midseason	0.0 ± 0.0a	0.0 ± 0.0a
Harvest	0.02 ± 0.02a	2.1 ± 1.7a

Means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

Few male PTB and LPTB were captured in pheromone traps in RAMP program orchards when PTB sprayable pheromone, Isomate PTB, or Isomate LPTB pheromone dispensers were applied (Table 13). PTB were also captured in low number in conventional orchards (Table 13). This may be due to the quality of the PTB lures used.

Table 13. Average total male capture per trap in PTB and LPTB pheromone traps: 2004

	Pheromone type used (X)			Average number of moths / trap			
	Sprayable	Dispensers		PTB		LPTB	
Site	PTB	PTB	LPTB	RAMP	Conventional	RAMP	Conventional
1			X	0.0	2.0	1.0	259.5
2	X			0.5	2.0	11.0	152.5
3	X			1.0	2.5	16.0	344.5
4	X			0.5	1.0	7.5	368.0
5		X	X	0.0	0.0	0.0	214.5
6		X	X	0.5	1.0	0.5	190.0
7		X	X	0.5	1.5	0.0	279.5
8		X	X	2.0	5.0	0.0	758.5

There were no differences in the number of PTB and LPTB exuviae between either programs (PTB: $F_{1,7}$ = 1.34, P = 0.285; LPTB: $F_{1,7}$ = 3.31, P = 112) (Table 14).

Table 14. Average number of PTB and LPTB exuviae per tree: 2004

	Average number ± se exuviae per trap	
Program	PTB	LPTB
RAMP	0.01 ± 0.00a	0.18 ± 0.04a
Conventional	0.00 ± 0.00a	0.31 ± 0.08a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

The number of natural enemy's species or group of species was larger in the RAMP blocks when compared with conventional blocks ($F_{1,7} = 10.72$, $P = 0.014$) (Table 15). *Coccinella septempunctata* L., Braconidae, and Syrphidae were more abundant in the RAMP orchards than conventional orchards ($F_{1,7} = 7.00$, $P = 0.033$; $F_{1,7} = 5.73$, $P = 0.048$; $F_{1,7} = 7.30$, $P = 0.031$, respectively) (Table 15). There were no differences in the number of the other natural enemies between both programs ($F_{1,7} \leq 3.50$, $P \geq 0.104$) (Table 15).

Table 15. Abundance of beneficial fauna: 2004

	Average number ± se				
Treatment	Neuroptera	Coccinella[1]	Harmonia[2]	Coleomegilla[3]	Ichneumon[4]
RAMP	445.1 ± 86. 3a	1.3 ± 0.4a	1.5 ± 0.5a	0.1 ± 0.1a	1.1 ± 0.5a
Conventional	341.5 ± 61.1a	0.3 ± 0.2b	0.9 ± 0.4a	0.0 ± 0.0a	0.5 ± 0.3a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

Table 15. Abundance of beneficial fauna: 2004 (Cont.)

	Average number ± se				
Treatment	Braconidae	Aphidiidae	Anthocoridae	Syrphidae	Araneae
RAMP	0.8 ± 0.3a	0.3 ± 0.2a	0.6 ± 0.4a	7.6 ± 1.0a	7.9 ± 0.8a
Conventional	0.0 ± 0.0b	0.8 ± 0.4a	0.4 ± 0.3a	5.9 ± 1.4b	7.1 ± 1.0a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

Table 15. Abundance of beneficial fauna: 2004 (Cont.)

	Average number ± se
Treatment	Numbers[5]
RAMP	6.0 ± 0.4a
Conventional	4.6 ± 0.3b

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

[1]*Coccinella septempunctata* L.
[2]*Harmonia axyridis* (Pallas)
[3]*Coleomegilla maculata* De Geer
[4]Ichneumonidae
[5]Average number of species or group of species observed

There was a high percentage of clean fruit in the midseason and harvest evaluations (Table 16). There were no differences in the amount of clean fruit between programs during either assessment (midseason: $F_{1,7} = 1.74$, $P = 0.228$; harvest: $F_{1,7} = 1.39$, $P = 0.277$).

Table 16. Average percent clean fruit: 2004

Assessment	Mean ± se percent damaged fruit	
	Conventional	RAMP
Midseason	97.7 ± 0.6a	98.2 ± 0.3a
Harvest	95.3 ± 0.9a	93.4 ± 2.0a

Means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

The total amount of insecticides used was significantly reduced in the RAMP blocks compared with the conventional blocks ($F_{1,7} = 37.45$, $P = 0.000$). Organophosphorus and carbamates use in the RAMP blocks was minimal ($F_{1,7} = 51.86$, $P = 0.000$) (Table 17). There was one accidental late season spray with Lorsban in one RAMP orchard against PTB and LPTB.

Table 17. Insecticides used in RAMP and conventional orchards: 2004

Treatment	Average amount (Lbs Ai/A)	
	OPs and Carbamates	Total
RAMP	0.2 ± 0.2b	0.8± 0.2b
Conventional	5.0 ± 0.6a	5.2 ± 0.6a

Means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

Conclusions

Mating disruption and reduced risk insecticides provided control of major arthropod pests that was equivalent to growers organophosphorus- and carbamate-based spray programs. The amount of OFM and TABM damaged fruit was very low and a few fruit with tunnels or larvae were detected. CF control was satisfactory in both programs. Early season control of PC with Avaunt and Actara in all RAMP orchards was satisfactory. Overall PC control was equivalent for both pest management programs. Trace amounts of PC scars and fruit infested with larvae were found. The increase of SJS fruit injury may be explained by the exclusion of organophosphorus insecticides from RAMP blocks. Substituting reduced risk pest management products for OP's, carbamates, and pyrethroids did not result in an increase in beneficial fauna abundance although we did observe an increase in few beneficial species. Overall fruit quality in the RAMP sites was as good as the conventional blocks. OP's and carbamates were excluded from the RAMP program orchards, except for one late Lorsban spray applied to one RAMP site. The major drawback of the RAMP program is the 1.4 to 2.7 times higher arthropod management costs.

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Biological Mite Control Of Spider Mites In Pennsylvania Apple Orchards and Controlling Periodical Cicadas with Reduced Risk Insecticides

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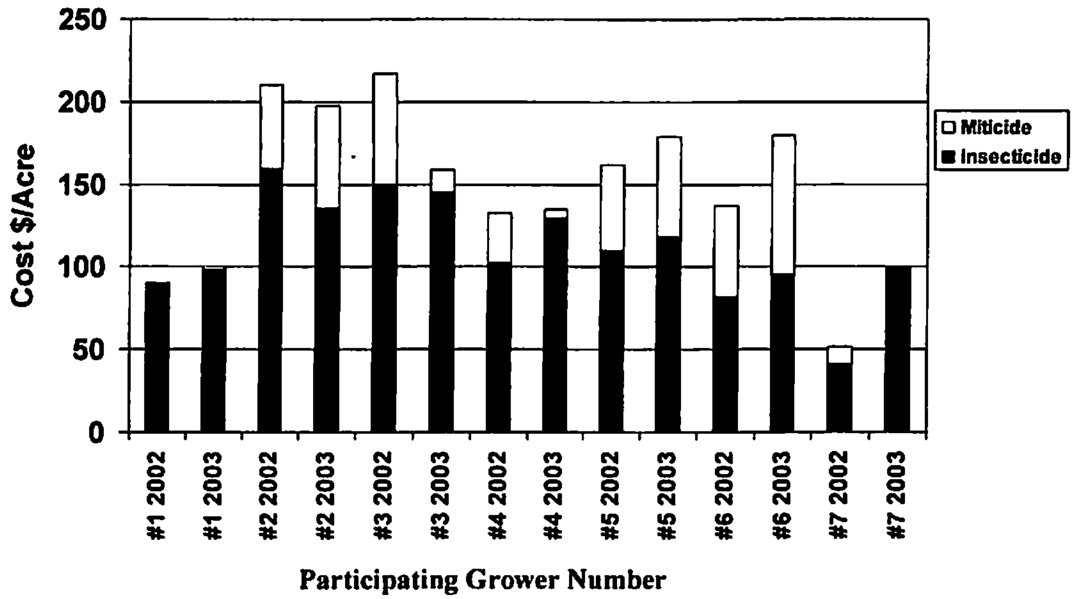
Introduction and Historical Background Data

European red mites (ERM) and the two-spotted spider mites (TSSM) are two pest mites that feed on the leaves of apple trees and interfere with photosynthesis and the production of carbohydrates. At high levels, damage from these mites to apple leaves reduces fruit quality and yield. As a general rule, keeping these mites from reaching an average of 2.5/leaf before July, below 5/leaf during July, and below 7.5/leaf in August will prevent economic loss from these pests (Nyrop 1999). The European red mite is a significant pest in most commercial apple plantings in Pennsylvania and growers currently rely on chemical pesticides to control them. Pesticide management has not proven to be sustainable because this pest has quickly and repeatedly developed resistance to miticides, probably more so than any other orchard pest. Before synthetic insecticides were widely introduced in the late 1940's, phytophagous mites were rarely pests of fruit because they were almost completely regulated by their natural enemies. Unsprayed apple orchards today still rarely have problems with phytophagous mites due to a large complex of arthropod predators that achieve almost complete biological control (Tanigoshi et al. 1983). Mite outbreaks and injury in commercial orchards arises from the use of synthetic insecticides, miticides, fungicides and plant growth regulators that disrupt these predators. The most common effects are direct mortality to the predators due to toxicity to some developmental stage or by causing sublethal physiological effects such as sterility or reductions in fecundity. When effective miticides are used, many of these predators are not able sustain populations, even at low levels, due to the lack of their main food source of pest mites or alternate food sources such as the apple rust mite.

Effective miticides with novel modes of action to combat resistance development continue to be developed, but the cost of using these materials are escalating during a period when many growers are attempting to remain viable by minimizing expenses. This is especially true of the lower profit margin processing apple industry that predominates in Pennsylvania. Currently Pennsylvania apple growers participating in the Reduced Risk Insecticide RAMP program are spending on average about \$155/A for arthropod pest control with about \$41/A (28%) of that being targeted to mite control (Fig. 1). Biological control of European red mite and the two-spotted spider mite is a feasible alternative to pesticide-based control that is sustainable and potentially of little or no cost.

Fig. 1. PA Ramp Miticide Costs In Grower Standards Blocks 2002-3



Pennsylvania had an international reputation as a model system for the biological control of mites with *Stethorus punctum* during the 1970's to the mid 1990's (Biddinger & Hull 1995). Miticide use was documented to have been reduced by over 50% during this time, but growers had to tolerate low to moderate level of bronzing injury in apple orchards because *Stethorus* only reproduced on trees with at least 8-10 mites/leaf. Often mite populations reached 15-20 mites/leaf with significant bronzing damage before being brought under control by this voracious ladybird beetle. While requiring larger spider mite populations than predaceous mites to sustain themselves, *Stethorus* had the advantage of being highly mobile and flying to new trees in search of higher mite populations when its food declined. Predator mites are not mobile and require a constant presence on each tree to give effective mite control. Thus, they are more susceptible to local extinctions due to lack of prey from a miticide application than *Stethorus* or from toxic materials such as Lannate. Such local extinctions may occur from even a single spray and afterwards predatory mites may take 2-3 years to re-establish themselves in an orchard providing no more applications of toxic compounds have been applied.

The *Stethorus* period of mite control in Pennsylvania was characterized by a lack of truly effective miticides as widespread resistance had reduced the effectiveness of many of the registered materials and there was a long delay in the development of new miticides from the chemical industry. The introduction of Agri-Mek on apple in the mid 1990's was the first truly effective miticide for many years, but the high cost prevented widespread use. The registrations of Pyramite, Apollo and Savey that followed a few years later offered slightly less expensive materials that were also very effective. Suddenly mite injury levels acceptable when *Stethorus* was the only alternative are now not acceptable. A general threshold of keeping ERM numbers below 2.5 mites/leaf before July, below 5 mites/leaf during July, and below 7.5 mites/leaf during August to prevent economic losses was not strictly followed by most growers. Miticide use increased dramatically and *Stethorus* began to disappear from apple orchards as the levels of ERM were never allowed to build to levels where *Stethorus* could reproduce. There is also strong evidence to indicate that the widespread use of the neonicitinoid pesticides such as Provado, Actara, and Assail are toxic to *Stethorus* adults and larvae and are acting as ovicides (Biddinger & Hull 1993). As a consequence, *Stethorus* is no longer a key component of Pennsylvania's IPM program, and is now rarely found in significant numbers in commercial orchards.

Predatory Mites

Of the many other mite natural enemies of European red mite and two-spotted spider mite, only the predaceous mites of the stigmaeid and phytoseiid families have been found by researchers to offer a chance of effective biological mite control. The stigmaeid mite, *Zetzellia mali*, was the dominant predator mite in Pennsylvania orchards during late 1980's to mid 1990's when widespread use of Lannate for tufted apple bud moth control had almost completely eliminated the less pesticide tolerant phytoseiid mite species. *Z. mali* is still common in orchards and appears to be tolerant of most of the new products that have been introduced since Lannate such as the neonicitinoid products, Intrepid, Spintor and the newer miticides, except for Pyramite. Unfortunately, *Z. mali* prefers to feed on apple rust mites, has almost twice the developmental time of phytoseiid predator mites and a much lower reproductive rate. *Z. mali* is also so sluggish in behavior that they only prey on spider mite eggs and only at a rate 1 or 2 eggs a day even as adults (Santos and Laing 1985). This means *Z. mali* has a much lower rate of increase than phytoseiids or even *Stethorus* and are rarely able to control a pest mite population by themselves without the help of dormant oil sprays or selective miticides, unless the pest mite populations exist at very low populations. It will feed on phytoseiid predator mite eggs and is cannibalistic. Besides being somewhat pesticide tolerant, *Z. mali* does have the advantage of being able to survive in low pest mite populations (<1 mites/leaf) by feeding on pollen and fungal spores. They can't reproduce on this diet, however. *Z. mali* also overwinters on the tree and not in the ground cover so that it is present on the trees early in the growing season. The sluggish *Z. mali* appears to be better adapted for lower populations of pest mites than phytoseiid mites and may complement biological control of spider mites by feeding on the eggs while the much more active phytoseiids prefer the mobile stages. *Z. mali* can even serve as an alternate food source for the phytoseiids when other prey is scarce.

For many years, during the early development of mite IPM programs, the phytoseiid mite predator, *Amblysieus fallacis*, was promoted as the most effective biological control agent for ERM. In recent years, however, it has been shown that *A. fallacis* gives sporadic and unreliable ERM control in NY and New England, while another phytoseiid species, *Typhlodromus pyri*, is highly effective in that capacity (Nyrop 1999). In the field *T. pyri* and *A. fallacis* are identical in appearance and based on its shorter generation time, higher oviposition and prey consumption rates, *A. fallacis* would appear to be the more effective biological control agent of spider mites. However, the most important advantage that *T. pyri* has over *A. fallacis* is that it is able to utilize other food sources when spider and rust mites are not available. Plant sap, tree pollen, and fungal spores such as those from powdery mildew can all serve as food sources, but unlike *Z. mali*, *T. pyri* can not only survive long periods on this diet, but also reproduce. *A. fallacis* can only survive on mite prey and will leave the tree and go to the ground cover if this food is not available, especially in the fall. This means that *A. fallacis* often does not become re-established as an effective control agent for spider mites until July or August, whereas *T. pyri* and *Z. mali* are present in the spring and fall and can regulate spider mite populations at low levels and prevent their building to damaging levels. *T. pyri* is less tolerant of hot summer weather than *A. fallacis* and is most effective in the spring and fall with lower temperatures. Orchards with both phytoseiid species and with *Z. mali* are probably the most desirable in establishing sustainable control. *T. pyri* was thought to be adapted to the colder climate of western NY, the Hudson Valley and New England and was not thought to range into Pennsylvania. The only survey of spider mite predators in Pennsylvania was almost 40 years ago and rather limited in scope, but *T. pyri* was not found (Horsburgh and Asquith 1968). Surveys of predatory mites in apple orchards of the neighboring states of Ohio (Welty 1995), New Jersey (Knisley and Swift 1972), and Michigan (Strickler & Whalon 1987), however, also did not find also did not find *T. pyri* to be present.

Discovery of *T. pyri* In Pennsylvania Apple Orchards in 2003 & Initial Orchard Survey

It was something of a surprise when in 2003 *T. pyri* was identified in high numbers in a commercial apple orchard of fresh market 'Delicious' & 'Golden Delicious' in Adams County, Pennsylvania (Lerew Orchards, York Springs). This orchard had received no pyrethroid or Lannate applications for at least 8 years nor have any miticides been applied during that time. This was unusual considering the mite-susceptible varieties. It was found during routine monitoring of reduced risk pesticide demonstration trials (RAMP) that, what was assumed to be *A. fallacis*, existed in high number throughout the season and even in the early season (Fig. 2). European red mite and two-spotted spider mite populations were almost non-existent during most of the season, so these predator mites were obviously feeding on another food source. This combination of factors indicated that the phytoseiid mites in question might be something other than *A. fallacis* since they did not follow what we know of the biology and ecology of that species. Specimens collected from leaves in the orchard and mounted on slides were identified by setal (hair) patterns under a compound microscope at 200X (Fig. 3) and found to be all *T. pyri* and not *A. fallacis*.

Fig. 2. RAMP 2003 Mite Data – Lerew Orchard

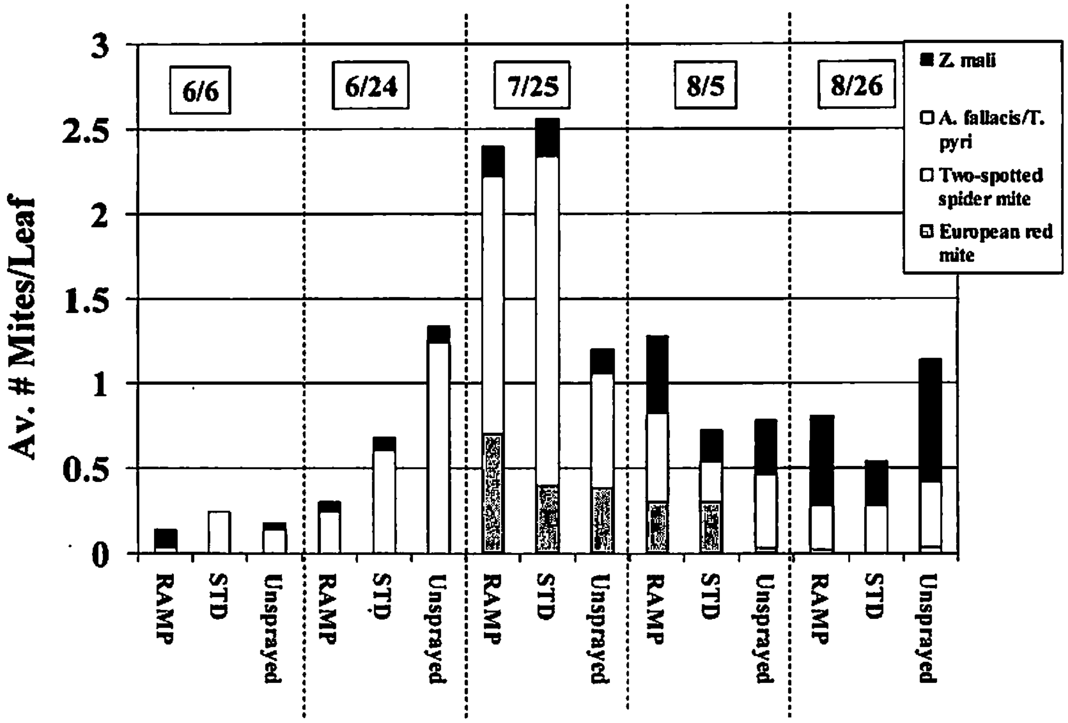
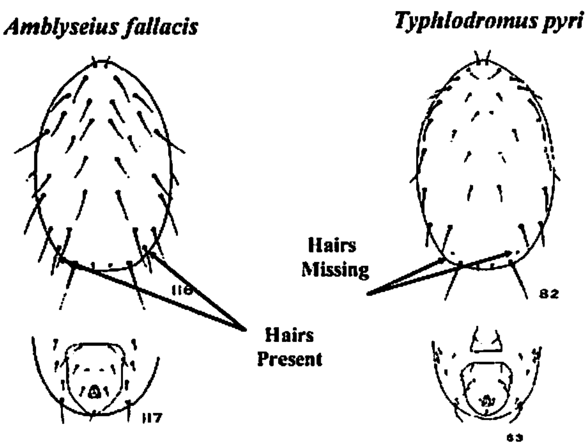


Fig. 3. Predator Mite Identification



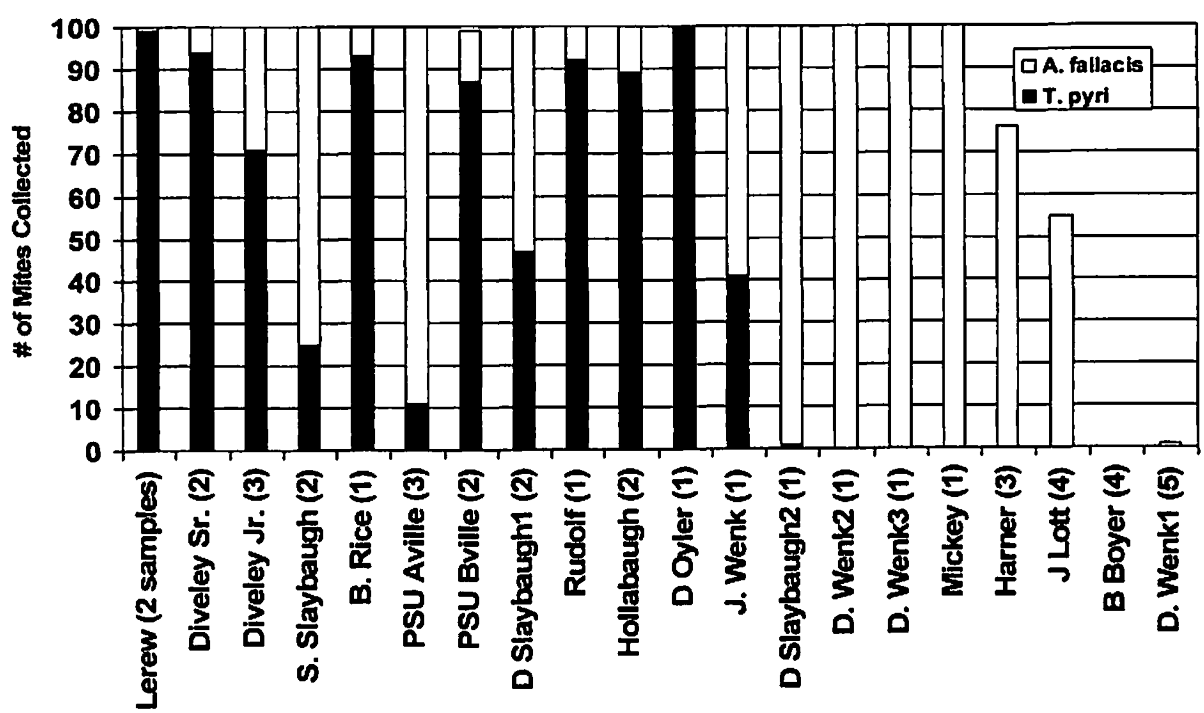
Two of the authors obtained a grant from the Pennsylvania Apple Marketing Board in the spring of 2004 to survey approximately 20 apple orchards for the presence of the predatory mite, *Typhlodromus pyri*. Preliminary data found in Fig. 4. indicate that *T. pyri* is present at significant levels in over half the orchards surveyed. This initial survey was the first step towards re-establishing integrated mite control into Pennsylvania apple orchards. With the help of natural enemies, the cost of managing mites in apples should be greatly reduced or possibly even eliminated for growers in a sustainable manner. Reliance on biological mite control should also reduce pesticide inputs that affect the environment and human health and at the very least help to delay the development of resistance to miticides.

Proposed Research Areas:

Objective 1. To expand the Pennsylvania predatory mite survey in apple orchards to all major fruit growing areas and greatly increase the number of orchards sampled.

Preliminary data from our initial survey grant (Fig. 4) are very exciting as they confirm that *T. pyri* is capable of tolerating the hotter summers of Pennsylvania and exist in multiple sites. Knowledge of specific species of predatory mites present in Pennsylvania apple orchards is important for sustainable mite control because different species are not equally affected by pesticides and species differ in food preferences, prey consumption rates, and seasonal activity patterns. It was surprising that a species of predatory mite previously unknown in Pennsylvania should be so widely distributed across over half the orchards surveyed in Adams county and somewhat perplexing as to where they came from. Three sites were surveyed outside of Adams county (Harner – Centre county, Boyer – Bedford County, and Mickey – Franklin County) but only the Franklin county orchard was found to have *T. pyri*. We will survey all major fruit growing areas in Pennsylvania and encourage growers to bring in leaf samples to be mite brushed for predators that will be slide mounted and identified.

Fig. 4. PA Predatory Mite Survey 2003-4



***Supported by SHAP/Apple Marketing Board 2004**

While it is possible that *T. pyri* moved into Pennsylvania from New York or New England on nursery stock or apple bins, we suspect that *T. pyri* existed in our apple orchards at undetectable levels when the 1968 survey was conducted. It may have since become more abundant as selective, reduced risk pesticides such as Confirm, Intrepid, and Provado became registered and replaced materials toxic to predator mites (i.e. Lannate, methyl parathion, Carzol, and Vydate). It is also important to survey for 'seed' orchards to provide local sources for the intial introduction into sites with little or no *T. pyri* (Objective 3) and to identify sites where conservation of existing populations can be further encouraged by using selective pesticides (Objective 2). There will probably be occasions when materials toxic to predatory mites will have to be used to rescue a crop from a difficult to control or sporadic pest (i.e. 17-year cicada) and it will be important to know where *T. pyri* can be obtained for re-establishing populations.

2. Conserve T. pyri in sites where it already exists.

In order for *T. pyri* to flourish and achieve biological control of pest mites, an environment must be established in the orchard wherein pesticides that are toxic to these beneficial mites not be used. Predatory mites have acquired resistance to some pesticides used in commercial orchards and are innately tolerant of others. However, many commonly used orchard pesticides are toxic to *T. pyri* and if biological mite control is to be achieved using this predator, these toxic materials should be avoided. Because *T. pyri* are resident in trees year round, and because these predators have a relatively slow growth rate, pesticides toxic to *T. pyri* cannot be used even intermittently (e.g., every other year) without serious disruption to biological control (Nyrop 1999). Certain cultural practices such as alternate-row middle or low volume applications of toxic materials may allow refugia areas for predatory mite survival as they did for *S. punctum* in the past.

Pesticide histories will be obtained in sites where *T. pyri* is present or absent in an attempt to determine if there is a link between applications of certain pesticides and their abundance. Lists of pesticides that can be used to control insects and diseases of apple while conserving *T. pyri* are available from New York and New England, but these estimates of toxicity reflect the pesticide histories of those regions and there are probably differences in pesticide susceptibility in *T. pyri* that reflect the historical pesticide use patterns unique to Pennsylvania. We plan to evaluate selected insecticides, miticides, fungicides, plant growth regulators, and foliar fertilizers for effects on *T. pyri* or other predatory mites both in the field and in controlled green house trials.

Examination of the spray records from the preliminary survey sites appear to indicate the following negatively impact the establishment of *T. pyri* populations:

a) summer Lannate applications for leafroller control when T. pyri populations have become quiescent and stressed during the hot summer months.

b) post-bloom applications of mancozeb fungicides which are known to sterlize predator mite eggs.

c) post-bloom applications of pyrethroids for late season control of codling moth and Oriental fruit moth.

3. Introduce or augment T. pyri populations in sites where they are currently absent or are present at very low levels.

Introduction of new populations of *T. pyri* into orchards would be much more labor intensive than the conservation of already existing populations and would probably take about 3 years for these slowly dispersing mites to distribute within an orchard. Such introductions have been successful in several states in the eastern U.S and the methodology has been worked out for collecting and transferring large numbers of *T. pyri* from other sites (Nyrop 1999, Prokopy et al 2000, Prokopy et al. 2003). Of the four methods that have been attempted so far in other states, the two most effective methods for such transfers of predatory mites have been:

a) Tranfering flower clusters from a 'seed' orchard.

T. pryi move from overwintering sites on the tree into flower clusters at tight cluster and remain there through bloom to feed on apple pollen. As many as 2-3 predators can be found in each flower cluster and the surrounding leaves. To transfer predators in this manner, at least 20 clusters should be placed in each recipient tree. One in every 6 trees in high density plantings and 1 in every 3 trees in low density planting would be seeded in such a way. The flower clusters are easily attached with paper clips, staples or twist ties and can be stored for several days in a cooler before being attached.

b) *Banding tree boles and/or large scaffold limbs from 'seed' orchards with burlap bands to create artificial overwintering sites for T. pyri in the late fall and then transferring them to recipient trees inthe spring.*

These bands would be placed on trees from the 'seed' orchards in late September by stapling them around the trunk or bole. In early December, these bands would be collected, tightly rolled with rubber bands and placed in sealed plastic bags with a bit of wet cotton to provide humidity. These bags would then be placed in cold storage at about freezing temperatures until the following spring. At the half inch green bud growth stage in the spring, the bands should be placed around the recipient trees. As many as 400 predators can be transferred in each band, but the number is variable. If the seed orchard had moderate to high numbers of *T. pyri* (1-2 per leaf) in the fall then only one band per tree may be needed, otherwise 2 bands/tree may be needed. One in every 6 trees in high density plantings and 1 in every 3 trees in low density planting would be seeded in such a way. Having a relatively large number of potential 'seed' orchards locally greatly simplifies such transfers.

After a new orchard is inoculated with *T. pyri,* it often takes 2-3 years for the predator population to become abundant enough to regulate pest mites without the need for any miticides. During this time, additional measures are often needed to keep pest mites under control. Early season dormant oil sprays should be used to reduce ERM populations in the spring. These early oil applications control the overwintering pest mite eggs on the surface of the wood, but do not kill the overwintering *T. pyri* hiding in deep crevices and under bark scales. Secondly, ERM numbers should be monitored through the season, and if pest mite densities exceed threshold levels, miticides not toxic to *T. pyri* should be used. Summer oil applications for pest mite control would be useful in this regard. It is important to leave some pest mites in the trees after inoculations to provide a food source for the predators and foster faster predator population growth.

4. Evaluation of success.

While it is difficult for growers to monitor pest mite populations and determine which species are dominant, we will monitor selected sites for predator to prey ratios and proportions of predator mite species. We will also document:

a) potential reductions in miticide applications and associated cost savings.
b) cost of using predatory mite-selective pesticides for control of other pests.
c) potential reductions in the amount of miticide active ingredient introduced into the environment.

Fortunately for growers, all that is needed to determine if biological mite control has been achieved is to note whether pest mites remain below threshold levels over time.

IPM Compatible Control of 17-Year Cicada in Pennsylvania Apple Orchards, 2004

Introduction

In 2004, a major disruption to Pennsylvania integrated pest management programs (IPM) in tree fruit was the emergence of the 17-year cicada, *Magicicada septendecim.* Oviposition injury from this pest is significant even on large, standard apple trees when population pressure is high enough and can be devastating on small, young semi-dwarf trees. In nursery stock, direct tree mortality is most often the outcome when the adults are not controlled over the 6 week oviposition period. Population pressure was generally the highest next to wooded areas or in older orchards that had been around during the previous emergence 17 years earlier. It is difficult to control a pest whose lifecycle is longer than the life of most insecticides, but previous control work had demonstrated pyrethroids and carbamates such as methomyl to be the most effective. For many growers, cicada pressures were low enough not to warrant chemical control or only border applications to areas adjacent to a woods or older apple orchard. For the rest of the growers, control was accomplished with multiple applications of pyrethroid insecticide (i.e. Asana, Warrior & Danitol) or the carbamate methomyl (Lannate). All of these products were potentially devastating to the predatory mite populations of *Typhlodromus pyri, Amblyseius fallacis*, and *Zetellia mali* as well as the coccinellid mite predator *Stethorus punctum.* Pyrethroids are also known to have a stimulatory effect on the physiology of pest mites (i.e. European red mite & two-spotted spider mite) known as hormolygosis in which fecundity is increased and developmental times are shortened. These well-documented effects are what cause the huge mite 'flare-up' following pyrethroid applications. Unfortunately, organophosphate insecticides which are generally safe to predatory mites were also mostly ineffective in controlling the 17 year cicada.

In order to conserve the recently discovered predatory mite, *T. pyri*, in some of our 3rd year reduced-risk insecticide demonstration plots, we conducted a series of bioassays on field collected adults of 17 year cicadas. We collected these adults from an unsprayed block of apples and the adjacent woodlot in order to reduce the risk of previously contacting pesticide residues. We chose several neo-nicotinoid insecticides that are considered to be relatively safe to predatory mites and that we thought might be effective on cicadas and conducted both dry-film and direct contact bioassays with aqueous solutions of formulated product. Six replicates of 30 adults (n=180 adults/treatment) of both sexes were tested in separate 0.025 bushel cardboard boxes for each treatment on the same date. Pesticide solutions were applied with 1 quart house-hold mist sprayers commonly used for houseplants. Control mortality was corrected for with Abbot's formula and means were analyzed using ANOVA at P=0.05, Fisher's Protected LSD.

Dry Film Bioassay

Assuming that the residual activity of the pyrethroids would be longer than the neonicitinoid materials, we first conducted a dry film bioassay where the inside of the boxes and apple shoots were sprayed to run-off and then allowed to air dry for 2 hours before freshly collected adults were placed in the boxes. Pesticide were applied at their full field use rates. After 48 hours the boxes were opened and evaluated for mortality. The results (Table 1) were somewhat surprising as even dry residues from the pyrethroid Warrior was not very effective on cicada and only Assail gave significant mortality.

Table 1. Insecticide dry-film residual bioassays of field collected adults of the periodical cicada, May 24, 2004.

Treatment	Rate/A	Concentration (ppm)	100 gal	Av. % Mortality	Av, % Corrected Mortality
Actara 25WDG	4 oz	75	100 gal	7.8 a	-3.7 a
Assail 70WG	2.5 oz	141	100 gal	45.6 b	39.0 b
Calypso 4SC	4 fl oz	150		12.2 a	1.1 a
Warrior 1CS	3 fl oz	28		22.2 ab	12.3 a
Water			100 gal	11.1 a	

Contact Bioassays

Since none of the materials tested gave significant residual mortality, contact bioassays were conducted that directly applied aqueous solutions to the adult cicadas and the apple shoots they were on inside the boxes. Again the boxes were sealed for 2 days and mortality was evaluated. Again, it was somewhat surprising that the pyrethroid Warrior was not the most effective compound tested. The neonicotinoids Assail and Calypso were most effective (Table 2) with Actara giving the same level of control as Warrior.

Table. 2. Insecticide direct contact bioassays of field collected adults of the periodical cicada, June 4, 2004.

Treatment	Rate/A	Concentration	Equivalent Water Vol/A	Av. % Mortality	Av, % Corrected Mortality
Actara 25WDG	4 oz	75	100 gal	58.3 b	51.8 a
Assail 70WG	2.5 oz	141	100 gal	97.8 c	97.4 c
Calypso 4SC	4 fl oz	150	100 gal	87.8 c	85.7 bc
Warrior 1CS	3 fl oz	28	100 gal	72.8 b	68.7 ab
Water				13.9 a	

For growers applications of pyrethroids like Warrior are much less expensive than the neonicotinoids if the cost of probable mite population flare-up and control costs are not considered. In order economize the costs of these compounds, we conducted a second contact bioassay of directly spraying the cicada adults with aqueous solutions of lower rates of both Assail and Calypso. The results in Table 3 indicate that the rates of both compounds (and costs) could be reduced greatly without appreciable loss of control. Control mortality, however, was increasing in this trial as the vigor of older adults that had already mated was beginning to fade as time approached the end of the adult emergence.

Table. 3. Insecticide direct contact bioassays of field collected adults of the periodical cicada, June 8, 2004.

Treatment	Rate/A	Concentration	Equivalent Water Vol/A	Av. % Mortality	Av, % Corrected Mortality
Assail 70WG	1.7 oz	96	100 gal	98.3 b	98.0 a
Assail 70WG	2.5 oz	141	100 gal	99.4 b	99.3 a
Calypso 4SC	4 fl oz	150	100 gal	97.8 b	97.2 a
Calypso 4SC	6 fl oz	225	100 gal	98.9 b	98.4 a
Water				25.6 a	

Personal field observations in grower orchards sprayed with Calypso and Assail and the higher rates that we tested, noted knockdown of the adults within 2 hours of application in a manner identical to that of applications of Lannate. The adults twitch and stridulated somewhat longer on the ground than with Lannate, but mortality levels appeared to be just as high. Direct comparisons with applications of pyrethroids were not made. It would appear that Assail and Calypso are viable, but expensive alternatives to pyrethroids and Lannate for 17 year cicada control. When comparing the almost invariable mite flare-ups and control costs of using pyrethroids and the negative impact of both pyrethroids and Lannate on predatory mites, the cost may not be that bad. This is especially true when it may take 3 seasons of more to recover predatory mite populations after a single pyrethroid application. Since residual active activity of even the pyrethroids appears to be negligible, spray coverage of the adults with high water volumes at times when the adults are not active (i.e. early morning and at night) would improve control for any of these products.

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COMPARISON OF DIFFERENT SPRAY SCHEDULES FOR CONTROL OF ORIENTAL FRUIT MOTH IN NEW YORK APPLES, 2004

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This study is to compare the effectiveness of different schedules of an insecticide in controlling fruit damage from the oriental fruit moth in commercial apple orchards in western New York State. This project will be conducted in small plots, ca. 0.33A, in two commercial orchards in Wayne Count, NY, the Verbridge orchard and the Bartleson orchard. Both of these small plots have been used in the past for OFM studies and were heavily infested during the 2003 growing season. Many of the unsprayed trees in 2003 had a 40-60% infestation level of OFM at harvest. Each orchard will consist of 4 treatments: 1) Protective schedule. Imidan at 3.0 lbs/A applied at pink, petal fall and every two weeks thereafter; 2) Optimum Timing, A single spray of Imidan at 3.0 lbs/A at the predicted first hatch of OFM eggs for every generation; 3) Late Season Control, no applications will be applied for the first generation, then two sprays of Imidan at 3.0 lbs/A will be applied for each of the subsequent generations starting at first egg hatch and then followed 10-14 days later; 4) Untreated Control. Untreated plots will be smaller than the larger plots and will consist of a square block of 12-16 trees along the outside edge of the block. All treatments were applied by a handgun sprayer (400 psi) to ensure proper coverage. Application dates were: Protective schedule-6 May, 21 May, 3 Jun, 16 Jun, 30 Jun, 20 Jul, 2 Aug, 17 Aug and 31 Aug, Optimum Timing- 6 May, 20 Jul and 31 Aug, Late Season Control - 20 Jul, 2 Aug and 31 Aug. Due to a slow accumulation of degree days, the Late Season Control program only received three sprays. Damage from the first generation was taken on 23 Jul by inspecting 100 fruit on 5 trees in each treatment. Final harvest evaluations were picked and inspected on 10 Sep (100 fruit on 3 trees/trt) and again on 8 Oct (100 fruit on 4 trees/trt). The two dates were to determine whether or not late season damage from a possible third brood would be apparent. Data was subjected to an AOV with SuperAnova (Abacus concepts). Means were separated with Fisher's Protected LSD Test ($P<0.05$). Data was transformed Arcsin (Sqrt X) prior to analysis.

Both orchards in 2004 had a drastic change in OFM populations than what was evident in 2003. Weather patterns are probably the cause due to the unseasonably cool and wet summer. First generation fruit counts indicate that the protective schedule is the best control in these historic problem blocks, while the optimum timing, which received a single spray for the first generation, was comparable to the untreated check plot and the late season program, which did not have an application for the first generation. These results would indicate that a single spray is not sufficient for control. The 10 Sep sample indicates that the Bartleson orchard has a higher population, and the comparison of the two orchards shows a similar pattern. The Optimum timing offered no control and was numerically higher in damage than the untreated check plot. The Late Season program did reduce damage from the check plot, but was only significant at one site. Again the Protective Seasonal schedule reduced damage substantially from the other treated programs as well as the untreated check plot. When the results are combined from both test orchards, the Protective schedule was the only treatment that separated out from the other programs, and there were no significant differences between the Late Season, Optimum and Untreated plot. The damage from the third generation taken on 8 Oct reiterated that the season long applications provide good control while the other two treatments reduced damage from that found in the untreated check. However, both were significantly higher than the seasonal program and one treatment at each location was comparable to the check. When data from the two orchards was combined and evaluated for this date, the Optimum and Late-Season programs were statistically similar, but not as effective as the Protective program, and slightly better than the untreated check.

	First Generation 23 Jul			Harvest 1 10 Sep			Harvest 2 8 Oct		
Treatment	Bartleson	Verbridge	Combined	Bartleson	Verbridge	Combined	Bartleson	Verbridge	Combined
Protective Schedule Pink, petal fall, 1-7 cover	1.4	0.6	1.0 a	2.7	0.3	1.5 a	1.8	0.5	1.13 a
Optimum OFM 1 spray @ 1st hatch/brood	12.2	1.4	6.8 b	26.7	8.7	17.7 b	12.5	5.8	9.0 b
Late Season Control 2 sprays for each of the second broods	9.2	2.4	5.8 b	14.0	5.0	9.5 b	5.3	10.3	7.8 b
Untreated Control	13.4	5.0	9.2 b	24.3	7.0	15.7 b	20.8	14.0	17.4 c

Means within a column followed by the same letter are not significantly different (Fisher's Protected LSD Test, $P \leq 0.05$). Data transformed arcsin (sqrt[x]) prior analysis.

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EFFICACY OF THREE MATING DISRUPTION TECHNOLOGIES AGAINST THE CODLING MOTH, *CYDIA POMONELLA*, AND ORIENTAL FRUIT MOTH, *GRAPHOLITA MOLESTA*, IN PENNSYLVANIA APPLE ORCHARDS

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Introduction

The codling moth, *Cydia pomonella* (L), and the Oriental fruit moth, *Grapholita molesta* (Busck) have become major pests again in Pennsylvania apple orchards over the past seven years. Fruit growers in this area have typically relied upon the use of insecticides to control these pests, but due to the development of insecticide resistance by both CM and OFM and the loss of other products due to the FQPA process, fruit growers have been forced to consider other alternatives. One alternative to the use of insecticides is pheromone mating disruption. In this report, we evaluated three formulations of mating disruption for their efficacy against CM and OFM in commercial orchards in Pennsylvania during the 2004 season.

Materials and Methods

Study 1

Two commercial apple orchards (*ca.* 10 and 14 acres each in size) located near Aspers, PA were selected for this study. The apple trees in these blocks were over 20 years old and approximately 13-15' in height. The trees were planted to a 24' x 18' row x tree spacing at 100 trees per acre. Both orchards had a history of CM infestation. All orchards received a standard seasonal insecticide treatment schedule including Guthion® (azinphos-methyl), Asana XL® (esfenvalerate), Intrepid® (methoxyfenozide), and Calypso® (thiacloprid). The mating disruption orchard (i.e., 14 acres) was subdivided to accommodate two 5-acre plots for testing the different mating disruption technologies separated by a 4-acre buffer zone in the center. Isomate CM/OFM TT mating disruption dispensers were applied at the rate of 200/acre (2 dispensers per tree). The dispensers were hung in the top one-third of the trees on 5 May.

All applications of sprayable pheromones were made as alternate row middle applications (ARM) (25 GPA per each side of trees), commencing with the first brood. For the first brood, applications on the following dates (and rates) 13 May (3.4 fl oz/acre/side), 24 May (1.7 fl oz/acre/side), 2 June (1.7 fl oz/acre/side), 10 June (1.7 fl oz/acre/side) were made. Applications against the second brood were made on the following dates 23 July (3.4 fl oz/acre/side), 29 July (1.7 fl oz/acre/side), 11 August (1.7 fl oz/acre/side), 19 August (1.7 fl oz/acre/side) were made. All sprayable MEC-CM applications included the adjuvant Lastick® (16 fl oz/100 gals).

Ten delta-style pheromone traps (Suterra LLC, Bend, OR) with long-lasting ("L2") 1X CM lures (Trécé Inc., Salinas, CA) were deployed at a density of one trap per 0.5 acre in both the MEC-CM block and the Isomate CM/OFM TT block. Only three CM traps with "L2" lures were deployed in the standard insecticide orchard. Three OFM pheromone traps (0.11 mg lures) were deployed in each of the three blocks. All traps were hung between 7 and 10 May. The OFM traps were hung at a height of 2 m from the orchard floor on the outer one-third of the trees. CM traps were hung from bamboo poles in the top one-third of the tree canopies. Traps were checked weekly for the duration of the experiment; trap bottoms and OFM lures were changed monthly, and the CM lures were changed every 8 weeks.

On 2 July, *in situ* evaluations of 2600 apples (100 randomly selected fruit on each of 26 trees) were conducted in each plot. On 27 September, near the time of harvest, *in situ* evaluations of 3000 apples (100 random fruit on 30 random trees per plot were conducted in each plot. All fruit examined were in the upper portions of the trees. Any apples exhibiting frass, or evidence of invasive larval feeding, were brought to the laboratory for closer examination and extraction of larvae. The larvae were identified to the species level.

Study 2

Two commercial apple orchards (*ca.* 10 acres each in size) located near Goodyear, PA were selected for this study. One orchard block ("old"), which contained 52-year old trees at a row and tree spacing of 22.5' by 20' (97 trees per acre), was subdivided into two plots–one each for MEC-CM sprayable pheromones and CM/OFM TT. The CM/OFM TT block (5.1 acres) was treated on 10 May. The hand-applied dispensers were hung in the top one-third of the trees at a rate of 200/acre (≈2 dispensers per tree). The MEC-CM regimen was started in the "old" orchard at the onset of the first brood flight of CM [14 May] and continued throughout first brood. Applications were started again at the onset of second brood flight and continued until near harvest. All MEC-CM applications were made with the alternate row middle (ARM) approach and applied at the rate of 50 GPA/side of the trees (equivalent to 100 GPA to both sides). Slightly to the north of the "old" orchard was a 14-year old orchard ("young"), in which the same subdivision scheme for mating disruption treatments was employed. In the "young" orchard, however, the trees were on semi-dwarfing rootstocks, and planted in a row and tree spacing of 10' by 20' (218 trees per acre). A 5.2 acre section of this block was treated with the CM/OFM TT dispensers (one dispenser per tree in the top one-third) on 4 May. Again, all MEC-CM applications were made with the ARM method, but at an application rate of 40 GPA/side of the trees (80 GPA both sides equivalent) and the timing for applications was similar to the "old' block. All sprayable MEC-CM applications included the adjuvant Lastick (16 fl oz/100 gals).

The apple trees in the "old" orchard were mixed plantings of 'Golden Delicious', 'Rome' and 'York', while the apple trees in the "young" orchard were a mixture of 'Fugi' and 'Granny Smith.' Both blocks had a history of CM infestation. An adjacent block of old, large 'Golden Delicious' trees was located across the road from the "old" block and it served as a conventional insecticide treated block. This block was ≈5 acres in size.
The grower's normal seasonal insecticide treatment schedule included Guthion ® (azinphos-methyl); Warrior® (cyhalothrin); Intrepid® (methoxyfenozide); and Calypso® (thiacloprid) and was applied to all blocks.

Ten delta-style pheromone traps (Suterra LLC, Bend, OR) with long-lasting ("L2") 1X CM lures (Trécé Inc., Salinas, CA) were deployed at a density of one trap per 0.5 acre in both the MEC-CM blocks and the Isomate CM/OFM TT blocks ("old" and "young"). Only four CM traps with the "L2" lures were deployed in the standard insecticide orchard. Three OFM pheromone traps (0.11 mg lures) were deployed in each of the five treatments blocks. All traps were hung between 7 and 10 May. The OFM traps were hung at a height of 2 m from the orchard floor on the outer one-third of the trees. CM traps were hung from bamboo poles in the top one-third of the tree canopies. Traps were checked weekly for the duration of the experiment; trap bottoms and OFM lures were changed monthly, and the CM lures were changed every 8 weeks.

Mid-season *in situ* evaluations of 3000 immature fruit in each of the mating disruption and standard insecticide treatment blocks were made on 7 July. Between 20 September and 3 October, near the time of harvest, additional evaluations of 100 apples from 25 to 34 randomly selected trees were made in each of the mating disruption and standard treatment blocks. Any apples exhibiting frass, or evidence of invasive larval feeding, were brought to the laboratory for closer examination and extraction of larvae. The larvae were identified to the species level.

Study 3

The commercial apple orchard site was approximately 4 miles north of Biglerville, PA. The orchard site consisted of large apple trees (ca. 13-15 ft in height). There were a total of three treatment blocks: Treatment 1 (≈ 5 acres) – 3M Canada OFM (P5) [Low rate – 1.5-3.0 g AI/acre/side], Treatment 1 (≈ 5 acres) – 3M Canada OFM (P5) [High rate – 3.0-6.0 g AI/acre/side], Treatment 3 (≈ 10 acres) – conventional insecticide. All pheromone and insecticide applications were made with an airblast sprayer as alternate row middle (ARM) applications, and the MEC pheromones were incorporated into the grower's normal insecticide schedule every 7-11 days starting with the initial pheromone application on 14 June (Tables 1-2). All pheromone and insecticide applications were applied in a water volume rate of 50 GPA (both sides), 25 GPA per side of the tree as an ARM application.

Three Delta-style pheromone traps with 0.11 mg OFM lures (Scenturion, Inc., Bend, OR) were deployed in all three treatments with the exception of High Rate treatment block, where four traps were used to monitor adult populations. A single Delta-style codling moth (CM) trap was also hung in each treatment block. All traps were hung before the start of the study in mid-June and monitored twice weekly for the duration of the season. The lures and bottoms were replaced monthly until the end of August, unless the condition of the trap bottom indicated the need for more frequent replacement.

Prior to normal harvest (29 Sept), *in situ* evaluations of apples showing evidence of internal lepidopteran larvae were conducted in each treatment block. For each treatment block, 28 'Yorking' trees were randomly selected within each plot and 100 apples were randomly evaluated for the presence of entries from internal lepidopteran larvae. In addition, 100 dropped fruit scattered throughout each block were examined for entries. Any apples showing such injury were returned to the laboratory, examined for live larvae; those found were identified to species.

Results and Discussion

Study 1

Both mating disruption technology programs successfully suppressed CM trap capture as compared to the standard program, but the Isomate CM/OFM TT formulation was the most effective treatment for reducing trap capture of adult moths over the entire study (Fig. 1). Monitoring traps in the Isomate CM/OFM TT block caught a total of 5 CM adults over the entire season while traps in the MEC-CM block caught 72 CM adults over the course of the study. The differences in CM trap capture between these two MD technologies may be partially due to rainfall events following the MEC-CM application dates, and washing/removing of the pheromone formulations from the trees' foliage. It is notable, that directly following the 10 June application of pheromones, 3 inches of rain was recorded, initiating a period of elevated rainfall. In addition, more CM adults were caught in the MEC-CM block during 1st brood flight than during the 2nd brood flight (Fig. 1). Again, rainfall was much more intense during 1st brood flight while more frequent but less intense amounts of rainfall occurred during 2nd brood flight.

OFM/CM TT was also effective against OFM, reducing the trap capture to zero over the course of the season (Fig. 1). Fewer OFM adults were captured in the CM sprayable plots, suggesting that the MEC-CM formulation might have some effect on OFM's response to monitoring traps or that the wild OFM populations were just lower in this block compared to the standard insecticide block (Fig. 1).

No fruit injury was found in any of the study blocks during the mid-season evaluation on 2 July (Table 1). The harvest fruit samples yielded no major differences in fruit injury between any of the three treatment blocks (Table 1). A total of 7 larvae were recovered: 2 CM larvae, one each in the MEC-CM and standard insecticide blocks; and 5 OFM larvae – 3 in the CM/OFM TT block and 2 larvae in the standard insecticide block (Table 1). Despite the discovery of these larvae, the control of the two insects by the combination of mating disruption and insecticide was comparable to the insecticide alone. The grower reported no loads of fruit rejected from any of these monitored blocks.

In conclusion, Isomate CM/OFM TT was much more effective than MEC-CM in preventing adult CM from finding monitoring traps in the orchard. It was also very effective in the overall management of OFM populations, although some live OFM larvae were found in the fruit at harvest. The registration of this product should certainly assist fruit growers throughout Pennsylvania in the management of this pest complex and assist in the eventual reduction of insecticide use for their control.

Study 2

Five ARM applications of MEC-CM during the first brood flight of CM and five ARM applications during the second brood flight failed to prevent male adults from finding pheromone traps in the "old" block (Fig. 2A). The total amount of CM-MEC active ingredient applied over the season in each of the "old" and "young" blocks was 70 g (Table 2). A total of 399 adults were captured in 10 traps (avg. 39.9 adults per trap) during the season in the MEC-CM "old" block. In comparison, capture of adult males in the CM/OFM TT "old" block was greatly reduced and only 19 adults were caught in 10 monitoring traps (1.9 adults per trap) (Fig 2A). The total of 138 adults in four traps (avg. 34.5 adults per trap) were captured on the standard insecticide block (Fig 2A). In the "old" orchard treated with CM-MEC, 2.6 as many CM were captured in the three most heavily CM-traps intercepted traps as in three next-most intercepted (as illustrated by the red and brown numerals, respectively, in Fig. 1). We suspect two factors contributed to this occurrence: the presence of a bin pile near the edge (50 m to the west) of the "old" MEC-CM block which may have provided a refuge for overwintering CM; and the onset of rainfall events near the timings for MEC-CM applications. Directly following the 10 June application of MEC-CM, the largest amount of rainfall of the entire 2004 season was recorded on 14 June. Again, following the 24 July application, high rainfall was recorded. Spikes in precipitation throughout the season contributed to a rapidly increasing accumulation of total rainfall that undoubtedly compromised the MEC-CM control potential by washing the pheromone capsules from the foliage.

In the "young" treated blocks, adult CM capture in monitoring traps was similar and lower throughout the season than in the "old" block (Fig. 2B). A total of 43 male CM were caught in 10 traps (avg. 4.3 moths per trap) over the course of the season in the CM/OFM TT block while only 31 adults (avg. 3.1 moths per trap) were caught in the MEC-CM block (Fig. 2B). The number of CM adults caught in the "young" CM/OFM TT block was surprisingly higher than expected. Part of this may be due to the nearby bin pile mentioned above, as it was just 50 m from the edge of the CM/OFM TT block at this site. Also, there were some missing trees in this block as well as the trees were shaped to a central leader design. This was a somewhat of an open and windy site.

In both the "old" and "young" blocks, OFM populations were greatly reduced from the populations captured in the standard insecticide block (Fig. 3AB). CM/OFM TT contains OFM pheromone and obviously is quite effective in suppressing the response of adult males to monitoring traps. Interestingly, the MEC-CM applications also suppressed trap OFM capture, as compared with the standard plot (Fig 3B). Only late in the season did traps capture OFM adults in the "old" MEC-CM block. Either OFM populations were very low in both of these sites or there may be chemical or physical properties in the MEC-CM formulation to which OFM respond, and subsequently fail to locate pheromone traps.

Since the most CM adults were captured in the MEC-CM "old" block, it is not surprisingly, then, that more injured fruit and live CM larvae were found in this block at the time of injury evaluations–both mid-season and harvest (Table 2). A similar number of injured fruit were also found in the standard insecticide block at harvest, but all of the live larvae found were identified as OFM. The "old" MEC-CM block was notable in being the sole site where the combination of insecticide and mating disruption failed to prevent fruit injury. At mid-season, the CM/OFM TT program clearly outperformed MEC-CM in the "old" orchard; and, both mating disruption technologies in combination with insecticides were quite effective in the "young" blocks. At the end of the season, all treatments, except the MEC-CM "old" block, that incorporated mating disruption with supplemental insecticides protected the fruit better than just a standard insecticide schedule. Slightly less insecticide was used in the CM/OFM TT blocks than used in the MEC-CM and standard insecticide blocks.

In conclusion, the formulation of Isomate CM/OFM TT outperformed the MEC-CM formulation in management of CM, especially in the "old" block. It is the feeling of the authors that the amount of rainfall experienced during the 2004 season had a significant effect on the residual activity and effectiveness of the MEC-CM formulation. In addition, the bin pile likely also represented an impediment to the success of the MEC-CM in the "old" orchard and possibly the CM/OFM TT formulation in the "young" block.

<u>Study 3</u>

A total of 11 ARM applications of both the low and high rate treatments of the MEC-OFM (P5) formulation were made starting with the first application on 14 Jun and ending with the last application on 3 Sep. The rate applied for both treatments during the course of study increased in a stepwise fashion in order to try and shutdown trap capture of OFM adults. The low rate treatment started at an application rate of 1.5 g AI/acre/side for the first two applications, was increased to 2.0 g AI/acre/side for the next 5 ARM applications, and was finally increased to 3.0 g AI/acre/side for the final 4 ARM applications. A similar increase was followed for the high rate treatments from 3.0 g AI/acre/side, to 4.0 g, and finally to a rate of 6.0 g AI/acre/side. For the low and high rate treatments, a seasonal total of 25.0 and 50.0 g AI/acre, respectively, was applied.

The mean numbers of OFM adults captured per trap per week, and mean cumulative adult captures over the season were highest in the conventional insecticide block (Fig. 4). Capture of OFM adults in the low and high rate treatments was less than the conventional insecticide block, but it was only marginally less than that in the conventional insecticide block during the first four ARM applications (Fig. 4). It was not until the 5th ARM application (low – 2.0 g AI and high – 4.0 g AI) that significantly fewer moths were caught in the two MEC treatments. Moths continued to be captured in both MEC treatments until late August despite additional applications of pheromone and there was little difference in trap capture between the low and high rate treatments. It was not until late August that moth capture was completely shutdown in either of the two pheromone treatments.

During the harvest assessment the standard insecticide treated block has the lowest percentage of apples with frass – 4.65%, followed by the low rate – 6.96%, and finally the high rate – 14.04% (Table 3). All larvae found during the harvest evaluations were OFM. No CM larvae were found and trap captures of CM during the study were very low (i.e., highest trap capture recorded was 1 moth per trap per week). Even though there were fewer moths captured in the low and high rate blocks during the study, fruit injury was still above that observed in the conventional insecticide block. The grower used the same insecticide program in all three blocks throughout the study. It initially appears that the two rates of MEC-OFM added little to the protection of fruit from OFM infestation. Conversations with the farm manager revealed that a number of loads of fruit were rejected from these blocks in 2003 for live OFM larvae in the fruit at harvest, especially fruit from the high rate treatment block.

The 2004 season was characterized as one with high precipitation. Over 10 inches of rainfall was recorded during the period of the pheromone applications – 14 June until 2 September. This rainfall pattern may have significantly impacted the pheromone residue on the foliage as others (Waldstein and Gut, unpublished data) have shown that rain events of >0.5 inch removes 50% or more of pheromone residues.

This study needs to be repeated again next year (2005) to determine if MEC-OFM can be used to successfully lower high populations of OFM when applied at recommended label rates (i.e., 2-4 g AI/acre) using the LRFA and ARM techniques. In addition, it would be very worthwhile to measure the canopy distribution of pheromone capsules in trees of the size utilized in this study, especially when sprayed with the ARM method. There may not be adequate amounts of pheromone scattered evenly enough throughout the tree to affect overall mating of OFM. The author is also going to investigate if insecticide resistance is a problem in these orchards.

Acknowledgments

The authors would like to thank Mr. Tony Fetters of Fetters Orchards, Mr. Brian Knouse of Knouse FruitLand Inc., Mr. John Lott and Ms. Joy Cline of Bear Mountain Orchards for their willingness to cooperate on these studies and to make all of the MEC-CM and MEC-OFM pheromone applications. We also want to thank 3M Canada and CBC America for supplying the various CM and OFM pheromone formulations. We also wish to acknowledge Chris Jeffcoat and Kevin Knouse for monitoring the traps throughout the season and for Ken Mickley, Tim Baker, Clayton Myers and Melanie Schupp in their assistance in the harvest evaluations.

Table 1. Comparison of 3M Canada CM-MEC pheromone (P4S), Isomate CM/OFM TT formulation, and a standard insecticide program for codling moth mating disruption control, Fetters Orchards, Gardners, PA - 2004.

Treatment	Seasonal g AI/acre	% apples - frass[1] 2 Jul	% apples - frass[1] 16 Sep	ID and number of live larvae 16 Sep CM	ID and number of live larvae 16 Sep OFM
3 M Canada CM-MEC (P4S)	50.0	0.00 a	0.16 a	1	0
Isomate CM/OFM TT[2]	CM (63.7) OFM (21.1)	0.00 a	0.19 a	0	3
Standard insecticide	--	0.00 a	0.28 a	1	2

* Means followed by the same letter(s) are not significantly different, (Fisher's Protected LSD, $P \leq 0.05$).

[1] On each sampling date 100 apples per tree on 26-30 randomly selected trees per treatment block were examined in situ for the presence of frass. The number of apples per treatment block on 2 Jul was 2600; whereas, on 16 Sep, the number of apples per treatment block was 3000. In addition, 200 dropped fruit were randomly chosen below 15-20 trees per treatment block and examined for frass.

[2] 200 dispensers per acre (2/tree) were placed in the upper 1/3 of trees on May 5.

Table 2. Comparison of 3M Canada CM-MEC pheromone (P4S), Isomate CM/OFM TT formulation, and a standard insecticide program for codling moth mating disruption control, Knouse Fruitlands, Oakwood Farms, PA – 2004.

Treatment	Block	Seasonal g AI/Acre	% apples with frass[1]		ID and number of live larvae			
					7 Jul		20 Sep/4 Oct	
			7 Jul	20 Sep/4 Oct	CM	OFM	CM	OFM
3M Canada CM-MEC (P4S)	Old	CM (70)	0.20 b	0.47 b	4	3	5	0
Isomate CM/OFM TT[2]	Old	CM (63.7) OFM (21.1)	0.00 a	0.03 a	0	0	1	2
3M Canada CM-MEC (P4S)	Young	CM (70)	0.00 a	0.00 a	0	0	0	0
Isomate CM/OFM TT[2]	Young	CM (63.7) OFM (21.1)	0.03 a	0.07 a	1	0	0	0
Standard insecticide	Old	- -	0.00 a	0.44 b	0	0	0	5

* Means followed by the same letter(s) are not significantly different, (Fisher's Protected LSD, $P \leq 0.05$).

[1] On each sampling date 100 apples per tree on 25-34 randomly selected trees per treatment block were examined *in situ* for the presence of frass. The number of apples per treatment block on 7 Jul was 3000; whereas, on 20 Sep to Oct 4, the number of apples per treatment block was as follows: CM-MEC (Old) – 3400, CM/OFM TT (Old) – 3200, CM-MEC (Young) – 3000, CM/OFM TT (Young) – 3000, and Standard insecticide – 2500.

[2] 200 dispensers per acre were placed in the upper 1/3 of trees in the Young Block on May 4 and in the Old Bock on May 10.

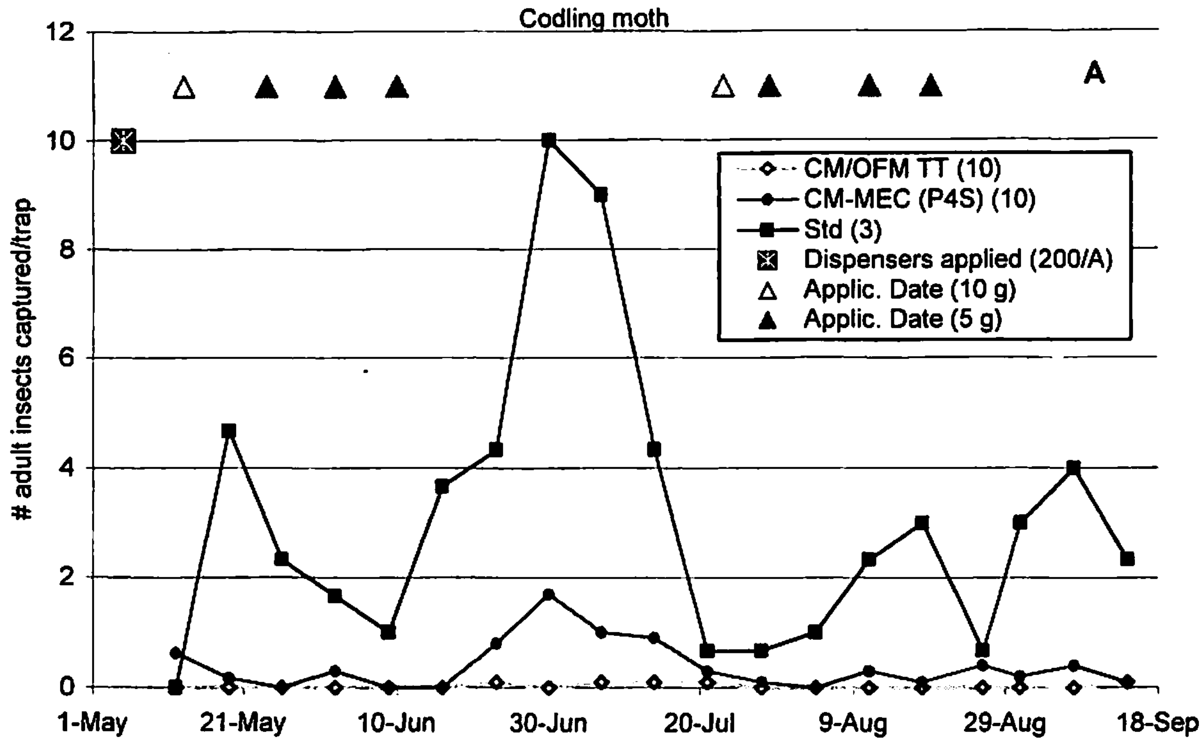
Table 3. Comparison of two rates of 3M Canada OFM-MEC (P5) applied using the Low Rate Frequent Application (LRFA) and Alternate Row Middle (ARM) method for the control of the Oriental fruit moth, Aspers, PA – 2004.

Treatment	g AI/acre/ applic.	No. ARM applic.	Seasonal Amt - g AI/acre[1]	No. apples evaluated[2] 29 Sep	% apples - frass 29 Sep	ID and no. live larvae	
						CM	OFM
1. 3 M Canada OFM sprayable (P5) Low Rate - LRFA	1.5, 2.0, 3.0	11	25.0 g	2600	6.96 b	0	8
2. 3M Canada OFM Sprayable (P5) High Rate - LRFA	3.0, 4.0, 6.0	11	50.0 g	2600	14.04 c	0	69
3. Conventional insecticide	- -		- -	2600	4.65 a	0	8

* Means followed by the same letter(s) are not significantly different, (Fisher's Protected LSD, $P \leq 0.05$).

[1] See Table 2 for dates of application.

[2] 100 apples per tree on 25 random trees per treatment block were examined *in situ* for the presence of frass. In addition, 100 apples were randomly collected from the ground in each treatment block. All apples with frass were examined for the presence of live larvae and identified to species.



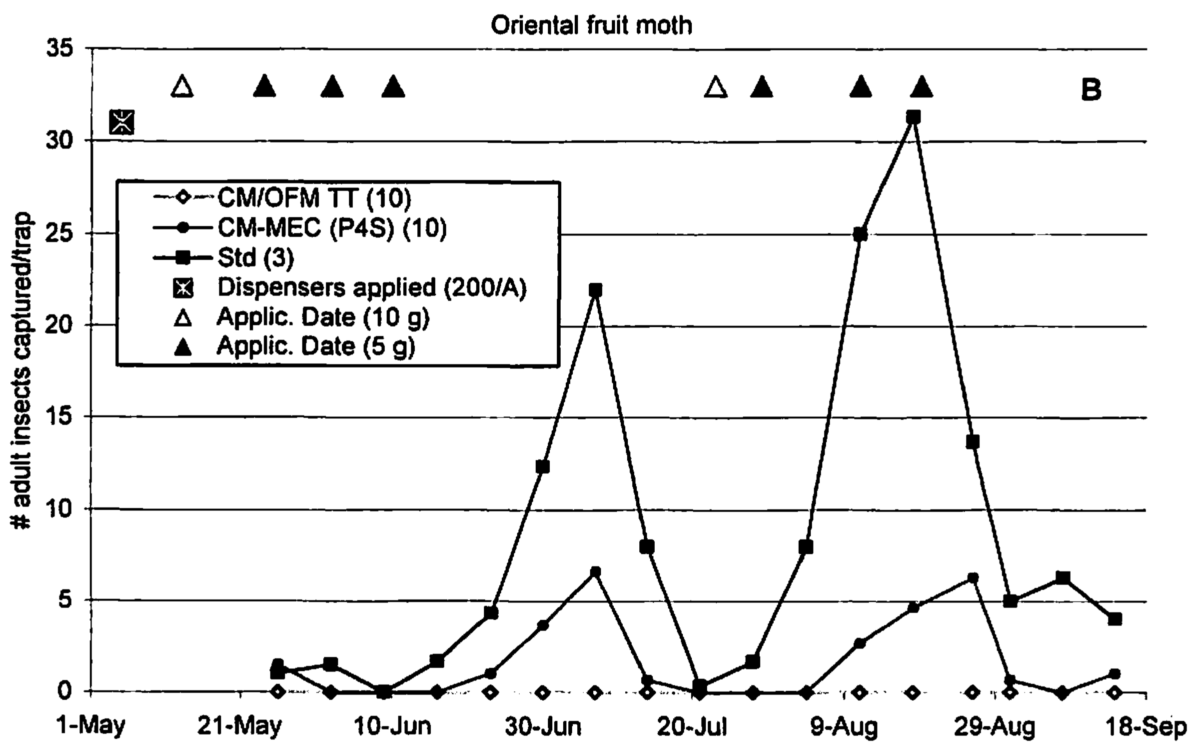
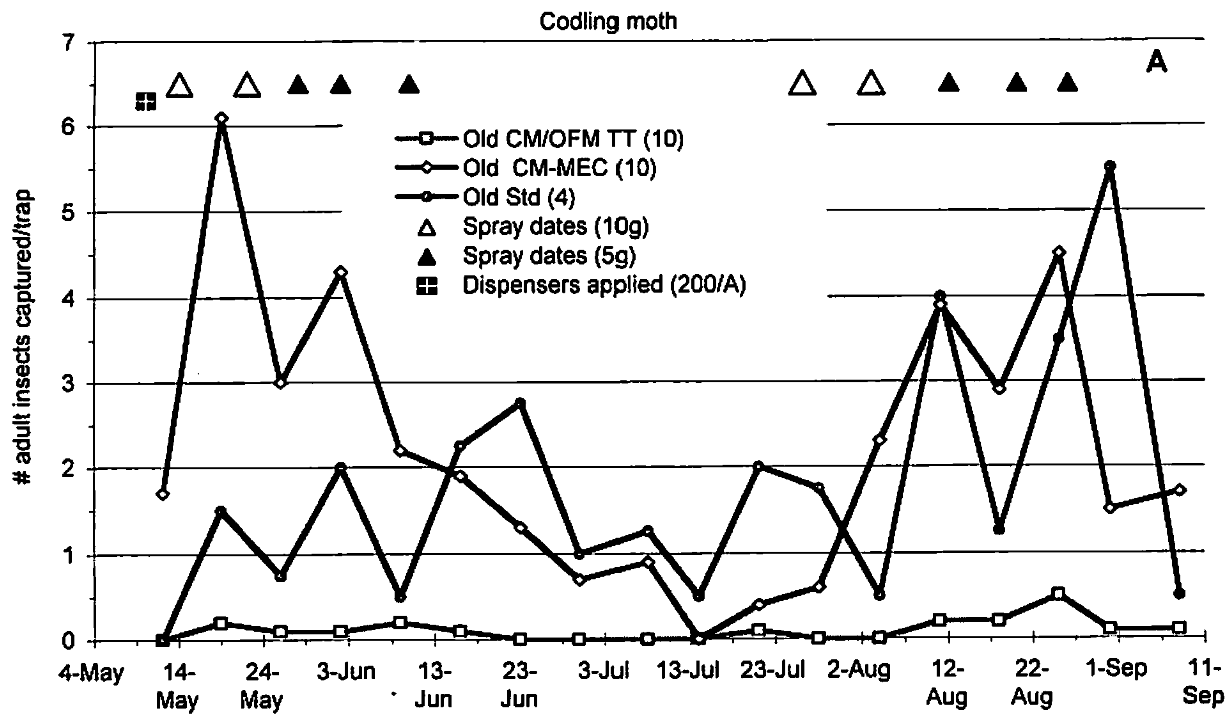


Fig. 1. Comparison of frequent applications of 3M Canada CM-MEC (P4S) and Isomate CM/OFM TT on seasonal trap capture of CM (A) and OFM (B), Fetters Orchards, Aspers, PA – 2004



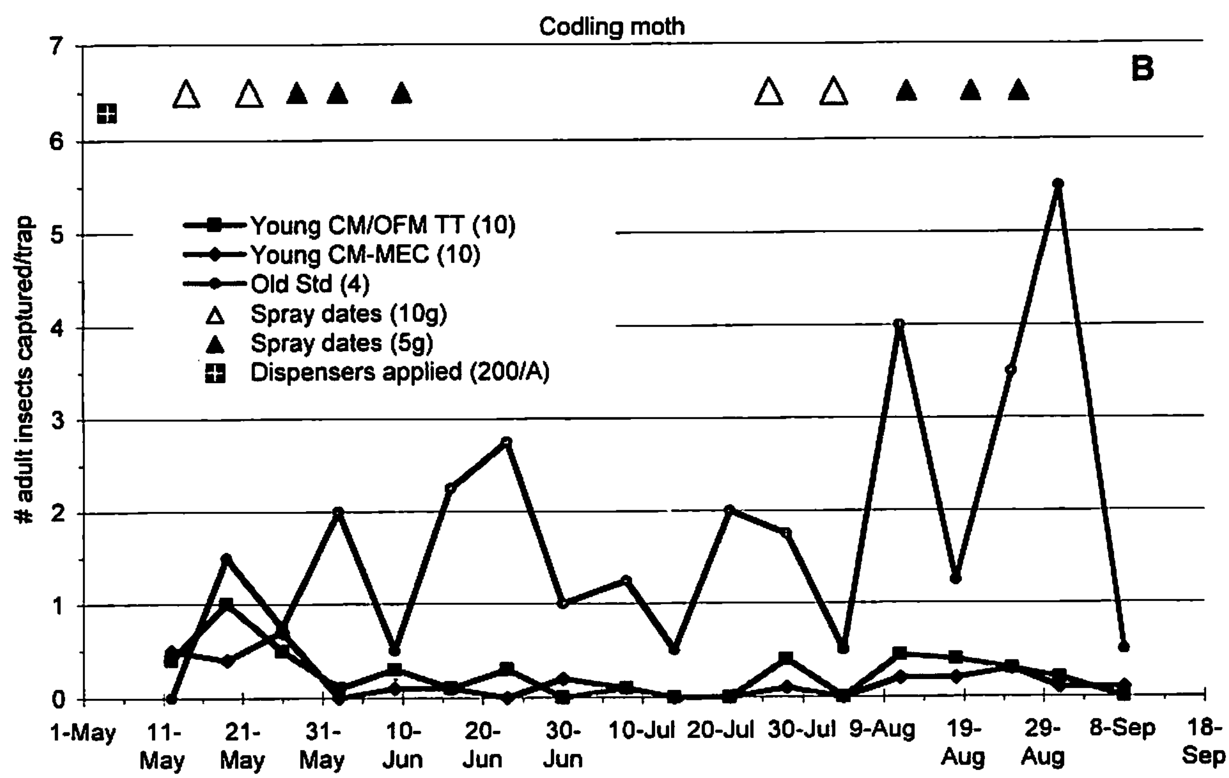
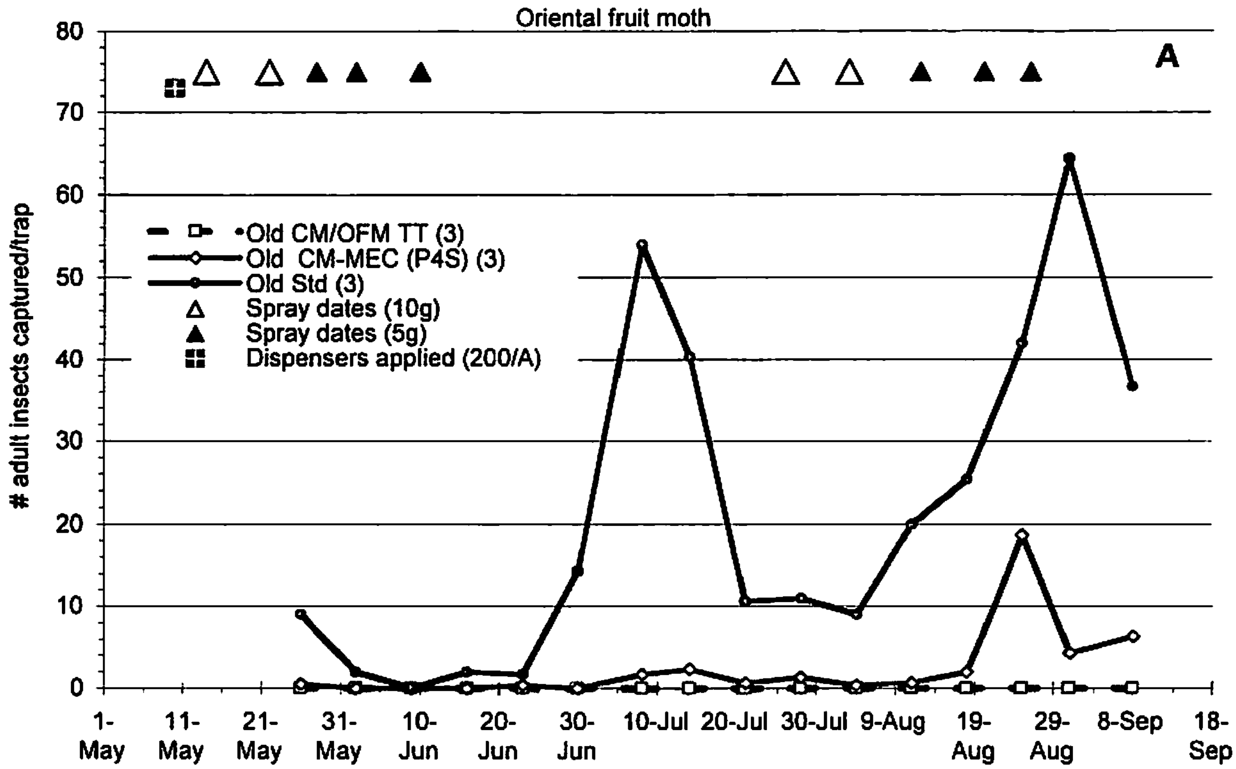


Fig. 2. Comparison of frequent applications of 3M Canada CM-MEC (P4S) and Isomate CM/OFM TT on seasonal trap capture of CM-Old Block (A) and CM-Young Block (B), KFL Oakwood, Goodyear, PA – 2004



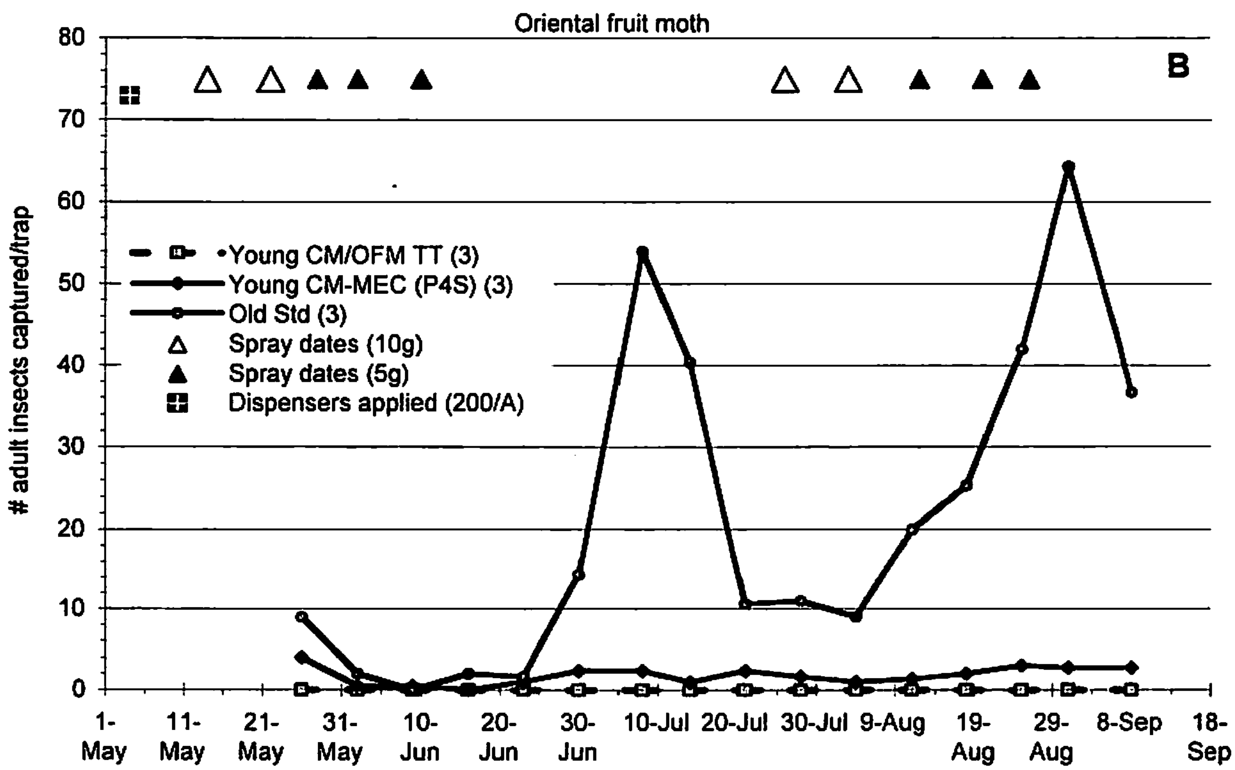


Fig. 3. Comparison of frequent applications of 3M Canada CM-MEC (P4S) and Isomate CM/OFM TT on seasonal trap capture of OFM-Old Block (A) and OFM-Young Block (B), KFL Oakwood, Goodyear, PA – 2004

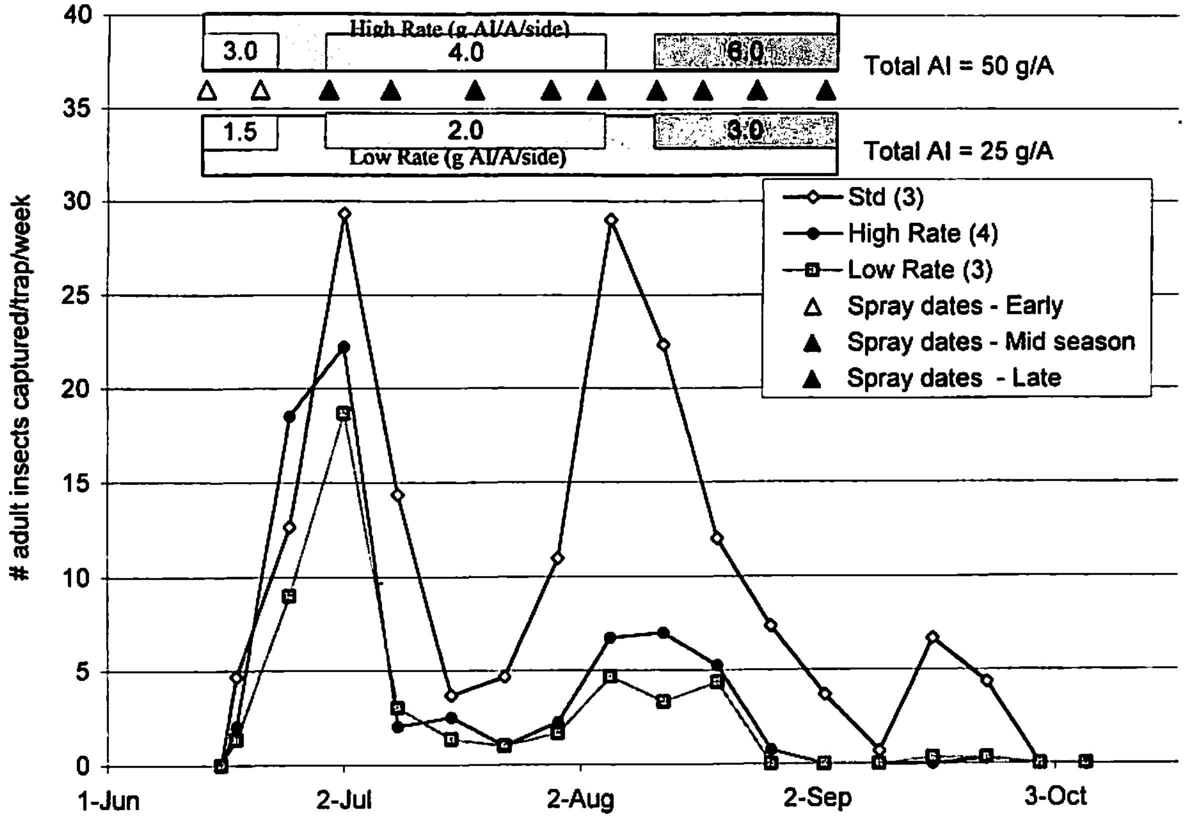


Fig. 4. Comparison of two rates of 3M Canada OFM-MEC (P5), applied using the LRFA and alternate row middle techniques, and a conventional insecticide program on OFM trap capture through time, BMO orchards, Aspers PA - 2004.

RESIDUAL ACTIVITY OF NEWLY REGISTERED REDUCED RISK COMPOUNDS

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OBJECTIVE: To assess the ovicidal and larvicidal residual activity of reduced risk compounds against oriental fruit moth and codling moth during field and laboratory bioassays

TREATMENTS:

1. Acetamiprid (Assail™ 70 WP applied @ 3.5 oz/acre)
2. Acetamiprid (Assail™ 70 WP applied @ 2.7 oz/acre plus JMS Stylet oil @ 0.5 gal /acre)
3. Indoxacarb (Avaunt 30WDG applied @ 6.0 oz/acre)
4. Fenpropathrin (Danitol 2.4 EC applied @ 21 oz/acre)
5. Control

METHODS:

Evaluated insecticide solutions were applied to young, about 6 year old apple trees using back pack sprayer (Solo Deluxe Model 425 w/Piston pump) to the point of drip. All sprays were applied with a pump pressure of at least 60 psi. Each treatment was replicated four times (single tree). Each treatment was separated from the next one by buffer trees. For OFM testing all insecticides were applied on July 15 and the fruit and leaves from each tree were collected at 0, 1, 4, 7, and 12 days after the application. The rainfall data for that period is presented in Figure 1. Trees used during the codling moth bioassays were treated on Aug 26. The precipitation data for the period of CM bioassays is presented in Figure 2. The trees used for the bioassays received regular fungicide sprays throughout the season but did not receive insecticide spray for at least 30 days prior to each treatment date.

Ovicidal bioassays: During the OFM bioassays ten spur leaves were collected from each treated tree. In the laboratory, collected leaves were placed overnight in the mating chamber with adult moths. The next day the number of eggs on each leaf was counted and eight leaves with the highest number of eggs were used for evaluation. The egg mortality was assessed at 6 days after oviposition. The leaves with eggs were kept at a temperature 72F and 16:8 h daylight. Non-hatched eggs were counted as dead.

Larvicidal bioassays: Ten fruit were collected from each treated tree (total of 40 fruit per treatment). Fruits were placed singly in a plastic 16 oz tightly closed container and ten OFM neonates were placed at the stem end of each fruit. For CM bioassays only 5 neonates were placed per fruit. The larval mortality data was assessed by counting the number of pupae and larvae in each container at 15 days after larval placement.

STATISTICAL ANALYSIS: The egg mortality data and corrected larval mortality (Abbot 1925) were compared among treatments using Fisher's Protected LSD test at P=0.05.

RESULTS AND DISCUSSION: Both rates of Assail reduced the survival of Oriental fruit moth eggs deposited on treated foliage (Fig. 3). The highest egg mortality was observed immediately after the treatment (up to 80 percent on foliage treated with Assail 2.7 plus oil) but even 12 days after the application the egg mortality still remained close to 45 percent in both Assail treatments. No differences were observed between used two rates of Assail. The effect of the Avaunt treatment on eggs mortality was low to insignificant, with about 40 percent mortality recorded only while eggs were deposited on the treated foliage immediately after the treatment. No residual ovicidal eggs bioassays were performed on codling moth eggs.

During larvicidal bioassays both concentrations of Assail (3.4 oz/acre and 2.7 oz acre plus oil) and Danitol provided very high (above 95 %) mortality of Oriental fruit moth neonates (Fig. 4) up to 12 days after the insecticide application. The larvicidal efficacy of Avaunt applied at 6.0 oz decreased significantly at 4 and 7 day readings and was below 20 percent at 12 days after the treatment.

During the codling moth larval bioassays all tested compounds provided excellent control of CM neonates up to 12 days after the treatment. At 19 days reading only Assail @3.5 oz/acre maintained excellent control of larvae. At the same evaluation date the larval mortality for other compounds was reduced to about 80 percent. In contrast to OFM larvicidal bioassays, even Avaunt treatment maintained high efficacy at 12 days after the application. It is possible that such long residual activity of Avaunt and other evaluated compounds were related to the period of dry weather following the applications with the first precipitation at 13 days after the treatments (Fig. 2).

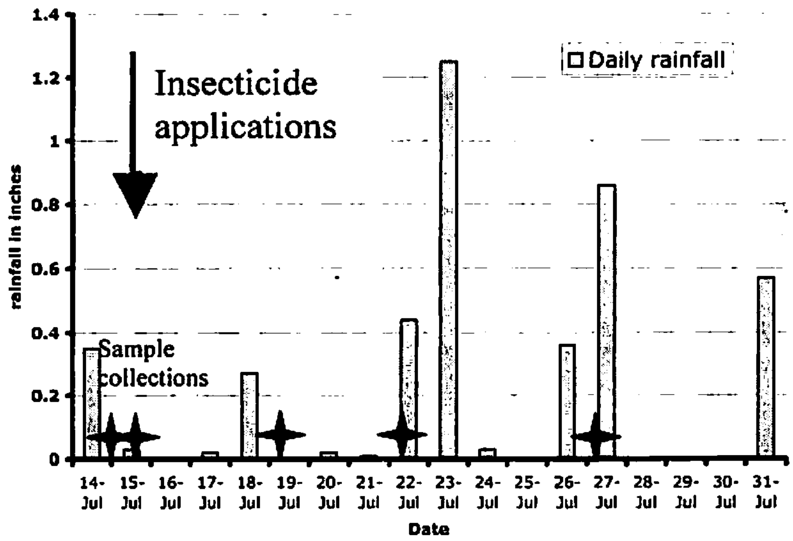

Figure 1. Daily precipitation in the Biglerville, PA area during the period of July 14 – July 30, 2004. The insecticides were applied on July 15; the fruit and foliage samples were collected on July 14, July 15, July 19 (Assail 2.7 oz only), July 22 and July 27. PSU FREC, 2004

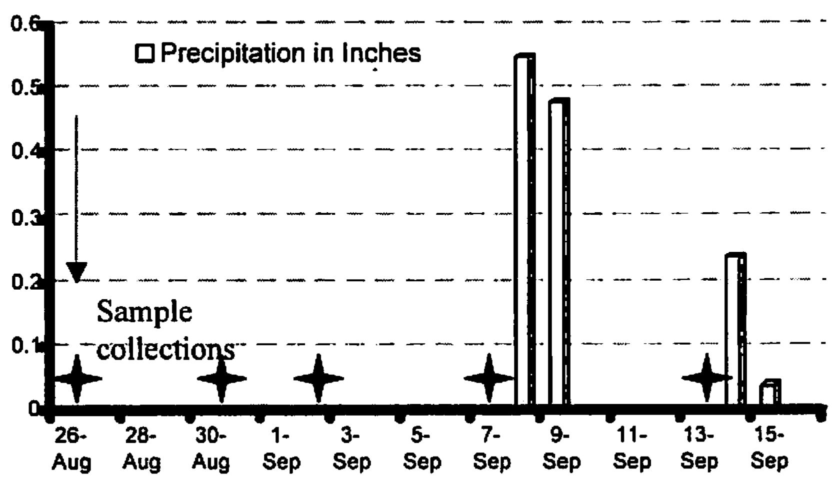

Figure 2. Daily precipitation in the Biglerville, PA area during the period of Aug 26 – Sep 15, 2004. The insecticides were applied on Aug 26; the fruit and foliage samples were collected on Aug 27, Aug 31, Sep 02, Sep 07 and Sep 14. PSU FREC, 2004

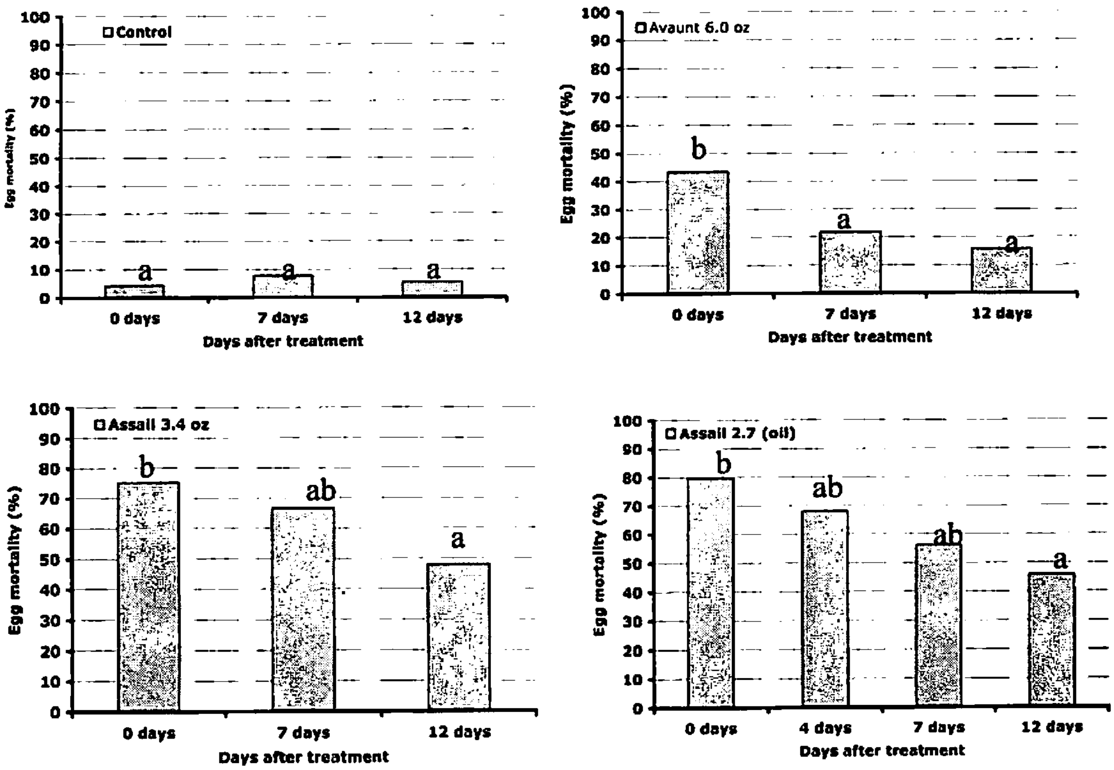

Figure 3. Ovicidal residual activity of various insecticides against Oriental fruit moth eggs deposited on treated foliage. Bars with the same letter(s) are not significantly different (Fisher's Protected LSD, $P < 0.05$). PSU FREC 2004.

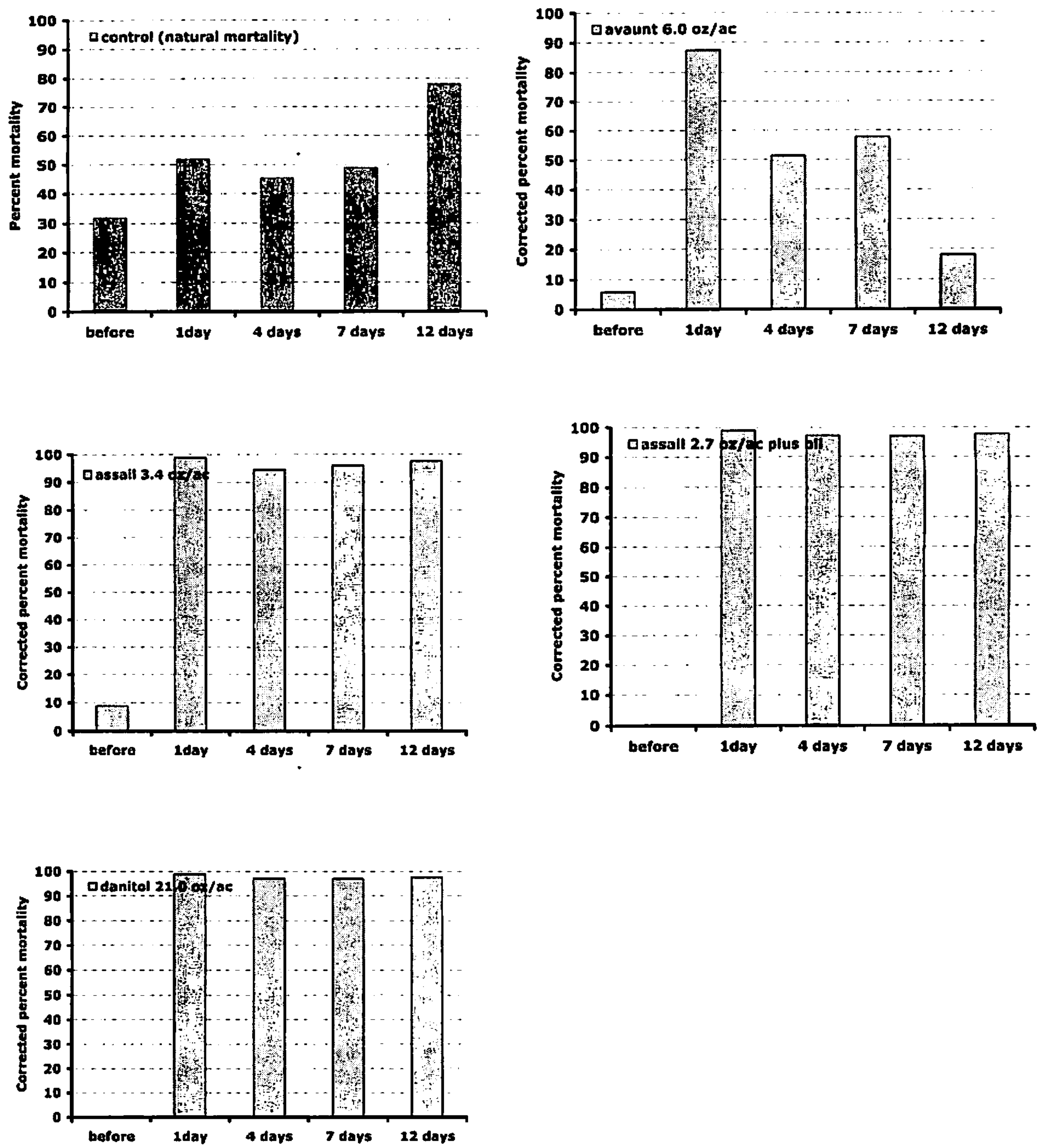

Figure 4. Larvicidal residual activity of various insecticides against neonate Oriental fruit moth. Fruit were collected from treated trees and ten OFM larvae were placed per fruit. Larval mortality was assessed at 15 days after the placement of the larvae on fruit. The larval mortality in insecticide treatments presented as a corrected mortality . PSU FREC, 2004

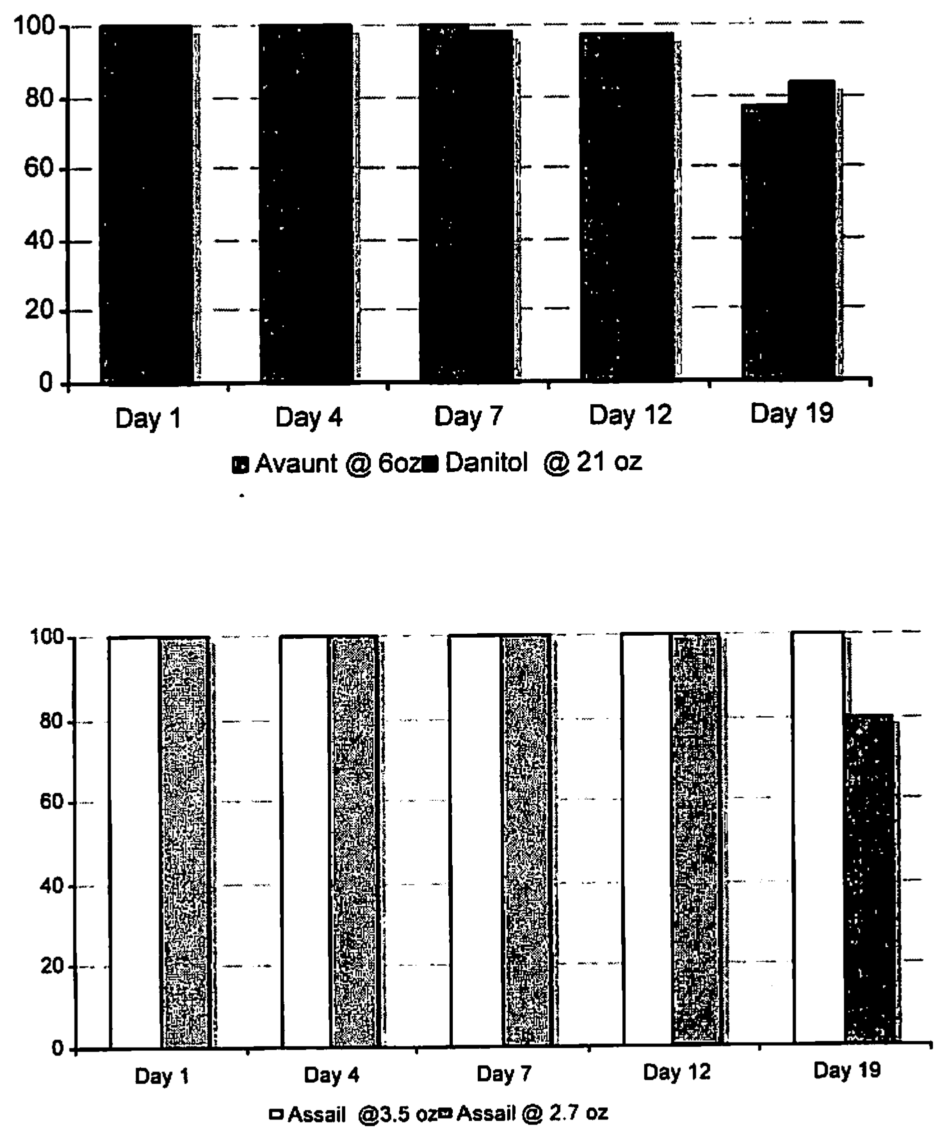

Figure 5. Larvicidal residual activity of various insecticides against neonate codling moth. Fruit were collected from treated trees and five larvae were placed per fruit. Larval mortality was assessed at 15 days after the placement of the larvae on fruit. The larval mortality in insecticide treatments presented as a corrected mortality. PSU FREC, 2004

Mating disruption of codling moth and oriental fruit moth in Virginia - 2004

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I. Introduction: Codling moth (CM), *Cydia pomonella* (L.), has been the subject of mating disruption in Virginia since 1987 (Pfeiffer et al. 1993). Results have been promising to date. However, existing dispenser technology is expensive and further work is needed to find a system that is both efficacious and economical for growers. Oriental fruit moth, *Grapholita molesta* (Busck) (OFM) was the first target of mating disruption in Virginia orchards (Pfeiffer and Killian 1988). In recent years OFM has been causing increased infestation in apple orchards. This tortricid complex was the subject of this mating disruption trial.

A major impediment to the adoption of CM/OFM mating disruption has been the cost. Recently, alternative pheromone dispensing systems have become available. It is desirable to compare the competing technologies in order to better incorporate mating disruption into management programs. The main technologies to be incorporated are Isomate rope-style dispensers (CM CTT/OFM Rosso, separate products for each species), and Cyd-X (codling moth granulovirus) with OFM Rosso.

II. Materials and Methods: Mating disruption research was carried out in three orchards in 2003, one in northern and two in central Virginia. These orchards had the following characteristics:

- **Rappahannock** – 2004 was the third year of MD; severe problems with internal feeders (for past two years have worked with timing, pesticide chemistry, and calibration issues; have improved situation, but insufficient progress). This year, we attempted to combine mating disruption with a normal insecticide program and Cyd-X CM granulovirus in an effort to control this intractable population.
- **Albemarle** – by 2004, had been in MD program for several years; light population of CM, moderate-high pressure of OFM
- **Botetourt** – 2004 was third year of MD; light population of CM, moderate-high pressure of OFM

In general, normal sprays were applied through first cover. Three pheromone traps were placed in each plot for the target insects (CM and OFM, plus three leafroller species: tufted apple bud moth (*Platynota idaeusalis* (Walker)), variegated leafroller (*Platynota flavedana* Clemens) and redbanded leafroller (*Argyrotaenia velutinana* Walker); pheromone traps were monitored weekly. Damage was assessed *in situ* every 3-4 weeks. At harvest time, 600 fruit per plot were collected for final damage evaluation (900/plot in Rappahannock).

Rappahannock County: A mixed block ('Delicious', 'Golden Delicious', 'York') in Washington, Rappahannock County, was selected for the mating disruption trial as part of a multi-pronged attempt to control intense internal feeder injury. Trees were about 20-22 feet tall, with thick canopies. The ShinEtsu Isomate CTT and Isomate Rosso ropes were was the only disruption treatment; ropes were applied on 12, 18 and 30 May. Cyd-X was applied on 25 May and 30 Aug (6 fl oz/A).

Albemarle County: Sections of an apple orchard composed primarily of 'Delicious' trees at Miller School, Albemarle County, were treated with several types of pheromone dispensers for CM and OFM. Trees were 2.4-3.0 m tall (8-10 ft), in a 10'x15' spacing (290 trees/A). In section A, a rope-style dispenser (Isomate CTT and Isomate Rosso) was used (500/ha (200/A) on 27 April) (ca 10 A (4 ha)). In section B, Cyd-X (2.5 fl oz/A, 120 gallons/acre on 7 August and 20 August) and Isomate Rosso were applied for late season OFM activity, starting in late July. Section C was a conventionally treated control. Azinphosmethyl was applied at first cover (5/24) (diazinon in the 3M sprayable block). The control block received a conventional spray program

Fruit were examined on the tree periodically during the season; 10 fruit were examined on each of 20 trees. Harvest injury was assessed on 27 August. At that time, 300 fruit from the edge and center of each block were picked and returned to Blacksburg for examination, for a total of 600 fruit per pheromone treatment.

Botetourt County: In a 'Rome' and 'Jonathan' orchard block in Troutville, Botetourt County, the pheromone treatment program was established in two separate 5-acre blocks. Trees were about 15' tall, in a 15'x25' spacing (120 trees/A). Rope pheromone dispensers (Isomate CTT and Isomate Rosso) were placed on 4 May. In pheromone-treated blocks, a conventional insecticide program was followed through first cover. Three pheromone traps each for CM, OFM, VLR, TBM, and RBL were placed in each block and monitored weekly. The grower harvested most fruit before harvest injury samples were collected; an incomplete sample was taken. At that time, 200 fruit from the center of each block were picked and returned to Blacksburg for examination, for a total of 200 fruit per pheromone treatment.

III. Results and Discussion:

Flight data: Moth flights differed markedly among the orchards for both moth species.

In the Rappahannock County orchard, trap catches occurred all season, similar to previous years. While numbers were usually low, there were two substantial peaks of 56.7/trap on 3 Jun, and 32.3/trap on 27 Aug. Numbers of OFM were very low, after a peak of 32 and 20.2/trap on 21 and 29 Apr (before dispenser placement).

In Albemarle County, excellent trap shutdown was seen for CM and OFM.

In Botetourt County, CM numbers in traps were substantially below economic levels in the control block; most moths captured were OFM. Total trap shutdown was achieved, except for OFM with 0.3/trap in the main pheromone block on 25 May, and 4.7 and 0.3/trap in the long block on 17 and 25 Apr. Percent shutdown was 99.6 in the main block, and 93.2 in the long block

Damage data: Rappahannock County: On 5 Sep, 30 fruit were collected from each of 30 trees in the single mating disruption/ Cyd-X program (Table 1). There were 5 fruit with internal larval injury among the 900 fruit (0.6%). This is a greater degree of control than in previous years. In 2003, the control had 9.6% injury, with 9.2% in the mating disruption block

Albemarle County: Data are presented in Table 2. Damage from both species was at very low levels in all treatments in this orchard, despite OFM trap captures in the control being above the action threshold, and the lack of apparent trap shutdown in the late treatment of OFM sprayable.

Botetourt County: Sample was incomplete because of earlier harvest by grower. In a preliminary field count on 2 Jun, 200 fruit per block were examined. In the control, 0.5% CM injury was detected. No internal injury was detected in either of the two disruption blocks. In the control block there were 0.5% fruit injured by plum curculio, and no fruit injured by either *Platynota* or RBL. In the main disruption block, there was 10% plum curculio injury and no leafroller injury. In the narrow block, 15.5% of the fruit were inured by plum curculio, and 2% by *Platynota* leafrollers. In another preliminary examination (25 Aug) in the two disruption blocks, 1% internal injury was seen in both blocks. In the partial harvest sample collected, in the narrow disruption block there were 3% fruit with internal injury in the block center (n=305); in the edge, 1 fruit with internal injury was found out of a sample of 22 (4.5%). In the main block center, there were no furit with internal injury (n=290); in the edge no fruit were found in the 16-fruit sample. In the control, no fruit with internal injury were found in the block center (n=19) or edge (n=18).

Summary: The combination of Isomate CTT and Rosso provided effective control of CM and OFM. Improved control of CM was seen in Rappahannock County, an orchards with a difficult problem with internal feeders. This may have bee aided by the addition of Cyd-X CM granulovirus, and by placing the entire orchard under mating disruption.

Table 1. Percent fruit injury in mating disruption plots compared with conventional standard in Rappahannock orchard (900 fruit/treatment)

Treatment	Internal	Leafrollers	TPB	GFW	SJS
Isomate/Cyd-X	0.6	0	0.1	0	0.7

Table 2. Percent fruit injury in mating disruption plots compared with conventional standard in Albemarle orchard (six samples of 50 fruit in each plot section; 600 fruit per pheromone treatment)

Treatment	Internal	Platynota	RBL	TPB
Control - Edge	0	0	0.3	0.3
Center	0	1.0	0.3	0
Isomate - Edge	0	1.0	0	0.7
Center	0	2.5	0	0.5
Isomate Edge	0	0	0.3	0
Cyd-X Late - Center	0	0	0.7	0.3

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Analysis of *Wolbachia* strains associated with plum curculio using *Wolbachia* surface protein (*wsp)* gene in the eastern United States

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Introduction:

Plum curculio, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae), is a major pest of fruits in eastern North America. There is a wide host range: apple, peach, nectarine, plum, cherry, apricot, pear and blueberry, all major fruits in eastern North America.

There are two strains of plum curculio. Normally, the northern strain has a winter diapause; and is therefore a univoltine strain. The southern (multivoltine) strain does not display diapause. It has two or three generations annually. Chapman (1938) gave a rough distribution of the two strains. In his map, the mid-Atlantic region is the convergence area of the two strains and Virginia contains both strains. Presence of a second generation may cause the imposition of a trade barrier by other states or countries because larvae may be present in the fruit at harvest. In addition, the differing number of generations complicates the control the pest in the area.

Stevenson and Smith (1961) and Padula and Smith (1971) reported reproductive incompatibility from crosses of the southern strain and the northern strain. The reproductive incompatibility is similar to that reported from other arthropods associated with infection of reproductive tissues by *Wolbachia* that is a very common cytoplasmic symbiont of insects, crustaceans, mites, and filarial nematodes. *Wolbachia* can cause several reproductive alterations in their hosts including cytoplasmic incompatibility, parthenogenesis (Rousset et al. 1992, Bandi et al. 2001), thelytoky (Stouthamer et al. 1990), increased fecundity (Vavre et al. 1999), and killing of male embryos (Hurst et al. 1999). We suspect *Wolbachia* infection may cause the reproductive incompatibility known to exist between the two strains of plum curculio. However, the role of *Wolbachia* in plum curculio reproduction is still unknown.

In this research, PCR analysis for *Wolbachia* DNA was used. The analysis of *Wolbachia* strains associated with plum curculio is a potential method to test for plum curculio strain distribution. This analysis will aid in plum curculio management in Virginia fruit production and the rest of the mid-Atlantic region. The trade barrier may be lifted if no multivoltine strain exists in fruit-producing counties and monitoring will be increased if the multivoltine strain exists. At the same time, *Wolbachia* analysis will enrich our knowledge of population ecology and biosystematics of plum curculio and may help for future control research.

Materials & Methods:

Sample collecting:

Plum curculios were collected in multiple sites in the northern and southern parts of plum curculio's range. Sites in the extreme portions of the range were included, and eastern and western parts of the ranges (Massachusetts, New York, New Jersey, Florida, Georgia, South Carolina, West Virginia, Virginia).

DNA extraction

PC adults were placed in 300 µl of TE (Tris-HCl, EDTA) buffer and frozen at –80°C until processed. The DNA extraction protocol was modified from a protocol developed for *Drosophila melanogaster* by Ashburner (1989).

Polymerase Chain Reaction (PCR)

PCR was carried out in a total volume of 20ul containing 300 nM *wsp* primers, 81F (5'-TGG TCC AAT AAG TGA TGA AGA AAC-3') and 691R (5'-AAA AAT TAA ACG CTA CTC CA-3') (Zhou et al. 1998), 5-10 ng of weevil DNA, 1.5 mM $MgCl_2$, 200 µM dNTP mix (PE Applied Biosystems), 2 µl 10x PCR buffer, 0.5 unit AmpliTaq™ Gold (PE Applied Biosystems), and 13.5 µl distilled water. Amplification was completed with the following cycling profile on a GeneAmp® PCR System 9700 (PE Applied Biosystems): 94°C for 10 min, then 35 cycles of 94°C for 1 min, 55°C for 1 min, 72°C for 1 min, final extension 72°C for 7 min and held at 4°C. A total of 10 µl was run on a 1.5% agarose gel containing ethidium bromide to estimate the size of the amplified DNA fragment.

Cloning and DNA Sequencing

Fragments amplified with *wsp* gene primers were prepared for cloning as follows: 1-2 µl of the PCR reaction will be directly ligated into TOPO-TA® vector (Invitrogen, Carlsbad) without purification. The vector was introduced into bacterial cells. Cells which tested positive for transformation were cultured overnight in LB medium containing ampicillin. Plasmids containing the PCR product were extracted from bacterial transformants. The purified plasmids were sent to Davis Sequencing (UC Davis). 1-2 sequenced clones for the *wsp* gene from the *Wolbachia* associated with individuals were from each population. These sequences were aligned and compared to generate a consensus sequence for that population. The consensus sequences were used in the phylogenetic analyses.

Phylogenetic Analysis

The nucleotide sequence of the *wsp* gene was used to analyze the phylogenetic relationships of the *Wolbachia* from the populations of plum curculio using CLUSTAL W (Thompson et al. 1994) and PAUP*4 (Sinauer Associates, Sunderland, MA).

Results:

Sample collecting: PC adults were frozen at –80°C until DNA analysis from 11 locations (Table 1).

Table 1 Plum curculio samples number and locations

Location	Host	No. tested
Amherst, MA	Apple	4
Geneva, NY	Apple	6
Bridgeton, NJ	Nectarine	3
Chatsworth, NJ	Blueberry	2
Kearneysville, WV	Peach, plum	6
Washington, VA	Apple	2
Troutsville, VA	Apple	2
Blacksburg, VA	Pear, plum	2
Kentland, VA	Apple	2
Clemson, SC	Peach	1
Byron, GA	Peach, plum	4
Quincy, FL	Peach	4
	Total:	38

Cloning and DNA Sequencing

All tested samples are positive. There are 48 clones from 38 individuals sequenced (Table 2). Two clones from individual PCR products were sequenced for seven samples (Nja1, Nja2, WVu1, WVu2, FL1, FL2, BL1). Two clones from the same PCR products for three samples (NY14, NY15, MA32) were sequenced. One clone for each of other sample was sequenced. Four different sequences were produced. According to the guidelines of Zhou et al. (1999), they are referred to wCne1 (593bp), wCne2 (593bp), wCne3 (590bp) and wCne4 (593bp) respectively. wCne1 and wCne2 are 97% identical and they are both 84% identical with wCne3 (see Table 3). According to 97.5% the criterion for inclusion in a given reference group, wCne1 can be used as a new reference group. wCne2 is 99% identical with wNag1 (*Orius nagaii*). WCne3 is 100% identical with wDes *(Dacus destillatoria*). In summary, a distribution map was made based on Chapman's map. (see Fig.1) Using LARD (Likelihood Analysis of Recombination in DNA, Andrew Rambaut, Evolutionary Biology Group, Department of Zoology, University of Oxford) analysis, wCne4 is a recombination of wCne1 and wCne3 and the recombination site is 313th nucleotide from 5' end.

Phylogenetic Analysis

According to phylogenetic analysis, wCne1 and wCne2 belong to supergroup B. wCne3 strain is in supergroup A. (see Fig 2.)

Conclusion and Discussion

In the *Wolbachia* analysis, all samples are infected by *Wolbachia*. There are two close *Wolbachia* strains (97% identical) existing in the northern and middle parts of eastern North America (New York, Massachusetts, New Jersey, West Virginia and Virginia).

There is one main *Wolbachia* strain existing in the southern part of eastern North America (Georgia, South Carolina and Florida). Virginia is the convergence area of the three strains. The Florida population has a higher diversity of *Wolbachia*. In four individuals, two are infected by wCne3, one is infected by wCne1 and the last one is infected by wCne4; wCne4 was found only in this individual.

Due to the diversity, 2-3 more Florida samples should be assessed to confirm the distribution of infection. Sampling locations in Virginia should be increased because the region is the convergence area. The locations are along with the valley of Appalachian Mountains. More locations should be from eastern Virginia. According to other researchers, superinfection (more than one *Wolbachia* strain infection in same individual) is very common in many other insects. And, *Wolbachia* strain infection is not consistent with the mating compatibility of different geographical population (unpublished data), i.e. Blacksburg population is compatible with New York population and incompatible with West Virginia population. However, NY and WV populations have same *Wolbachia* infection. So, superinfection detection should be employed in the further research. Restriction Fragment Length Polymorphism (RFLP) may be used for superinfection. The PCR product will be digested by specific restrict enzyme. Different fragment length pattern will show the difference of infection status.

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Table 2 Cloned and sequenced samples

Sequences	Clone of samples
wCne1	NY2, NY14, NY15, MA5, MA32, Nja1, Nja1-2, Nja2, Nja2-2, Nja5, WVu1, WVu1-2, WVu2, WVu2-2, WVu4, WVp3, FL1, FL1-2
wCne2	NY3, NY36, NY37, MA4, MA31, NJb1, NJb2, WVu3, WVp1, Ra22, BL1, BL1-2, BL21
wCne3	Gap1, Gap2, Gau1, Gau3, FL2, FL2-2, FL3, Ke1, Ke22, Bo1, Bo2, Ra3, SC4
wCne4	FL4

Table 3 Sequence alignments (Identity%)

	wCne1	wCne2	wCne3	wCne4
WCne1	--	--	--	--
WCne2	97%	--	--	--
WCne3	84%	84%	--	--
WCne4	90%	89%	93%	--

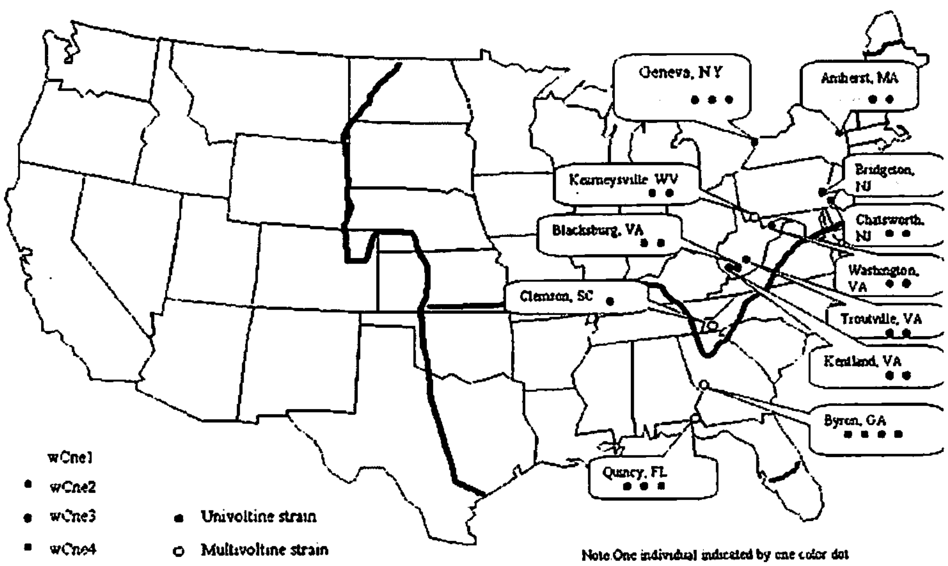
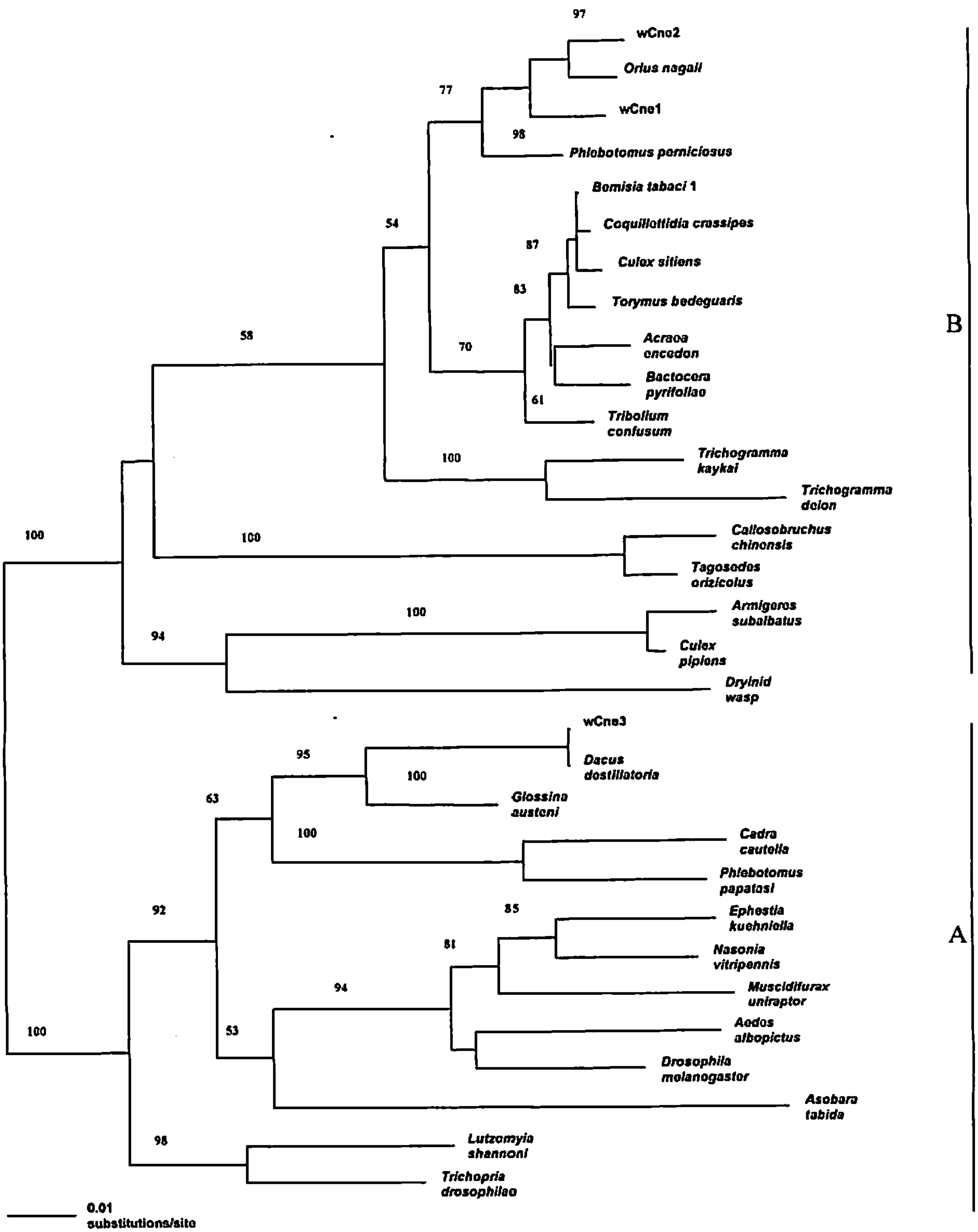


Fig 1. *Wolbachia* strains distribution map

Fig 2. Phylogenetic tree of *Wolbachia* based on the wsp sequences. Wolbachia strains are named by host insect species. The tree has been constructed by the Neighbour Joining algorithm using the Kimura distance and midpoint rooted. Numbers on the nodes indicate percentage of 500 bootstrap replications.



Dogwood borer infestation in burrknot tissue in 'Empire' scions on several clonal apple rootstocks

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Dogwood borer is a common invader in burrknot tissue of apple trees. The biology and importance of this insect were recently reviewed by Bergh and Leskey (2003). Most attention previously has been given to burrknots (adventitious root primordia) occurring near the graft union. However some varieties are also likely to develop significant numbers of burrknots in the scion, occurring at various heights of the trunk and scaffold limbs. Pfeiffer and Killian (1999) reported aerial burrknots on trunks of 'Gala' trees, most of which were infested with dogwood borer. Marini et al. (2003) reported on the relative tendency of 'Gala' trees to develop burrknots on scions growing in North Carolina and Virginia on eight dwarfing rootstocks. P.1 and Ott.3 produced the most burrknots and trees on M.27 produced the fewest burrknots.

Methods: In a rootstock planting at the College of Agriculture and Life Sciences' Kentland Farm at Virginia Tech (six cultivars randomized on five rootstocks (Bud. 9, M.26 EMLA, M.9 EMLA, Mark and Ott.3), aerial burrknot development was greatest on Gala and Empire, and very low numbers in 'Golden Delicious', 'York', 'Jonagold', 'Stayman' and 'Rome'. In this study, burrknots were counted on 'Empire' scions, measured along the longest axis, and presence of dogwood borer exuviae was determined on 5, 12, 19, 21, 29 Jul, 6, 16, 23, 30 Aug, and 9 Sep. 'Gala' were not included because that variety was primarily present as guard trees at row ends and not represented on the range of rootstocks.

Results: There appeared to be a bimodal pattern in production of exuviae (Table 1). There have been earlier reports of bimodal trap captures (Pfeiffer and Killian 1999, Bergh and Leskey 2003), with speculation whether both peaks were produced from apple0festing populations, or whether the early peak occurred in dogwood and other hosts. Traps placed by Pfeiffer and Killian (1999) produced data that were consistent with the former hypothesis. However, the exuviae counts present4d here show production of adults at both periods. Eliason and Potter (2000) showed that exuviae production was evenly divided among two peaks in horned oak galls.

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Table 1. Dogwood borer exuviae collected from lower 2 m of 'Empire' scion per 6 trees for each clonal rootstock – Kentland Farm, 2004

Rootstock	5 Jul	12 Jul	19 Jul	21 Jul	29 Jul	6 Aug	16 Aug	23 Aug	30 Aug	9 Sep	Total/6 trees/Rootstock
Mark	0	0	3	4	1	2	5	2	2	2	**21**
M.26	0	0	1	5	3	1	4	1	1	0	**16**
M.9	0	0	0	3	1	2	0	0	6	0	**12**
Ott.3	0	2	6	4	5	0	9	4	1	1	**32**
B.9	1	0	3	1	2	3	7	1	2	0	**20**
Total	**1**	**2**	**13**	**17**	**12**	**8**	**25**	**8**	**12**	**3**	

Table 2. Rootstock effects on production of burrknots in lower 2 m of trunk and cumulative dogwood borer exuviae in 'Empire' apple trees – Kentland Farm, 2004.[1]

Rootstock	Total burrknots	Total exuviae	Exuviae/burrknot
Mark	14.3	3.8	3
M.26	23.3	2.3	1
M.9	16.7	2.0	0
Ott.3	22.7	5.0	6
B.9	21.3	2.8	3

[1]Data were transformed for analysis ($(x+0.5)^{-0.5}$); no significant differences (α=0.10) were detected.

Evaluation of the efficacy of three non-organophosphate insecticides toward grape berry moth - 2004

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GRAPE: Concord'
Grape berry moth (GBM): *Endopiza viteana* (Clemens)

A spray trial was performed in a vineyard in Ladd, Augusta County, using Concord vines. This vineyard has a history of consistently high populations of GBM. The following materials were tested: Intrepid 2F (methoxyfenozide) 16 fl oz/100 gal, SpinTor 2C (spinosad) 8 fl oz 100 gal, Dipel 4L (*Bacillus thuringiensis*) 32 fl oz/100 gal, and Dipel 4L 64 fl oz/100 gal. An untreated control was included. Spray dates were applied 12 Jun, 24 Jun, 9 Jul, 23 Jul, 6 Aug, and 25 Aug. Treatments were applied using a backpack sprayer. There were four replications per treatment, each consisting of a panel of 3-4 vines. Two reps were in the edge row, and two in the next vineyard row. A randomized block design used vineyard row as the blocking factor. Intrepid and SpinTor were both registered for grape last year. Two rates of Dipel were used because of increased grower interest and frequent questions on efficacy toward GBM.

Grapes were harvested on Sep 14. Ten clusters of grapes were collected from each panel, for a total of 40 clusters per treatment. Clusters were retrieved to Blacksburg, where berries were removed from the rachis and inspected individually for GBM injury.

In 2004, GBM injury was much lower than in 2003. SpinTor, Intrepid, and Dipel low rate had significantly less fruit injury than Dipel high, but not significantly different from the control Numbers of live larvae reflected the same pattern as injured berries. The unusual results for the high Dipel treatment are difficult to explain.

Table 1. Grape berry moth injury in a Concord grape vineyard using three non-organophosphate insecticides.

Treatment, rate/100 gal	% injured berries	Mean live larvae/cluster
Intrepid 2F, 16 fl oz	1.46a	0.00a
SpinTor 2C, 8 fl oz	1.22a	0.00a
Dipel 4L, 64 fl oz	3.23b	0.25b
Dipel 4L, 32 fl oz	1.52a	0.08a
Control	2.44ab	0.10ab

Means in a column followed by the same letter are not significantly different, $\alpha=0.05$ (Fisher's protected LSD test, following arcsine transformation)

Mite control in apple - 2004

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European red mite (ERM), *Panonychus ulmi* (Koch)
Apple rust mite (ARM), *Aculus schlechtendali* (Nalepa)
Predatory mite (NF), *Neoseiulus fallacis* (Garman)

This trial used three acaricides, etoxazole (Zeal 72W), hexythiazox (Savey 50W), and dicofol (Kelthane 50W), in addition to UltraFine oil, in comparison with an untreated control. Acaricides were applied using a CO_2-powered backpack sprayer. Zeal was applied at the rate of 567 mg per gal, Savey at 850 mg/gal, Kelthane at 5953 mg/gal, and oil at 75.7 ml/gal. Treatments were applied on 15 Jul; the oil treatment was reapplied on 24 Jul. There were four replicates per treatment, each consisting of a single tree.

Mite populations were assessed by collecting 10 leaves per tree and processing using a mite-brushing machine. A pretreatment count was made on 15 Jul. Post-treatment counts were made on 28 Jul, 9, 16, 24 and 30 Aug, and 10 Sep. Data were subjected to analysis of variance, and mean separation using Tukey's HSD test (α=0.10), after transformation ($(x+0.5)^{0.5}$).

ERM pressure was low during this trial. Motile ERM mite densities significantly higher than the control were seen in the Kelthane treatment on 16 August, 24 Aug. On 30 Aug and 10 Sep, Zeal trees had significantly higher numbers of ERM than the control, and Kelthane was higher than both Zeal and the control. ERM eggs (RME) were lower in the oil treatment than in the control on 28 Jul. Savey, an ovicide, did not have RME numbers different from the control. This may have resulted in the tendency of eggs that fail to hatch to accumulate on the leaves. Kelthane temporarily suppressed RME (9 Aug), but numbers rebounded thereafter, becoming significantly greater than the control on 24 Aug and later, following the elevated motile ERM numbers.

Populations of NF were affected on only one date, the first post-treatment count (28 Jul). The oil treatment suppressed NF numbers. Savey was not significantly different from the control, but was higher than oil. The other acaricides were intermediate, different from neither the control/Savey grouping, nor oil. The high population of NF was probably responsible for the overall low densities of ERM throughout the trial.

There were significantly higher densities of ARM in the oil treatment in the first post-treatment count, and in the Zeal-treated trees on 9 and 16 Aug. Mean numbers seemed high in the Zeal trees on 24 and 30 Aug, but this difference was not significant.

Table 1. Populations of European red mite motile forms (ERM) and eggs (RME) per leaf in a York/Golden Delicious apple block

	15 Jul		28 Jul		9 Aug		16 Aug		24 Aug		30 Aug		10 Sep	
Acaricide, product/378.5L	ERM	RME	ERM	RME	ERM	RME	ERM	RME	ERM	RME	ERM	RME	ERM	RME
Zeal 72W, 56.7g	2.1a	4.1a	0.8a	7.4ab	1.2a	6.8a	3.5a	6.9a	7.2a	17.2ab	12.2b	23.4a	3.2b	12.3a
Savey 50W, 85.0g	0.6 a	1.4a	3.6a	5.7ab	1.5a	6.9a	5.2a	6.5a	3.8a	16.1ab	3.8c	5.4b	1.9c	3.2b
Kelthane 50W, 595.3g	1.0a	2.9a	1.1a	6.6ab	0.6a	1.2b	15.2b	18.0a	20.8b	46.7b	25.8a	39.0a	8.8a	20.6a
Oil, 7.6L	1.8a	3.9a	0.3a	1.1a	3.1a	6.9a	2.9a	6.0a	4.6a	9.3a	3.6c	10.6b	1.7c	5.3b
Control	0.9a	3.4a	0.6a	10.4b	2.2a	6.2a	4.9a	8.8a	3.4a	7.2a	4.7c	7.5b	2.0c	2.0b

Means in a column followed by the same letter are not significantly different, α=0.10 (Tukey's HSD test)

Table 2. Populations of *Neoseiulus fallacis* (NF) per leaf in a York/Golden Delicious apple block

Acaricide, product/378.5L	15 Jul	28 Jul	9 Aug	16 Aug	24 Aug	30 Aug	10 Sep
Zeal 72W, 56.7g	3.6a	2.3ab	2.1a	0.6a	1.4a	1.7a	0.3a
Savey 50W, 85.0g	2.8 a	5.4b	3.0a	1.3a	1.0a	1.7a	0.9a
Kelthane 50W, 595.3g	4.1a	1.7ab	3.2a	1.4a	1.4a	0.8a	0.8a
Oil, 7.6L	4.1a	0.4a	2.3a	0.8a	0.7a	0.9a	0.3a
Control	4.5a	4.6b	4.1a	2.2a	1.7a	2.6a	0.8a

Means in a column followed by the same letter are not significantly different, α=0.10 (Tukey's HSD test)

Table 3. Populations of apple rust mite (ARM) per leaf in a York/Golden Delicious apple block

Acaricide, product/378.5L	15 Jul	28 Jul	9 Aug	16 Aug	24 Aug	30 Aug	10 Sep
Zeal 72W, 56.7g	176.8a	82.6ab	207.9a	170.1a	118.5a	24.0a	3.3a
Savey 50W, 85.0g	219.5a	66.4ab	37.8b	85.2ab	40.5a	16.8a	3.0a
Kelthane 50W, 595.3g	192.6a	32.3b	33.6b	28.6c	54.9a	37.5a	3.6a
Oil, 7.6L	179.3a	117.0a	27.0b	29.4bc	41.4a	30.9a	3.3a
Control	327.6a	58.2b	42.8b	37.8bc	33.6a	8.5a	1.2a

Means in a column followed by the same letter are not significantly different, α=0.10 (Tukey's HSD test)

Grape root borer pheromone trap monitoring

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Introduction

Grape root borer (GRB), *Vitacea polistiformis* (Harris) (Lepidoptera: Sesiidae) is a major pest of grapes in southeastern states, and has recently become established in some Virginia vineyards. It is expected to become more prominent in Virginia as grape growing expands.

The GRB life cycle lasts two or three years, and almost all of this is spent as larvae feeding on grape roots. Larvae bore into the roots and crown below the soil surface, reducing the productivity of the vine. Roots may be hollowed and packed with frass. Vines eventually die; there may also be increased susceptibility to cold injury. Full-grown larvae are about 25 mm long. They pupate near the soil surface beginning in June. In southern states, adults begin emerging about the first week of July, with greatest numbers present in the last two weeks of July. Females lay an average of 300 eggs on grape foliage, canes, and weeds. About two weeks after hatching, first instar larvae drop to the ground and tunnel to roots.

Materials and Methods

In 2003 and 2004, pheromone traps were installed in several Virginia vineyards to monitor GRB flight data and severity. Lures were purchased from IPM Technologies, Portland, Oregon. Delta traps were employed in 2003 but due to the large size of GRB moths, traps quickly became saturated.

In 2004, bucket traps were employed in two vineyards. Traps were installed in both vineyards on June 12. On July 30, delta traps were installed in one of these vineyards in a grid pattern with the bucket traps. All traps were sampled and emptied weekly, and the delta trap sticky liners were replaced weekly.

Results

GRB flight period: Pheromone trap data from several counties in 2003 and 2004 indicate that, like more southerly states, peak activity of GRB moths is concentrated in late July and early August (fig. 1)

Comparison of bucket and delta traps: Although delta traps were installed after peak GRB emergence, trap counts almost exactly mirrored bucket trap counts, indicating that as long as trap liners are replaced weekly, delta traps are as effective as bucket traps in sampling GRB moths (Fig. 1).

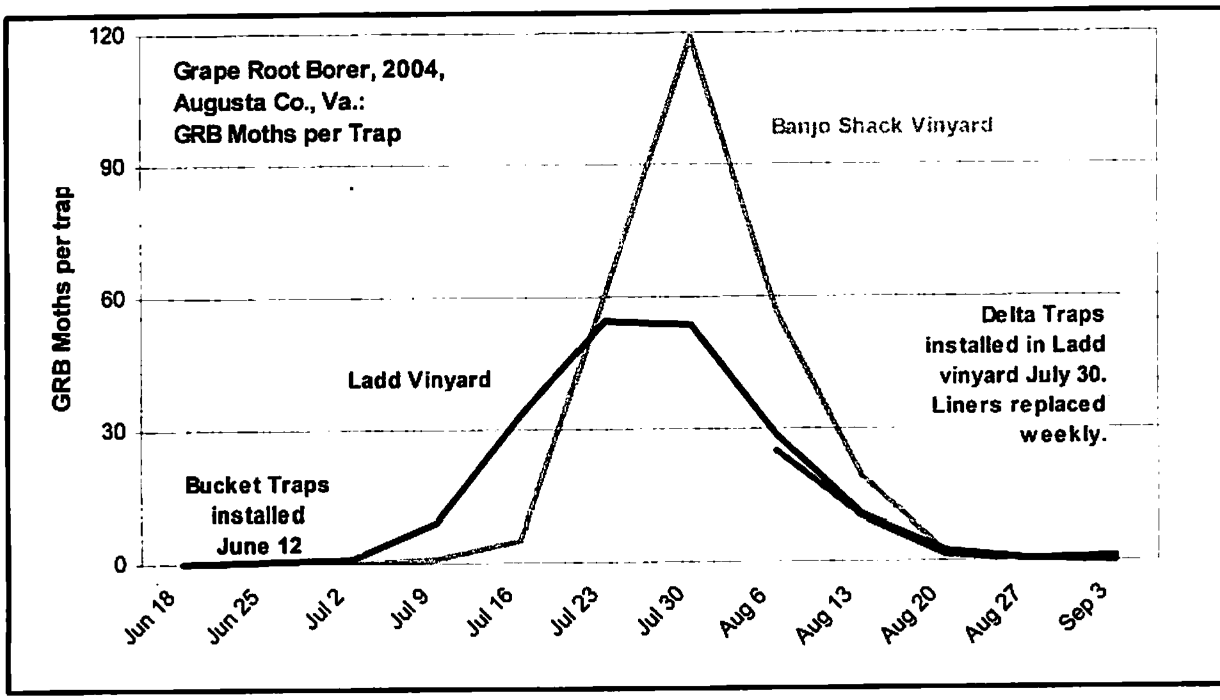
Late summer sampling of vines: Late summer sampling of vines for GRB larvae and cocoons in several counties indicates that GRB is becoming widespread in Virginia vineyards.

Fall sampling of vines for larvae: In November 2003 an unthrifty portion of a vineyard in Patrick Co. was removed. As vines were removed, roots were sampled for GRB larvae and tunneling. Of 165 vines examined, 77.0% contained one or more tunnels, and 34.5% contained one or more GRB larvae.

Summary

Detection of heavy grape root borer larval damage and activity combined with high adult trap counts indicate that GRB is well established across the state.

Fig. 1. Grape root borer adult trapping data for two vineyards in Augusta Co, VA. 2004



Effects of Surround on the Apple Maggot Behavior

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In North Carolina the apple maggot (AM), *Rhagoletis pomonella* (Walsh) is a sporadic pest although, in 2001, fruit were found infested with large numbers of AM that caused great economical loses to apple growers. This was not an isolated case because increments of the AM populations have been reported in several apple regions on the USA and the reduction in the use of broad-spectrum insecticides might be the cause for these increments (Chen *et al.* 2001). Feeding of the AM larva results in tunnels in the fruit, then fruit rotten and becomes worthless for direct consumption or processing.

Surround® (Engelhard Co. Iselin NJ) is a modified natural aluminum silicate clay known as kaolin that has been one the new products used against several insect pests including the AM (Knight et al 2001). Surround is generally used in organic orchards in North Carolina. When sprayed, this product covers fruit and foliage with a thin layer of kaolin film that protects plants from insects as a barrier, repellent or irritant. Surround remains in the plants for two or three weeks depending on environmental factors such as rain (Villanueva and Walgenbach 2002). Kaolin particle film sprays also have been used to reduce sunburn however, applications later than June reduced red fruit color of apples and resulted in smaller fruit in Idaho and New York (Schupp *et al.* 2002).

Surround changes the apple orchard appearance, turning the entire apple orchard color from green to a snowy-whitish coloration. It was suggested that the highly reflective white coating makes the tree less recognizable as a host. However, it is unknown if this whitish coloration of fruit and leaves can reduce the optical cues of AM to detect fruits and hence reduce AM infestation in orchards. Here we are going to study how partial Surround coverage of fruits affects AM infestations and if the change on foliage and fruit coloration can reduce AM infestation and densities in the field.

Material and Methods

The studies were completed in 2003 in an abandoned Red Delicious orchard on Henderson Co. NC. This orchard had a history of abundant AM in previous years and AM captures in plastic sphere traps in 2003 were higher than the orchards in the Mountain Horticultural Crops and Extension Center (MHCREC) and commercial orchards of western NC (Fig 1).

<u>Comparative AM abundance in trees sprayed with and without kaolin</u>

In the abandoned orchard described above, four trees were sprayed with water and four were sprayed with kaolin (25 lbs/100 gal/A). All the trees were in the same row and the treatments were alternated and separated by 3 or 5 trees. Seven observers were placed under a designated tree and counted AM on foliage and fruit for five-minute intervals, then they moved to the next tree until completion of the 8th tree. Each observer counted each tree once. Counts were repeated on 5, 8, 12 and 14 August 2003. Data were transformed using $\sqrt{x + 0.5}$, then subjected to multiple factor ANOVA.

Apple maggot choice test on apples with and without Surround

Red Rome apples were collected from a commercial orchard with their peduncles attached. Apple pairs of similar color and size were selected for these choice tests. On each pair, one of the apples was submerged in a solution of 25 lbs Surround/100 gal/A and the other was left as it was collected from the orchard. A 15 cm nylon string was tied to the apple peduncle, apples were transported to the abandoned orchard described above and the pairs of apples were hung at the same height (~1.5 m) and ~5 cm distant from each other on unsprayed trees. Bearing apples from these trees in a radius of ~50 cm or less surrounding the pair of hung apples were removed. Ten min observations on the hung apples were completed and the numbers of AM that landed in either apple were recorded. Observations without AM landing were discarded. For each date 4 pairs of apples were prepared and 8 trees were used to change the apples of site after every observation. A total of 7, 8 and 8 observations were finished on the 25, 27 and 29 August, respectively.

Evaluation of hung-AM-free apples coated with kaolin in an heavily AM infested orchard

A total of 120 Red Delicious apples were collected from an MHCREC orchard and taken to the laboratory. These apples were kept with their peduncles attached to the fruit and a 15 cm nylon string was tied to the peduncle. In the laboratory 40 apples were completely submerged in water for 5 s, 40 were fully dipped for 5 s. in a solution prepared with Surround (25 lbs/100 gal/A) and the last 40 apples were coated on the latter solution only covering only half of the fruit surface longitudinally (Figure 2). All apples were air-dried and transported to the abandoned orchard. In this orchard all fruits were hung on apple tree branches in groups of 10 using the nylon string tied to the fruit peduncle. A total of 10 apples per tree/ treatment were hung during 1 wk between 8 to 15 September 2003 and a total of 4 replicates per treatment were completed. After this time all the apples were collected brought to the laboratory and placed in plastic buckets with arena. Apple maggot pupae were collected after 1 month. Data were transformed using $\sqrt{x + 0.5}$, then subjected to a single factor ANOVA and means were compared using the Duncan multiple comparison test.

Results

Comparative AM abundance in trees sprayed with and without kaolin

Table 1 shows the ANOVA results on AM flies abundance on trees with and without Surround. Significant results ($P < 0.01$) were found between treatments and dates sampled. After partitioning of these data to analyze the treatments on the different dates, highly significant differences were found on 5 ($P < 0.001$, F = 27.5; df = 2,6), 12 ($P < 0.001$, F = 8.7; df = 2,6), and 14 ($P < 0.001$, F = 19.1; df = 2,6) August but 5 August ($P = 0.1$, F = 2.18; df = 2,6) (Fig. 3).

Apple maggot choice test on apples with and without Surround

The numbers of AM that landed in hanging fruits without kaolin were significantly higher than in fruits that were kaolin coated for all dates. Apple maggots that landed on the hung fruits without and with kaolin on 25, 27 and 29 August, were 1.3 ± 0.2 and 0.4 ± 0.2 (df = 7, t = 2.44, P < 0.05); 1.4 ± 0.2 and 0.5 ± 0.2 (df = 8, t = 2.36, P < 0.01); and 1.3 ± 0.3 and 0.3 ±0.1 (df = 8, t = 2.36, P < 0.05), respectively.

Evaluation of hung-AM-free apples coated with kaolin in an heavily AM-infested orchard

The mean numbers (± SEM) of AM pupa/ 10 fruit collected after 1 month were 16.3 ± 3.5, 13.3 ± 1.1 and 3.3 ±1.6 for the water control, half-coated and completely-coated surround treatments, respectively. These data showed significantly fewer AM pupae in the full surround treatment than the rest of treatments (df = 2,9; F= 12.19, and P < 0.01).

Discussion

The high abundance of AM in the abandoned orchard coincided with the studies completed here, between 5 August and 15 September (Fig. 1). The higher abundance of AM in Surround sprayed trees than water sprayed trees (Fig 3) may imply that the whitish coloration on the Surround-sprayed trees can reduce the recognition of host trees by the AM fly. It is possible that apples were camouflaged with the whitish coloration of the Surround spray. In addition, the hung apple choice test (on unsprayed trees) showed that AM significantly prefers Surround-free apples and this film of Surround can make more difficult for AM to land in the fruit not only as a barrier to the AM but also reducing the fruit contrast with its background. This choice results coincide with the studies by Mazor and Erez (2003), they made choice tests in female Mediterranean fruit flies *Ceratitis capitata* (Wiedemann) on 'Sunsnow' nectarines and found significantly higher numbers of *C. capitata* in the non-sprayed fruits than nectarines sprayed with 6% W/W Surround in laboratory cages. In our case, we tried to conduct these tests in the laboratory but the choice tests were inconclusive (Villanueva unpublished) because AM flies remained or walked on the cages wall without making any choice for more than 30 minutes. Cages were also placed on outdoor benches but results were similar. In the AM case, its behavior on captivity is unpredictable and it has been described by several authors (O'Kane 1914, Porter 1928).

Apple maggot pupa counts in the water sprayed and half- coated Surround apples were 1.6 and 1.3 pupae/apple, respectively; while the full-coated Surround apples had 0.3 pupae/apple that were significantly low (P < 0.01). Although, these results were inflated due to the high AM pressure in this orchard, they are important because indicates that protection of Surround is highly effective when there is a full coverage of fruits, Villanueva and Walgenbach (2002) found that high infestations of AM occurred on the upper canopy fruit where there was poor Surround coverage. Similarly, Knight *et al.* (2000) found that the Obliquebanded leafroller *Choristoneura rosaceana* (Harris) (Lepidoptera Tortricidae) oviposited in Surround treated leaves that had low levels of Surround residues. Theses studies showed that AM numbers are reduced in Surround sprayed trees and that AM prefer Surround free apples not only because the Surround coated apples are a barrier but also they may be difficult to detect. Surround appears to be an important tool against the AM however, it is effectivity increased with the full fruit coverage.

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Table 1 Multiple factor ANOVA table for trees sprayed with kaolin (25 lbs/100 gal/A) and water on 4 dates and with seven observers.

Source	d.f.	F	p
Treatments	1, 168	46.55	< 0.01
Dates	3,168	15.68	< 0.01
Observers	6, 168	0.73	0.62
Treatments * Dates	3,168	8.46	0.06
Treatments * Observers	6, 168	1.61	0.15
Dates*Observers	18,168	0.86	0.62
Treatments*Dates*Observer	18,168	0.73	0.78

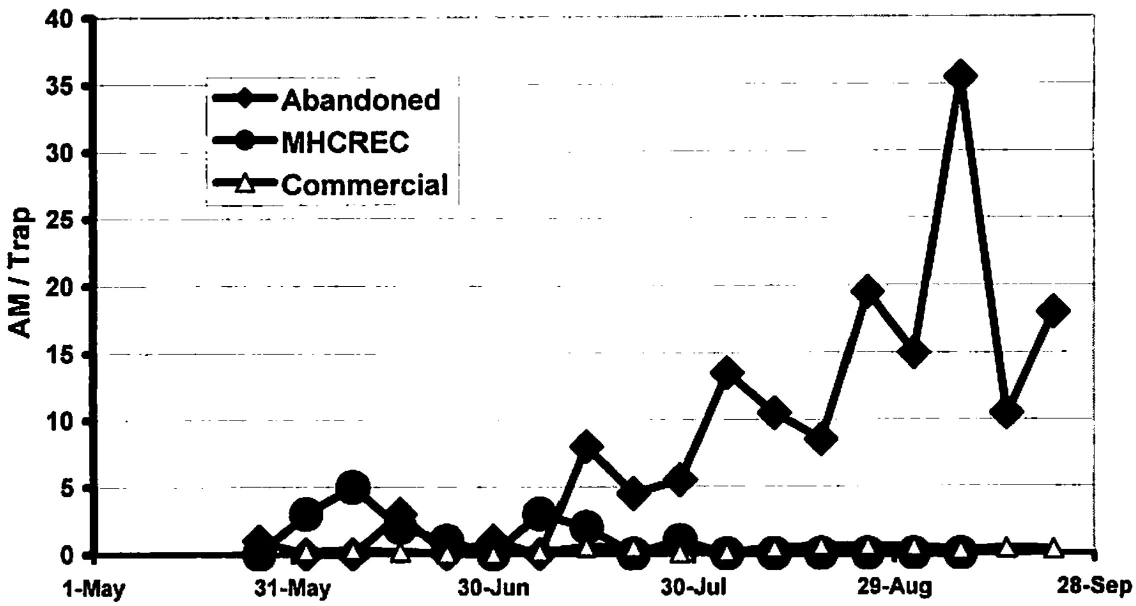

Figure 1. Mean numbers of apple maggot collected in plastic sphere traps in an abandon, commercial and MHCREC apple orchards.

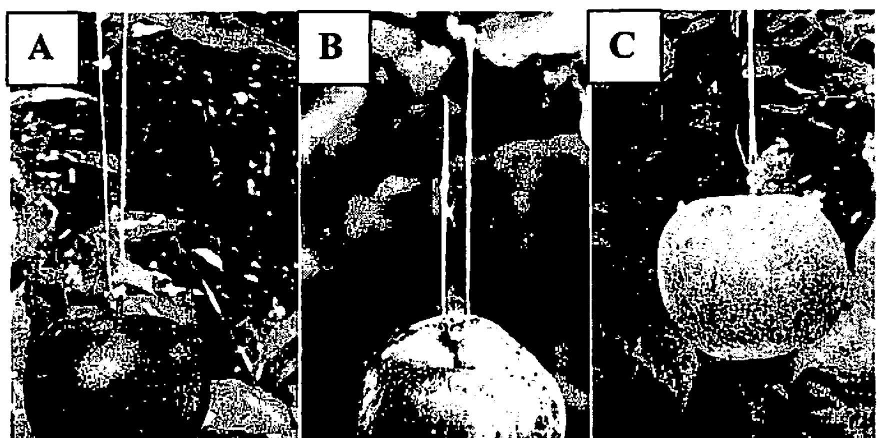

Figure 2. Apples hung for one week in an abandoned orchard with high populations of apple maggot. (A) Water sprayed, (B) half coated, and (C) full coated fruit.

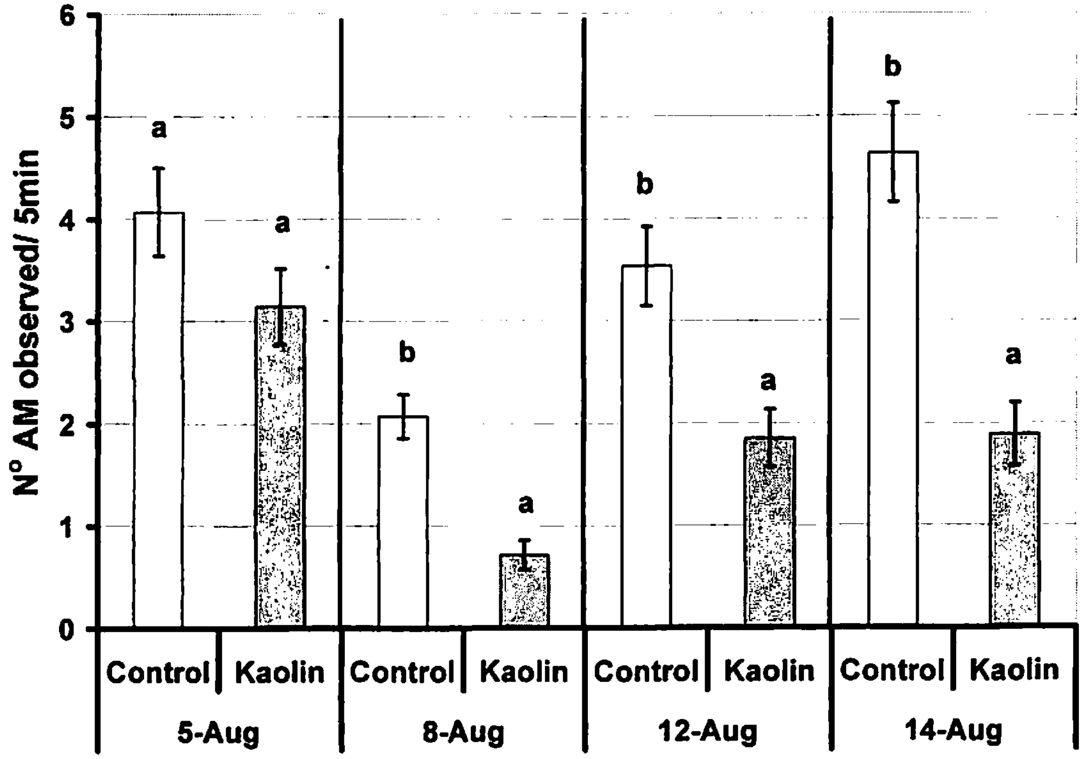

Figure 3. Mean numbers (±MSE) of apple maggot observed landing in fruit and foliage in trees sprayed with water and Surround. Different letter on the same date indicates significant differences ($P < 0.05$)

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Progress in Developing More Compatible Management Systems for OFM in Apples in Western NY

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NY apple growers have experienced difficulty in controlling internal lepidoptera, primarily oriental fruit moth (OFM) since the 2001 growing season. In 2003, most apple growers in western NY who had experienced unacceptable damage in the past began to intensify chemical control programs for control of internal Lepidoptera and consequently, fewer loads were rejected (13), from only about 11 growers. Even though western NY apple growers achieved temporary success in reducing internal Lepidoptera damage in 2003, many applied frequent sprays and used materials such as synthetic pyrethroids that are incompatible with IPM programs. Although such intensive control programs may be necessary to achieve acceptable control in orchards with high levels of internal Lepidoptera infestation, more cost-effective, IPM-compatible management programs for this pest complex need to be developed in the future. The objective of this study was to evaluate a multi-tactic management program that integrates mating disruption, monitoring, and improved timing of IPM-compatible insecticides in large-scale plots in grower orchards with various histories of infestation from internal lepidoptera in western NY

METHODS

Three management systems were compared in 10 commercial orchards in western NY. Plots were set up in both "high risk" orchards that had experienced severe damage from OFM in the past and in "low risk" blocks without a previous history of infestation. All research plots were 5-10A, and growers applied their own sprays. Two pheromone traps for OFM, codling moth (CM), and lesser appleworm (LAW) were placed in the center of each plot (4 OFM traps were deployed in the mating disruption plots) and checked weekly. Fruit was sampled on the trees on July 19, after the end of the activity of the first brood of OFM, on August 2, and August 17 (1000 apples/plot, 20 apples on 50 trees).

Positive chemical control treatment-One special OFM spray was timed at the estimated first hatch of OFM eggs for each of the three generations. A pink spray was applied to control egg hatch of the first generation based on expected activity patterns although subsequent trap catch patterns showed that this flight did not start until bloom. Originally, the Pennsylvania OFM DD model (base temp=45°f) was to be used to time sprays for first hatch of the other two generations, but initial early season observations showed that the model predictions were not accurate. Therefore, sprays for the second and third broods were recommended after the accumulation of 175-200 DD after biofix in pheromone traps. Sprays were recommended during the third week of July to coincide with egg hatch of the second brood, and during the last week in August for control of the third brood. Growers were advised to apply normal control sprays against other insect pests when needed throughout the season.

Seasonal Mating Disruption-Isomate M-Rosso ties (200/A) were deployed in April prior to the first OFM flight. Growers were advised not to apply special control sprays for OFM unless damaged fruit was observed during the July and August fruit samples or moths were captured in the pheromone monitoring traps deployed in the blocks. Growers were advised to apply normal control sprays against other insect pests when needed throughout the season.

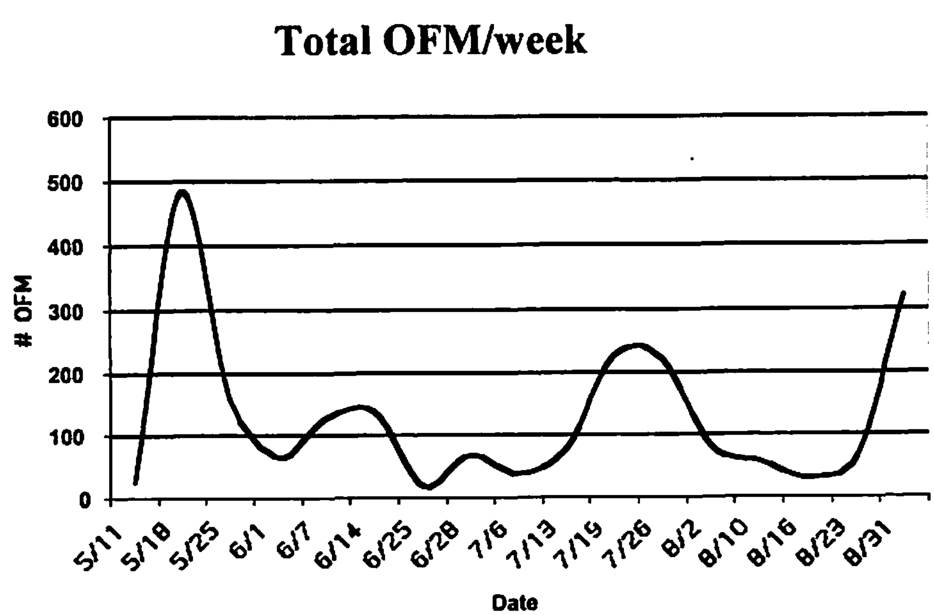
Monitoring treatment-A prophylactic control spray was applied at pink to coincide with the initially predicted OFM egg hatch of the first generation. No other special OFM sprays were recommended unless moth catches averaged more than 10/trap/week or fruit damage was found in sampling bouts during late July and August. Growers were advised to apply control sprays against other insects when needed.

Growers participating in the project used a wide variety of insecticides including chlorpyrifos at the pink bud stage, phosmet, azinphosmethyl, fenpropathrin, lambda cyhalaothrin, indoxacarb, and methoxyfenozide. Damage in each plot was compared at harvest during the first week of October. One thousand apples were evaluated from each plot,and samples were stratified by examining 100 apples (20/tree) along each of the edges and 400 (100/tree) in the center of each plot.

RESULTS

OFM Seasonal Pheonolgy-The development of OFM was later in NY apple orchards during the 2004 growing season than normal, probably because of generally cool, wet conditions throughout the summer. (Fig. 1). The initial flight began during early bloom on May 13, and peak flight of the first generation was observed during the week of May 18-25. The second flight began on July 13 and peaked around July 26. The third flight did not start until the last week in August, and continued during September and October.

Fig. 1. Seasonal activity of OFM in western NY apple orchards in 2004.



OFM Monitoring Treatments

Table 1. Orchards exceeding the provisional OFM trap catch thresholds in monitoring treatments.

Orchard	Risk Classification	1 st Flt	2 nd Flt.	3d Flt.
Bartleson	High	X		
Datthyn	High	X	X	X
Debadts	High	X	X	
Verbridge	High	X		
Beckons	Low	X		
Buhr	Low			
Fox	Low			
Kalir	Low			
Pettit	Low			

X=Weekly catches exceeded 10 moths/trap.

OFM catches never exceeded recommended treatment threshold levels throughout the season in 4 of the research orchards (Table 1). Trap catches exceeding thresholds were most common during the first flight of OFM (5 orchards), and only 2 and 1 of the monitoring plots exceeded the threshold levels, respectively, during the second and third flights.

Seasonal OFM Mating Disruption-The Rosso ties completely shut down OFM trap catches throughout the season, although codling moth catches were high in two of the orchards in the disrupted plots. A trace of fruit damage was observed during fruit sampling in late summer in one of the disrupted plots (0.1%), but since codling moth catches were high in that block, this fruit damage was attributed to that species. In one of the high risk blocks, a low percentage of fruit damage was observed during summer sampling, and chemical sprays were recommended. No fruit damage at harvest was observed in the other mating disruption plots.

Summer Fruit Monitoring in Different Research Treatments-No damaged fruit was observed in any treatments in 8 out of the 10 research orchards in fruit sampled during July and August. Damage was observed in all treatments during each sampling bout in one of the "high risk" orchards (Table 2). A trace of damage (0.1%) was observed in treatments in one of the low risk orchards, but since codling moth catches were high in this orchard this damage was attributed to this species.

Table 2. Comparison of summer fruit damage in OFM plots in the Datthym orchard, 2004.

	% Damaged Fruit		
Treatment	7/19	8/2	8/17
Mating disruption	0.8	0.8	0.0
Positive chemical Control	2.3	3.2	1.7
Monitoring	0.5	1.1	0.3

Harvest Fruit Damage-The average percentages of damaged fruit observed at harvest in all of the treatments in all orchards was not significantly different among treatments and was very low (Fig. 3). The Datthyn orchard was the only site in which consistent levels of fruit damage were detected at harvest, and overall damage in this orchard was similar among the different treatments (Fig. 4). Damage in the mating disruption treatment was higher in fruit sampled from the edges of the plot than in the middle, which suggests gravid females may have immigrated into the edges of this relatively small plot from sources outside of the orchard.

Fig. 3. Comparison of average fruit damage at harvest in different treatments in all research orchards in western NY, 2004.

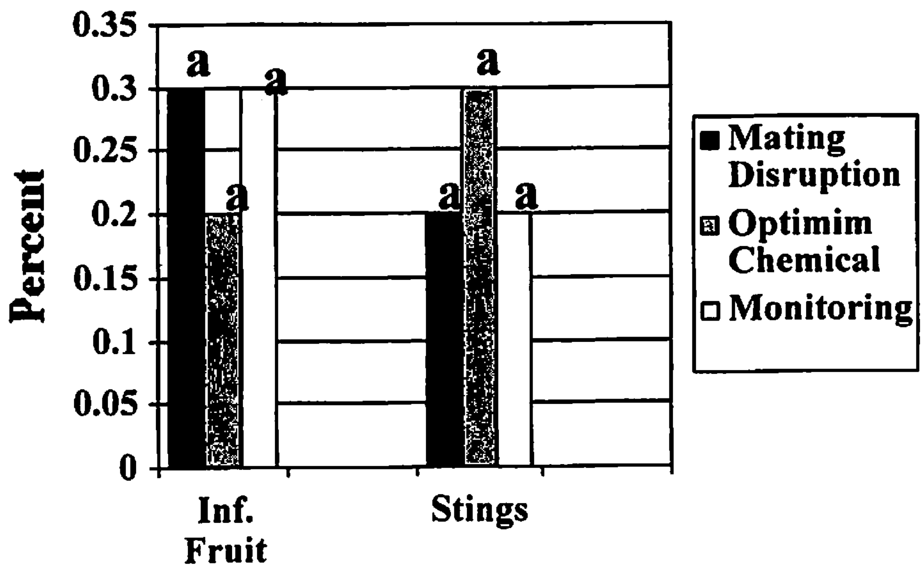
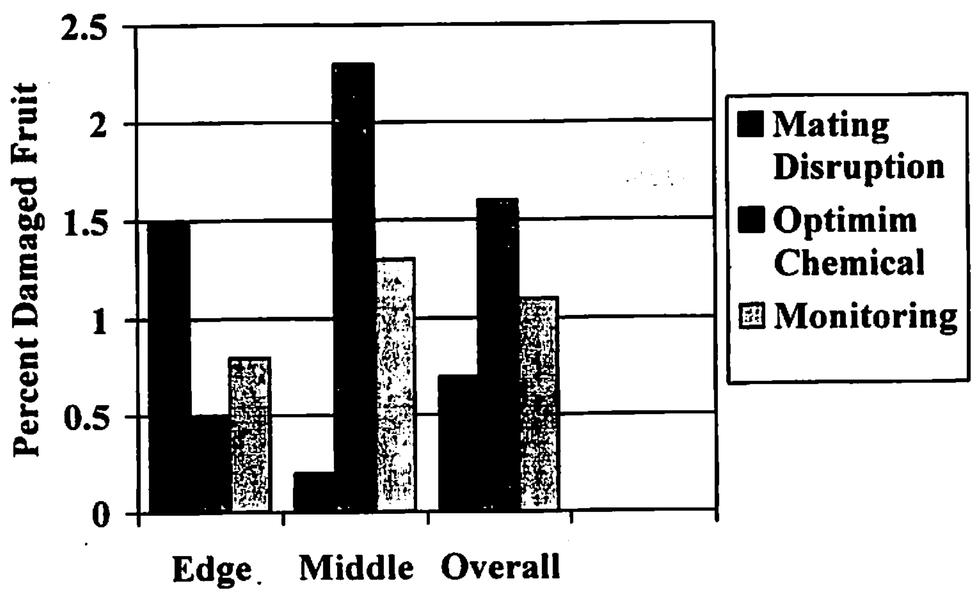


Fig. 4. Comparison of fruit damage at harvest in different OFM treatments in the Datthyn Orchard, 2004.



DISCUSSION

The Pennsylvania DD model did not accurately predict seasonal development of OFM in western NY apple orchards during the 2004 growing season, possibly because the spring and summer were unusually cool and wet. For example, the last flight started considerably earlier than predicted by this model. Because of the abnormalities of the season, it was difficult to determine when to time sprays for OFM in the proposed 3-spray Optimum Insecticide program. For example, the hatch of eggs from the first brood of OFM usually occurs during bloom, and consequently, the first spray for this brood was recommended at the pink bud stage. However, since pheromone trap catches showed that the first flight did not start until bloom, a petal fall spray would have coincided better with first hatch. The spray applied against the second brood based on estimated hatch predicted at 175-200 DD after the pheromone trap biofix, which was recommended during the third week in July, appeared to be timed correctly according to seasonal patterns of flight. However, the third flight did not start until the last week in August, and we estimated that the first hatch of third brood eggs would not occur until about the middle of September. Therefore, we advised growers to apply their last spray for OFM during the last week in August just before the Labor Day Holiday in September. The flight of this last generation continued during September and October. However, based on comparisons of damage in the plots during late August and at harvest in October, it did not appear that fruit damage increased in most of the plots as a result of this late third brood activity.

The trap catches were highly variable in the monitoring plots set up in the research orchards and generally correlated with estimated risk. These initial results suggested that trap catch thresholds can be used in commercial orchards to determine when and if sprays for OFM are necessary, although additional work may have to be done to more thoroughly test this concept.

Mating disruption was very effective in preventing OFM damage except in one high risk orchard, and observed patterns of damage suggested that injury in this block may have been due to immigration from outside sources into this relatively small plot. Therefore, it appears that mating disruption can eliminate the need for special chemical control sprays against OFM except in extremely high-risk orchards.

Monitoring fruit on trees during the season can accurately detect low levels of fruit damage in time to apply appropriate control sprays. However, this technology may not be practical for growers or consultants because it requires about 30 minutes to sample 1000 apples in a single orchard block for internal lepidoptera damage. Perhaps, in the future, this technique can be refined to require less time to monitor fruit during the season, by optimizing timing so that only one session is required and reducing numbers of sampling apples so that only higher unacceptable infestation levels will be detected.

Bin Pile Mating Disruption of Codling Moth

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In North Carolina apple systems, the codling moth is an occasional pest that is most frequently a problem near bin storage areas. Management of populations in these areas is difficult, because bins harbor a large number of moths in a concentrated area, and a diversity of microclimates within bin piles results in an extended emergence period. Management is further complicated in that little is known about the population dynamics of codling moth in these environments. Growers generally make frequent applications of broad-spectrum insecticides in areas adjacent to bin piles, but even this dose not prevent damage. The use of pheromone-mediated mating disruption in combination with frequent insecticide applications has helped to minimize damage in certain circumstances.

The purpose of this study was evaluate the use of mating disruption within bin piles as a strategy to help manage codling moth infestations in orchards adjacent to bin piles, and to monitor the activity of adults adjacent to bin piles.

Materials and Methods

Study sites. The study was conducted at three different sites where two separate stacks of bins were located adjacent to apple orchards. At each location, one bin pile was designated the "mating disruption" treatment and the other the "control." Bins in the mating disruption treatment were treated with Isomate-C Plus pheromone dispensers at the density of one dispenser per three bins. Pheromone dispensers were stapled to the outside of wooden bins. Each dispenser contained 182.3 mg of pheromone, and included 50% (E, E)-8, 10-dodecadien-1-ol, 29.7% dodecanol, and 6% tetradecanol. Dispensers were hung on multiple dates between 15 March and 1 May (dispensers were added as bins were stacked in piles over time). Pheromone dispensers were not applied to bins in the control pile. The three study sites are briefly described below:

Hend-Edney orchard: The mating disruption bin pile consisted of approximately 175 bins, and was separated from the control bin pile by ≈500 m. Both bin pile treatments were adjacent to the same block of mature 'Rome Beauty' apples, approximately 10 m from the nearest row of trees.

Hend-Gilbert: The mating disruption and control bin piles consisted of approximately 550 and 780 bins, respectively, and were separated by ≈300 m. Both bin pile treatments were adjacent to the same block of mature 'Rome Beauty' apples. Both bin piles were <5 m from the nearest row of trees.

Hend-Staton: The mating disruption and control bin piles consisted of approximately 2,200 and 1,50 bins, respectively, and were separated by ≈200 m. The mating disruption bin pile was located approximately 20 m from the nearest row of a block of 'Golden Delicious" apples, while the control bin pile was located approximately 50 m from the nearest row of a block of 'Rome Beauty' apples.

At each bin pile, codling moth and oriental fruit moth pheromone traps (Pherocon ICP baited with a pheromone lure) were hung on the bin pile (≈6' high, attached to bins), the second row of apple trees nearest the bin piles, and 50 and 100 m into the orchard. Trap sites are referred to as bin pile, 0, 50 and 100 m, which corresponds to traps placed at the bin pile, edge of orchard nearest bin pile, and 50 and 100 m into the orchard, respectively. Traps were checked weekly from April through harvest in mid to late September, and pheromone lures were replaced monthly. Fruit were assessed for damage by examining 100 fruit from each of two trees near each in-orchard pheromone trap location. All live worms were removed from apples and identified. Pheromone trap and damage data were subjected to ANOVA, with trap capture data transformed by square root before analysis. Means are presented as non-transformed data.

Results and Discussion

Codling moth and oriental fruit moth pheromone trap captures were abundant at both study sites, with codling moth populations particularly high at the Gilbert site and OFM relatively high at the Edney site (Fig. 1). Pheromone trap captures were not affected by bin treatment ($F = 0.17$; df = 1, 13; $P = 0.31$) or orchard effect ($F = 0.3.29$; df = 2, 13; $P = 0.07$), but were affected by distance from bin piles ($F = 31.22$; df = 3, 13; $P < 0.01$). As is evident in Fig. 2, codling moth trap captures increased with increasing distance from bin piles, regardless whether or not bins were treated with pheromone dispensers. Virtually no moths were caught in traps hung on bins, and capture was low in traps placed in trees on the edge of rows closest to bin piles. The absence of captures in traps at bin piles suggests that moths quickly disperse from bins upon emergence. The higher number of moths captured in traps placed 35 and 85 m into the orchard compared to those placed in trees on the edge of the orchard nearest bins suggests that moths were stimulated to move beyond the periphery of the orchard, or perhaps traps on the periphery of the orchard were less responsive to males compared to those in the interior of the orchard.

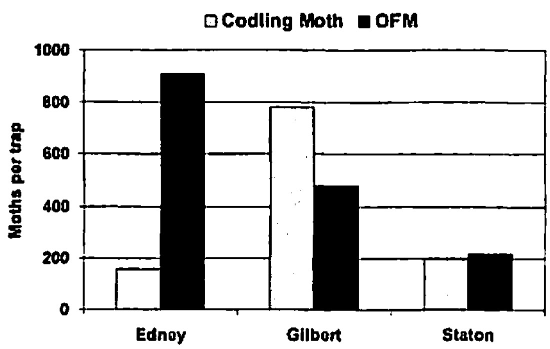

Fig. 1. Season-total pheromone trap capture of codling moth and OFM at three sites used for assessing bin mating disruption of codling moth.

In contrast to codling moth pheromone traps, distance from bin piles was not a significant factor in the ANOVA ($F = 1.51$; df = 3, 13; $P = 0.18$), although trap capture was numerically lower at pheromone-treated bin piles compared to other traps (Fig. 3). Orchard effect was significant ($F = 3.79$; df = 2, 13; $P = 0.04$), but bin treatment was not ($F = 0.44$; df = 1, 13; $P = 0.39$). The difference between codling moth and OFM trap capture at various distances from bins suggests that either OFM behavior after emerging from bins is different from codling moth, or alternatively there were very few OFM emerging from bins and trap captures reflect the activity of resident populations in the orchard. Although wooden bins are well documented as overwintering sites of codling moth larvae, the suitability of wooden bins as overwintering sites for OFM is not well understood.

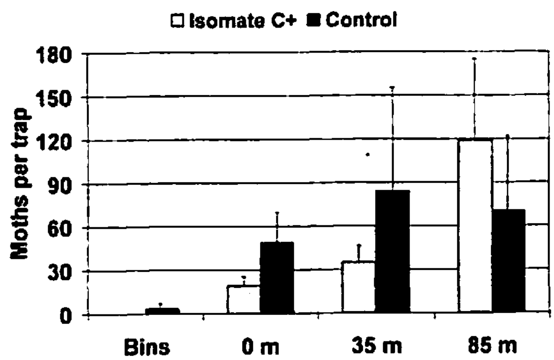

Fig. 2. Mean codling moth pheromone trap captures at bin piles and in trees at various distances from the edge of orchards adjacent to non-treated and Isomate C+ treated bin piles.

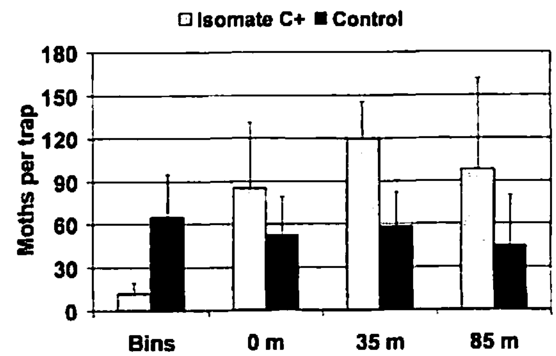

Fig. 3. Mean OFM pheromone trap captures at bin piles and in trees at various distances from the edge of orchards adjacent to non-treated and Isomate C+ treated bin piles.

Similar to codling moth pheromone trap captures, fruit damage ANOVA showed that damage did differ significantly with distance from bins ($F = 5.32$; df = 2, 17; $P = 0.02$), while bin treatment effect was not significant ($F = 0.007$; df = 1, 7; $P = 0.97$). However, in contrast to trap capture results, the highest fruit damage occurred in trees on the edge of the orchard nearest bin piles (Fig. 4). There was also a significant distance x orchard interaction ($F = 4.83$; df = 4, 7; $P = 0.04$), which was the result of low overall damage at the Endey site, where only one damage fruit was detected in all samples. A total of 23 live worms were collected from damaged apples at harvest, of which 19 were codling moth and 2 OFM.

The contrast in results between pheromone trap captures and larval damage at various distances from bin piles is difficult to explain, and suggests that pheromone traps may not provide an accurate assessment of codling moth dispersal from bin piles. Other factors may be affecting male response to pheromone traps near bin piles. For instance, perhaps female moths do indeed aggregate in trees nearest bin piles, and a high concentration of calling females (relative to trees in the interior of the orchard) out compete pheromone traps for male moths. Regardless, these studies indicate that bin mating disruption is probably not a viable strategy for managing codling moth populations near bin piles.

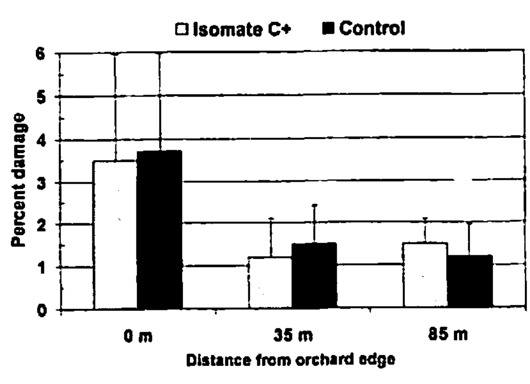

Fig. 4. Percentage of fruit damaged by internal-feeding lepidopteran larvae on apple trees located at various distances from the edge of orchard nearest bin piles.

Horticulture

Yield, Fruit Size, and Leaf Nutrient Content of Three Peach Tree Growth Habits Grown at Four Spacings and With Two Training Systems [1]

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In the United States, peach production per hectare (National Peach Council, 2003) is significantly below that for apple (Belrose, 2003). Apple production is higher and has increased significantly in the past several decades mostly through the use of dwarfing rootstocks, spur growth habit trees, and high-density planting systems. Acceptable dwarfing rootstocks for commercial peach production have not been identified at this time, so the techniques which have supported high-density plantings in apple are not available for peach. Attempts to apply specialized training and pruning techniques to standard growth habit peach trees and adapt these standard trees to high density systems has found little success. An alternative approach to training and pruning systems that rely on standard growth habit trees is the development of growth habits suited to high-density systems (Scorza,1984). Scorza identified two growth habits with the potential for high density planting, the pillar (or columnar) (P) and the upright (UP) form tree (Scorza, 1988). Because of their vigorous vertical growth and compact type canopies (Miller and Scorza, 2002; Scorza, 1988), these trees will likely require specialized training and management systems for efficient production.

Previous reports (Miller and Scorza, 2002, 2003) have described the performance for P ('Crimson Rocket') and UP ('Sweet-N-UP') trees compared to a standard (S) ('Harrow Beauty') growth habit peach tree in terms of initial training and pruning, growth, yield, fruit size, and dormant and summer pruning times. This report provides an update on the yields and fruit size in the sixth leaf (2004), and leaf nutrient levels in the third (2001) and fifth (2003) leaf.

Details concerning the design, planting, pruning, cultural management, harvest, and data collection for trees in this study have been previously published (Miller and Scorza, 2002, 2003). Dormant pruning following the 2003 growing season was considered more severe than in previous years and was employed as a means of reducing crop load and with the desire to improve fruit size compared to previous years. Only S trees were fertilized in 2004 (28 Apr.) using 0.91 kg/tree 10N-4.4P-8.3K. The first picking for P, S, and UP trees was on 30 July, 2 Aug., and 12 Aug., respectively. The second picking for the P, S, and UP trees was on 5 Aug., 9 Aug., and 17 Aug., respectively. Leaves were collected between 15 July and 1 Aug. in 2001 and again in 2003 from the mid-terminal portion of current year shoots from each tree in the planting, washed in distilled, deionized water, dried in a forced-air oven at 80°C and ground to pass a 40-mesh sieve. Dried leaf tissue was analyzed at the Pennsylvania State University Soil and Tissue Analysis Lab by plasma emission spectroscopy. Data were analyzed by ANOVA as a factorial and means separated by Duncan's new multiple range test at $P = 0.05$.

Yields (kg/tree) for UP trees in 2004 were significantly greater than for P or S trees. Annual yields per tree in each year from 2000 (the first bearing year) through 2004 have been greater for UP trees than for P trees. P growth habit trees have had the lowest cumulative yield (82 kg/tree) during the first five bearing years followed by S trees (143 kg/tree) with UP trees showing the highest cumulative yield (173 kg/tree). When actual yields per tree and in-row spacing in the fifth and sixth leaf were used with a projected between-row spacing to calculate potential yield per ha, P trees spaced 1.5 x 4.9 m showed an average yield of 28.6 MT/ha. If between-row spacing was reduced to 4.3 m, potential yield increased to 32.6 MT/ha. Applying a similar approach with UP trees spaced 3.0 x 5.5 m, potential yield averaged over the fifth and sixth leaf was calculated to be 32.5 MT/ha. Reducing the in-row spacing of UP trees to 2.0 m would increase mean yields to 35.6 MT/ha. These yields compare with S trees planted at a more traditional spacing of 6.0 x 6.0 m where the calculated potential yield would be 20.4 MT/ha. If in-row spacing is reduced to 4.0 m, mean yields only increased to 21.0 MT/ha.

In this study, as in-row spacing increased from 1.5 m to 6.0 m, yields per tree increased. In 2004 (sixth leaf), trees spaced 6.0 m apart in the row produced greater yields per tree than the other three in-row spacings (1.5, 2.0, and 4.0 m). Training system [central leader (CL) or multiple leader (ML)] or summer pruning (SP) had no effect on yields in the 2000 and 2001 growing seasons, but trees trained to the ML system did produce significantly more fruit per tree in 2003 and 2004. Similarly, SP reduced yield per tree each year between 2002 and 2004. CL training reduced the 5-year cumulative yield per tree about 8% compared to ML trained trees. Summer pruning reduced the 5-year cumulative yield per tree about 7% compared to trees that received no SP.

The largest peaches were produced by the UP growth habit trees. Peaches from P trees were significantly smaller than UP fruit, but larger than fruit from S trees. These results agree with those obtained in the 2001 through 2003 growing seasons. Additionally, as in-row spacing increased fruit size (diameter) increased, which agrees with earlier findings (Miller and Scorza, 2003). Despite a more severe dormant pruning regime and a reduced crop load (mean reduction of 23.7%) for all growth habits in 2004, mean fruit diameter was slightly less than that recorded in 2003 for P (6.50 cm vs 6.90 cm, respectively) and UP (6.72 cm vs 7.32 cm, respectively) trees. For S trees fruit diameter was slightly greater in 2004 (6.30 cm) compared to 2003 (6.10 cm). A clear explanation for this fruit size response is not obvious. Moisture was not a limiting factor in either 2003 or 2004. P and UP trees had no supplemental N fertilizer applied after the 2000 growing season, which may be a contributing factor to reduced fruit size. Temperatures during the critical cell division period (late Apr. through early May) averaged 2.4°C below normal in 2003, but 2.3°C above normal in 2004. These elevated temperatures may have had a negative impact on cell division and/or the distribution of carbohydrates between fruit and vegetative shoots ultimately reducing fruit size. Since no data was collected on fruit size during the growing season, changes in fruit size during Stage III cannot be compared between 2003 and 2004. However, mean temperatures and moisture levels were very similar during this period for the two years.

As in previous years (Miller and Scorza, 2003, 2004) fruit size was reduced slightly by SP. This response was exhibited in fruit at the first picking, but not for fruit harvested at the second picking. A similar response in fruit size has been observed when trees were trained to the ML system compared to trees trained to the CL system.

Foliar analysis revealed a significant difference in leaf N levels between all three growth habits in both 2001 and 2003. Leaf N levels were highest in S trees and lowest in UP trees. Average leaf N levels decreased slightly for all three growth habits between 2001 and 2003. S growth habit trees also had higher levels of K and B than P or UP trees in both years sampled. In contrast P and UP trees had higher levels of foliar Ca, Mg (2001 only), and P (2001 only) than S trees. Mean leaf nutrient levels for N, P, K, Ca, Mg, and B fell within an accepted range (Pa Tree Fruit Production Guide, 2002-2003) for peach in both years sampled. Analysis for the coefficient of correlation (r) between leaf nutrient levels and yield revealed no relationships for N, P, K, Ca, or Mg. In-row spacing had little or no effect on leaf nutrient levels except for Mn where trees at 2.0, 4.0 and 6.0 m spacing had lower Mn levels than trees planted at the closets spacing (1.5 m). Training system had no effect on leaf nutrient levels. SP tended to increase leaf nutrient levels for most elements measured except for K where SP decreased the mean K levels.

This research project continues to demonstrate the yield benefits of P and UP peach growth habit trees planted at high density (610 to 1551 trees/ha) compared to S habit trees planted at conventional tree densities (274 to 410 trees/ha). The only concern has been fruit size, especially for the 'Crimson Rocket' P trees.

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Not for Citation or Publication
Without Consent of the Author

Long-term Use of Apogee® for 'Nittany' Apple On M.9 Rootstock – The Second Year [1]

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The effect of Apogee (prohexadione-calcium) on the suppression of vegetative shoot growth in apple has been well documented. Apogee has also been shown to suppress the shoot blight stage of fire blight in apple and increase fruit set in apple. Most studies reporting the effects of Apogee on apple have focused on single or multiple sprays applied during a single growing season. A limited number of studies have reported on carryover effects when mature trees were treated in two successive growing seasons. Only one study has addressed Apogee sprays applied to young apple trees growing under field conditions (Norelli and Miller, 2004).

The objective of this study was to evaluate the long-term effects of annual Apogee sprays on young apple trees using a combination of the low to moderate rates employed by Norelli and Miller (2004). Reviews of the literature describing the effects of Apogee on apple are presented elsewhere (Miller, 2003; Miller and Tworkoski, 2003).

Initial sprays of Apogee were applied to 'Nittany' apple trees on Malling.9 rootstock in their fourth leaf in 2003. Details of these initial applications and the results of treatment have been presented (Miller, 2003). In March 2004 all trees were dormant pruned and pruning time recorded in seconds per tree. On 20 April, at the late pink to early bloom stage of flower development, one representative limb per tree was tagged and the number of blossom clusters counted. Limbs selected were between 5.0 and 10.2 cm in circumference and directly attached to the central leader. Spray treatments were repeated in 2004 to the same trees treated in 2003 except only two sprays were applied in 2004 (in 2003 the initial spray was washed off by rain soon after application). The first spray was applied on 30 Apr. (petal fall) at 125 $mg \cdot l^{-1}$ and the second spray 2-weeks later on 14 May at 63 $mg \cdot l^{-1}$. Yield, fruit quality, and growth data were collected as previously described (Miller, 2003). Symptoms of the shoot blight stage of fire blight were first observed in both control and Apogee treated trees on 10 May. Blighted shoots appeared to be the result of earlier blossom blight, which was visible on several remnant blossoms. Blighted spurs and/or shoots were removed with alcohol sterilized shears beginning on 10 May. Trees were inspected regularly and blighted shoots were removed when first observed. The last blight was pruned out on 16 June. The total number of blighted shoots removed was recorded per tree. Data was analyzed with an ANOVA and treatment means compared using the Student's *t*-test.

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[1] The author gratefully acknowledges the technical contributions of Chris Hott, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV in this work.

Apogee trees required 28.9 sec/tree dormant pruning time compared to 48.0 sec/tree for control trees. This represented a 40% reduction in pruning time for Apogee treated trees and while not statistically different at the $P = 0.05$ level perhaps of practical significance ($P = 0.081$). Return bloom did not differ between treatments. Apogee treated trees had an average of 15.9 flower clusters per cm limb cross-sectional area (LCSA) compared to 16.9 blossom clusters per cm LCSA for control trees. Of significance ($P = 0.022$) was the difference in the number of fire blight strikes removed per tree for Apogee treated trees and control trees (3.9 vs. 11.3 strikes /tree, respectively).

At harvest (7-8 Oct.), Apogee treated trees did not differ from controls in the mean number of fruit per tree, yield per tree, individual fruit weight, or fruit diameter (data not shown). Yield per tree for control trees was about double (21.7 kg/tree) in 2004 compared to yields (10.9 kg/tree) for control trees in 2003 and Apogee treated trees had about 2.3 times the yield in 2004 (20.2 kg/tree) compared to their yield (6.05 kg/tree) in 2003. Unlike the results in 2003, when mean diameter and individual fruit weight for Apogee treated fruit was less than control fruit, in 2004 fruit size (weight and diameter) on Apogee treated trees did not differ from that on control trees (data not shown). These differences in response between 2003 and 2004 may be the result of very different temperature conditions during a critical fruit growth period (30 to 45 days) after full bloom. Mean daily temperatures during May 2004 were 2.3°C above normal while in 2003 mean temperatures for May were 2.4°C below normal. Fruit quality (flesh firmness, soluble solids and starch index rating) also did not differ for Apogee treated trees when compared to fruit from control trees in 2004 (data not shown). This is in contrast to results in 2003 when Apogee treated fruit was firmer, but more advanced in maturity than untreated control fruit (Miller, 2003).

Two Apogee sprays were effective in reducing mean terminal shoot growth (12.5 cm for Apogee treated trees vs. 21.8 cm for untreated control trees) (Fig. 1), tree height, and canopy spread (average of cross-row and within-row measurements), but not trunk cross-sectional area in 2004. These effects on tree growth mirrored those found when sprays were applied to the same trees in the 2003 growing season. No carryover effects were observed in 2004 on shoot growth that could be accredited to the applications made in 2003.

Results from Apogee spray treatments in 2004 may be summarized as follows: 1) no carryover effects were observed in 2004 from sprays applied in 2003, 2) two sequential Apogee sprays at an effective cumulative dose of 188 $mg \cdot l^{-1}$ reduced terminal growth and canopy size compared to untreated controls, and effects were similar to those observed in 2003, 3) Apogee sprays in 2004 had no effect on yield, fruit size, or fruit quality, compared to untreated controls, and 4) Apogee reduced the number of fire blight strikes compared to the untreated controls. In conclusion, after two successive yearly applications of Apogee to young bearing apple trees, response to Apogee appears to be the result of the application(s) in the given growing season and not an effect of previous applications.

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Fig. 1. Four-year-old Apogee treated (right) and untreated control (left) 'Nittany'/M.9 apple tree at harvest in 2004. Note more compact terminal shoot growth in Apogee treated tree.

Interaction of Cultivar with Apple Training Systems

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Intensive orchard planting systems are becoming more common in the mid-Atlantic apple production region. Their development is largely driven by the need to increase labor efficiency and to improve the precocity of the planting to generate earlier returns. An orchard system is the sum of numerous interacting factors. Some of the factors most commonly studies include system training, rootstock, and tree spatial arrangement. We were interested in studying how tree growth habit might interact with training systems. Lespinasse and Delort (1993) described four basic growth patterns of cultivars primarily on the manner of their branching and flower location. The first or Type I is characterized by little branching and an abundance of spurs. At the other end of the spectrum was the Type IV where flowers are normally born terminally on bourse shoots and the overall growth habit has been described as weeping.

Pruning techniques must differ to take into account the growth and flowering patterns. For example spur types must be spread to ensure strong crotch angles and benefit from heading cuts to encourage additional branching and to maintain vigor. The Type IV on the other hand naturally exhibit a more spreading growth habit and do not require very many heading cuts. They do however require constant undercutting to allow adequate sunlight into the center of the tree. It therefore stands to reason that different types of cultivars may not be equally adapted to all training systems. The purpose of this experiment was to look at three different growth patterns and how they might perform under different training systems.

Materials & Methods

Three popular fresh market cultivars that have dramatically different growth habits were chosen: Crimson Gala, Ginger Gold and Fuji (BC#2). The planting was established in 1997 at the Horticultural Research Farm at Rock Springs in central Pennsylvania. The trees were propagated on M.9 NAKB T337 rootstock. Four systems were established. 1) Four wire trellis (T), 2) Slender spindle (S), 3) Vertical axe (A) and 4) Offset Axe (V). The planting was laid out in three large blocks with rows running north to south and 15 meters separating the three blocks. There were five tree replication of all three cultivars in a row with each row being one training system. The systems (rows) were randomly assigned within a block with two replications within a block for a total of eight replications. Initially at planting the largest trees were planted in the first block followed by the next largest in the second and the smallest in the third block.

Tree spacing within the V system was set at 0.9 m in the row while all the others were planted at 1.8 m in the row for the other three systems. Between row spacing was

4.9 m for the V and 3.7 m for the other systems. The trees of the V system were angled to grow at 600 from horizontal. Tree density therefore was 2241 trees/ha for the V system and 1495 trees/ha for all the other systems.

All trees were pruned and trained by the authors. Tree training has been described previously (Crassweller & Smith, 1999). Trunk circumference on each tree was taken annually and converted to trunk cross sectional area to compare tree size. Harvest data was collected as a total for each cultivar/system/replication. Harvest data consisted of counting all the fruit on the trees and weighing them. All the fruit were then run across a grader to determine fruit size distribution. After the first growing season time for pruning and training each system by cultivar/system/replication was collected. Beginning in 2003 time it took to summer prune the trees was also measured.

Results and Discussion

Costs of System Construction: Estimated costs to construct the systems for materials only, varied due to the need and size of support posts. The T system cost the least; while the V system cost the most due to the heavier posts needed to support the trees. The cost of erecting a S system was less than the A system due to the stature of the posts required.

Table 1. Estimated construction costs for different apple training systems; materials only.

System	Cost ($USD / ha)
Trellis	$5,110
Spindle	$6,336
Axe	$8,698
Offset Axe	$11,248

Tree Size: Initially trees in the trellis system were significantly larger than the other three systems (Table 2). However by the end of the second growing season the difference disappeared. After the 3rd growing season the trees in the V were significantly smaller an have remained that way. The smaller tree size may be the combination of two factors one could be root competition and the other may be due to the 60 degree angle to which the trees are trained.. At planting Fuji trees had a significantly larger trunk cross sectional area. This has been maintained throughout the life of this planting. In 2004 there was a significant interaction between cultivar and system for overall TCSA. For Ginger Gold and Fuji, trees trained to a spindle were the largest. For Gala, trees in the Axe system had the largest TCSA.

Yearly Increase in TCSA: Increase of TCSA in the fall of the year of planting was significantly greater for the trellis system (Table 3). In the second year there was no difference in TCSA increase between systems. However, by the third leaf TCSA increase for trees in the Offset Axe system had significantly less growth than any of the other system through 2003. In 2004 there was a cultivar system interaction. In general Fuji had the greatest annual growth increase as measured by increase in TCSA. Increase in TCSA for Gala and Ginger Gold were usually similar with the exceptions in the year 2000 and 2003 when Ginger Gold was significantly less than Gala.

Yield per hectare: Yields per hectare were not always significantly different by cultivar or training system. In 1999 there was not significant difference by training system but there were differences by cultivar (Table 4). Fuji had the highest yields and Gala the lowest with Ginger Gold intermediate. In 2000 there were no differences by either training system or cultivar. In 2001 there were some differences by training system, with the T system having the lowest and the V the highest. Fuji had the highest yields but there were no differences in yield between the other two cultivars. Beginning in 2002 there was a significant cultivar x system interactions (Table 5).

Ginger Gold on a unit of land basis had the highest yields when trained to the V system in three out of four years. The lowest yields were observed on trees trained to the trellis in three out of four years. Yields of Gala on a unit of land basis was highest on the V system in two out of four years with the Axe system having the highest yields in 2002 and similar yields to the V in 2003. Yields of Gala on trellis system were the lowest in three our of four years. Fuji yields were much less dependant upon training system. There were no significant differences by training system in three out of five years. In 2003 the Axe had the highest and the V had the lowest yields, however, in 2004 there were no differences between the Axe, S, or V systems but the T system was lower.

This data suggests that cultivars having a Type I (Gala) and Type IV (Ginger Gold) growth habit may yield equally well when trained systems similar to an axe with a reliance growth in the upper portions of the tree that is purposely kept weak by removing strong vigorous growth but allowing more vigorous growth lower in the tree. Cultivars with an intermediate growth habit of Type II or Type III (Fuji) seem to be able to adapt well to a variety of systems. Their adaptability is likely related to the diversity of their flowering habits having both short spurs and intermediate length bourses. Cultivars of Type I and Type IV did not adapt well to trellis training.

Pruning Time by System: Generally, the trellis took the most time to dormant prune each year (Table 6). The Axe usually took the least amount of time. The Offset Axe took more time to prune than the Axe in 2001 and 2003 but not in 2000, 2002 or 2004. Even though there were more trees per acre the pruning was not as difficult because of the canopy being so dense there was not the need to carefully weigh which cuts to make. There was a system x cultivar interaction in 2004. There were no differences by system for Ginger Gold, Gala and Fuji, except that the Fuji trellis system took longer to prune than the other systems.

By cultivar, it normally took longer to prune Ginger Gold and the least amount of time to prune the Gala with Fuji being intermediate. The greater time to prune the Ginger Gold was due to the cultivar's Type IV growth habit which required many undercuts to shorten and stiffen fruiting branches.

Summer Pruning Time: It became obvious that it was necessary to institute a summer pruning program if we were to get color into the center of the Spindle and the Offset Axe. In both of these systems trees growth was excessive and poor coloring fruit would have resulted. Therefore, the time to summer prune each system was also measured.

As with the dormant pruning, the Axe took the least amount of time to prune (Table 7). The Offset Axe in 2004 required similar time to prune as the Axe even though tree density was much higher. Within cultivars Ginger Gold took the longest to summer prune in both years. Gala took the least amount of time with Fuji intermediate although not statistically different.

Conclusions

Since growth habit can directly impact upon flowering habit (Lespinasse & Delort, 1993). It therefore, can be expected there may be some impact on orchard productivity of how the trees are trained and pruned. In this experiment for the purpose of this discussion we can classify Crimson Gala as closer to a Type I growth pattern in that it produces numerous spurs and does not branch as readily as other cultivars. The other extreme is Ginger Gold in that it tends to produce fruit at the terminally on of 1-year-old shoots that arose from a previous fruiting spur or as a lateral bud the previous year. Fuji's flowering and growth habit are in-between the other two. It flowers and fruits on some spurs but may also produce short, less than 25 cm long bourse shoots. With the two extreme opposite growth Types, I & IV they both seem to respond to axe type training and do not respond well to trellising or to systems that require heading and structural height restrictions such as the spindle. Fuji on the other hand because of its' diverse flowering habit seems to be less sensitive to training systems.

The amount of pruning is also impacted by growth habit with the Type IV requiring the most and Type I cultivars requiring less. A trellis system because of the constant need to position and tie limbs requires a greater amount of time to prune.

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Table 2. Annual tree size as measured in trunk cross sectional area (cm^2) and determined by measuring trunk circumference at planting and each fall after harvest.

	planting	1997	1998	1999	2000	2001	2002	2003	2004
Offset Axe	1.0 a	1.5 a	4.8 a	8.3 a	11.5 **	15.8 a	19.1 a	24.4 a	29.4 **
Spindle	1.0 a	1.5 a	5.2 ab	9.9 b	14.9	21.1 b	26.6 b	33.3 b	40.1
Axe	1.0 a	1.6 a	4.7 a	8.8 ab	13.7	19.5 b	24.5 b	30.9 b	38.3
Trellis	1.3 b	2.1 b	5.5 b	9.7 b	14.2	20.0 b	25.1 b	30.8 b	36.1
P-value	0.0001	0.0001	0.0186	0.0061	**	0.0003	0.0001	0.0001	
Ginger Gold	1.0 a	1.5 a	4.5 a	8.1 a	11.5 **	16.2 a	21.1 a	25.8 a	30.5 **
Gala	1.0 a	1.5 a	4.6 a	8.3 a	12.5	17.3 a	21.7 a	27.1 a	32.7
Fuji	1.2 b	2.0 b	5.9 b	10.7 b	16.7	21.9 b	28.7 b	36.6 b	40.9
P-value	0.0001	0.0001	0.0004	0.0001	**	0.0001	0.0001	0.0001	

** Significant cultivar training system interaction.
Letters refer to Tukey-Kramer mean separation, P=0.05.

Table 3. Annual increase in trunk cross sectional area (cm^2) as determined from trunk circumference measured annually in the fall of each year across all cultivars.

	1997		1998		1999		2000		2001		2002		2003		2004	
Offset Axe	0.5	a	3.3	a	3.6	a	3.2	a	4.3	a	3.3	a	5.3	a	4.9	**
Spindle	0.5	a	3.7	a	4.8	b	4.9	b	6.3	b	5.3	b	6.7	b	7.0	
Axe	0.5	a	3.1	a	4.2	ab	4.9	b	5.9	b	4.9	b	6.3	ab	7.5	
Trellis	0.9	b	3.4	a	4.2	ab	4.6	b	5.7	b	5.3	b	5.7	ab	5.2	
P value			0.1914		0.0005		0.0016		0.0001		0.0001		0.0174			
Ginger Gold	0.5	a	3.0	a	3.6	a	3.3	a	5.0	a	4.1	a	4.5	a	5.7	**
Gala	0.5	a	3.1	a	3.9	a	4.2	b	5.1	a	3.7	a	5.3	b	6.4	
Fuji	0.8	b	3.9	b	4.8	b	5.8	c	5.9	b	5.5	b	7.8	c	5.6	
P value			0.0010		0.0001		0.0001		0.0009		0.0001		0.0001			

** Significant cultivar training system interaction.
Letters refer to Tukey-Kramer mean separation, P=0.05.

Table 4. Annual yield (kg) per hectare of three cultivars and four training systems in 1999 – 2001.

	1999		2000		2001	
Offset Axe	9991	a	16870	a	28604	b
Spindle	7731	a	15087	a	24016	ab
Axe	8016	a	12987	a	27456	ab
Trellis	8667	a	13377	a	22768	a
P - Value	0.0859		0.0715		0.0157	
Ginger Gold	9047	b	14477	a	19850	a
Gala	5050	a	13290	a	21637	a
Fuji	11706	c	15974	a	35645	b
P - Value	0.0001		0.1053		0.0001	

Letters refer to Tukey-Kramer mean separation, P=0.05
Based on 1495 trees/ha for Spindle Axe, and Trellis and 2241 trees/ha for Offset Axe

Table 5. Cultivar x training system annual yield (kg/ha) interaction for 2002 through 2004.

2002	Ginger Gold		Gala		Fuji			
Offset Axe	21,804	ab	27,389	ab	36,042	a		
Spindle	19,924	ab	21,007	a	34,165	a		
Axe	26,583	b	29,529	b	31,355	a		
Trellis	12,502	a	22,928	ab	37,241	a		
P - Value	0.0048		0.0107		0.1417			
	Offset Axe		*Spindle*		*Axe*		*Trellis*	
Ginger Gold	21,804	a	19,924	a	26,583	a	12,502	a
Gala	27,389	a	21,007	a	29,529	a	22,928	b
Fuji	36,042	b	34,165	b	31,355	a	37,241	c
P - Value	0.0006		0.0001		0.3267		0.0001	

2003	Ginger Gold		Gala		Fuji			
Offset Axe	52,011	b	43,954	b	27,316	a		
Spindle	30,706	a	35,443	ab	38,240	ab		
Axe	43,513	ab	44,932	b	48,571	b		
Trellis	34,720	a	29,321	a	34,388	ab		
P - Value	0.0048		0.0015		0.0175			
	Offset Axe		*Spindle*		*Axe*		*Trellis*	
Ginger Gold	52,011	b	30,706	a	43,513	a	34,720	a
Gala	43,954	b	35,443	a	44,932	a	29,321	a
Fuji	27,316	a	38,240	a	48,571	a	34,388	a
P - Value	0.0006		0.1588		0.6785		0.1842	

2004	Ginger Gold		Gala		Fuji			
Offset Axe	49,246	c	44,181	c	71,018	b		
Spindle	33,703	ab	30,441	ab	57,937	b		
Axe	42,759	bc	38,083	bc	65,550	b		
Trellis	29,233	a	24,839	a	38,251	a		
P - Value	0.0002		0.0002		0.0002			
	Offset Axe		*Spindle*		*Axe*		*Trellis*	
Ginger Gold	49,246	a	33,703	a	42,759	a	29,233	ab
Gala	44,181	a	30,441	a	38,083	a	24,839	a
Fuji	71,018	b	57,937	b	65,550	b	38,251	b
P - Value	0.0001		0.0001		0.0207		0.0207	

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

Table 6. Hours per hectare to dormant prune apple trees by training system and cultivar in 2000 – 2004

Training Sys.	2000	2001	2002	2003	2004
Offset Axe	61.0 b	48.9 b	55.4 ab	55.4 b	36.6 **
Spindle	39.3 a	44.2 a	58.8 ab	65.5 b	52.5
Axe	51.4 ab	33.0 a	36.9 a	50.7 a	50.7
Trellis	115.4 c	45.3 a	68.0 b	93.7 c	61.6
P - Value	0.0001	0.0020	0.0455	0.0001	
Cultivar					
Ginger Gold	72.9 a	28.3 b	75.7 c	171.7 c	98.9 **
Gala	64.5 a	17.2 a	36.9 a	88.7 a	73.2
Fuji	63.0 a	24.7 b	51.7 b	134.7 b	88.0
P - Value	0.0734	0.0001	0.0001	0.0001	

Letters refer to Tukey-Kramer mean separation, P=0.05.
** Significant cultivar x system interaction.

Table 7. Hours per hectare to summer prune apple trees by training system and cultivar in 2003 and 2004.

System	2003	2004
Offset Axe	69.6 b	51.3 a
Spindle	63.6 b	61.9 ab
Axe	50.7 a	43.5 a
Trellis	65.6 b	90.9 b
P - Value	0.0021	0.0021
Cultivar		
Ginger Gold	78.5 c	80 b
Gala	42.8 a	53.1 a
Fuji	65.9 b	58.1 a
P - Value	0.0001.	0.0001

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

LEAF REMOVAL ON FRESH DUG STRAWBERRY TRANSPLANTS PRIOR TO PLANTING AND ITS EFFECT ON FLOWER PRODUCTION

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Any system for producing strawberries in the Fall for the mid-Atlantic region will rely on nurseries that will be able to supply plant material for the intended harvest season. Nursery location may play a large part in providing plants suitable for this system. This material may be dormant, fresh dug, plug plants and anything in between or beyond. It may be that an annual or a perennial system with varieties that we have not learned enough about will achieve the best Fall yields.

Nurseries need to provide plant material that will establish quickly. Delay in field establishment can result in reduced Spring yields. Some Western nurseries mow the leaves off before digging the plants. This aids handling and shipment of the plants. Recommendations for the plasticulture system in the mid-Atlantic region have always been to preserve as much foliage as possible beginning at plant establishment. This is achieved usually through use of overhead irrigation during the post-transplant period.

This trial was to evaluate the effects of clipping the leaves of fresh-dug plants on Fall production of strawberries in a high tunnel system. Plug plants from a local nursery (Davon Crest Farms, Hurlock MD) were planted at similar times for comparison.

Materials and Methods

Culture. The field was prepared and fertility levels adjusted per 2003 Maryland commercial production recommendations EB-236. Planting beds were shaped (20.3cm high x 73.6cm wide at the bed shoulder), one line of drip tape buried at 5.0cm and covered with 1.25 Mil black plastic. Fresh-dug Sweet Charlie plants were received from a Colorado nursery (Ruby Mountain Nursery, La Jara, Co) shipped by common carrier on two dates September 24 and October 17.

All plants were received in good condition. It was noted that there was some variation in crown size, so the plants were graded into three sizes: small (<10mm), medium (10-20mm) and large(>20mm). About 85% of the plants fell into the 10-20mm size. Planting holes were made by hand using a narrow piece of steel to make a slit so that the roots could be inserted without causing a "J-hook" with the roots. Roots were trimmed by one-third and planted in a staggered configuration 30cm x 30cm double-row. A dilute transplant water solution (Millers 20-20-20 @ 0.5Kg/380 liters water) was applied at planting.

Leaves were either removed completely or left intact. Intermittent sprinkler irrigation post-plant was used for seven days to facilitate plant establishment. No plant mortality occurred and all intact leaves at planting survived. The high tunnel plastic was installed and daily management began on October 15.

Treatment plots were ten plants replicated four times.

Results

Flowers per plant

Count date	Crown size	Clipped	Unclipped
Nov 17	Small	0.2	1.6
	Medium	0.1	1.9
	Large	1.0	1.8
Dec 9	Small	2.4	5.9
	Medium	3.4	6.2
	Large	5.8	5.7

Fruit harvest (grams per plant)

Harvest date	Crown size	Clipped	Unclipped
January 5	Small	0	35.3
	Medium	2.7	20.9
	Large	7.1	20.7
	Plugs	-	6.3

Discussion

The late-planted material did not produce flowers by the second count date. Both planting dates were too late to produce fruit during the desired market window of Thanksgiving through Christmas. Leaf removal delayed flower production for all crown sizes at the Nov 17 count. On the Dec 9 count, only the large crown had the least differences between clipped and unclipped. Harvest yields amounted to about one large high-quality fruit per plant. Although yields are far lower than what would be acceptable for a commercial grower, we continue to learn about plant performance in the mid-Atlantic region under new growing systems.

INFLUENCE OF FLOATING ROW COVER (FRC) WEIGHT, PLANTING DATE AND FRC DEPLOYMENT TIME ON ANNUAL STRAWBERRY PRODUCTION

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Annual production of strawberries using the plasticulture system has the potential of producing high-quality and high-yielding fruit. Challenges for the Mid-Atlantic and colder production areas using this system are insuring adequate Fall growth and limiting Winter and Spring injury. Unlike the traditional Eastern-bred plants that go dormant in the Winter, the varieties currently used remain actively growing longer into the Fall and resume growing earlier in the Spring. It is for these reasons that the system goes from a propagated strawberry tip to final harvest in nine months.

Floating row covers (FRC) are an intrical component in the production system. Spring frost protection, advancing plant growth and over-Winter protection can all be influenced with FRC. For the coastal Mid-Atlantic regions a planting date of the first week of September has proven to be the planting window for highest yields. The FRC deployment date for over-Wintering the plants has also been determined to be mid December. This Winter FRC deployment date is intended to coincide with the time that a conventional matted-row strawberry grower would straw mulch their beds.

FRC are available in several weights, and as the weight of the FRC increases the quantity of light transmission decreases but the insulation from cold can increase. Management of the FRC becomes important because the wrong FRC applied to early or to late can affect Spring yields. This report presents data that examines FRC type and the deployment time of the FRC and its effects on planting date.

Materials and Methods

Culture. The field was prepared and fertility levels adjusted per 2003 Maryland commercial production recommendations EB-236. Planting beds were shaped (20.3cm high x 73.6cm wide at the bed shoulder), one line of drip tape buried at 5.0cm and covered with 1.25 Mil black plastic. Plug plants (50 cell tray packs) were ordered and purchased from a local nursery (Davon Crest Farms, Hurlock MD), for the desired planting dates. All plants were received in good condition. Planting holes were made with a commercial type water-wheel in a staggered configuration 30cm x 30cm. A dilute transplant water solution (Millers 20-20-20@0.5Kg/380 liters water) was applied at planting. Intermittent sprinkler irrigation post-plant was used for two days to facilitate plant establishment.

All runners were counted and removed on Dec 19-03 before the final FRC were deployed for over-wintering. All FRC were removed on Feb 19-04 and redeployed on five different dates when low temperatures threatened flower injury. Sprinkler irrigation was used on April 8-04 to prevent flower injury. A high-degree of certainty exist that no damage to flower buds occurred during these freeze events.

Harvest began on May 7-04 and concluded on June 2-04. Red-ripe fruit was harvest two times per week. Fruit was graded as marketable if berry size was greater than 8 grams and free from deformities. Disease incident was very low. Spring fertility and pesticide applications were applied as recommended by EB-236 based on leaf petiole sap analysis and weather conditions. Irrigation was applied based on soil tensiometers at 15 and 30 cm soil depth.

FRC were either a 2.1 oz/sq yd (Amoco 4801) needle punch polypropylene material or a 1.2 oz/sq yd Typar polypropylene product.

Treatments consisted of:

2 FRC	1.2 oz and 2.1 oz
2 Planting dates	Sept 9 and Sept 24
3 FRC deployment dates	Oct 16, Nov 17 and Dec 19
3 Varieties	Chandler, Camarosa and Allstar

Plots consisted of twenty plants replicated four times.

Results

Spring Fruit Yield By Individual component

Variety	grams/plant
Allstar	478.4 a
Camarosa	455.6 a
Chandler	401.7 b

FRC	grams/plant
1.2 FRC	471.7 a
2.1 FRC	418.9 b

Covering date	
Oct 16	416.6 b
Nov 17	462.1 a
Dec 19	457.5 a

Planting date	
Sept 9	540.0 a
Sept 24	350.5 b

Significance @ .05 within column

Early-planted x FRC Type x Covering date

Early-covered	**1.2 FRC** gr/plant	**2.1 FRC** gr/plant
Allstar	576.2	598.5
Camarosa	454.6	473.0
Chandler	476.3	363.9**
Mid-covered		
Allstar	503.2	591.0
Camarosa	619.4	641.0
Chandler	604.6	511.0**
Late-covered		
Allstar	615.2	634.1
Camarosa	604.6	571.5
Chandler	575.5	421.2**

Late-planted x FRC type x Covering date

Early-covered	**1.2 FRC** gr/plant	**2.1 FRC** gr/plant
Allstar	362.8	334.5
Camarosa	384.3	312.2
Chandler	391.5	283.3**
Mid-covered		
Allstar	416.0	336.1
Camarosa	380.7	320.2
Chandler	418.3	270.6**
Late-covered		
Allstar	390.2	382.3
Camarosa	359.4	346.0
Chandler	356.0	263.4**

Discussion

The average fruit yield for 10 years of research at Queenstown for Chandler, Camarosa and Allstar is 508, 508, and 517 grams per plant respectively when the recommended planting date and late FRC covering date is observed. This data further illustrates the importance of the correct planting window.

Chandler yields were reduced the greatest by the use of the 2.1 FRC, and had the greatest negative impact on yields when applied to the late-planted strawberries for all three varieties. On the early-planted strawberries, the 2.1 FRC yields for Camarosa and Allstar were increased in the two early covering dates and nearly equal for the late-covered treatment when compared to the 1.2 FRC.

Differences in variety response to light and temperature are important factors that influence plant growth, flower initiation and subsequent fruit yields of plasticulture strawberries. Presently, Chandler and Camarosa are two important varieties for the annual strawberry cropping system in the mid-Atlantic, both of which were not bred the for mid-Atlantic region. This data presents evidence that crop management techniques such as planting date and temporal uses of FRC will need to be fine tuned for specific varieties. As local breeding efforts increase and new varieties are developed for the strawberry plasticulture system, management refinement will follow.

PROPAGATION METHOD FOR PRODUCING STRAWBERRY PLANTS FOR FALL CROPPING IN THE MID-ATLANTIC COAST REGION

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Interest in out-of-season strawberry production systems is increasing in the mid-Atlantic coast region. Specifically, the interest is in meeting the market demand for locally produced fresh strawberries from September to December. During this period strawberries are not readily available and can demand a high price. By generating conditioned strawberry plants that are ready to produce fruit shorting after planting and combining plasticulture, floating rowcover, and micro-sprinklers and high tunnels for frost protection the harvest season can potentially extended well into late December. The emphasis on 'short-term' cropping system permits growers to produce a variety of fruit and vegetable crops for their niche market. Income from fall and spring strawberry production (double cropping) can raise farm profitability.

The plant type is a concern for extending harvest season of strawberries into late autumn period. Historically, dormant or frigo plants that have been cold stored at ~1.5 °C for six to eight months have been used for perennial, matted-row culture systems. In the last 20 years, fresh dug Canadian plants have become available. Each of these transplant types has presented problems for the mid-Atlantic coast growers using the annual plasticulture system. The cold-stored plants have started flower-bud initiation under the declining daylengths of autumn, before being placed into cold storage and stored for about six to eight months. These plants often show low vigor and do not transplant well. It has been shown that the yield potential of such plants declines during the storage period. The costs of long-term cold storage makes these plants expensive and fresh-dug plants need daily overhead irrigation for 1 to 2 weeks after planting for successful establishment. Also, they are not available until the third week of September, past the best planting dates for our region. Another option is to double crop day-neutral strawberry cultivars for "spring" and "fall" crops. In this system plants are carried over through the hot summer months and fall fruit quality is not high.

Fernandez and Ballington (2003) produced only a moderate crop (175 g/plant) in the fall with 'conditioned' "Sweet Charlie" plants in the coastal region of North Carolina. We have evaluated several types of planting material for extended-season cropping under protected culture. In one greenhouse system, runner tips were harvested over several months from tissue culture-produced mother-plants growing in suspended gutters and plugged into small volume containers to produce "plug" plants. We observed that the time of runner tip harvest and how they were handled before plugging influenced their performance in the field. For example, "Chandler" strawberry transplants prepared in early July flowered in October at Wye, MD, but not those plugged in August. Our objectives for this study were to evaluate the runner-tip production capacity of tissue-culture derived "Carmine" strawberry plants in soilless greenhouse system and the effects of tip harvest time on subsequent field performance.

Materials and Methods

Plant material. Strawberry cultivar ('Carmine') was used in this experiment. "Carmine" strawberry is a 2002 release from the University of Florida strawberry breeding program. It tends to produce fruit earlier than "Sweet Charlie".

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Plant production and greenhouse culture system. Tissue culture plantlets maintained at the University of Maryland, College, Park, were the source stock for plant material used in this experiment. After several subcultures of explants on Stage II strawberry proliferation media and crowns were divided and planted into 48-cell packs containing a peat-perlite growing medium. Plantlets were grown under intermittent mist sprinklers until they developed a cohesive root ball that could be removed intact from the cell pack. Plants with fully developed root systems were established in early May in nutrient film technique culture. The greenhouse was maintained at 23 °C day and 18 °C night temperatures and photoperiod was extended to 16-h using 1,000-W high pressure sodium lamps.

Runner tip and plug production. Stolons were harvested in June, July, and August. Daughter (runner tips) plants were sorted into two size classes (large-tip daughter plants weighing ~ 3.0 g and small-tip daughter plants weighing 0.9 g), stuck in 48-cell packs and placed under intermittent mist sprinklers until a cohesive root system was formed. After that, transplants were irrigated as needed until 31 August.

Field evaluation of plug plants. On 1 September, the plug plants were established in a plasticulture field at Wye, Md. after the methods described by Poling (1993). Ten plant plots were randomized in a complete block design with four replications for each cultivar/treatment. On 3 November, runner and branch crown numbers were recorded for each plant. Runners were removed by hand at the conclusion of each count. Also, each plant was rated for reproductive development. The most advanced reproductive unit (flower bud or fruit, if present) was rated on a scale of 1 to 5 (0 = no visible flower bud, 1 = a flower bud at pre-bloom, 2 = a flower at full bloom, 3 = a flower at petal fall, 4 = a green fruit, and 5 = a red fruit). On 18 November, all visible reproductive structures were detached from each plant and counted and the weight of the largest fruit was determined.

Results

Runner tips were collected from "Carmine" mother-plants starting in mid June and ending in early August. The average number of stolons harvested from each mother-plant growing in the gutter production system was 25 in June, 7 in July, and 44 in August for a total of 77 per plant. Since many of these stolons had two or three daughter plants ranging in size from less than 1.0 g to more than 6.0 g, as many as 150 daughter plants were produced for propagation. Of large tips plugged in July and August, more than 92% of runner tips formed cohesively rooted, field-transplantable plants after three weeks on the propagation bench, but 72 to 78% of small runner tips harvested in July and August formed enough roots in 3 weeks on the propagation bench.

By November, July-plugged plants had increased their branch crown number to three. Among August-plugged daughter plants, crown number averaged just over two branch crowns for large-tip plants and only 1.6 branch crowns for small-tip plants. Runner production in the field was negligible in all plants. Fall reproductive development was influenced by runner-tip harvest date and daughter plant size. Among August-plugged "Carmine" plants, reproductive structures had not emerged in transplants generated from small tips and only 35% of large transplants had produced a flower bud or fruit. In contrast, flowers and fruit were present on 80% or more of "Carmine" transplants that were propagated in July. Among those plants that developed inflorescence structures, none was rated at "tight bud" stage on 1 November. This suggested that no new inflorescences had emerged during the second –half of October.

Each of the July-plugged plant possessed between 8 and 10 flowers and fruit (rating of 2 to 5) in November. Half of July-propagated plants had green and red fruit by that time. Some of the ripe fruit weighed 34 g. This suggested that these plants had the potential to produce a significant crop (>200 g/plant) before Christmas.

Discussion

The strawberry production season in the mid-Atlantic coast region is rather short (less than 2 months from early May to late June). New techniques to extend the production period could increase fruit production and income and lessen the risk of weather related crop loss. Fresh strawberries produced in the region during September-November months sell 3-4 times higher than the fruit harvested during the main spring season (B. Butler, Univ. of MD, personal communication). Other researchers have relied on post-plug 'conditioning' treatments such as exposure to low temperatures and short-day photoperiod) to force transplants to flowers shortly after establishment in out-of-season production system. These treatments involve labor intensive daily movement of transplants in-and-out of cold rooms or dark rooms or the drawing of a black drop cloth over the plants for up to 3 weeks. We have developed a simple protocol to generate enough transplant material in a greenhouse runner-tip production system, induce these transplants of short-day strawberry cultivars ("Carmine" and "Chandler") to develop branch crowns and multiple flower buds shortly after field establishment in early September, and produce ripe fruit by late October under field conditions. When this transplant production technique is combined with protective tunnel culture, the potential for producing fresh strawberries from October to December in the mid-Atlantic coast region is significantly enhanced.

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Plant Pathology

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*
Rots (Alternaria sp. *Phomopsis* and unidentified)
Bitter rot; *Colletotrichum* sp.
White rot; *Botryosphaeria dothidea*
Brown rot; *Monilinia* sp.

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EVALUATION OF FUNGICIDE SCHEDULES AND MIXTURES FOR BROAD SPECTRUM DISEASE MANAGEMENT ON STAYMAN, IDARED, AND GRANNY SMITH APPLES, 2004.

Ten treatments directed mostly at fungicide resistance management approaches and broad spectrum control, including the experimental fungicides Scala and Pristine (a package mix of pyraclostrobin and boscalid) were tested on 18-yr-old trees. The test was conducted in a randomized block design with four three-cultivar replicate tree sets separated by untreated border rows. Treatment rows had been used as non-treated border rows in 2003 to stabilize mildew inoculum pressure for 2004. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Treatments were applied to both sides of the trees on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 7 Apr (TC, tight cluster); 16 Apr (Idared OC, open cluster; Stayman & G. Smith, TC); 22 Apr (Bl, full bloom). 1st- 7th covers, 1C-7C: 4 May, 18 May, 2 Jun, 15 Jun, 29 Jun, 16 Jul, 19 Aug. Maintenance materials, applied separately to the entire test block with the same equipment, included Ambush 2E, Lannate LV, NAA + Sevin XLR, Pyramite, Provado, and Imidan 70WSB. Cedar rust galls were placed over each Idared test tree 9 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies were placed over each Idared test tree 26 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of scab on ten cluster leaf sets from each of four replicates 7 Jun (Stayman); 8 Jun (Idared); 14 Jun (Granny Smith) or ten terminal shoots per tree 7 Jul (Stayman); 13 Jul (Idared); 28 Jul (Granny Smith). A 25-fruit sample was taken from Stayman trees 29 Sep and rated after harvest and again after 14 and 35 days at 21 C. Idared trees were sampled 21 Sept and rated after storage at 1C 38 days; Granny Smith sampled 30 Sept and rated after storage at 1C 29 days. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Weather was favorable for development of all the major diseases in 2004, and presented a strong test for scab and summer diseases. Scab pressure was at its highest in more than 28 years. The first application was made four days after an 83-hr infection period. The strobilurin Flint performed better than the sterol-inhibiting (SI) fungicide Nova as a mixing partner with mancozeb for scab control (Trt. #1 vs. #7). This may be relevant considering that in 2004 resistance to the SI fungicides has been found in the scab fungus for the first time in the Winchester area. Rubigan + Dithane gave better control of fruit scab than Nova + Dithane on Stayman and Idared. Alternating Scala (pyrimethanil) with Flint gave good scab and mildew control. In general, including non-SI chemistry (Scala, Flint or Pristine) with after-infection control in the early season schedule, improved scab control. Cumulative wetting throughout the mid-season and heavy rains before harvest in September contributed to heavy summer disease pressure. Brooks spot was adequately controlled by Flint and Pristine and those treatments which included full rates (6 lb/A) of captan + ziram. Because of the heavy rains in September following the last application, many treated fruit were infected with sooty blotch and flyspeck and comparative control might be more recognized by percent area affected. Pristine gave superior control of flyspeck; Topsin M treatments rank highest numerically for sooty blotch suppression. Pristine, applied in the 5th to 7th covers, gave the greatest rot suppression through the 35-day postharvest incubation period, with good activity on bitter, white, and Alternaria rots. No treatment had a deleterious effect on fruit finish of any cultivar. Treatment #4 significantly reduced russetting and treatments #2-5 & 6 significantly reduced opalescence of Stayman. Treatments #2-6 &10 significantly reduced russetting, and all treatments except #9 significantly reduced opalescence of Idared. Treatments #1-8 significantly reduced opalescence of Granny Smith.

Table 1. Scab and Brooks spot control by experimental and registered fungicides on Stayman, Idared and Granny Smith apples, 2004

		Scab, % flower cluster or shoot leaves infected									Brooks spot, % fruit		
		Stayman			Idared			Granny Smith					
	Treatment and rate/A; timing	cluster	shoot	fruit	cluster	shoot	fruit	cluster	shoot	fruit	Stayman	Idared	Granny Smith
0	No fungicide	53 g	77 e	84 e	43 e	59 d	78 d	55 g	89 d	83 e	23 d	46 e	16 b
1	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	11 ef	38 d	15 cd	9 d	12 c	6 bc	10 ef	31 c	16 b-d	10 bc	8 cd	0 a
2	Rubigan 1E 9 fl oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	6 de	28 cd	2 ab	5 bc	5 ab	1 ab	5 c-e	24 bc	12 b-d	11 cd	12 d	0 a
3	Flint 50WG 2 oz; TC, 1C Procure 50WS 10 oz + Captan 50W 3 lb; OC-Bl Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	2 bc	14 ab	0 a	3 b	2 a	0 a	1 ab	14 ab	4 ab	1 a	3 ab	0 a
4	Pristine 38WDG 14.5 oz; TC, 1C Procure 50WS 10 oz + Dithane 75DF 3 lb; OC-Bl Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	4 cd	24 b-d	3 ab	3 bc	4 ab	1 ab	2 bc	15 ab	2 a	2 a	0 a	0 a
5	Scala 60SC 10 fl oz; TC-OC Flint 50WG 2 oz; Bl-1C, 5C-7C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	1 ab	11 a	1 ab	0 a	2 a	0 a	<1 a	11 a	3 a	1 a	6 b-d	1 a
6	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-Bl Captan 50W 3 lb + Ziram 76DF 3 lb; 1C-4C Flint 50WG 2 oz; 5C-7C	13 f	33 d	9 b-d	10 d	9 bc	16 c	12 f	26 c	15 cd	1 a	5 b-d	0 a
7	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-OC Flint 50WG 2 oz + Dithane 75DF 3 lb; Bl-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C Flint 50WG 2 oz + Captan 50W 3 lb; 5C-7C	0 a	16 a-c	0 a	<1 a	4 ab	1 ab	2 a-c	10 a	2 a	0 a	4 a-d	0 a
8	Pristine 38WDG 14.5 oz; TC-OC, 5C-7C Nova 40W 4 oz + Dithane 75DF 3 lb; Bl-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	5 de	28 cd	4 a-c	2 b	4 a	6 c	4 cd	20 a-c	6 a-c	3 ab	4 a-c	0 a
9	Penncozeb 75DF 3.0 lb + Microthiol Disperss 80DF 3 lb; TC-3C Topsin M 4.5F 12.4 fl oz; 4C-7C	9 d-f	37 d	18 d	7 cd	9 bc	11 c	8 d-f	22 bc	22 d	0 a	1 ab	0 a
10	TD 2409-06 4F 2.25 qt + Microthiol Disperss 80DF 3 lb; TC-3C Topsin M 4.5F 12.4 fl oz; 4C-7C	9 d-f	40 d	17 cd	7 cd	12 c	15 c	11 f	32 c	20 d	1 a	3 a-c	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05); four single-tree replications. Counts based on ten flower cluster leaf sets per rep 7 Jun (Stayman); 8 Jun (Idared); 14 Jun (Granny Smith) or ten terminal shoots per tree 7 Jul (Stayman); 13 Jul (Idared); 28 Jul (Granny Smith) and postharvest fruit counts. Treatments were applied to both sides of the tree on each indicated date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. as follows: 7 Apr (TC, tight cluster) 16 Apr (Idared OC, open cluster; Stayman & G. Smith, TC); 22 Apr (Bl, full bloom). 1st- 7th covers, 1C-7C: 4 May, 18 May, 2 Jun, 15 Jun, 29 Jun, 16 Jul, 19 Aug.

Table 2. Mildew and rust control by experimental and registered fungicides on Stayman, Idared and Granny Smith, 2004.

		Mildew, % leaves, leaf area, or fruit infected									c-a rust, % lvs inf.
		Stayman			Idared			Granny Smith			
	Treatment and rate/A; timing	% lvs	lf. area	fruit	% lvs	lf. area	fruit	% lvs	lf. area	fruit	Idared
0	No fungicide	46 e	26 b	17 b	57 e	42 b	46 c	52 e	52 d	39 d	6 e
1	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	23 a-d	3 a	0 a	17 ab	3 a	1 a	19 ab	4 ab	0 a	0 a
2	Rubigan 1E 9 fl oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	20 a-c	3 a	0 a	18 a-c	3 a	9 b	25 b-d	5 bc	2 a	2 d
3	Flint 50WG 2 oz; TC, 1C Procure 50WS 10 oz + Captan 50W 3 lb; OC-BI Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	19 ab	3 a	0 a	16 a	2 a	1 a	24 b-d	4 ab	1 a	<1 ab
4	Pristine 38WDG 14.5 oz; TC, 1C Procure 50WS 10 oz + Dithane 75DF 3 lb; OC-BI Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	23 a-d	3 a	0 a	22 a-d	3 a	1 a	25 b-d	4 ab	1 a	2 cd
5	Scala 60SC 10 fl oz; TC-OC Flint 50WG 2 oz; BI-1C, 5C-7C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	17 a	2 a	1 a	24 a-d	3 a	7 b	24 b-d	4 bc	6 b	<1 b-d
6	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-BI Captan 50W 3 lb + Ziram 76DF 3 lb; 1C-4C Flint 50WG 2 oz; 5C-7C	25 b-d	3 a	0 a	25 b-d	3 a	1 a	27 cd	5 bc	0 a	2 cd
7	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-OC Flint 50WG 2 oz + Dithane 75DF 3 lb; BI-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C Flint 50WG 2 oz + Captan 50W 3 lb; 5C-7C	20 ab	3 a	1 a	18 a-c	2 a	7 b	22 bc	4 ab	0 a	2 cd
8	Pristine 38WDG 14.5 oz; TC-OC, 5C-7C Nova 40W 4 oz + Dithane 75DF 3 lb; BI-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	20 a-c	3 a	0 a	18 a-c	3 a	3 ab	15 a	3 a	2 a	1 bc
9	Penncozeb 75DF 3.0 lb + Microthiol Disperss 80DF 3 lb; TC-3C Topsin M 4.5F 12.4 fl oz; 4C-7C	28 d	4 a	2 a	27 cd	4 a	12 b	30 d	7 c	16 c	2 cd
10	TD 2409-06 4F 2.25 qt + Microthiol Disperss 80DF 3 lb; TC-3C Topsin M 4.5F 12.4 fl oz; 4C-7C	27 cd	4 a	3 a	30 d	4 a	5 ab	32 d	6 bc	11 c	<1 b-d

Mean separation by Waller-Duncan K-ratio t-test (p=0.05); four single-tree replications.
Counts based on ten terminal shoots per rep 7 Jul (Stayman); 13 Jul (Idared); 28 Jul (Granny Smith) or 25 fruit per rep after harvest.
Fungicide application dates: treatments were applied to both sides of the tree on each indicated date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. as follows: 7 Apr (TC, tight cluster) 16 Apr (Idared OC, open cluster; Stayman & G. Smith, TC); 22 Apr (BI, full bloom). 1st- 7th covers, 1C-7C: 4 May, 18 May, 2 Jun, 15 Jun, 29 Jun, 16 Jul, 19 Aug.

Table 3. Evaluation of sooty blotch and flyspeck control on Stayman, Idared and Granny Smith apples, 2004.

		Sooty blotch, % fruit or % fruit area infected						Flyspeck, % fruit or fruit area infected					
		Stayman		Idared		Granny Smith		Stayman		Idared		Granny Smith	
	Treatment and rate/A	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0	No fungicide	100 a	29 b	100 c	31 c	100 b	23 b	100 f	13 h	100 e	20 g	100 c	22 d
1	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	91 a	11 a	81 a-c	14 b	68 ab	5 a	97 ef	9 e	96 de	11 f	98 c	11 c
2	Rubigan 1E 9 fl oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	84 a	9 a	85 a-c	9 ab	70 ab	6 a	97 ef	10 ef	95 de	10 ef	100 c	13 c
3	Flint 50WG 2 oz; TC, 1C Procure 50WS 10 oz + Captan 50W 3 lb; OC-BI Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	96 a	12 a	86 a-c	9 ab	74 ab	6 a	99 f	12 gh	95 de	10 ef	90 c	10 c
4	Pristine 38WDG 14.5 oz; TC, 1C Procure 50WS 10 oz + Dithane 75DF 3 lb; OC-BI Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	86 a	6 a	56 a	3 a	57 a	4 a	97 f	12 fg	86 cd	6 cd	94 c	9 c
5	Scala 60SC 10 fl oz; TC-OC Flint 50WG 2 oz; BI-1C, 5C-7C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	86 a	9 a	89 a-c	10 ab	49 a	5 a	68 bc	4 bc	46 b	2 b	66 b	4 b
6	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-BI Captan 50W 3 lb + Ziram 76DF 3 lb; 1C-4C Flint 50WG 2 oz; 5C-7C	91 a	12 a	96 bc	11 b	63 a	5 a	79 cd	5 c	43 b	2 b	63 b	4 b
7	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-OC Flint 50WG 2 oz + Dithane 75DF 3 lb; BI-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C Flint 50WG 2 oz + Captan 50W 3 lb; 5C-7C	72 a	10 a	79 a-c	11 ab	61 a	8 a	56 b	3 b	44 b	2 b	61 b	4 b
8	Pristine 38WDG 14.5 oz; TC-OC, 5C-7C Nova 40W 4 oz + Dithane 75DF 3 lb; BI-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	72 a	8 a	66 ab	6 ab	58 a	5 a	21 a	1 a	19 a	1 a	16 a	1 a
9	Penncozeb 75DF 3.0 lb + Microthiol Disperss 80DF 3 lb; TC-3C Topsin M 4.5F 12.4 fl oz; 4C-7C	71 a	6 a	49 a	6 ab	43 a	4 a	88 de	8 de	85 cd	8 de	89 bc	9 c
10	TD 2409-06 4F 2.25 qt + Microthiol Disperss 80DF 3 lb; TC-3C Topsin M 4.5F 12.4 fl oz; 4C-7C	73 a	7 a	48 a	4 a	41 a	3 a	76 b-d	6 cd	65 c	5 c	64 b	5 b

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit samples from each of four single-tree replications.

Fungicide application dates: treatments were applied to both sides of the tree on each indicated date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. as follows: 7 Apr (TC, tight cluster) 16 Apr (Idared OC, open cluster; Stayman & G. Smith, TC); 22 Apr (BI, full bloom). 1st-7th covers, 1C-7C: 4 May, 18 May, 2 Jun, 15 Jun, 29 Jun, 16 Jul, 19 Aug.

Stayman trees sampled 29 Sep and rated at harvest; Idared trees were sampled 21 Sept and rated after storage at 1C 38 days; Granny Smith sampled 30 Sept and rated after storage at 1C 29 days.

Table 4. Post harvest rot counts on fruit treated with experimental fungicides, Stayman apple, 2004.

	Fruit disease, % fruit rotted, after indicated *days* incubation												
	% any rot			Bitter rot			Bot rot		Alternaria		Brown rot		Phomopsis
Treatment rate/A and timing	*1*	*14*	*35*	*1*	*14*	*35*	*14*	*35*	*14*	*35*	*14*	*35*	*35 days*
0 No fungicide	15 b	41 e	88 d	8 c	25 e	45 d	12 b	33 c	4 b	11 c	13 b	15 b	14 b
Nova 40W 4 oz + Dithane 75DF 3 lb; TC-1C 1 Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	0 a	11 a-d	27 ab	0 a	2 ab	6 a	5 ab	10 ab	1 a	5 bc	1 a	1 a	5 ab
Rubigan 1E 9 fl oz + Dithane 75DF 3 lb; TC-1C 2 Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	1 a	9 a-c	31 ab	0 a	2 ab	12 a-c	3 ab	8 a	1 a	2 ab	2 a	3 a	6 ab
Flint 50WG 2 oz; TC, 1C Procure 50WS 10 oz + Captan 50W 3 lb; OC-BI 3 Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	1 a	7 ab	39 bc	1 ab	4 ab	21 bc	3 ab	14 ab	0 a	2 ab	0 a	0 a	4 ab
Pristine 38WDG 14.5 oz; TC, 1C Procure 50WS 10 oz + Dithane 75DF 3 lb; OC-BI 4 Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-7C	2 a	8 a-c	33 a-c	0 a	4 bc	15 a-c	1 ab	11 ab	0 a	0 a	3 a	3 a	3 ab
Scala 60SC 10 fl oz; TC-OC Flint 50WG 2 oz; BI-1C, 5C-7C 5 Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	0 a	7 a	31 ab	0 a	4 ab	19 a-c	3 ab	10 ab	0 a	1 a	0 a	0 a	2 a
Nova 40W 4 oz + Dithane 75DF 3 lb; TC-BI Captan 50W 3 lb + Ziram 76DF 3 lb; 1C-4C 6 Flint 50WG 2 oz; 5C-7C	1 a	16 b-d	37 a-c	0 a	10 cd	12 a-c	3 ab	19 bc	1 a	1 a	1 a	2 a	5 ab
Nova 40W 4 oz + Dithane 75DF 3 lb; TC-OC Flint 50WG 2 oz + Dithane 75DF 3 lb; BI-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C 7 Flint 50WG 2 oz + Captan 50W 3 lb; 5C-7C	0 a	8 ab	26 ab	0 a	3 ab	12 ab	4 ab	8 ab	1 a	2 ab	1 a	1 a	4 ab
Pristine 38WDG 14.5 oz; TC-OC, 5C-7C Nova 40W 4 oz + Dithane 75DF 3 lb; BI-1C 8 Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C	1 a	4 a	19 a	0 a	1 a	7 ab	0 a	5 a	0 a	0 a	3 a	4 a	2 a
Penncozeb 75DF 3.0 lb + Microthiol Disperss 80DF 3 lb; TC-3C 9 Topsin M 4.5F 12.4 fl oz; 4C-7C	4 a	19 cd	51 c	3 b	14 de	31 cd	4 ab	16 a-c	1 a	2 ab	1 a	1 a	6 ab
TD 2409-06 4F 2.25 qt + Microthiol Disperss 80DF 3 lb; TC-3C 10 Topsin M 4.5F 12.4 fl oz; 4C-7C	1 a	21 d	52 c	0 a	13 d	25 cd	5 ab	22 bc	0 a	1 a	1 a	1 a	7 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit samples from each of four single-tree replications.

Fungicide application dates: treatments were applied to both sides of the tree on each indicated date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. as follows: 7 Apr (TC, tight cluster) 16 Apr (Idared OC, open cluster; Stayman & G. Smith, TC); 22 Apr (BI, full bloom). 1st-7th covers, 1C-7C: 4 May, 18 May, 2 Jun, 15 Jun, 29 Jun, 16 Jul, 19 Aug.

Stayman trees sampled 29 Sep and rated at harvest and again after 14 and 35 days storage at 21 C.

APPLE (*Malus domestica* 'Golden Delicious', 'Red Delicious', and 'Rome Beauty')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust, *Gymnosporangium juniperi- virginianae*
Quince rust, *Gymnosporangium clavipes*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Rots (unidentified)
Fruit finish

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EVALUATION OF EXPERIMENTAL FUNGICIDES ON THREE APPLE CULTIVARS, 2004

Nine treatments involving selected rates and mixed schedules of two experimental fungicides, Difenoconazole and Tanos (a mixture of famoxadone and cymoxanil) were tested for season-long fungal disease control and fruit finish effects on three apple cultivars. Treatments were evaluated on 15-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 2003 to allow buildup of powdery mildew inoculum. The dilute treatments were applied to the point of runoff with a single nozzle handgun at 450 psi as follows: 8 Apr, all treatments (Red Delicious TC, tight cluster- early open cluster; Golden Del. TC ; Rome ½-in. G); 16 Apr, Trts #1-6, 8 & 9; Trt. 7 omitted for after-infection (Red. Del. OC-early pink; G. Del. and Rome TC-OC); 23 Apr, all treatments (R. Del. and G. Del. PF, petal fall; Rome 60% bloom). First-third covers (1C-6C) 6 May, 21 May, 4 Jun, 18 Jun, 1 Jul and 16 Jul. Maintenance sprays, applied separately with a commercial airblast sprayer, included Supracide 25W + oil BacMaster, Ethrel + Sevin XLR, Imidan 70 WSB, Lannate LV, Intrepid, and Provado. Cedar rust galls were placed over each Idared test tree 21 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi and bitter rot mummies were placed over each Golden Delicious test tree 25 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of scab on ten cluster leaf sets from each of four replicates 1 Jun (Red and golden Delicious); or ten terminal shoots per tree 15 Jun (Rome); and 24 June (Golden Delicious). Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 20 Sep (Red and Golden Delicious), or 24 Sep (Rome) and placed in cold storage at 1C. Red Delicious was rated after 29 days cold storage; Golden Delicious after 24 days cold storage and Rome after 31 days cold storage. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Scab pressure was at its highest in more than 28 years. The first application was made five days after an 83-hr infection period. Heavy scab infection occurred on non-treated leaves and fruit. The three Rubigan + Dithane treatments (#1, 8, & 9) had significantly more shoot leaves infected and were among the weakest for fruit scab on Red Delicious and Rome. Tank-mix treatments of Vangard + Difenoconazole (Trts. 4 & 5) gave significantly better fruit scab control on one or more cultivars than Difenoconazole alone at the same rates (Trts. 3 & 2). The higher rate of Difenoconazole gave better control than the lower rate whether alone or in combination with Vangard. Treatment #7 was intended to be limited to post-infection use in early season applications, but because of the frequent scab infection periods, there was only one opportunity to make this application comparison. Although there was little difference in control by the comparative treatments 6 &7 on leaves, there was a significant difference in resulting scab on Red Delicious and Golden Delicious fruit. All treatments gave significant suppression of mildew. Difenoconazole gave numerically better mildew control at the higher rate on leaves and fruit. The higher rate of Difenoconazole gave significantly better control of cedar apple rust which resulted from numerous infections periods, as late as the early cover sprays; Rubigan + Dithane treatments were significantly weaker. All treatments adequately controlled quince rust. Although applied only through third cover, Difenoconazole showed indications of sooty blotch and flyspeck control, especially at the higher rate (Trt. 3 vs. 2 and 4 vs. 5). Vangard, tank-mixed with Difenoconazole in the early cover sprays, appeared to improve control of Brooks spot on Golden Delicious compared to Difenoconazole alone. Suppression of sooty blotch and flyspeck was comparable with Tanos 2 oz and Captan 1.5 lb; tank-mixing Tanos + captan significantly improved sooty blotch and flyspeck suppression. Rot spot and rot incidence were erratic, likely due to heavy late season rains. In a year in which Golden Delicious fruit finish was rather poor, several Difenoconazole-related treatments apparently caused a significant increase in the russet ratings. Fruit finish of Red Delicious and Rome was not significantly affected by any treatment.

Table 5. Scab control on Red Delicious, Golden Delicious and Rome apples, 2004

			Scab, % spur or shoot leaves or % fruit infected							Brooks spot, % fruit infected	
			spur leaves		shoot leaves		fruit				
	Treatment and rate per 100 gal dilute	Timing	R. Del.	G. Del.	G. Del.	Rome	R. Del.	G. Del.	Rome	G. Del.	Rome
0	No fungicide	---	51 c	56 c	45 e	39 d	99 f	50 d	83 c	25 f	9 b
1	Rubigan 1E 2.25 fl oz + Dithane RSNT 75DF 12 oz Captan 50W 1.5 lb	TC-3C 4C–6C	5 b	6 ab	13 cd	24 c	28 c-e	5 a-c	23 b	8 de	0 a
2	Vangard 75WG 1.25 oz .... Difenoconazole 2.09EC 20.2 ml .... Captan 50W 1.5 lb	TC, OC PF-3C 4C–6C	6 b	8 b	8 a-c	8 ab	31 de	9 c	14 b	12 e	1 a
3	Vangard 75WG 1.25 oz .... Difenoconazole 2.09EC 29.5 ml .... Captan 50W 1.5 lb	TC, OC PF-3C 4C–6C	2 a	3 a	3 a	11 b	15 bc	0 a	9 ab	6 de	0 a
4	Vangard 75WG 1.25 oz .... Vangard 75WG 1 oz + Difenoconazole 29.5 ml Captan 50W 1.5 lb	TC, OC PF-3C 4C–6C	5 b	5 ab	5 a-c	8 ab	6 a	0 a	4 a	0 a	0 a
5	Vangard 75WG 1.25 oz .... Vangard 75WG 1 oz + Difenoconazole 20.2 ml Captan 50W 1.5 lb	TC, OC PF-3C 4C–6C	1 a	4 ab	7 a-c	12 b	17 bc	0 a	8 ab	2 a-c	0 a
6	Vangard 75WG 1.25 oz .... Difenoconazole 2.09EC 29.5 ml .... Flint 50WG 0.5 oz .... Captan 50W 1.5 lb	TC, OC PF-1C 2C–3C 4C–6C	4 ab	3 a	4 ab	3 a	11 ab	1 ab	6 ab	0 a	0 a
7	Vangard 75WG 1.25 oz *(Post inf. omit 2nd app.)* .... Difenoconazole 2.09EC 29.5 ml .... Flint 50WG 0.5 oz .... Captan 50W 1.5 lb	TC PF-1C 2C–3C 4C–6C	3 ab	6 ab	4 ab	3 a	22 cd	7 c	8 ab	1 ab	1 a
8	Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz .... Tanos 50WG 2 oz + Captan 50W 12 oz .... Captan 50W 1.5 lb	TC-1C 2, 4, 6C 3C, 5C	5 b	5 ab	17 d	23 c	37 de	9 c	21 b	4 cd	0 a
9	Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz .... Tanos 50WG 2 oz	TC-1C 2C- 6C	6 b	6 ab	9 b-d	21 c	41 e	4 bc	7 ab	4 b-d	0 a

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

Counts of ten cluster leaf sets from each tree 1 June, ten terminal shoots 15 June (Rome) and 24 June (Golden Del.), or harvest fruit counts.

Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 450 psi as follows: 8 Apr, all treatments (Red Delicious TC, tight cluster- early open cluster; Golden Del. TC ; Rome ½-in. G); 16 Apr, Trts #1-6, 8 & 9; Trt. 7 omitted for after-infection (Red Del. OC-early pink; G. Del. and Rome TC-OC); 23 Apr, all treatments (R. Del. and G. Del. PF, petal fall; Rome 60% bloom). First-third covers (1C-6C) 6 May, 21 May, 4 Jun, 18 Jun, 1 Jul and 16 Jul.

Table 6. Powdery mildew and rust control on Golden Delicious, Red Delicious and Rome Beauty apples, 2004

			Mildew, % leaves or leaf area inf.					Cedar-apple rust			Quince rust	
			G. Delicious		Rome			% leaves inf.		Rome	% fruit inf.	
	Treatment and rate per 100 gal dilute	Timing	lvs	lf. area	lvs	lf. area	fruit	G. Del.	Rome	% fruit	R. Del.	Rome
0	No fungicide	—	42 c	9 b	56 c	22 b	38 b	22 d	29 e	4 b	8 b	5 a
1	Rubigan 1E 2.25 fl oz + Dithane RSNT 75DF 12 oz	TC-3C	20 ab	3 a	38 ab	4 a	5 a	3 c	6 d	2 ab	1 a	4 a
	Captan 50W 1.5 lb	4C–6C										
2	Vangard 75WG 1.25 oz	TC, OC	24 ab	3 a	40 b	5 a	12 ab	1 ab	4 b-d	0 a	0 a	2 a
	Difenoconazole 2.09EC 20.2 ml	PF-3C										
	Captan 50W 1.5 lb	4C–6C										
3	Vangard 75WG 1.25 oz	TC, OC	20 ab	3 a	30 ab	3 a	8 a	0 a	1 a	0 a	0 a	1 a
	Difenoconazole 2.09EC 29.5 ml	PF-3C										
	Captan 50W 1.5 lb	4C–6C										
4	Vangard 75WG 1.25 oz	TC, OC	23 ab	3 a	31 ab	4 a	4 a	<1 ab	3 a-c	0 a	0 a	0 a
	Vangard 75WG 1 oz + Difenoconazole 29.5 ml	PF-3C										
	Captan 50W 1.5 lb	4C–6C										
5	Vangard 75WG 1.25 oz	TC, OC	25 b	3 a	35 ab	4 a	10 ab	1 ab	5 b-d	0 a	0 a	1 a
	Vangard 75WG 1 oz + Difenoconazole 20.2 ml	PF-3C										
	Captan 50W 1.5 lb	4C–6C										
6	Vangard 75WG 1.25 oz	TC, OC	19 a	3 a	30 ab	4 a	12 ab	<1 ab	2 ab	0 a	0 a	0 a
	Difenoconazole 2.09EC 29.5 ml	PF-1C										
	Flint 50WG 0.5 oz	2C–3C										
	Captan 50W 1.5 lb	4C–6C										
7	Vangard 75WG 1.25 oz *(Post inf. omit 2nd app.)*	TC	21 ab	3 a	27 a	3 a	8 a	<1 ab	3 ab	0 a	0 a	0 a
	Difenoconazole 2.09EC 29.5 ml	PF-1C										
	Flint 50WG 0.5 oz	2C–3C										
	Captan 50W 1.5 lb	4C–6C										
8	Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz	TC-1C	25 ab	3 a	38 ab	4 a	8 a	<1 bc	6 cd	0 a	0 a	1 a
	Tanos 50WG 2 oz + Captan 50W 12 oz	2, 4, 6C										
	Captan 50W 1.5 lb	3C, 5C										
9	Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz	TC-1C	23 ab	3 a	39 b	4 a	11 a	1 bc	7 d	1 a	0 a	0 a
	Tanos 50WG 2 oz	2C- 6C										

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

Counts of ten ten terminal shoots 15 June (Rome) and 24 June (Golden Del.) or postharvest fruit counts..

Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 450 psi as follows: 8 Apr, all treatments (Red Delicious TC, tight cluster- early open cluster; Golden Del. TC ; Rome ½-in. G); 16 Apr, Trts #1-6, 8 & 9; Trt. 7 omitted for after-infection (Red Del. OC-early pink; G. Del. and Rome TC-OC); 23 Apr, all treatments (R. Del. and G. Del. PF, petal fall; Rome 60% bloom). First-third covers (1C-6C) 6 May, 21 May, 4 Jun, 18 Jun, 1 Jul and 16 Jul.

Table 7. Evaluation of sooty blotch and flyspeck control on Golden Delicious, Red Delicious and Rome Beauty apples, 2004

			Sooty blotch, % fruit or % fruit area infected						Flyspeck, % fruit or fruit area infected					
			Red Delicious		G. Delicious		Rome		Red Delicious		G. Delicious		Rome	
	Treatment and rate per 100 gal dilute	Timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0	No fungicide	---	100 e	12 d	100 f	16 e	100 d	12 e	100 e	16 g	100 d	16 f	100 e	18 e
1	Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz	TC-3C												
	Captan 50W 1.5 lb	4C–6C	42 cd	3 c	70 e	6 d	27 c	2 d	81 cd	8 f	96 cd	11 de	93 d	11 d
2	Vangard 75WG 1.25 oz	TC, OC												
	Difenoconazole 2.09EC 20.2 ml....................	PF-3C												
	Captan 50W 1.5 lb	4C–6C	30 b-d	2 bc	35 bc	3 bc	19 bc	1 cd	47 ab	3 bc	89 a-c	8 b-e	66 b	6 bc
3	Vangard 75WG 1.25 oz	TC, OC												
	Difenoconazole 2.09EC 29.5 ml....................	PF-3C												
	Captan 50W 1.5 lb	4C–6C	4 a	<1 a	18 ab	1 ab	0 a	0 a	27 a	2 a	68 a	5 ab	42 a	3 a
4	Vangard 75WG 1.25 oz	TC, OC												
	Vangard 1 oz + Difenoconazole 29.5 ml	PF-3C												
	Captan 50W 1.5 lb	4C–6C	6 a	<1 a	9 a	1 a	10 b	1 b	30 a	2 ab	77 ab	7 a-c	47 a	3 a
5	Vangard 75WG 1.25 oz	TC, OC												
	Vangard 1 oz + Difenoconazole 20.2 ml	PF-3C												
	Captan 50W 1.5 lb	4C–6C	28 b	2 bc	24 ab	2 ab	17 bc	1 b-d	54 bc	5 cd	75 a-c	7 a-c	73 bc	5 bc
6	Vangard 75WG 1.25 oz	TC, OC												
	Difenoconazole 2.09EC 29.5 ml....................	PF-1C												
	Flint 50WG 0.5 oz	2C–3C												
	Captan 50W 1.5 lb	4C–6C	25 bc	2 bc	32 bc	2 bc	9 b	1 bc	61 bc	5 d-f	92 b-d	8 c-e	81 c	7 c
7	Vangard 1.25 oz *(Post inf. omit 2nd app.)*	TC												
	Difenoconazole 2.09EC 29.5 ml....................	PF-1C												
	Flint 50WG 0.5 oz	2C–3C												
	Captan 50W 1.5 lb	4C–6C	33 b-d	2 c	47 cd	4 cd	21 bc	1 b-d	80 d	7 ef	95 cd	12 e	94 d	9 d
8	Rubigan 2.25 fl oz + Dithane 75DF 12 oz	TC-1C												
	Tanos 50WG 2 oz + Captan 50W 12 oz	2, 4, 6C												
	Captan 50W 1.5 lb	3C, 5C	22 b	1 b	36 bc	2 bc	15 bc	1 b-d	62 bc	5 cd	71 a	7 a-d	69 bc	6 bc
9	Rubigan 2.25 fl oz + Dithane 75DF 12 oz	TC-1C												
	Tanos 50WG 2 oz	2C- 6C	45 d	3 c	64 de	5 cd	27 c	2 d	74 cd	5 d-e	66 a	5 a	73 bc	5 b

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit samples from each of four single-tree replications.
Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 450 psi as follows: 8 Apr, all treatments (Red Delicious TC, tight cluster- early open cluster; Golden Del. TC ; Rome ½-in. G); 16 Apr, Trts #1-6, 8 & 9; Trt. 7 omitted for after-infection (Red Del. OC-early pink; G. Del. and Rome TC-OC); 23 Apr, all treatments (R. Del. and G. Del. PF, petal fall; Rome 60% bloom). First-third covers (1C-6C) 6 May, 21 May, 4 Jun, 18 Jun, 1 Jul and 16 Jul.

Table 8. Treatment effects on rot incidence and fruit finish of Red Delicious, Golden Delicious and Rome.

Treatment and rate per 100 gal dilute	Timing	% fruit with rot spots, G. Del.	Rome, % rot: any rot	Rome, % rot: bitter rot	Russet ratings or USDA grade *: Ratings (0-5) R. Del.	Ratings (0-5) Rome	Ratings (0-5) G. Del.	G. Del. % fancy/x-fcy	Opalescence rating (0-5) R. Del.	Opalescence rating (0-5) Rome
0 No fungicide	---	50 d	43 a	14 a	1.2 a	1.6 a	2.4 a	81 a	1.1 a	1.7 a
1 Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz	TC-3C									
Captan 50W 1.5 lb	4C–6C	19 bc	33 a	5 a	1.2 a	1.3 a	3.1 c	57 ab	1.3 a	1.3 a
2 Vangard 75WG 1.25 oz	TC, OC									
Difenoconazole 2.09EC 20.2 ml.............................	PF-3C				1.1 a	1.3 a	3.0 bc	61 ab	0.9 a	1.4 a
Captan 50W 1.5 lb	4C–6C	18 bc	26 a	5 a						
3 Vangard 75WG 1.25 oz	TC, OC									
Difenoconazole 2.09EC 29.5 ml.............................	PF-3C				1.3 a	1.5 a	3.0 bc	66 ab	1.1 a	1.6 a
Captan 50W 1.5 lb	4C–6C	10 ab	16 a	2 a						
Vangard 75WG 1.25 oz	TC, OC									
4 Vangard 75WG 1 oz + Difenoconazole 29.5 ml	PF-3C				1.1 a	1.3 a	2.8 a-c	56 ab	1.0 a	1.5 a
Captan 50W 1.5 lb	4C–6C	13 a-c	30 a	10 a						
5 Vangard 75WG 1.25 oz	TC, OC									
Vangard 75WG 1 oz + Difenoconazole 20.2 ml	PF-3C				1.3 a	1.2 a	2.7 a-c	58 ab	1.0 a	1.5 a
Captan 50W 1.5 lb	4C–6C	9 a-c	16 a	9 a						
6 Vangard 75WG 1.25 oz	TC, OC									
Difenoconazole 2.09EC 29.5 ml.............................	PF-1C									
Flint 50WG 0.5 oz	2C–3C				1.1 a	1.4 a	2.8 a-c	57 ab	0.9 a	1.4 a
Captan 50W 1.5 lb	4C–6C	7 a	25 a	6 a						
Vangard 75WG 1.25 oz *(Post inf. omit 2nd app.)*	TC									
7 Difenoconazole 2.09EC 29.5 ml.............................	PF-1C									
Flint 50WG 0.5 oz	2C–3C				1.3 a	1.3 a	3.0 c	46 b	0.9 a	1.4 a
Captan 50W 1.5 lb	4C–6C	21 c	16 a	6 a						
Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz	TC-1C									
8 Tanos 50WG 2 oz + Captan 50W 12 oz	2, 4, 6C				1.0 a	1.4 a	2.8 a-c	64 ab	0.8 a	1.5 a
Captan 50W 1.5 lb	3C, 5C	18 bc	25 a	9 a						
9 Rubigan 1E 2.25 fl oz + Dithane 75DF 12 oz	TC-1C									
Tanos 50WG 2 oz	2C- 6C	21 c	36 a	7 a	1.0 a	1.3 a	2.5 ab	68 ab	0.8 a	1.5 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications. Dilute treatments applied to the point of runoff with a single nozzle handgun at 450 psi as follows: 8 Apr, all treatments (Red Delicious TC, tight cluster- early open cluster; Golden Del. TC ; Rome ½-in. G); 16 Apr, Trts #1-6, 8 & 9; Trt. 7 omitted for after-infection (Red Del. OC-early pink; G. Del. and Rome TC-OC); 23 Apr, all treatments (R. Del. and G. Del. PF, petal fall; Rome 60% bloom). First-third covers (1C-6C) 6 May, 21 May, 4 Jun, 18 Jun, 1 Jul and 16 Jul.

Fruit counts are means of 25-fruit samples picked 20 Sep (Red and Golden Delicious), or 24 Sep (Rome) and placed in cold storage at 1C. Red Delicious was rated after 29 days cold storage; Golden Delicious after 24 days cold storage and Rome after 31 days' cold storage.

* Russet rated on a scale of 0-5 (0=perfect finish; 5=severe russet). USDA Extra fancy and fancy grades after down-grading by russet.

APPLE (*Malus domestica* 'Red Delicious')
Scab; *Venturia inaequalis*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Rots (unidentified)
Fruit finish

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SUMMER DISEASE CONTROL BY DIFENOCONAZOLE ON RED DELICIOUS APPPLE, 2004.

Eight treatments involving Difenoconazole and alternating schedules with registered fungicides were tested for summer disease control and fruit finish effects on 19-yr-old Redchief Red Delicious / MM 106 trees in a four-replicate randomized block design. Early season scab infection was suppressed by Nova 2 oz + Syllit 8 oz /100 gal applied to the entire test block 7 Apr, 15 Apr, and 23 Apr. After a 3-wk break in fungicide protection, the test treatment series was initiated. Treatments were applied to the point of runoff with a single nozzle handgun at 350 psi as first through sixth cover sprays 12 May, 26 May, 9 June, 23 June, 8 July and 30 July. Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each test tree25 May. Maintenance sprays, applied separately with a commercial airblast sprayer, included Supracide 25W + oil, Ethrel + Sevin XLR, Imidan 70 WSB, Lannate LV, Provado, Pyramite and Intrepid. Fruit counts represent means of 25-fruit samples picked from each of four single-tree reps 22 Sep and rated after 26 days in cold storage at 1 C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Weather was favorable for development of sooty blotch and flyspeck throughout the summer months; two 4-inch rains occurred with hurricanes in September. Under moderately heavy disease pressure, all treatments gave excellent control of sooty blotch and significant control of flyspeck. Schedules which involved a straight schedule of either rate of Difenoconazole gave excellent control of flyspeck, equal to the higher rate alternated with Topsin M + captan, and significantly stronger than a straight schedule of Topsin M + captan. Control of flyspeck by a straight schedule of the lower Difenoconazole rate was significantly better than the lower rate alternated with Topsin M + captan or applied as early cover consecutive sprays where Topsin M + captan was applied as consecutive late cover sprays. Alternating Flint with Topsin M + captan gave control of flyspeck equal to a straight schedule of Topsin M + captan. No treatment significantly affected fruit finish compared to trees receiving no summer fungicide.

Table 9. Summer Disease Control by Difenoconazole

			% fruit or % fruit area infected				
			Scab,	Sooty blotch		Flyspeck	
	Treatment and rate/100 gal dilute	Timing	% fruit	fruit	area	fruit	area
0	No summer fungicide	---	7 b	92 c	8 c	100 d	15.7 e
1	Topsin M 70W 4 oz + Captan 50W 20 oz	1C-6C	3 ab	1 ab	<1 ab	18 c	1.4 d
2	Difenoconazole 250EC 29.5 ml Topsin M 70W 4 oz + Captan 50W 20 oz	1C-3C 4C-6C	1 a	0 a	0 a	5 ab	0.3 ab
3	Difenoconazole 250EC 29.5 ml Topsin M 70W 4 oz + Captan 50W 20 oz	1C, 3C, 5C 2C, 4C, 6C	2 ab	0 a	0 a	5 ab	0.4 a-c
4	Difenoconazole 250EC 20.2 ml Topsin M 70W 4 oz + Captan 50W 20 oz	1C-3C 4C-6C	2 ab	0 a	0 a	14 bc	1.0 cd
5	Difenoconazole 250EC 20.2 ml Topsin M 70W 4 oz + Captan 50W 20 oz	1C, 3C, 5C 2C, 4C, 6C	0 a	0 a	0 a	14 bc	0.9 b-d
6	Difenoconazole 250EC 29.5 ml	1C-6C	0 a	2 ab	<1 ab	6 a-c	0.3 a-c
7	Difenoconazole 250EC 20.2 ml	1C-6C	3 ab	2 ab	<1 ab	5 a	0.2 a
8	Flint 50WG 0.75 oz Topsin M 70W 4 oz + Captan 50W 20 oz	1C, 3C, 5C 2C, 4C, 6C	1 a	4 b	<1 b	17 bc	0.9 b-d

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

APPLE (*Malus domestica* 'Jonagold')
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Fruit finish

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EVALUATION OF BUPIRIMATE FOR MILDEW CONTROL ON JONAGOLD APPLE, 2004

Seven treatments were evaluated in a test of bupirimate (Nimrod 25EC) for powdery mildew control on 13-yr-old, trees. Nova 1.25 oz + Captan 50W 1.5 lb had been applied to the entire test block including "untreated" trees on 9 Apr, 15 Apr, 22 Apr, 30 Apr. To encourage continued growth and favor heavier mildew infection during the cover spray period, each test tree was fertilized 13 May with 2 lb calcium nitrate per tree. For mildew control evaluation, rapidly growing monitoring shoots were selected and the youngest leaf at the growing point was tagged as a reference for rating at the time the test treatment series was initiated. Treatments were applied in a four-replicate randomized block design. Test treatments were applied dilute to the point of runoff with a single nozzle handgun at 300 psi as second-fifth covers, 25 May, 9 Jun, 23 Jun, 8 Jul, and 23 Jul. Mildew inoculum was present in an adjacent Ginger Gold mildew test row; in addition three heavily mildewed shoots were placed in each test tree 15 June. Maintenance sprays, applied separately with a commercial airblast sprayer, included Ambush 2E, NAA 10 ppm + Sevin XLR, Imidan 70 WSB, Lannate LV, and Provado. Foliar data represent means of counts of six terminal shoots from each of four single-tree replications 12 Aug. Fruit data are harvest counts of 8-25 fruit per tree 31 Aug. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Although wet weather early in the test period was not particularly favorable for mildew development, enough disease appeared on non-treated trees to provide a mildew test for the treatments. All treatments gave significant suppression of percent leaves infected with mildew. Under relatively light sooty blotch and flyspeck pressure, all treatments gave good control. There was no significant deleterious treatment effect on fruit finish.

Table 10.

	Mildew infection (%)		% fruit infected		Fruit finish (0-5)*	
Treatment and rate/100 gal dilute	leaves	area	Sooty blotch	Fly speck	russet	opal-escence
Untreated	41 c	3 b	17 b	19 c	0.9 a	0.9 a
Nimrod 25EC 51 ml	10 a	2 a	0 a	1 b	0.8 a	0.9 a
Nimrod 25EC 101 ml	18 b	2 ab	0 a	0 a	0.7 a	0.7 a
Nimrod 25EC 101 ml + Captan 50W 1.5 lb	16 ab	2 a	0 a	0 a	0.8 a	0.9 a
Rubigan 1E 89 ml	17 ab	2 ab	0 a	0 a	0.7 a	0.8 a
Microthiol Disperss 3 lb	11 ab	2 a	0 a	0 a	1.0 a	1.0 a
Flint 50WG 0.5 oz	16 ab	2 a	0 a	0 a	0.8 a	0.8 a

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

Counts of six terminal shoots from each of four single-tree replications 12 Aug. Harvest counts of 8-25 fruit per tree 31 Aug.

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

APPLE (*Malus domestica* 'Ginger Gold')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust,
Gymnosporangium juniperi-virginianae
Fly speck; *Zygophiala jamaicensis*
Rots (unidentified)
Botryosphaeria rot; *B. dothidea*
Rhizopus rot; *Rhizopus* sp.
Fruit finish

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Broad spectrum disease management by certified organic and home fruit fungicides on Ginger Gold, 2004

Six treatments suitable for organic or backyard fruit production were evaluated compared to a Nova/captan schedule on 13-yr-old trees in a four-replicate randomized block design. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 300 psi as follows: 9 Apr (TC, tight cluster); 15 Apr (P, pink); 22 Apr (PF, petal fall). First cover (1C): 30 Apr; Second covers (2C): 7 May & 20 May. Third-sixth covers (3C-6C): 8 Jun, 23 Jun, 8 Jul, and 23 Jul. Maintenance sprays, applied separately with a commercial airblast sprayer, included Ambush 2E, NAA 10 ppm, Sevin XLR, Imidan 70 WSB, Lannate LV, and Provado. Cedar rust galls were placed over each test tree 9 Apr. Other diseases developed from inoculum naturally present in the test area. Foliar counts were conducted on ten terminal shoots from each of four single-tree replications 21 Jul. A sample of 25 fruit per tree was counted at harvest 5 Aug and again after 13 days postharvest incubation at ambient temperatures 20-29 C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Under heavy scab and mildew pressure, all treatments gave significant disease suppression. The tank-mix combination of Nova + captan gave the best scab and mildew control, but all other treatments were more effective than sulfur (Microthiol). All treatments gave good control of flyspeck and all treatments except JMS Stylet Oil, gave some control of rots. Although no treatment significantly affected fruit finish compared to non-treated fruit, Immunox / captan had significantly less russet than Cuprofix treatments.

Table 11. Test of certified organic and home fruit fungicides for broad spectrum disease management, Ginger Gold, 2004

		% leaves, leaf area, or fruit infected										
		Scab		Mildew		cedar rust,	Fruit at harvest		13 days postharvest			Russet Rating
	Treatment, rate/100 gal dilute and timing	lvs	fruit	lvs	area	leaves	% fly speck	any rot	any rot	Bot rot	Rhiz-opus	(0-5)
0	No fungicide	86 d	97 e	53 e	39 c	4 c	32 b	11 c	23 c	7 ab	7 b	1.7 ab
1	Microthiol Disperss 1.5 lb; TC-6C	60 c	41 c	38 cd	13 b	1 bc	1 a	0 a	21 c	1 a	8 ab	1.6 ab
2	JMS Stylet Oil 1 gal; TC-PF	42 b	67 d	40 de	10 ab	<1 ab						
	JMS Stylet Oil 1.5 gal; 1C-6C						2 a	10 c	15 bc	9 b	0 a	1.6 ab
3	Lime sulfur 2 qt + Microthiol Disperss 1.5 lb; TC-2C	40 b	18 b	33 b-d	9 ab	<1 ab						
	Microthiol Disperss 1.5 lb; 3C-6C						1 a	3 ab	18 bc	4 ab	8 b	1.5 ab
4	Lime sulfur 2 qt + Microthiol Disperss 1.5 lb; TC-2C	44 b	16 b	22 ab	4 a	<1 bc						
	Cuprofix 20DF 12 oz; 3C-6C						1 a	4 bc	7 ab	4 ab	0 a	2.0 b
5	Lime sulfur 2 qt + Microthiol Disperss 1.5 lb; TC-2C	43 b	14 b	34 cd	8 ab	<1 ab						
	Cuprofix 20DF 12 oz + Surround 6 lb; 3C-6C						0 a	0 a	21 bc	5 ab	11 b	2.0 b
6	Immunox 1.55EC 50 fl oz; TC-PF	33 b	14 b	27 a-c	5 ab	0 a						
	Immunox 1.55EC 50 fl oz + Captan 50W 1.5 lb; 1-2C											
	Captan 50W 1.5 lb; 3C-6C						0 a	1 ab	1 a	1 a	0 a	1.2 a
7	Nova 40W 1.25 oz + Captan 50W 12 oz; TC-2C	8 a	1 a	19 a	3 a	0 a						
	Captan 50W 1.5 lb; 3C-6C						1 a	0 a	1 a	1 a	0 a	1.5 ab

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

Counts of ten terminal shoots from each of four single-tree replications 21 Jul. Fruit counts at harvest 5 Aug or after 13 days postharvest incubation at ambient temperatures 20-29 C.

Fungicide treatments: Dilute treatments applied to runoff with a single nozzle handgun at 300 psi as follows:
9 Apr (TC, tight cluster); 15 Apr (P, pink); 22 Apr (PF, petal fall). First cover (1C): 30 Apr; Second covers (2C): 7 May & 20 May. Third-sixth covers (3C-6C): 8 Jun, 23 Jun, 8 Jul, and 23 Jul.

APPLE (*Malus domestica* 'Golden Delicious', 'Rome Beauty')
Fireblight; *Erwinia amylovora*

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FIRE BLIGHT BLOOM TREATMENTS ON GOLDEN DELICIOUS AND ROME BEAUTY APPLES, 2004

A blossom blight control test with experimental materials was conducted on pairs of adjacent 32 yr-old trees of each cultivar in four randomized blocks. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 450 psi to both Golden Delicious and Rome. Treatments were applied on the morning of 16 Apr (trt. # 10 only Golden Delicious, open cluster), 20 Apr (all treatments; full bloom, Golden; early bloom Rome), 23 Apr (all treatments; Golden Delicious petal fall; Rome 80% full bloom); 30 Apr, all treatments, (late bloom on Rome). Four selected branches per tree with 25-40 blossom clusters were inoculated by spraying to wet with a bacterial suspension containing$1X10^6$ *E. amylovora* cells/ml, during the evening of 20 Apr (Golden & Rome) and 23 Apr (Rome only). Infection was assessed by counting the number of clusters infected per total clusters on inoculated branches. Golden Delicious was rated 7 & 10 May; Rome was rated 10 & 13 May. A cluster was rated as infected if it had at least one blossom showing fire blight symptoms. Maintenance materials, applied throughout the season with a commercial airblast sprayer at 100 gal per acre, included Nova, Syllit, Captan, Flint, Supracide + oil, Imidan 70WSB, Lannate LV, Provado, and Sevin XLR + Ethrel (as a thinning spray). Harvest ratings of fruit finish were based on a 25-fruit sample from each tree.

Warm weather prevailed through the peak of bloom and conditions were favorable for fireblight infection from 20- 25 Apr. Generally, Golden Delicious had less infection than Rome, probably because the Romes were inoculated twice. The two streptomycin formulations, Agri-Mycin and BacMaster were equally effective and performed as expected. The higher rates of GWN 9350 (10% gentamicin) and GWN 9760 (30% gentamicin, 10% oxytetracycline) were also quite effective. The lowest rate of GWN 9350, GWN 9730 (31% oxytetracycline), and Cuprofix gave significant (p=0.05) suppression of blossom cluster infection on Golden, but not on Rome. GWN 9760 performed significantly better than GWN 9730 at comparable rates on both cultivars. On Golden Delicious all treatments except Brotomax gave significant control compared to non-treated trees. There was no significant effect by any treatment on fruit finish of either Golden Delicious or Rome Beauty compared to non-treated trees; however, Cuprofix treated Golden Delicious fruit had significantly more russet than fruit from several of the streptomycin and gentamicin related treatments.

Table 12. Blossom blight control and fruit finish effects on Golden Delicious and Rome apples.

Treatment and rate/100 gal dilute	Application dates	% clusters with blight symptoms		Fruit finish ratings (0-5) *		% fruit X-fcy/fcy
		G. Del.	Rome	Rome	G. Del.	G. Del.*
0 No treatment	---	65e	69fg	0.7a	2.4a-c	72a-c
1 Agri-Mycin 17 4 oz + Regulaid 1 pt	20, 23, 30 Apr	6a	30b-d	0.8a	2.2ab	79ab
2 Agri-Mycin 17 8 oz + Regulaid 1 pt	20, 23, 30 Apr	6ab	14ab	0.8a	2.8bc	53bc
3 BacMaster 8 oz + Regulaid 1 pt	20, 23, 30 Apr	3a	13a	0.6a	2.3ab	80ab
4 GWN 9350 10W 254 g + Regulaid 1 pt	20, 23, 30 Apr	15bc	51d-f	0.8a	2.2ab	77ab
5 GWN 9350 10W 567 g + Regulaid 1 pt	20, 23, 30 Apr	10ab	24ab	0.8a	1.9a	84a
6 GWN 9350 10W 756 g + Regulaid 1 pt	20, 23, 30 Apr	9ab	28bc	0.7a	2.4a-c	62a-c
7 GWN 9750 40W 254 g + Regulaid 1 pt	20, 23, 30 Apr	15bc	34b-e	0.8a	2.4a-c	70a-c
8 GWN 9760 40W 254 g + Regulaid 1 pt	20, 23, 30 Apr	12ab	27ab	1.1a	2.7bc	61a-c
9 GWN 9730 30W 252 g + Regulaid 1 pt	20, 23, 30 Apr	25cd	54ef	0.7a	2.4a-c	66a-c
10 Brotomax 1.5 pt + Kinetic 4 fl oz Applied at open cluster and thru bloom	16, 20, 23, 30 Apr	51e	78g	0.8a	2.5a-c	62a-c
11 Cuprofix Disperss 20DF 12 oz	20, 23, 30 Apr	30d	33c-f	0.8a	3.1c	42c

Means of four replications; mean separation by Waller-Duncan K-ratio t-test (p=0.05).

* Russet rated at harvest on a 25-fruit sample; rated on a scale of 0-5 (0=perfect finish; 5=severe russet). USDA Extra fancy and fancy grades after down-grading by russet.

APPLE (*Malus domestica* 'Fuji')
Blue mold; *Penicillium expansum*
Bitter rot ; *Colletotrichum spp.*

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Control of blue mold and latent bitter rot by Scholar on Fuji apples, 2003-04.

An experiment was conducted to test the effectiveness of fludioxonil (Scholar 50W) as a post-harvest dip treatment on Fuji apples. Test fruit were selected from trees which had been uniformly sprayed with the commercial fungicides Nova, Sovran, Topsin M + captan, Captan and Topsin M in 2003. Fruit were harvested 16 Oct '03. Fruit without visible rot symptoms were dipped 1 min. in 200 ppm sodium hypochlorite, allowed to dry overnight and randomized into four 25-fruit replications. Each fruit was wounded in three places with the tip of a nail to a depth of 5 mm. Replicated samples were then dipped in the indicated treatment for 30 sec, placed in open-sided plastic storage crates and held at 1 C in a commercial apple storage until 10 Mar '04. Samples were then retained at ambient temperatures (28-67 F) 23 days until the final rating 2 Apr.

Blue mold developed from inoculum typically present in the commercial storage. The effectiveness of the Mertect and Mertect + captan treatments was likely impacted by the presence of benzimidazole-resistant *Penicillium* inoculum present in the storage. All rates of Scholar gave perfect control of blue mold under these simulated commercial conditions. All rates of Scholar also gave complete suppression of apparently latent bitter rot infection which developed in non-wounded areas of the fruit. Treatments involving Mertect or captan did not control latent bitter rot.

Table 13.

	% fruit infected	
Treatment, rate/100 gal	Blue mold	Bitter rot
Untreated	48 d	29 b
Water dip	37 d	39 b
Scholar 50W 2 oz dip	0 a	0 a
Scholar 50W 4 oz dip	0 a	0 a
Scholar 50W 8 oz dip	0 a	0 a
Scholar 50W 16 oz dip	0 a	0 a
Mertect 340F 1 pt	20 c	30 b
Captan 50W 2 lb	9 b	26 b
Mertect 340F 1 pt + Captan 50W 1 lb	15 c	36 b

Four replications, 25 fruit/rep. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

APPLE (*Malus domestica* 'Golden Delicious')
'Red Delicious', and 'Rome Beauty')
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Rots (unidentified)

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Summer disease and postharvest rot development on Red Delicious, Golden Delicious and Rome apples, 2003-04.

An experimental fungicide (Pristine) and a recently registered copper formulation (Cuprofix) were tested for fungal disease and fruit finish effects on three apple cultivars. Nine treatments were evaluated on 14-yr-old, three-cultivar tree sets in a four-replicate randomized block design. Treatments were applied dilute to the point of runoff with a single nozzle handgun at 450 psi. The first application, Cuprofix on Trt.#1 only, at green tip on Red Delicious 28 Mar, was before any scab infection occurred. The second application involving all treatments was made on 14 Apr after scab infection periods had occurred 4-5 Apr and 7-9 Apr (Rome and Golden open cluster – pink; Red Delicious full pink). Later applications were as follows: 24 Apr (Rome bloom-petal fall; Red and Golden petal fall;); 7 May Rome petal fall); 1st to 7th covers (1C-7C): 20 May, 6 June, 23 June, 9 July, 24 July, 8 Aug, and 26 Aug. Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Golden Delicious test tree 19 June. Other diseases developed from inoculum naturally present in the test area. Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep (Red and Golden Delicious), or 29 Sep (Rome) and placed in cold storage at 1C. The first postharvest fruit counts (Table 14) were conducted after the following periods in cold storage: Red Delicious was rated after 50 days; Golden Delicious after 59 days; Rome after 44 days. Following the initial evaluation, fruit samples were returned to cold storage and then re-evaluated as follows: Golden Delicious in cold storage until 6 Jan '04, again rated after 15 and 29 days out of cold storage; Red Delicious in cold storage until 10 Jan '04 and rated after 28 and 51 days out of cold storage; Rome Beauty in cold storage until 2 Feb '04 and rated after 7 and 30 days out of cold storage. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The early season was wet, and cool weather continued into early summer, resulting in the heaviest scab pressure in 27. Throughout most of the post-bloom period, the cumulative wetting hour total was the highest in the past ten years. The 250-hr threshold for presence of the sooty blotch and flyspeck fungi on fruit was met in late May and sooty blotch and flyspeck were evident by mid-August in this test block on fruit treated with captan + ziram on 2-wk schedules. Under this heavy disease pressure the strobilurin materials performed well, with Pristine being significantly more effective on sooty blotch but somewhat less effective on flyspeck. Cuprofix was slightly less effective than captan + ziram for control of sooty blotch and flyspeck. Pristine, Flint, and Sovran all gave excellent control of Brooks spot infection which was not well controlled by Vangard, Nova or Rubigan. In the first postharvest rot counts, all treatments gave adequate control of bitter rot on Rome (Table 14) but were more variable on unidentified rots on Golden Delicious. In later counts, particularly after the longer incubation periods out of cold storage, Pristine and Flint gave superior control of bitter, Bot and Phomopsis rots. Compared to non-treated fruit, none of the treatments had a significant deleterious effect on fruit finish of any cultivar; several treatments reduced Golden Delicious russetting.

Table 14. Treatment effects on summer disease incidence on Red Delicious, Golden Delicious and Rome, 2003.

		% fruit with Brooks spot		Rots (%)		% fruit infected			
				G. Del	Rome,	Sooty blotch			flyspeck
Rate per 100 gal dilute	Timing	G. Del	Rome	rots	bitter	R. Del.	G. Del.	Rome	G. Del.
0 No fungicide	---	22 b	3 ab	6 d	8 b	100 f	100 g	100 d	99 d
1 Cuprofix Disperss 20DF 20 oz .. Vangard 75WG 1 oz+ Microthiol Disperss 80DF 1 lb.	½" G OC-7C	20 b	5 ab	1 ab	2 a	71 de	80 ef	82 c	71 bc
2 Cuprofix Disperss 20DF 20 oz + Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb ... Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb Cuprofix Disperss 20DF 12 oz ..	 OC P-2C 3C-7C	15 b	7 b	4 b-d	1 a	48 cd	69 de	58 bc	68 b
3 Cuprofix Disperss 20DF 20 oz .. Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb	OC P-7C	18 b	3 ab	2 a-c	1 a	82 e	88 f	97 d	73 bc
4 Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb	OC-7C	23 b	5 ab	6 cd	3 a	70 de	82 ef	71 c	79 c
5 Nova 40W 1 oz Captan 50W 1lb + Ziram 1 lb	OC-2C 3C-7C	17 b	7 b	3 a-d	0 a	31 bc	49 c	14 a	55 b
6 Rubigan 1E 2.25 fl oz Captan 50W 1lb + Ziram 1 lb	OC-2C 3C-7C	17 b	0 a	1 ab	0 a	33 bc	53 cd	42 b	65 bc
7 Pristine 38WDG 3.6 oz	OC-7C	0 a	0 a	0 a	0 a	1 a	10 a	8 a	20 a
8 Sovran 50WG 1 oz	OC-7C	1 a	0 a	0 a	0 a	17 b	27 b	7 a	12 a
9 Flint 50WG 0.5 oz	OC-7C	1 a	0 a	0 a	0 a	17 b	31 b	12 a	13 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Treatments applied dilute to the point of runoff with a single nozzle handgun as follows: 28 Mar (Trt.#1 only, green-tip); 14 Apr (Rome and Golden open cluster – pink; Red Delicious full pink); 24 Apr (Rome bloom-petal fall; Red and Golden petal fall;); 7 May Rome petal fall); 1st to 7th covers (1C-7C): 20 May, 6 June, 23 June, 9 July, 24 July. 8 Aug, and 26 Aug.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep (Red and Golden Delicious), or 29 Sep (Rome) and placed in cold storage at 1C. Red Delicious was rated after 50 days cold storage; Golden Delicious after 59 days cold storage and Rome after 44 days' cold storage.

Table 15. Post harvest rot counts on Golden Delicious apple fruit, 2003-04.

		Rot	% fruit rotted, *days* out of cold storage						
		spots,	% any rot		Bot rot	Bitter rot		Phomopsis	
Rate per 100 gal dilute	Timing	harvest	*15*	*29*	*29*	*15*	*29*	*15*	*29*
0 No fungicide	---	6 d	33 cd	65 d	6 b	32 bc	58 d	1	6 b
Cuprofix Disperss 20DF 20 oz ..	½" G								
Vangard 75WG 1 oz+									
1 Microthiol Disperss 80DF 1 lb.	OC-7C	1 ab	31 cd	51 b-d	3 ab	31 bc	46 b-d	1	4 ab
Cuprofix Disperss 20DF 20 oz +									
Vangard 75WG 1 oz +									
Microthiol Disperss 80DF 1 lb ...	OC								
Vangard 75WG 1 oz +									
Microthiol Disperss 80DF 1 lb	P-2C								
2 Cuprofix Disperss 20DF 12 oz	3C-7C	4 b-d	23 bc	45 bc	1 ab	23 bc	42 b-d	0	3 ab
Cuprofix Disperss 20DF 20 oz ..	OC								
Vangard 75WG 1 oz +									
3 Microthiol Disperss 80DF 1 lb	P-7C	2 a-c	38 d	57 cd	3 ab	38 c	52 cd	0	2 ab
Vangard 75WG 1 oz +									
4 Microthiol Disperss 80DF 1 lb	OC-7C	6 cd	20 b	41 bc	6 ab	19 b	32 b	1	3 ab
Nova 40W 1 oz	OC-2C								
5 Captan 50W 1lb + Ziram 1 lb	3C-7C	3 a-d	21 b	34 b	4 ab	22 bc	29 b	0	1 a
Rubigan 1E 2.25 fl oz	OC-2C								
6 Captan 50W 1lb + Ziram 1 lb	3C-7C	1 ab	24 bc	35 b	0 a	24 bc	33 bc	0	2 ab
7 Pristine 38WDG 3.6 oz	OC-7C	0 a	0 a	3 a	0 a	0 a	3 a	0	0 a
8 Sovran 50WG 1 oz	OC-7C	0 a	20 b	34 b	4 ab	20 b	31 b	0	0 a
9 Flint 50WG 0.5 oz	OC-7C	0 a	4 a	10 a	1 ab	4 a	9 a	0	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit from each of four reps.

Treatments applied dilute to the point of runoff with a single nozzle handgun as follows: 28 Mar (Trt.#1 only, green tip); 14 Apr (Rome and Golden open cluster – pink; Red Delicious full pink); 24 Apr (Rome bloom-petal fall; Red and Golden petal fall;); 7 May Rome petal fall); 1st to 7th covers (1C-7C): 20 May, 6 June, 23 June, 9 July, 24 July. 8 Aug, and 26 Aug.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep, placed in cold storage at 1C, first rated after 59 days cold storage, returned to cold storage until 6 Jan '04, then again rated after 15 and 29 days out of cold storage.

Table 16. Post harvest rot counts on Red Delicious apple fruit, 2003-04.

	Rate per 100 gal dilute	Timing	% fruit rotted, *days* out of cold storage					
			% any rot		Bot rot		Bitter rot	
			28	*51*	*28*	*51*	*28*	*51*
0	No fungicide	---	20 c	87 e	13 b	49 e	5 b	37 de
	Cuprofix Disperss 20DF 20 oz	½" G						
	Vangard 75WG 1 oz+							
1	Microthiol Disperss 80DF 1 lb	OC-7C	3 ab	60 d	0 a	18 cd	3 ab	41 e
	Cuprofix Disperss 20DF 20 oz +							
	Vangard 75WG 1 oz +							
	Microthiol Disperss 80DF 1 lb	OC						
	Vangard 75WG 1 oz +							
	Microthiol Disperss 80DF 1 lb	P-2C						
2	Cuprofix Disperss 20DF 12 oz	3C-7C	2 ab	43 b-d	1 a	6 a-c	1 ab	33 de
	Cuprofix Disperss 20DF 20 oz	OC						
	Vangard 75WG 1 oz +							
3	Microthiol Disperss 80DF 1 lb	P-7C	6 b	55 d	0 a	20 d	5 ab	31 c-e
	Vangard 75WG 1 oz +							
4	Microthiol Disperss 80DF 1 lb	OC-7C	1 a	51 cd	0 a	12 b-d	0 a	35 de
	Nova 40W 1 oz	OC-2C						
5	Captan 50W 1lb + Ziram 76DF 1 lb	3C-7C	2 ab	27 b	0 a	13 b-d	2 ab	12 b
	Rubigan 1E 2.25 fl oz	OC-2C						
6	Captan 50W 1lb + Ziram 76DF 1 lb	3C-7C	3 ab	43 b-d	1 a	16 cd	2 ab	19 b-d
7	Pristine 38WDG 3.6 oz	OC-7C	1 a	4 a	0 a	2 a	0 a	0 a
8	Sovran 50WG 1 oz	OC-7C	3 ab	32 bc	0 a	11 b-d	2 ab	16 bc
9	Flint 50WG 0.5 oz	OC-7C	0 a	9 a	0 a	5 ab	0 a	2 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit from each of four replications Treatments applied dilute to the point of runoff with a single nozzle handgun as follows: 28 Mar (Trt.#1 only, green tip); 14 Apr (Rome and Golden open cluster – pink; Red Delicious full pink); 24 Apr (Rome bloom-petal fall; Red and Golden petal fall;); 7 May Rome petal fall); 1st to 7th covers (1C-7C): 20 May, 6 June, 23 June, 9 July, 24 July. 8 Aug, and 26 Aug.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep, placed in cold storage at 1C, first rated after 50 days cold storage then returned to cold storage until 10 Jan '04; then again rated after 28 and 51 days out of cold storage.

Table 17. Post harvest rot counts on Rome apple fruit, 2003-04.

		Fruit disease, % fruit rotted, days out of cold storage							
		% with any rot		Bot rot	Bitter rot		Blue mold	Phomopsis	
Rate per 100 gal dilute	Timing	*7*	*30*	*30*	*7*	*30*	*30*	*7*	*30*
0 No fungicide	---	9 a	96 e	37 d	9 a	69 e	3 a	3 a	15 d
Cuprofix Disperss 20DF 20 oz ..	½" G								
Vangard 75WG 1 oz+									
1 Microthiol Disperss 80DF 1 lb.	OC-7C	4 a	68 d	19 bc	3 a	49 de	1 a	0 a	7 cd
Cuprofix Disperss 20DF 20 oz +									
Vangard 75WG 1 oz +									
Microthiol Disperss 80DF 1 lb ...	OC								
Vangard 75WG 1 oz +									
Microthiol Disperss 80DF 1 lb	P-2C								
2 Cuprofix Disperss 20DF 12 oz ..	3C-7C	6 a	37 b	10 ab	4 a	24 a-c	0 a	1 a	8 cd
Cuprofix Disperss 20DF 20 oz ..	OC								
Vangard 75WG 1 oz +									
3 Microthiol Disperss 80DF 1 lb	P-7C	3 a	62 cd	18 bc	3 a	42 cd	2 a	0 a	5 bc
Vangard 75WG 1 oz +									
4 Microthiol Disperss 80DF 1 lb	OC-7C	3 a	65 d	20 cd	3 a	44 cd	0 a	0 a	5 a-c
Nova 40W 1 oz	OC-2C								
5 Captan 50W 1lb + Ziram 1 lb	3C-7C	2 a	41 bc	13 bc	2 a	30 bc	2 a	0 a	1 a
Rubigan 1E 2.25 fl oz	OC-2C								
6 Captan 50W 1lb + Ziram 1 lb	3C-7C	5 a	68 d	20 bc	5 a	52 de	3 a	0 a	9 cd
7 Pristine 38WDG 3.6 oz	OC-7C	1 a	14 a	2 a	1 a	11 a	0 a	0 a	1 a
8 Sovran 50WG 1 oz	OC-7C	7 a	42 bc	10 bc	5 a	27 a-c	0 a	0 a	6 bc
9 Flint 50WG 0.5 oz	OC-7C	3 a	24 ab	9 ab	3 a	13 ab	0 a	0 a	2 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit from each of four replications Treatments applied dilute to the point of runoff with a single nozzle handgun as follows: 28 Mar (Trt.#1 only, green tip); 14 Apr (Rome and Golden open cluster – pink; Red Delicious full pink); 24 Apr (Rome bloom-petal fall; Red and Golden petal fall;); 7 May Rome petal fall); 1st to 7th covers (1C-7C): 20 May, 6 June, 23 June, 9 July, 24 July. 8 Aug, and 26 Aug.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 29 Sep, placed in cold storage at 1C, first rated after 44 days cold storage then returned to cold storage until 2 Feb '04; then again rated after 7 and 30 days out of cold storage.

APPLE (*Malus domestica* 'Stayman Winesap', 'Idared', 'Ginger Gold')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Rots (unidentified)
Fruit finish

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EVALUATION OF FUNGICIDE SCHEDULES AND MIXTURES FOR POSTHARVEST ROT DEVELOPMENT ON STAYMAN, IDARED, AND GINGER GOLD APPLES, 2003-04.

Ten treatments involving registered fungicides and an experimental package mix of pyraclostrobin and boscalid (Pristine) were tested for season-long disease management on 17-yr-old trees. The test was conducted in a randomized block design with four three-cultivar replicate tree sets separated by untreated border rows. Treatment rows had been used as non-treated border rows in 2002 to stabilize mildew inoculum pressure for 2003. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Treatments were applied to both sides of the trees on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster – open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug. Bitter rot mummies were placed over each Idared test tree 21 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Idared test tree 18 June. Other diseases developed from inoculum naturally present in the test area. Ginger Gold trees were harvested 25 Aug and rated 27 Aug; Stayman trees were sampled 16 Sep and Idared 17 Sep, and the 25-fruit samples were rated after storage at 1C 49 days (Idared), 58 days (Stayman). Following the initial evaluation, fruit samples were returned to cold storage and then re-evaluated as follows: Ginger Gold stored at 1C until 6 Jan '04 and rated 15 days out of cold storage; Stayman stored until 31 Jan '04 and rated 8 and 31 days out of cold storage; Idared stored until 14 Jan '04 and rated 28 and 51 days out of cold storage. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Weather was favorable for development of the major diseases in 2003, presenting a strong test for early season and summer diseases. Scab pressure was at its highest in more than 27 years, and cumulative wetting totals throughout 2003 were among the highest in ten years. In the first postharvest evaluation, all treatments except Penncozeb gave adequate control of Brooks spot. Nearly all non-treated fruit were infected with sooty blotch and fly speck but under these rigorous test conditions, most treatments performed as expected, and Pristine gave excellent control. Under relatively heavy postharvest rot development conditions, treatment schedules involving Pristine, Flint and Dithane / captan / ziram gave excellent control of rots, particularly on Stayman, where some bitter rot did not appear until after 31 days out of cold storage.

Table 18. Post storage rot counts on Ginger Gold apples, 2003-2004.

	Treatment and rate/A	Timing	Rot spots at harvest	% fruit rot, 15 days post-cold storage: any rot	Bitter rot	Bot rot	Blue mold	Phomopsis rot
0	No fungicide	---	23c	90e	43c	20d	51d	16c
	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb	TC –2C						
1	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C	2ab	29b	9b	3a-c	18bc	0a
	Rubigan 9 fl oz + Dithane RSNT 75DF 3 lb	TC –2C						
2	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C	1ab	31bc	5ab	1a-c	26c	1a
	Flint 50WG 2 oz	TC, 1C						
	Procure 50WS 10 oz + Dithane RSNT 3 lb	Bl, PF, 2C						
3	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C	1ab	38b-d	3ab	4bc	31cd	2b
	Cuprofix Disperss 20DF 5 lb	GT						
	Sovran 50WG 3.2 oz + Polyram 80DF 3 lb	TC, Bl, 2-3C						
	Nova 40W 5 oz + Polyram 80DF 3 lb	PF, 1C						
4	Captan 50W 3 lb + Ziram 76DF 3 lb	4C–6C	0a	32bc	3ab	2a-c	26c	0a
	Cuprofix Disperss 20DF 10 lb	GT						
	Sovran 50WG 3.2 oz + Polyram 80DF 3 lb	TC, Bl, 2C						
	Nova 40W 5 oz + Polyram 80DF 3.0 lb	PF, 1C						
5	Cuprofix Disperss 20DF 3 lb	3C–6C	1ab	35b-d	14b	5c	17bc	0a
	Cuprofix Disperss 20DF 10 lb	GT						
	Cuprofix MZ30 42DF 5 lb +							
	Microthiol Disperss 80DF 3 lb	TC-2C						
6	Cuprofix Disperss 20DF 3 lb	3C–6C	2ab	48cd	29c	4bc	19bc	0a
	Penncozeb 75DF 3.2 lb +							
	Microthiol Disperss 80DF 3 lb	TC-PF						
7	Topsin M 70W 10 oz	1C-6C	3b	52d	30c	1ab	30cd	1ab
	Penncozeb 75DF 3.2 lb +							
	Microthiol Disperss 80DF 3 lb	TC-PF						
8	Topsin M 4.5F 12.4 fl oz	1C-6C	0a	33b-d	10b	5c	19bc	2ab
9	Pristine 38WDG 14.5 oz	TC-6C	0a	8a	2ab	0a	6a	0a
	Pristine 38WDG 14.5 oz	TC-Bl						
	Nova 40W 5 oz + Polyram 80DF 3.0 lb	PF – 1C						
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C, 4-5C						
10	Pristine 38WDG 14.5 oz	3C, 6C	2ab	12a	2a	0a	10ab	0a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit from each of four single-tree reps.

Fungicide application dates: 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster – open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug. Ginger Gold trees sampled 25 Aug; fruit first rated 27 Aug then stored at 1C until 6 Jan '04 and rated 15 days out of cold storage.

Table 19. Post storage rot counts on Stayman apple, 2003-04.

		Rot spots, harv.	Fruit disease, % fruit rot, *days* post cold storage						
			% any rot		Bot rot	Bitter rot		Brown rot	
Treatment and rate/A	Timing		*8*	*31*	*31*	*8*	*31*	*8*	*31*
0 No fungicide	---	33c	57b	91g	12b	8c	35g	36c	41c
Nova 40W 5 oz + Dithane 75DF 3 lb	TC –2C								
1 Captan 50W 3 lb + Ziram 76DF 3 lb	3C–7C	0a	0a	8ab	4a	0a	2ab	0a	0a
Rubigan 9 fl oz + Dithane 75DF 3 lb	TC –2C								
2 Captan 50W 3 lb + Ziram 76DF 3 lb	3C–7C	0a	2a	17b-e	2a	0a	10b-d	2b	4b
Flint 50WG 2 oz	TC, 1C								
Procure 50WS 10 oz + Dithane 3 lb	Bl, PF, 2C								
3 Captan 50W 3 lb + Ziram 76DF 3 lb	3C–7C	0a	0a	9a-c	2a	0a	3ab	0a	0a
Cuprofix Disperss 20DF 5 lb	GT								
Sovran 50WG 3.2 oz + Polyram 3 lb	TC, Bl, 2-3C								
Nova 40W 5 oz + Polyram 80DF 3 lb	PF, 1C								
4 Captan 50W 3 lb + Ziram 76DF 3 lb	4C–7C	0a	0a	22c-f	2a	0a	13c-e	0a	2ab
Cuprofix Disperss 20DF 10 lb	GT								
Sovran 50WG 3.2 oz + Polyram 3 lb	TC, Bl, 2C								
Nova 40W 5 oz + Polyram 3.0 lb	PF, 1C								
5 Cuprofix Disperss 20DF 3 lb	3C–7C	0a	1a	13a-d	3a	0a	10b-d	0a	0a
Cuprofix Disperss 20DF 10 lb	GT								
Cuprofix MZ30 42DF 5 lb + Microthiol Disperss 80DF 3 lb	TC-2C								
6 Cuprofix Disperss 20DF 3 lb	3C–7C	0a	1a	41f	14b	1b	24ef	0a	0a
Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb	TC-PF								
7 Topsin M 70W 10 oz	1C-7C	2b	1a	36ef	8ab	0a	28ef	1bc	3bc
Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb	TC-PF								
8 Topsin M 4.5F 12.4 fl oz	1C-7C	0a	1a	26d-f	3a	0a	21d-f	1bc	ab 1c
9 Pristine 38WDG 14.5 oz	TC-7C	0a	0a	9a-c	2a	0a	3a-c	0a	0a
Pristine 38WDG 14.5 oz	TC-Bl								
Nova 40W 5 oz + Polyram 3.0 lb	PF - 1C								
Captan 50W 3 lb + Ziram 76DF 3 lb	2C, 4-5C								
10 Pristine 38WDG 14.5 oz	3C, 6-7C	0a	0a	5a	1a	0a	1a	0a	0a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit from each of four single-tree reps.

Fungicide application dates: 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster – open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug. Stayman trees sampled 16 Sep; fruit first rated after 58 days storage at 1C then returned to cold storage until 31 Jan '04 and rated 8 and 31 days out of cold storage.

Table 20. Post storage fruit rot counts, Idared apple, 2003-04.

			Fruit disease, % fruit rot, *days* out of cold storage						
			% any rot		Bot rot	Bitter rot		Blue mold	
	Treatment and rate/A	Timing	*28*	*51*	*51*	*28*	*51*	*28*	*51*
0	No fungicide	—	9 b	37 d	14 c	4 b	20 d	0	1 a
	Nova 40W 5 oz + Dithane 75DF 3 lb	TC –2C							
1	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–7C	0 a	1 a	0 a	0 a	0 a	0	1 a
	Rubigan 9 fl oz + Dithane 75DF 3 lb	TC –2C							
2	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–7C	0 a	3 a-c	0 a	0 a	3 bc	0	0 a
	Flint 50WG 2 oz	TC, 1C							
	Procure 50WS 10 oz + Dithane 3 lb	Bl, PF, 2C							
3	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–7C	1 a	3 ab	1 ab	0 a	0 a	1	2 a
	Cuprofix Disperss 20DF 5 lb	GT							
	Sovran 50WG 3.2 oz + Polyram 3 lb	TC, Bl, 2-3C							
	Nova 40W 5 oz + Polyram 80DF 3 lb	PF, 1C							
4	Captan 50W 3 lb + Ziram 76DF 3 lb	4C–7C	0 a	1 a	0 a	0 a	1 ab	0	0 a
	Cuprofix Disperss 20DF 10 lb	GT							
	Sovran 50WG 3.2 oz + Polyram 3 lb	TC, Bl, 2C							
	Nova 40W 5 oz + Polyram 3.0 lb	PF, 1C							
5	Cuprofix Disperss 20DF 3 lb	3C–7C	3 ab	5 a-c	2 ab	1 a	1 ab	2	2 a
	Cuprofix Disperss 20DF 10 lb	GT							
	Cuprofix MZ30 42DF 5 lb +								
	Microthiol Disperss 80DF 3 lb	TC-2C							
6	Cuprofix Disperss 20DF 3 lb	3C–7C	3 ab	9 bc	4 b	2 ab	3 a-c	0	1 a
	Penncozeb 75DF 3.2 lb +								
	Microthiol Disperss 80DF 3 lb	TC-PF							
7	Topsin M 70W 10 oz	1C-7C	6 ab	11 c	1 ab	5 ab	8 c	1	2 a
	Penncozeb 75DF 3.2 lb +								
	Microthiol Disperss 80DF 3 lb	TC-PF							
8	Topsin M 4.5F 12.4 fl oz	1C-7C	2 ab	4 ab	1 ab	2 ab	2 a-c	0	1 a
9	Pristine 38WDG 14.5 oz	TC-7C	1 a	3 ab	2 ab	0 a	1 ab	0	0 a
	Pristine 38WDG 14.5 oz	TC-Bl							
	Nova 40W 5 oz + Polyram 3.0 lb	PF - 1C							
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C, 4-5C							
10	Pristine 38WDG 14.5 oz	3C, 6-7C	0 a	0 a	0 a	0 a	0 a	0	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit from each of four reps. **Fungicide application dates:** 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster – open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug. Idared trees sampled 17 Sep; fruit first rated after 49 days storage at 1C then returned to cold storage until 14 Jan '04 and rated 28 and 51 days out of cold storage.

PEACH (*Prunus persica* 'Redhaven')
NECTARINE: (*P. persica* var. *nucipersica* 'Redgold')
Leaf curl; *Taphrina deformans* .
Scab; *Cladosporium carpophilum*
Brown rot; *Monilinia fructicola*

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Evaluation of fungicides for broad spectrum disease control on Redhaven peach and Redgold nectarine, 2004:

Registered and experimental fungicides were compared for broad spectrum disease control on 12-yr-old trees. The test planting, composed of 3-tree sets, includes Redhaven peach not treated with fungicides in 2003 to allow the buildup of scab inoculum, Redgold nectarine test trees re-randomized from the 2003 fungicide test, and Loring peach which was not used in the 2004 test. Brown rot inoculum was standardized in the orchard by placing three mummified fruit in each Redhaven and Redgold test tree before bloom 8 Apr. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 300 psi in a randomized block design with four replications. Applications were as follows: 11 March (BS, bud swell, #2-4 only); 7 Apr (P, pink, all treatments), 16 Apr (bloom); 22 Apr (PF, petal fall); 5 May (SS, shuck split); 1st through 4th covers: 21 May, 3 June, 18 Jun, and 2 Jul. Preharvest sprays for Redhaven were 9 Jul (2 wk pre-harvest, 2PH) and 19 Jul (1 wk pre-harvest, 1PH). Actual harvest date was 22 Jul, 3 days after the last application. Preharvest sprays for Redgold were 16 Jul (2 wk pre-harvest, 2PH) and 2 Aug (1 wk pre-harvest, 1PH) with harvest 9 Aug. Commercial insecticides, applied to the entire test block with a commercial airblast sprayer, included Ambush 2E, Imidan, Asana XL, Lannate LV, Provado, and Sevin XLR. Samples of 40 apparently rot-free fruit per replicate tree were harvested, rated for scab, fruit were selected for uniform ripeness, grouped into 20-fruit subsamples, and placed on fiber trays. One set was misted with de-ionized water, and the other subsample was inoculated with a suspension containing benzimidazole- sensitive *M. fructicola* conidia/ml, 12,000 conidia/ml for Redhaven and 50,000/ml for Redgold. All were incubated in polyethylene bags at ambient temperature 20-29 C for the indicated interval before rating rot development at the indicated intervals.

Leaf curl infection was moderately heavy on non-treated Redgold trees but light on Redhaven. Bravo, Ziram, and Kocide, applied at bud swell, gave excellent control (Table 21). None of the treatments which were delayed until pink gave significant leaf curl suppression compared to non-treated trees. Weather during the early cover spray period was favorable for scab infection. On Redhaven, superior control was achieved with schedules involving experimental compounds V10116 and USF2010 and Pristine followed by Indar and Elite + Flint. Treatments involving sulfur applied at shuck split to first cover were less effective although all treatments gave significant scab control compared to non-treated trees. Similar trends were noted on Redgold under heavier, but more variable scab pressure. Laboratory testing of fruit from the Topsin-M + sulfur treated trees indicated that about half of the scab isolates were resistant to benzimidazole fungicides. Brown rot pressure was heavy as indicated by failure of sulfur to provide significant control (Table 22 & 23). Under these conditions Pristine, V10116, USF2010, Elite + Flint and Indar all gave outstanding brown rot control. Several treatments involving Indar pre-harvest apparently were significantly impacted by different earlier cover spray schedules. Postharvest fruit inoculation increased brown rot pressure on Redgold, resulting in earlier, increased incidence on all treatments; however this did not seem to change the relative order of effectiveness among the treatments as indicated by percent of fruit without rots after 6-7 days incubation.

Table 21. Control leaf curl and scab on Redgold nectarine and Redhaven peach, Winchester, VA, 2004

			Leaf curl, % shoots infected		Scab, % fruit with indicated number of lesions					
					Redhaven			Redgold		
	Treatment and rate/100 gal dilute	Timing	Redgold	Redhaven	0	1-10	>11	0	1-10	>11
0	No fungicide	---	65 c	3 a	0 h	11 cd	89 f	1 d	15 ab	84 c
1	Microfine Sulfur 90W 3 lb	P- PH	35 a-c	0 a	34 fg	39 fg	26 e	27 bc	23 a-c	51 bc
2	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	BS P- 4C 2&1PH	0 a	0 a	27 g	49 g	24 e	25 bc	23 a-c	52 bc
3	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb Pristine 38WDG 7.25 oz	BS P- 4C 2&1PH	2 a	0 a	38 e-g	36 fg	26 e	28 bc	36 a-c	36 ab
4	Kocide 2000 35DF 3 lb Microfine Sulfur 90W 3 lb Topsin M 70W 4 oz + Sulfur 90W 3 lb	BS P- 4C 2&1PH	6 ab	0 a	43 e-g	41 fg	16 de	25 bc	21 a-c	54 bc
5	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	Pink-SS 1C - 4C 2&1PH	30 a-c	0 a	54 d-f	28 ef	18 c-e	34 bc	43 c	24 ab
6	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	Pink-SS 1C - 4C 2&1PH	41 a-c	0 a	73 cd	20 de	7 b-d	31 bc	32 a-c	38 ab
7	Microfine Sulfur 90W 3 lb Topsin M 70W 4 oz + Sulfur 90W 3 lb	P-PF, 3C-4C SS-2C, 2&1PH	36 a-c	0 a	58 de	36 fg	7 b-d	48 ab	35 bc	18 ab
8	Microfine Sulfur 90W 3 lb USF2010 500SC 3.0 fl oz	P-PF, 3C-4C SS-2C, 2&1PH	15 a-c	1 a	89 a-c	11 b-d	1 ab	86 a	13 ab	2 a
9	Microfine Sulfur 90W 3 lb Elite 45DF 1.74 oz + Flint 50WG 1.56 oz	P-PF, 3C-4C SS-2C, 2&1PH	60 bc	4 a	80 bc	14 cd	6 ab	58 ab	28 a-c	14 ab
10	Indar 75W 1 oz+ B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	22 a-c	3 a	82 bc	13 cd	6 a-c	61 ab	33 a-c	7 ab
11	Pristine 38WDG 7.25 oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	43 a-c	0 a	89 ab	9 a-c	2 ab	49 ab	29 a-c	23 ab
12	V10116 1.81Fl 2.83 fl oz+ B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	22 a-c	0 a	96 a	4 a	0 a	93 a	7 a	0 a
13	V10116 50WD 1.28 oz + B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	65 c	0 a	96 a	4 ab	1 ab	51 ab	37 bc	12 ab

Four single tree replications. Column mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Leaf curl was rated on 25 shoots per tree 10 May. Scab was rated on 40 fruit per tree at harvest: Redhaven 22 Jul; Redgold 9 Aug.
Treatments applied dilute to runoff at 300 psi as follows: 11 March (BS, bud swell, #2-4 only); 7 Apr (P, pink, all treatments); 16 Apr (bloom); 22 Apr (PF, petal fall); 5 May (SS, shuck split); 1st through 4th covers: 21 May, 3 June, 18 Jun, 2 Jul; 9 Jul (3 wk pre-harvest, 3PH, Redhaven only); 16 Jul (3PH, Redgold only); 19 Jul (1 wk pre-harvest, 1PH, Redhaven only); 2 Aug (1PH, Redgold only).

Table 22. Treatment effects on postharvest brown rot development on Redhaven peach, 2004.

			Non-inoc. fruit / days incubation				Inoculated fruit / days incubation			
			% fruit with brown rot			% no rots	% fruit with brown rot			% no rots
	Treatment and rate/100 gal dilute	Timing	3 days	4 days	5 days	6 days	3 days	4 days	5 days	6 days
0	No fungicide	---	19 c	51 e	83 e	5 g	11 cd	46 e	89 f	4 g
1	Microfine Sulfur 90W 3 lb	P- PH	16 c	50 de	70 e	14 g	19 d	44 e	59 e	26 f
2	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	BS P- 4C 2&1PH	0 a	5 ab	23 cd	60 de	1 ab	8 b-d	20 bc	59 c-e
3	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb Pristine 38WDG 7.25 oz	BS P- 4C 2&1PH	3 a	8 ab	18 bc	68 cd	6 a-d	11 cd	24 bc	64 b-e
4	Kocide 2000 35DF 3 lb Microfine Sulfur 90W 3 lb Topsin M 70W 4 oz + Sulfur 90W 3 lb	BS P- 4C 2&1PH	10 bc	30 cd	41 d	35 f	8 b-d	19 d	46 de	44 ef
5	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	Pink-SS 1C - 4C 2&1PH	0 a	4 ab	8 a-c	80 a-c	1 ab	4 a-c	11 ab	69 a-d
6	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	Pink-SS 1C - 4C 2&1PH	3 ab	9 a-c	13 a-c	71 b-d	1 ab	6 b-d	13 a-c	73 a-d
7	Microfine Sulfur 90W 3 lb Topsin M 70W 4 oz + Sulfur 90W 3 lb	P-PF, 3C-4C SS-2C, 2&1PH	6 ab	13 bc	20 bc	48 ef	6 a-c	18 d	29 cd	56 de
8	Microfine Sulfur 90W 3 lb USF2010 500SC 3.0 fl oz	P-PF, 3C-4C SS-2C, 2&1PH	0 a	4 ab	6 ab	85 a	0 a	6 a-c	11 ab	83 ab
9	Microfine Sulfur 90W 3 lb Elite 45DF 1.74 oz + Flint 50WG 1.56 oz	P-PF, 3C-4C SS-2C, 2&1PH	0 a	3 ab	4 ab	84 ab	1 ab	3 a-c	14 a-c	75 a-d
10	Indar 75W 1 oz+ B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	0 a	1 ab	5 ab	73 b-d	1 ab	0 a	4 a	84 ab
11	Pristine 38WDG 7.25 oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	0 a	4 ab	9 a-c	79 a-c	0 a	1 ab	6 ab	84 a-c
12	V10116 1.81Fl 2.83 fl oz+ B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	0 a	1 ab	1 a	89 a	0 a	4 a-c	8 ab	86 a
13	V10116 50WD 1.28 oz + B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	0 a	0 a	3 a	85 ab	0 a	0 a	4 a	88 ab

Four single tree replications. Column mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Treatments applied dilute to runoff at 300 psi as follows: 11 March (BS, bud swell, #2-4 only); 7 Apr (P, pink, all treatments), 16 Apr (bloom); 22 Apr (PF, petal fall); 5 May (SS, shuck split); 1st through 4th covers: 21 May, 3 June, 18 Jun, 2 Jul; 9 Jul (2 wk pre-harvest, 2PH); 19 Jul (1 wk pre-harvest, 1PH). Actual harvest date was 22 Jul, 3 days after the last application.

Table 23. Treatment effects on brown rot development on Redgold nectarine, 2004.

			% brown rot on tree 8 Aug	Non-inoc. fruit / days incubation				Inoculated fruit / days incubation			
				% fruit with brown rot			% no rots	% fruit with brown rot			% no rots
	Treatment and rate/100 gal dilute	Timing		3 days	5 days	6 days	7 days	3 days	5 days	6 days	7 days
0	No fungicide	---	29 f	8 b	51 c	84 de	11 ef	18 c	69 e	86 e	8 f
1	Microfine Sulfur 90W 3 lb	P- PH	13 e	6 ab	59 c	88 e	5 f	13 bc	90 f	98 f	0 g
2	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	BS P- 4C 2&1PH	9 de	0 a	5 ab	18 ab	73 ab	1 a	13 ab	25 ab	59 ab
3	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb Pristine 38WDG 7.25 oz	BS P- 4C 2&1PH	5 b-d	0 a	6 ab	18 ab	78 ab	0 a	24 a-c	34 bc	53 bc
4	Kocide 2000 35DF 3 lb Microfine Sulfur 90W 3 lb Topsin M 70W 4 oz + Sulfur 90W 3 lb	BS P- 4C 2&1PH	5 c-e	3 ab	13 ab	42 c	47 cd	15 c	53 de	60 d	23 de
5	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	Pink-SS 1C - 4C 2&1PH	2 a-c	3 ab	18 b	33 bc	61 bc	3 ab	31 b-d	40 bc	55 bc
6	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb Indar 75W 1 oz+ B-1956 8 fl oz	Pink-SS 1C - 4C 2&1PH	2 a-c	0 a	9 a	13 a	83 a	0 a	16 ab	25 ab	71 ab
7	Microfine Sulfur 90W 3 lb Topsin M 70W 4 oz + Sulfur 90W 3 lb	P-PF, 3C-4C SS-2C, 2&1PH	8 de	6 b	49 c	68 d	25 de	16 c	75 e	84 e	10 ef
8	Microfine Sulfur 90W 3 lb USF2010 500SC 3.0 fl oz	P-PF, 3C-4C SS-2C, 2&1PH	4 a-c	0 a	8 ab	19 ab	75 ab	4 ab	21 a-c	41 b-d	53 bc
9	Microfine Sulfur 90W 3 lb Elite 45DF 1.74 oz + Flint 50WG 1.56 oz	P-PF, 3C-4C SS-2C, 2&1PH	0 a	0 a	3 a	13 ab	80 ab	3 ab	38 cd	53 cd	36 cd
10	Indar 75W 1 oz+ B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	2 ab	0 a	8 ab	14 ab	74 ab	3 ab	10 a	13 a	76 a
11	Pristine 38WDG 7.25 oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	3 a-c	0 a	5 ab	8 a	90 a	1 a	14 ab	28 b	65 ab
12	V10116 1.81Fl 2.83 fl oz+ B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	1 ab	1 ab	14 ab	19 ab	80 ab	0 a	25 a-c	35 bc	59 ab
13	V10116 50WD 1.28 oz + B-1956 8 fl oz Microfine Sulfur 90W 3 lb	P-1C, 2&1PH 2C-4C	0 a	0 a	5 ab	11 a	85 a	1 a	13 ab	26 ab	69 ab

Four single tree replications. Column mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Treatments applied dilute to runoff at 300 psi as follows: 11 March (BS, bud swell, #2-4 only); 7 Apr (P, pink, all treatments), 16 Apr (bloom); 22 Apr (PF, petal fall); 5 May (SS, shuck split); 1st through 4th covers: 21 May, 3 June, 18 Jun, 2 Jul. 16 Jul (3 wk pre-harvest, 3PH, Redgold only); 2 Aug (1 wk pre-harvest, 1PH). Actual harvest date was 9 Aug, 7 days after the last application.

APPLE (*Malus domestica*, 'Golden Delicious', 'York Imperial', and 'Idared')
Scab; *Venturia inaequalis*

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EVALUATION OF MPCA P130A AS A BIOFUNGICIDE FOR CONTROL OF APPLE SCAB, 2003-04.

The objective of this project, funded through the IR-4 Biopesticide Research Program, was to evaluate the effect of a fall field application (Nov. '03) of an antagonistic fungus (*Microsphaeropsis ochracea*, MPCA P130A) on overwintering of the apple scab fungus, ascospore discharge and subsequent primary infection in established test blocks the spring 2004. The goal was to reduce primary inoculum thereby improving the relative efficacy of the within-season organic and conventional treatments. The standard for comparison to this approach was Topsin M + urea, recognized to have an effect on suppression of ascospore discharge.

MATERIALS AND METHODS

MPCA P130A was supplied by Engage Agro, Guelph, Ont. Each treatment was applied to a single, uniform 0.86 acre block containing apple cvs. Golden Delicious, York Imperial and Idared, planted as three-tree sets. In spring 2004, each treatment block was subdivided to contain four-replicate sets of nontreated control trees and four-replicate sets/block was be treated with Kocide / sulfur (2 lb/ 100 gal dilute) suitable for organic production. Plot setup facilitated statistical analysis within the blocks. Comparative ascospore discharge was monitored through most of the primary infection period (to 10 May) with Rotorod spore traps, placed near the center of each block, activated by a single wetness sensor which triggered the traps in each test plot to run and stop running simultaneously. Primary foliar scab was rated on the oldest six leaves of evaluation shoots. Mean separation is by Waller-Duncan k-ratio t-test (p=0.05).

Fall Treatments 2003: All fall treatments were applied to the trees and row middle areas via airblast sprayer 17 Nov '03 at 50-70% leaf fall. Border areas adjacent to Plot #2 (Topsin M + urea) were also covered to reduce potential interference from inoculum outside the test area.

Spring treatments: (dilute treatments, blocked replications for statistical analysis of fall treatment effect):

0 – No spring fungicide treatment.
1 – Kocide 2000 1.5 lb/100 gal only, 29 Mar; followed by sulfur 2 lb/100 gal, 6 Apr and later apps.
2 – Microfine sulfur 2 lb / 100 gal, 6 Apr and later applications.
3 – Nova+Syllit started at 5 May and later cover sprays applications.

2004 treatment application schedule (all cvs): 29 Mar. (silver tip, Trt. #1 Kocide 2000 1.5 lb / 100 gal only); Microfine sulfur 2 lb / 100 gal Trts. 1 & 2: 6 Apr (1/2' green- tight cluster); 15 Apr (open cluster); 22 Apr (full bloom-petal fall); 30 Apr (petal fall); Trts. 1, 2 & 3: 5 May (1st cover); 20 May (2nd cover); 3 June (3rd cover); 18 June (4th cover).

2004 plot maintenance schedule: 29 March (Asana XL 2E 5 fl oz); 19 Apr (Agri-Mycin 17 8 oz + LI-700 1 pt /100 gal); 23 April (BacMaster 8 oz + Regulaid 4 fl oz /100 gal); 6 May (Intrepid 4 fl oz + Provado 2 fl oz / 100 gal); 13 May (Bayleton 1 oz/ 100 gal); 25 May (Asana 4 fl oz/100 gal); 27 May (Sevin XLR 2 pt + Lannate LV 1.5 pt/A); 7 Jun (Lannate LV 1 pt/A); 16 June (Provado 2 fl oz + Imidan 1 lb/A). 30 Jun and 13 Jul (Imidan 1 lb + Lannate LV 1 pt/A).

RESULTS

Scab ascospore trap counts (presumed spore discharge) were quite variable from plot area to plot area over the monitoring period (Table 1). During an early heavy infection period 30 Mar-3 Apr, the Topsin M + urea plot area had more total spores than the other three areas combined. During a more brief collection period 8 Apr, more spores were trapped in the non-treated plot area, and the treated areas were about equal. During another relatively heavy collection period 23-24 Apr, the fewest spores were trapped in the P130A + urea treated area. Surprisingly, the heaviest spore collection occurred 1-2 May, after petal fall, more than six weeks after the first spores were trapped in the AREC orchards, and a week after primary lesions first appeared. In this collection the number trapped in the P130A + urea treated area exceeded by 4X the next closest plot area in counts and by 6X the non-treated area.

Scab infection: In 2004, Golden Delicious trees in the fall plot Topsin M + urea treatment had significantly less foliar scab than the non-treated area trees (Table 2). Idared trees in the fall plot area treated with Topsin M + urea had significantly less foliar scab than the non-treated area trees (Table 3). and less fruit scab than the non-treated area trees (Table 4). In no case did either MPCA treatment significantly reduce scab incidence; in fact, on York Imperial, MPCA had more scab on foliage (Table 5), and MPCA + urea had significantly more fruit infected with scab than the trees in the non-treated area (Table 6).

DISCUSSION

Although the spore trap counts were rather erratic, significant reductions in scab by the fall Topsin M + urea treatment on the Golden Delicious and Idared cultivars shows that significant results were achievable under this test design. It is possible that results with the biofungicide might have been improved by earlier application timing. Although the protocol that was suggested to us called for intended application timing near leaf drop, a recent publication (1) indicates that in Quebec the best results were obtained when *M. ochracea* was applied in August. This timing should be targeted in future studies.

REFERENCE:

1. Carisse, O. and D. Rolland. 2004. Effect of timing of application of the biological control agent *Microsphaeropsis ochracea* on the production and ejection pattern of ascospores by *Venturia inaequalis*. Phytopathology 94:1305-1314.

Table 1. Rotorod trap counts of *Venturia* ascospore in MPCA P130A test plot areas.

Rod set	Date	Hours ran	Scab inf. period?	Number of ascospores trapped in plot area: 1-untreated	2- Topsin + urea	3- P130A	4- P130A + urea
1	24-25 March	11	No	0	0	0	0
2	25-26 March	12	No	0	0	0	0
3	27 March	11	No	0	1	1	0
4	30-31 March	18	Heavy	0	0	0	0
5	31 Mar-1 Apr	20		0	0	0	0
6	1-2 Apr	24		3	10	4	1
7	2-3 Apr	24		0	0	0	0
8	4 Apr	4	No	0	0	0	0
9	8 Apr	7	No	22	11	15	14
10	8-9 Apr	16	Light	0	0	0	0
11	11-12Apr	25	Heavy	0	0	0	1
12	12 Apr	7		2	5	5	1
13	12-13 Apr	18		0	0	0	0
14	13 Apr	6		0	0	0	0
15	13-14 Apr	18	No	0	1	0	0
16	20-21 Apr	11	Light	0	0	0	0
17	23 Apr	7	No	0	0	0	0
18	23-24 Apr	10	Light	15	13	16	2
19	25-26 Apr	17	Heavy	3	2	4	4
20	26-27 Apr	22		--	--	--	--
21	1-2 May	16	Moderate	18	27	20	108
22	5 May	13	No	0	0	0	0
23	10 May	3	No	0	0	0	0
	Total spores collected			**63**	**70**	**65**	**131**

Table 2. Scab infection on Golden Delicious apple leaves, 2004

Fall plot treatment rates/A	0- None % lvs	0- None les/lf	1- Kocide/S % lvs	1- Kocide/S les/lf	2- Sulfur % lvs	2- Sulfur les/lf	3-Nova+Syllit % lvs	3-Nova+Syllit les/lf	Fall plot mean scab infection % lvs	Fall plot mean scab infection les/leaf
1 Untreated control	27.1	0.52	5.6	0.07	13.2	0.16	15.3	0.25	**15.3 b**	**0.25 b**
2 Topsin-M 8 oz + urea 1 lb	8.3	0.11	7.0	0.07	5.6	0.07	0.0	0.00	**5.2 a**	**0.06 a**
3 MPCA P130A 107.5 ml + Nu-Film 17 1 pt	18.8	0.31	9.8	0.12	17.4	0.29	20.8	0.32	**16.7 b**	**0.26 b**
4 MPCA P130A 107.5 ml + Nu-Film 17 1 pt + urea 1 lb	18.8	0.76	8.4	0.13	13.9	0.30	25.0	0.32	**16.5 b**	**0.38 b**
Spring '04 treatment means:	**18.3**	**0.43**	**7.7**	**0.10**	**12.5**	**0.21**	**15.3**	**0.22**		

Spring treatments: scab, % leaves infected, lesions/leaf

Table 3. Scab infection on Idared apple leaves, 2004

Fall plot treatment rates/A	0- None % lvs	0- None les/lf	1- Kocide/S % lvs	1- Kocide/S les/lf	2- Sulfur % lvs	2- Sulfur les/lf	3-Nova+Syllit % lvs	3-Nova+Syllit les/lf	Fall plot mean scab infection % lvs	Fall plot mean scab infection les/leaf
1 Untreated control	18.1	0.27	13.2	0.14	17.4	0.30	9.8	0.17	**14.6 b**	**0.22 b**
2 Topsin-M 8 oz + urea 1 lb	11.1	0.13	8.4	0.11	4.9	0.05	9.8	0.12	**8.6 a**	**0.10 a**
3 MPCA P130A 107.5 ml + Nu-Film 17 1 pt	18.8	0.23	9.7	0.13	13.2	0.17	13.9	0.27	**13.8 b**	**0.20 b**
4 MPCA P130A 107.5 ml + Nu-Film 17 1 pt + urea 1 lb	11.1	0.19	7.7	0.12	7.7	0.13	12.5	0.16	**9.8ab**	**0.15 ab**
Spring '04 treatment means:	**14.8**	**0.21**	**9.8**	**0.13**	**10.8**	**0.16**	**11.5**	**0.18**		

Spring treatments: scab, % leaves infected, lesions/leaf

Foliar data based on the oldest six leaves of six shoots from each of four single-tree reps 13 May '04.

Table 4. Scab infection on Idared apple fruit, 2004

Fall plot treatment rates/A	Spring treatments: scab, % fruit infected				Fall plot mean scab infection
	0- None	1- Kocide/S	2- Sulfur	3-Nova+Syllit	
1 Untreated control	100	71	85	64	**80**
2 Topsin-M 8 oz + urea 1 lb	75	36	35	64	**53**
3 MPCA P130A 107.5 ml + Nu-Film 17 1 pt	82	90	65	68	**76**
4 MPCA P130A 107.5 ml + Nu-Film 17 1 pt + urea 1 lb	88	83	--	35	**77**
Spring '04 treatment means:	**86**	**70**	**62**	**58**	

Based on 13-43 fruit per fall treatment area 20 July '04.

Table 5. Scab infection on York Imperial apple leaves, 2004

Fall plot treatment rates/A	Spring treatments: scab, % leaves infected, lesions/leaf								Fall plot mean scab infection	
	0- None		1- Kocide/S		2- Sulfur		3-Nova+Syllit			
	% lvs	les/lf	% lvs	les/lf	% lvs	les/lf	% lvs	les/lf	% lvs	les/leaf
1 Untreated control	16.7	0.43	15.3	0.23	22.2	0.58	29.2	0.53	**20.9 a**	**0.44 a**
2 Topsin-M 8 oz + urea 1 lb	30.6	1.47	13.2	0.43	17.4	0.25	27.8	0.56	**22.3 a**	**0.68 a**
3 MPCA P130A 107.5 ml + Nu-Film 17 1 pt	46.5	1.79	34.0	1.01	23.6	0.62	33.4	0.84	**34.4 b**	**1.07 a**
4 MPCA P130A 107.5 ml + Nu-Film 17 1 pt + urea 1 lb	31.9	1.29	19.4	0.75	17.4	0.49	15.3	0.35	**21.0 a**	**0.72 a**
Spring '04 treatment means:	**31.4**	**1.25**	**20.5**	**0.61**	**20.2**	**0.49**	**26.4**	**0.57**		

Foliar data based on the oldest six leaves of six shoots from each of four single-tree reps 27 May '04.

Table 6. Scab infection on York Imperial apple fruit, 2004

Fall plot treatment rates/A	Spring treatments: scab, % fruit infected				Fall '03 plot, mean scab infection
	0- None	1- Kocide/S	2- Sulfur	3-Nova+Syllit	
1 Untreated control	71.0	45.8	50.0	40.0	**51.7 a**
2 Topsin-M 8 oz + urea 1 lb	66.0	42.9	53.0	46.4	**52.1 a**
3 MPCA P130A 107.5 ml + Nu-Film 17 1 pt	89.0	61.7	43.0	68.0	**65.4 ab**
4 MPCA P130A 107.5 ml + Nu-Film 17 1 pt + urea 1 lb	79.6	52.6	68.6	67.9	**67.2 b**
Spring '04 treatment means:	**76.4**	**50.8**	**53.7**	**55.6**	

Based on 28-100 fruit per fall treatment area 20 July '04.

Management of Peach Scab and Leaf Curl: Influence of Fungicide Application at Bud Swell on Disease Incidence and Sporulation

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Past and current studies have indicated that fungicides applied at bud swell for control of leaf curl may have the additional benefit of controlling scab infection on fruit. Fungicides with different chemistries that act as either systemics (strobulurin) or preventatives (ziram, chlorothalonil, copper) were applied at bud swell and tested for efficacy against both leaf curl and scab infection. In addition, the effect of these fungicides on scab twig lesion development and sporulation was also examined.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2004 growing season. The test blocks consisted of 8-year-old 'Redgold' nectarine and 'Encore' peach orchards. Trees were planted at 25 ft x 25 ft spacing. Treatments were replicated four times in a randomized complete block design with single tree plots for each block. 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. Fungicide applications were made on the following dates and tree growth stages: 18 Mar (BS, bud swell); 5 May (SS, shuck split); and 14, 27 May, 10, 24 Jun, 8 Jul (1C-5C, 1^{st} though 5^{th} cover). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Sporadic cold periods from mid-March to mid-April prolonged bud development during spring (Fig. 1). Buds were most susceptible to leaf curl infection between bud swell (14 Mar) and pink (10 Apr). Six rainy periods with >0.10 inches accumulation occurred during this period. For some of these wet periods, temperatures were favorable for pathogen development (45 F to 78.8 F). However, for the majority of the susceptibility period, either temperatures were too cool or there were no rainy periods.

Frequent rainfalls throughout the spring and summer were favorable for the development of scab. The number of rain days with >0.10 inches of accumulation following each spray were: BS, 12; SS, 1; 1C, 6; 2C, 5; 3C, 4; 4C, 1 and 5C, 1.

Assessment. Leaf Curl (*Taphrina deformans*) was evaluated on 12 & 13 May for Redgold and 19 - 24 May for Encore by examining 25 fruiting shoots per tree. Total buds and infected buds on each shoot were counted and percentage buds infected was calculated.

Scab (*Fusicladosporium carpophilum*) was assessed on fruit by counting the lesions on 40 fruit arbitrarily selected from each replicate tree. When lesions coalesced and could not be counted individually, the number of lesions was estimated. A marker was used to mark the counted lesions or areas to keep track of what had been counted. Redgold and Encore fruit were assessed on 29 June – 1 July and 9 – 13 July, respectively.

Sporulation on Regold twigs was assessed by arbitrarily selecting ten twigs from each replicate tree on 15 June. The twigs were cut to 15 cm length (distal end), then washed in deionized water and dried. They were then incubated at high humidity (>95% RH) at 25 C constant temperature. After 24 hours incubation, the twigs from each replicate tree were placed in a flask of deionized water and shaken vigorously for 30 seconds to dislodge the conidia. A spore suspension aliquot (2 ml) from each sample was centrifuged at 5300 rpm for 10 minutes. The number of spores per ten twig sample was estimated using a hemacytometer. This process was repeated for all treatments. After the twigs had been rinsed of spores, they were placed in plastic bags and stored in a refrigerator.

To determine twig and lesion area, five twigs were randomly chosen from the ten selected for assessing sporulation. The bark on each twig was slit longitudinally with a scalpel and peeled away from the wood using a fingernail. The flattened bark was placed under a transparency and the bark perimeter traced and lesions colored using a black marker. The transparency was copied onto a white sheet of paper to create an opaque image that was scanned into a computer at 150 dpi. Twig and lesion areas were calculated by digital image analysis software (Assess, APS Press).

RESULTS AND DISCUSSION

Leaf Curl. Those treatments in the Redgold block not receiving a bud swell spray, the nontreated control and Bravo/Captan treatment, each sustained approximately 39% bud infection (Table 1). The Topsin-M and Abound treatments had slightly less disease incidence than the nonsprayed, but were not significantly different from it. Leaf curl incidence for the remaining treatments was significantly lower than Topsin-M and Abound. The fungicide applied at bud swell and percent control achieved were: Bravo (100%); Ziram (99.7%); Pristine (86.0%); Flint (79.4%); and Champ (67.7%).

The Encore block had very little leaf curl infection; only 3.4% bud infection occurred in the nontreated control (Table 2). Consequently, mean separation was poor and no treatment was significantly different from the control.

Fruit Scab. The nontreated fruit in both blocks had a very high level of scab infection and severity (Tables 1 & 2). All treatments drastically reduced disease severity as evidenced by the reduction in the # lesions/fruit. However, treatments with the bud swell spray did not have a significant improvement in disease control over the standard treatment that received sprays starting at shuck split. It is likely that the large amount of scab inoculum and the effectiveness of the standard fungicide program (Bravo at SS and Captan for the cover sprays) masked any effect of the much earlier bud swell treatments.

Scab development on twigs. No significant differences in twig disease severity (% area infected) were observed among any of the Redgold treatments (Table 1). However, all fungicide treatments had significantly less sporulation then the non-treated control. The standard scab program, which did not receive the bud swell application, had 36% less conidia/mm^2 lesion than the nonsprayed. Although all other treatments which received a bud swell spray had less sporulation than this standard, most were not significantly different from it. Only those twigs which received Flint at bud swell had significantly less sporulation than the standard. This treatment reduced sporulation 46% and 66% below that of the standard and nonsprayed control, respectively.

CONCLUSIONS

- Redgold nectarine was more susceptible to leaf curl than Encore peach.
- The protectant fungicides Ziram and Bravo WeatherStik were most effective at controlling leaf curl. Pristine, Flint, and Champ also had good results.
- The combination of Bravo WeatherStik 6F at SS and Captan during the cover sprays was very effective in controlling the amount of fruit scab. None of the bud swell sprays significantly improved control when added to the standard Bravo/Captan program.
- The standard protectant scab program (Bravo/Captan) resulted in a significant and unexpected reduction in sporulation on twig lesions. Both chlorothalonil and captan act as fungicides by general disruption of enzyme activity. Thus, it is conceivable that the one Bravo and three Captan applications prior to twig harvest had some "anti-sporulant" effect on the superficial twig lesions.
- Fungicide application at bud swell had no effect on scab twig lesion development, as measured by twig disease severity. Although some scab lesions become visible as late as spring, infection takes place during the prior growing season. Thus, latent lesion development may have been too advanced to be influenced by bud swell fungicide application.
- We did not observe any further significant reduction in sporulation after addition of most fungicides at bud swell to the standard program. Thus, the unexpected antisporulant activity of the standard program may have masked the effect of these earlier sprays. However, we note that all seven of these control programs yielded less sporulation than the standard.
- Flint was the only fungicide applied at bud swell that significantly reduced scab sporulation below that of the standard. However, this reduction in inoculum did not translate into a significant reduction in scab incidence and severity on fruit (relative to the standard). Thus, additional experimentation is needed to confirm Flint's ability to act as a strong antisporulant.
- In general, application of fungicide at bud swell does not appear to provide any significant benefit for subsequent management of peach scab. However, our results showed significant anti-sporulant activity for most fungicides. Thus, application of these materials much closer to the time of fruit infection, such as during bloom, may well provide the additional scab control desired, as well as control of blossom blight.

TABLE 1. Leaf Curl and Scab Incidence and Severity on Redgold							
			Leaf Curl [1]	Scab Twig Lesion [1]		Fruit Scab [1]	
Treatment	Rate / A	Timing	% Buds infected	% Area infected	# Conidia / mm^2 lesion	% Fruit infected	# Lesions / fruit
Nontreated	--------	--------	39.3 a	44.7 a	627.4 a	100.0 a	257.5 a
Bravo WeatherStik 6F Captan 80WDG	4.0 pt 3.75 lb	SS 1C-6C	39.1 a	43.9 a	400.5 b	45.6 b	6.4 b
Ziram 76 DF Bravo WeatherStik 6F Captan 80WDG	8.0 lb 4.0 pt 3.75 lb	BS SS 1C-6C	0.1 b	39.5 a	365.72 b	51.9 b	10.8 b
Bravo WeatherStik 6F Bravo WeatherStik 6F Captan 80WDG	4.0 pt 4.0 pt 3.75 lb	BS SS 1C-6C	0.0 b	47.7 a	343.6 bc	54.4 b	8.0 b
Champ Formula 2 Bravo WeatherStik 6F Captan 80WDG	10.0 pt 4.0 pt 3.75 lb	BS SS 1C-6C	12.7 b	39.8 a	275.1 bc	53.8 b	7.9 b
Topsin-M 70WP Bravo WeatherStik 6F Captan 80WDG	2.25 lb 4.0 pt 3.75 lb	BS SS 1C-6C	31.5 a	39.4 a	309.7 bc	47.5 b	7.4 b
Abound 2.08F Bravo WeatherStik 6F Captan 80WDG	15.4 fl oz 4.0 pt 3.75 lb	BS SS 1C-6C	34.9 a	40.9 a	354.9 bc	49.4 b	5.5 b
Flint 50WG Bravo WeatherStik 6F Captan 80WDG	4.0 oz 4.0 pt 3.75 lb	BS SS 1C-6C	8.1 b	38.3 a	216.2 c	51.3 b	7.6 b
Pristine 38WG Bravo WeatherStik 6F Captan 80WDG	14.5 oz 4.0 pt 3.75 lb	BS SS 1C-6C	5.5 b	38.9 a	258.1 bc	51.0 b	8.7 b

[1] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, $K=100$).

TABLE 2. Leaf Curl and Scab Incidence and Severity on Encore					
			Leaf curl [1]	Scab incidence and severity [1]	
Treatment	**Rate / A**	**Timing**	**% Buds infected**	**% Fruit infected**	**# Lesions / fruit**
Nontreated Control	--------	--------	3.4 ab	100.0 a	581.3 a
Bravo WeatherStik 6F Captan 80WDG	4.0 pt 3.75 lb	SS 1C-6C	7.9 a	67.5 b	31.0 b
Ziram 76DF Bravo WeatherStik 6F Captan 80WDG	8.0 lb 4.0 pt 3.75 lb	BS SS 1C-6C	0.0 b	68.8 b	22.4 b
Bravo Weatherstik 6F Captan 80WDG	4.0 pt 3.75 lb	BS, SS 1C-6C	0.4 ab	59.8 b	17.7 b
Abound 2.08F Bravo WeatherStik 6F Captan 80WDG	15.4 fl oz 4.0 pt 3.75 lb	BS SS 1C-6C	3.3 ab	69.4 b	21.1 b
Flint 50WG Bravo WeatherStik 6F Captan 80WDG	4.0 oz 4.0 pt 3.75 lb	BS SS 1C-6C	3.1 ab	63.8 b	33.3 b
Pristine 38WG Bravo WeatherStik 6F Captan 80WDG	14.5 oz 4.0 pt 3.75 lb	BS SS 1C-6C	1.1 ab	70.0 b	29.0 b

[1] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, K=100).

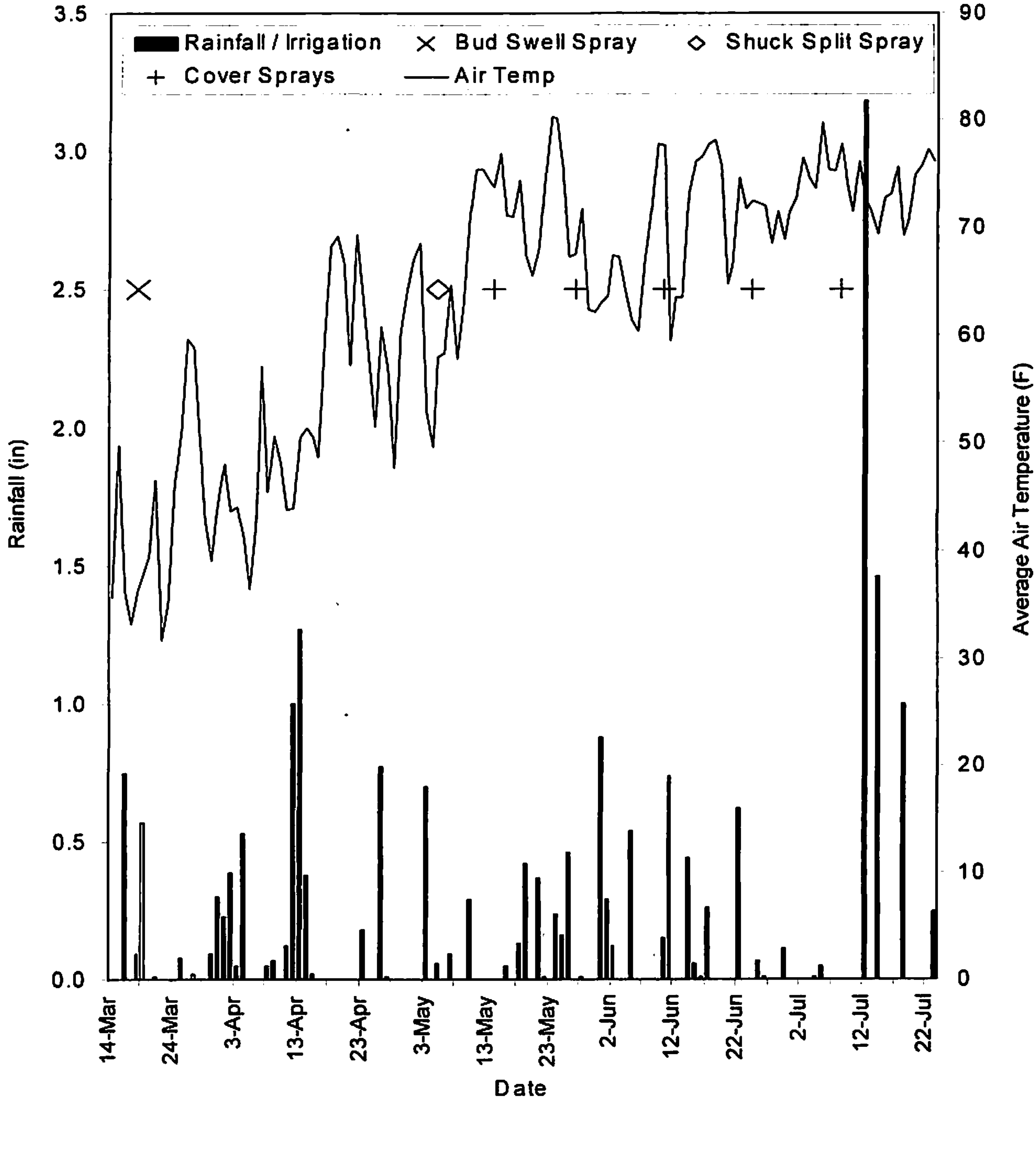

Figure 1. Rainfall, air temperature, and fungicide application timing on 'Encore' peach and 'Redgold' nectarine during the 2004 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. X, diamond, and + symbols represent application timing for bud swell (BS), shuck-split (SS), and 1st through 5th cover (1C-5C) respectively.

Management of Brown Rot, Scab, and Rusty Spot of Peach using DMI, QoI, and Biorational Fungicides

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Fungicides of different chemistry were examined in various combinations for their efficacy against one or more important peach diseases. Particular emphasis was placed on integrating DMI and QoI fungicides. These combinations were compared to each other and to the current standards for each disease. In addition, the biorational product Kaligreen (potassium bicarbonate) was examined for its efficacy against rusty spot and peach scab. Also, boscalid (Endura), a component of Pristine, was examined full season for its disease control capability.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2004 growing season. The test block consisted of mixed-cultivar orchard of 9-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. Only 'Autumnglo' trees were used in the experiment.

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.

Fungicide applications were made on the following dates and tree growth stages: 8 Apr (P, pink); 18 Apr (B, bloom); 30 Apr (PF, petal fall); 10 May (SS, shuck split); and 19 May, 2, 16, 30 Jun, 14, 26 Jul, 9 Aug (1C-7C, 1st through 7th cover). During the ripening period from late August through early September, two sprays for fruit rot control were applied at 14 and 2 DPH (days preharvest) on 20 Aug and 1 Sep, respectively. One treatment (Indar) received a single delayed preharvest application on 24 Aug (10 DPH). All trees in the block received Ziram 76DF at 4.0 lb/A on March 4th (bud swell) for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. The frequent rainfalls throughout the spring and much of the summer were favorable for the development of blossom blight, scab, and the harvest and post harvest rots (Figure 1). The warm weather between PF (Apr 30) and 2C (Jun 2) was conducive for rusty spot; however several rainy periods during this time kept incidence fairly low. The number of rain days with over >0.10 inch accumulation following each spray were: P, 4; B, 2; PF, 1; SS, 2; 1C, 7; 2C, 5; 3C, 3; 4C, 1; 5C, 3; 6C, 3 and 7C, 4. Conditions were favorable for brown rot on Autumnglo during its pre-harvest period due to inoculum in the block from untreated earlier cultivars and 6 rain periods with >0.10 inch accumulation in the month prior to harvest. For the treatments receiving two preharvest sprays, the number of rain days following each spray during this time was: 14 DPH, 1 and 2 DPH, 0. Only one rain event followed the treatment receiving one preharvest spray.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 25 May through 8 Jun by examining 25 fruiting shoots per tree. Rusty spot (*Podosphaera leucotricha*) was evaluated on 21 Jun by examining 40 fruit per tree. Scab (*Fusicladosporium carpophilum*) was evaluated at harvest on 3 Sept by examining 40 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 3 Sep by examining all fruit on four or more branches per replicate tree; a minimum of 100 fruit / tree was examined. For post-harvest evaluations, 40 healthy fruit (w/o visible symptoms) were harvested from each tree and placed on benches in a shaded greenhouse (ave. air temp. = 23.3°C). Brown rot, Rhizopus rot (*Rhizopus* spp.), and Anthracnose rot (*Colletotrichum gloeosporioides*) were assessed at 4 and 7 days postharvest (dph). For some replicates, early fruit loss from very severe brown rot disease pressure resulted in smaller sample sizes (# fruit) for the scab, brown rot, and postharvest disease assessments; in these cases, all available fruit were used for assessment.

RESULTS AND DISCUSSION

Blossom Blight. Non-sprayed trees had a 5% canker incidence, which is higher than most years (Table 1). Wet weather during pink and bloom stages and inoculum from mummies that overwintered on the ground and in trees were likely responsible for the higher disease levels. Most treatments reduced the level of blossom blight relative to the non-sprayed control. However, the treatment with Pristine applied at pink and PropiMax at bloom and one of the three treatments with PropiMax applied at pink and bloom reduced canker incidence to 2% which was not significantly different from the control.

Rusty Spot. Non-sprayed control trees had 31.2% infected fruit and an average severity of 0.4 lesions per fruit. All treatments significantly reduced disease levels when applied at the critical period for susceptibility for rusty spot between petal fall and second cover (Table 2). The Pristine and Nova treatment and both USF2010 treatments had the most effective rusty spot control; all provided control equivalent to the standard consisting of four Nova applications. Kaligreen provided the least amount of control. Endura and V10118 had intermediate levels of fruit infection.

Scab. A combination of high inoculum (twig lesions) and 21 rainy periods (> 0.10 in) from SS to 40 days before harvest resulted in extremely high disease pressure for scab. Control trees had 100% of their fruit with >10 lesions; many fruit were covered by large areas of coalescing lesions (Table 3). Kaligreen and Endura had no significant effect on scab. The standard treatments sprayed with Bravo WeatherStik at SS and Captan for the cover sprays had significantly less incidence and severity of scab than all the other treatments. Both rates of USF2010 provided intermediate levels of disease control. Although, none of the treatments provided acceptable control, inoculum levels in this orchard rarely, if ever, are approached in a commercial setting; thus all mean comparisons should be considered relative to the standard.

Brown Rot. At harvest, the non-sprayed trees in the test block had an 88.3% incidence of brown rot (Table 4). The wet weather throughout much of the growing season and a large amount of inoculum on earlier maturing cultivars in the test block contributed to the high disease level. All treatments provided significant control of brown rot at harvest. The Flint/Elite preharvest treatment was uncharacteristically the least effective, yielding only 25.9% disease control; this was probably due to the low efficacy provided by Kaligreen during the cover sprays. In contrast, the Pristine/Indar treatment and the full season USF2010 treatments attained 95-97% control of brown rot. These treatments and the one preharvest spray of Indar provided control equivalent to the standard. The anilide Endura provided 72.5% control and had significantly higher disease incidence than the standard Indar (92% control).

For the postharvest study, healthy mature fruit with yellow backround color were selected for study. However, since most of the ripe fruit for the non-sprayed control were showing symptoms of rot at harvest, not enough healthy fruit remained to include this treatment in the postharvest assessment.

Post-harvest brown rot development was severe, attaining a high percentage of rotted fruit for many of the treatments after 4 and 7 days incubation (Table 4). After four days, the treatments with the Flint/Elite applied at preharvest had significantly higher infection than any other treatment (again, most likely a result of using Kaligreen mid-season). Pristine/Indar, both rates of USF2010, one pre-harvest spray of Indar, and Endura provided postharvest rot control equivalent to the Indar standard at both 4- and 7-dph. However, the high rate of USF2010 had significantly less disease incidence than the Endura treatment.

Rhizopus Rot. The amount of Rhizopus at harvest was low, ranging from 0 to 2% (Table 5). After 7 days incubation, all treatments had some fruit with Rhizopus; disease levels ranged from 0.6% for the high rate of USF2010 to 14.7% for the Endura. USF2010 at 5.97 fl oz provided significantly better rot control than either the Indar standard or Endura.

Anthracnose Rot. Although disease levels were relatively low in grower orchards and in the test block, more anthracnose was seen this year than in prior years. Most treatments at harvest had some incidence of Anthracnose rot. After 4 and 7 dph, the Endura treatment had significantly higher fruit infection than all other treatments. The remaining treatments had <1% fruit infection and did not differ significantly.

CONCLUSIONS

- No single treatment was highly effective against all diseases.
- The high rate of USF2010 provided excellent control on most diseases with the exception of scab. The high and low rates of USF2010 were not statistically different from each other for any peach disease.

- All treatments provided significant control of rusty spot. However, only the Nova and USF2010 treatments provided acceptable control of rusty spot (<5%).

- Peach scab disease pressure was very high due to favorable weather, a large amount of overwintering inoculum, and the presence of non-sprayed buffer trees. Under these conditions, the standard Bravo/Captan treatment had significantly less incidence and severity of scab than any other treatment.

- Although brown rot disease pressure was intense, several treatments provided excellent control equivalent to the standard. There was no statistical difference in the amount of brown rot between the treatments that provided good control from harvest through 7 days incubation. However, the high rate of USF2010 consistently had the lowest incidence at harvest and at 4 and 7 dph.

- Brown rot control by the single Indar application at 10 DPH was statistically equivalent to the two-spray Indar standard (14 & 2 DPH) at harvest and at both 4- and 7-dph. Nevertheless, the amount of disease observed at all three assessments was always higher for the single-spray program.

- Endura provided excellent control of blossom blight (100%); moderate control of rusty spot (74%), where is would be acceptable as partner; no control of scab (0%); and inadequate control of brown rot (72% control at harvest). Also, Endura was the least effective fungicide against Rhizopus & Anthracnose. Although Endura will not be registered on peach, these results indicate a questionable peach scab disease control contribution for the boscalid component of Pristine.

- The experimental powdery mildew fungicide V10118 yielded reasonably good rusty spot control (76% vs. 98% for Nova), making it acceptable for use as partner.

- The biorational fungicide Kaligreen provided significant, but only partial control of rusty spot (46% control). This activity level, similar to Armicarb and Serenade, should allow it to be an acceptable partner for rusty spot control. Kaligreen was not active against peach scab.

TABLE 1. Blossom Blight Canker Incidence[1]			
Treatment	**Rate/ A**	**Timing**	**% Shoots w/Canker[2]**
Nontreated Control	----------------	----------------	5.0 a
PropiMax EC Nova 40W Nova 40W + BravoWeatherStik 6F Nova 40W + Captan 80WDG Captan 80 WDG Indar 75WSP + Latron B-1956	**4 fl oz** 5 oz 5 oz + 4pt 5 oz + 3.75 lb 3.75 lb 2 oz + 8 fl oz	**P, B** PF SS 1C, 2C 3C–7C 14, 2 DPH	0.0 b
PropiMax EC V10118 EC V10118 EC + BravoWeatherStik 6F V10118 EC + Captan 80WDG Captan 80 WDG Indar 75WSP + Latron B-1956	**4 fl oz** 9.36 fl oz 9.36 fl oz + 4 pt 9.36 fl oz + 3.75 lb 3.75 lb 2 oz + 8 fl oz	**P, B** PF SS 1C, 2C 3C–7C 10 DPH	1.0 b
Pristine 38WG **PropiMax EC** Pristine 38WG Nova 40W + BravoWeatherStik 6F Nova 40W + Captan 80WDG Captan 80WDG Pristine 38WG Indar 75WSP + Latron B-1956	**12.5 oz** **4 fl oz** 14.5 oz 5 oz + 4 pt 5 oz + 3.75 lb 3.75 lb 14.5 oz 2 oz + 8 fl oz	**P** **B** PF SS 1C, 2C 3C – 7C 14 DPH 2 DPH	2.0 ab
PropiMax EC Kaligreen 82SP + Latron B-1956 Flint 50WG Elite 45DF	**4 fl oz** 3 lb + 8 fl oz 4 oz 6 oz	**P, B** PF, SS, 1C-7C 14 DPH 2 DPH	2.0 ab
USF2010 500 SC	**5 fl oz**	**P, B,** PF, SS, 1C-7C 14, 2 DPH	0.0 b
USF2010 500 SC	**5.97 fl oz**	**P, B,** PF, SS, 1C-7C 14, 2 DPH	1.0 b
Endura 70WG	**6.12 oz**	**P, B,** PF, SS, 1C-7C 14, 2 DPH	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 ($P \leq 0.05$, $K=100$).

TABLE 2. Peach Rusty Spot Incidence and Severity [1]

Treatment	**Rate / A**	**Timing**	**% Inf. Fruit**[2]	**# Lesions/Fruit**[2]
Nontreated Control	----------------	----------------	31.2 a	0.425 a
PropiMax EC **Nova 40W** **Nova 40W** + BravoWeatherStik 6F **Nova 40W** + Captan 80WDG Captan 80 WDG Indar 75WSP + Latron B-1956	4 fl oz **5 oz** **5 oz** + 4pt **5 oz** + 3.75 lb 3.75 lb 2 oz + 8 fl oz	P, B **PF** **SS** **1C, 2C** 3C–7C 14, 2 DPH	0.6 c	0.006 c
PropiMax EC **V10118 EC** **V10118 EC** + BravoWeatherStik 6F **V10118 EC** + Captan 80WDG Captan 80 WDG Indar 75WSP + Latron B-1956	4 fl oz **9.36 fl oz** **9.36 fl oz** + 4 pt **9.36 fl oz** + 3.75 lb 3.75 lb 2 oz + 8 fl oz	P, B **PF** **SS** **1C, 2C** 3C–7C 10 DPH	7.5 bc	0.094 bc
Pristine 38WG PropiMax EC **Pristine 38WG** **Nova 40W** + BravoWeatherStik 6F **Nova 40W** + Captan 80WDG Captan 80WDG Pristine 38WG Indar 75WSP + Latron B-1956	12.5 oz 4 fl oz **14.5 oz** **5 oz** + 4 pt **5 oz** + 3.75 lb 3.75 lb 14.5 oz 2 oz + 8 fl oz	P B **PF** **SS** **1C, 2C** 3C – 7C 14 DPH 2 DPH	1.3 c	0.013 bc
PropiMax EC **Kaligreen 82SP + Latron B-1956** Flint 50WG Elite 45DF	4 fl oz **3 lb + 8 fl oz** 4 oz 6 oz	P, B **PF, SS, 1C, 2C,** 3C-7C 14 DPH 2 DPH	16.9 b	0.194 b
USF2010 500 SC	**5 fl oz**	P, B, **PF, SS, 1C, 2C,** 3C-7C 14, 2 DPH	5.0 c	0.050 bc
USF2010 500 SC	**5.97 fl oz**	P, B, **PF, SS, 1C, 2C,** 3C-7C 14, 2 DPH	1.9 c	0.019 bc
Endura 70WG	**6.12 oz**	P, B, **PF, SS, 1C, 2C,** 3C-7C 14, 2 DPH	8.1 bc	0.081 bc

[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 ($P \leq 0.05$, K=100).

TABLE 3. Scab Incidence and Severity [1]			% Fruit [2]		
Treatment	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated Control	----------------	----------------	100.0 a	0.0 d	100.0 a
PropiMax EC Nova 40W Nova 40W+**BravoWthrStik 6F** Nova 40W + **Captan 80WDG** **Captan 80 WDG** Indar 75WSP + Latron B-1956	4 fl oz 5 oz 5 oz + **4pt** 5 oz + **3.75 lb** **3.75 lb** 2 oz + 8 fl oz	P, B PF **SS** **1C, 2C** **3C–6C**, 7C 14, 2 DPH	64.0 c	38.5 ab	25.5 c
PropiMax EC V10118 EC V10118 EC+**BravoWthrStik 6F** V10118 EC + **Captan 80WDG** **Captan 80 WDG** Indar 75WSP + Latron B-1956	4 fl oz 9.36 fl oz 9.36 fl oz + **4 pt** 9.36 fl oz + **3.75 lb** **3.75 lb** 2 oz + 8 fl oz	P, B PF **SS** **1C, 2C** **3C–6C**, 7C 10 DPH	69.6 c	43.8 a	25.8 c
Pristine 38WG PropiMax EC Pristine 38WG Nova 40W+**BravoWthrStik 6F** Nova 40W+**Captan 80WDG** **Captan 80WDG** Pristine 38WG Indar 75WSP + Latron B-1956	12.5 oz 4 fl oz 14.5 oz 5 oz + **4 pt** 5 oz + **3.75 lb** **3.75 lb** 14.5 oz 2 oz + 8 fl oz	P B PF **SS** **1C, 2C** **3C–6C**, 7C 14 DPH 2 DPH	61.8 c	48.2 a	13.6 c
PropiMax EC **Kaligreen 82SP+Latron B-1956** Flint 50WG Elite 45DF	4 fl oz **3 lb + 8 fl oz** 4 oz 6 oz	P, B **PF, SS, 1C-6C**, 7C 14 DPH 2 DPH	100.0 a	0.0 d	100.0 a
USF2010 500 SC	**5 fl oz**	**P, B, PF, SS, 1C-6C**, 7C 14, 2 DPH	86.8 b	26.6 bc	60.2 b
USF2010 500 SC	**5.97 fl oz**	**P, B, PF, SS, 1C-6C**, 7C 14, 2 DPH	86.1 b	18.1 c	68.0 b
Endura 70WG	**6.12 oz**	**P, B, PF, SS, 1C-6C**, 7C 14, 2 DPH	100.0 a	0.0 d	100.0 a

[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 ($P \leq 0.05$, $K=100$).

TABLE 4. Brown Rot Harvest and Post-harvest Incidence [1]			**% Fruit Infected** [2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**4-dph**	**7-dph**
Nontreated Control	----------------	----------------	88.3 a	--------	--------
PropiMax EC Nova 40W Nova 40W + BravoWtherStik 6F Nova 40W + Captan 80WDG Captan 80 WDG **Indar 75WSP + Latron B-1956**	4 fl oz 5 oz 5 oz + 4pt 5 oz + 3.75 lb 3.75 lb **2 oz + 8 fl oz**	P, B PF SS 1C, 2C 3C–7C **14, 2 DPH**	7.0 de	10.6 bc	31.9 bc
PropiMax EC V10118 EC V10118 EC + BravoWtherStik 6F V10118 EC + Captan 80WDG Captan 80 WDG **Indar 75WSP + Latron B-1956**	4 fl oz 9.36 fl oz 9.36 fl oz + 4 pt 9.36 fl oz + 3.75 lb 3.75 lb **2 oz + 8 fl oz**	P, B PF SS 1C, 2C 3C–7C **10 DPH**	8.6 d	19.4 bc	46.3 bc
Pristine 38WG PropiMax EC Pristine 38WG Nova 40W + BravoWtherStik 6F Nova 40W + Captan 80WDG Captan 80WDG **Pristine 38WG** **Indar 75WSP + Latron B-1956**	12.5 oz 4 fl oz 14.5 oz 5 oz + 4 pt 5 oz + 3.75 lb 3.75 lb **14.5 oz** **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C – 7C **14 DPH** **2 DPH**	4.2 de	17.5 bc	43.8 bc
PropiMax EC Kaligreen 82SP + Latron B-1956 **Flint 50WG** **Elite 45DF**	4 fl oz 3 lb + 8 fl oz **4 oz** **6 oz**	P, B PF, SS, 1C-7C **14 DPH** **2 DPH**	65.4 b	40.3 a	73.1 a
USF2010 500 SC	**5 fl oz**	P, B, PF, SS, 1C-7C **14, 2 DPH**	4.6 de	11.9 bc	44.4 bc
USF2010 500 SC	**5.97 fl oz**	P, B, PF, SS, 1C-7C **14, 2 DPH**	2.4 e	2.5 c	25.6 c
Endura 70WG	**6.12 oz**	P, B, PF, SS, 1C-7C **14, 2 DPH**	24.3 c	22.1 b	53.7 ab

[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 ($P \leq 0.05$, K=100).

TABLE 5. Rhizopus Harvest and Post-harvest Incidence[1]			% Fruit Infected[2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**4-dph**	**7-dph**
Nontreated Control	----------------	----------------	0.0 a	--------	--------
PropiMax EC Nova 40W Nova 40W + BravoWtherStik 6F Nova 40W + Captan 80WDG Captan 80 WDG **Indar 75WSP + Latron B-1956**	4 fl oz 5 oz 5 oz + 4pt 5 oz + 3.75 lb 3.75 lb **2 oz + 8 fl oz**	P, B PF SS 1C, 2C 3C–7C **14, 2 DPH**	0.3 ab	6.9 ab	12.5 ab
PropiMax EC V10118 EC V10118 EC + BravoWtherStik 6F V10118 EC + Captan 80WDG Captan 80 WDG **Indar 75WSP + Latron B-1956**	4 fl oz 9.36 fl oz 9.36 fl oz + 4 pt 9.36 fl oz + 3.75 lb 3.75 lb **2 oz + 8 fl oz**	P, B PF SS 1C, 2C 3C–7C **10 DPH**	0.0 b	1.9 b	2.5 bc
Pristine 38WG PropiMax EC Pristine 38WG Nova 40W + BravoWtherStik 6F Nova 40W + Captan 80WDG Captan 80WDG **Pristine 38WG** **Indar 75WSP + Latron B-1956**	12.5 oz 4 fl oz 14.5 oz 5 oz + 4 pt 5 oz + 3.75 lb 3.75 lb **14.5 oz** **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C – 7C **14 DPH** **2 DPH**	0.0 b	3.1 ab	6.3 abc
PropiMax EC Kaligreen 82SP + Latron B-1956 **Flint 50WG** **Elite 45DF**	4 fl oz 3 lb + 8 fl oz **4 oz** **6 oz**	P, B PF, SS, 1C-7C **14 DPH** **2 DPH**	0.0 b	2.3 b	6.1 abc
USF2010 500 SC	**5 fl oz**	P, B, PF, SS, 1C-7C **14, 2 DPH**	0.0 b	3.8 ab	5.0 abc
USF2010 500 SC	**5.97 fl oz**	P, B, PF, SS, 1C-7C **14, 2 DPH**	0.0 b	0.6 b	0.6 c
Endura 70WG	**6.12 oz**	P, B, PF, SS, 1C-7C **14, 2 DPH**	2.0 a	11.0 a	14.7 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 ($P \leq 0.05$, K=100).

TABLE 6. Anthracnose Harvest and Post-harvest Incidence[1]			**% Fruit Infected**[2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**4-dph**	**7-dph**
Nontreated Control	----------------	----------------	0.6 ab	--------	--------
PropiMax EC Nova 40W Nova 40W + BravoWtherStik 6F Nova 40W + Captan 80WDG Captan 80 WDG **Indar 75WSP + Latron B-1956**	4 fl oz 5 oz 5 oz + 4pt 5 oz + 3.75 lb 3.75 lb **2 oz + 8 fl oz**	P, B PF SS 1C, 2C 3C–5C, 6C, 7C **14, 2 DPH**	0.0 b	0.0 b	0.0 b
PropiMax EC V10118 EC V10118 EC + BravoWtherStik 6F V10118 EC + Captan 80WDG Captan 80 WDG **Indar 75WSP + Latron B-1956**	4 fl oz 9.36 fl oz 9.36 fl oz + 4 pt 9.36 fl oz + 3.75 lb 3.75 lb **2 oz + 8 fl oz**	P, B PF SS 1C, 2C 3C–5C, 6C, 7C **10 DPH**	0.2 ab	0.0 b	0.6 b
Pristine 38WG PropiMax EC Pristine 38WG Nova 40W + BravoWtherStik 6F Nova 40W + Captan 80WDG Captan 80WDG **Pristine 38WG** **Indar 75WSP + Latron B-1956**	12.5 oz 4 fl oz 14.5 oz 5 oz + 4 pt 5 oz + 3.75 lb 3.75 lb **14.5 oz** **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C–5C, 6C, 7C **14 DPH** **2 DPH**	0.0 b	0.0 b	0.0 b
PropiMax EC Kaligreen 82SP + Latron B-1956 **Flint 50WG** **Elite 45DF**	4 fl oz 3 lb + 8 fl oz **4 oz** **6 oz**	P, B PF, SS, 1C-5C, 6C, 7C **14 DPH** **2 DPH**	0.5 ab	0.0 b	0.0 b
USF2010 500 SC	**5 fl oz**	P, B, PF, SS, 1C-5C **6C, 7C, 14, 2 DPH**	0.9 ab	0.0 b	0.6 b
USF2010 500 SC	**5.97 fl oz**	P, B, PF, SS, 1C-5C **6C, 7C, 14, 2 DPH**	0.4 ab	0.0 b	0.6 b
Endura 70WG	**6.12 oz**	P, B, PF, SS, 1C-5C **6C, 7C, 14, 2 DPH**	1.3 a	4.7 a	7.2 a

[1]Antracnose rot treatments, rates, and application timings in boldface; optimum timing is late cover sprays through harvest.
[2]Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, K=100).

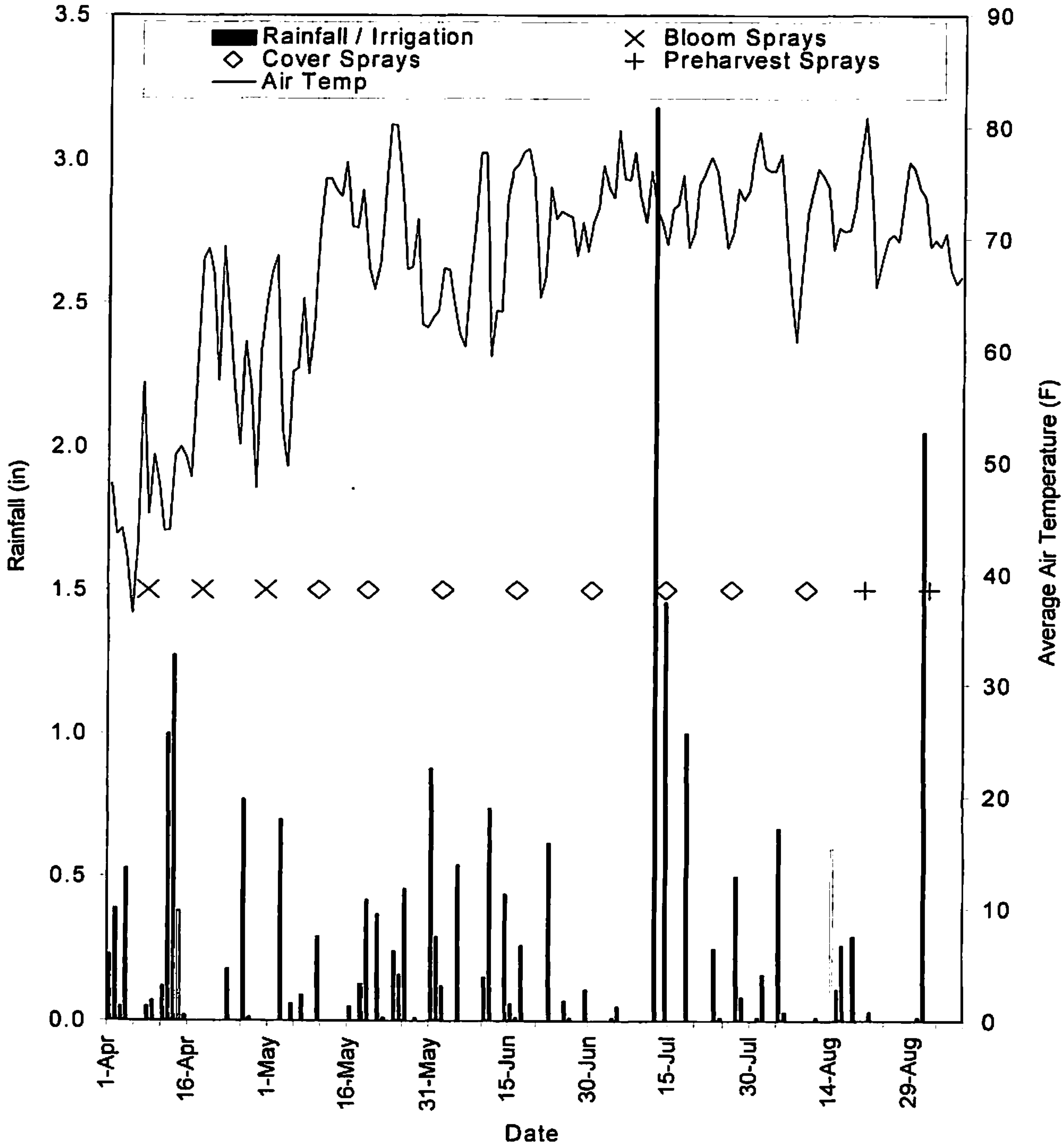

Figure 1. Rainfall, air temperature, and fungicide application timing on 'Autumnglo' peach during the 2004 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. X, diamond, and + symbols represent application timing for bloom (P, B, PF), shuck-split through seventh cover (SS-7C), and pre-harvest (PH) fungicide sprays, respectively

Examination of Biorational Fungicides for Pre-harvest Peach Brown Rot Control

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Peach fruit are most susceptible to brown rot during the preharvest ripening period. Hence, fungicide applications are required at this time to protect fruit. However, this timing also increases the likihood of fungicide residues on fruit to be consumed. Recently, many biological and biorational control materials have come to market. These organisms or compounds are usually rated lower in toxicity relative to conventional fungicides.

In this experiment, three such biorational fungicides were compared to each other and the Indar standard for brown rot prevention. The biorational fungicides tested were Serenade, a soil bacterium called *Bacillus subtilis* that stops spore germination and disrupts spore growth; Microthiol, a micronized version of sulfur that is typically used for cover sprays; and Oxidate, a hydrogen dioxide product that instantly kills fungal spores and mycelium upon contact.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the summer of the 2004 growing season. The test block consisted of an 8-year-old 'Jerseyglo' peach orchard. Trees were planted at 25 ft x 25 ft spacing. Treatments were replicated four times in a randomized complete block design with single tree plots for each block. 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 treatments except for the nonsprayed received 3.75 lb/A Captan 80WDG from 3C-6C (3rd through 6th cover) applied on: 16, 24 Jun, 8, 21 Jul. No fungicides were applied prior to 3C (orchard was used earlier in the season for a rusty spot study). Three preharvest sprays of the test materials were applied on 27 Jul, 5, 13 Aug (21, 12, and 4 days preharvest, DPH). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. The weather was conducive for brown rot with several periods of rain throughout the summer and during the preharvest fruit ripening period (Figure 1). The number of rain days with >0.10 inch accumulation following each spray were: 3C, 2; 4C, 1; 5C, 3; 6C, 2; 21 DPH, 2; 12 DPH, 0 and 4 DPH, 3.

Assessment. Brown rot (*Monilinia fructicola*) was assessed on 17 Aug by picking all fruit on 4 or more branches; a minimum of 100 fruit per tree was examined. For postharvest evaluations, 40 healthy fruit without visible symptoms were harvested from the tree and placed on benches in a shaded greenhouse. Brown rot was assessed at 3 and 6 days postharvest (dph). For some replicates, early fruit loss from severe brown rot disease pressure resulted in smaller sample sizes (# fruit) for the brown rot harvest and postharvest disease assessments; in these cases, all available fruit were used for assessment.

RESULTS AND DISCUSSION

Harvest assessment. Nonsprayed trees had 24.8% fruit rotted at harvest (Table 1). Fruit treated with Serenade preharvest or fruit which did not receive preharvest sprays (only captan cover sprays) had less disease incidence than nonsprayed fruit, but the difference was not significant. Indar, Oxidate and Microthiol were able to significantly reduce disease incidence providing 58.9%, 71.8% and 72.1% control, respectively.

Postharvest assessment. Brown rot pressure was high during the postharvest incubation period with incidence reaching 91.4% for nonsprayed fruit after 6 days (Table 1). The three consecutive days of rain just prior to harvest on 17Aug might have contributed to the high incidence by spreading inoculum and washing off the third preharvest spray that was applied on 13 Aug. After 3- and 6-dph, fruit which did not receive preharvest sprays (only captan cover sprays) had almost the same amount of brown rot as nonsprayed fruit.

Fruit treated with Indar and Microthiol had significantly lower incidence than nonsprayed fruit for both postharvest assessments. However, they only provided 47.7% and 49.8% control at 3 days and 32.8% and 39.9% control at 6 days postharvest, respectively. Oxidate and Serenade provided intermediate control and were not significantly different from the nonsprayed, Indar, or Microthiol treatments at both assessments.

Peach scab. Although scab control was not an objective of this study, a harvest assessment was nevertheless performed. Because of heavy inoculum levels, favorable weather, and lack of earlier fungicide sprays, 100% of all fruit on all treatments were infected with scab; 94 to 100% of these fruit had >10 lesions / fruit.

CONCLUSIONS

- Microthiol was equivalent to the standard Indar for pre-harvest brown rot control and was the most effective biorational fungicide tested.

- Oxidate appeared somewhat more active than Serenade in controlling brown rot, particularly at harvest. However, neither material provided post-harvest rot control.

Lack of postharvest control with Oxidate may be due to its "kill on contact", non-residual nature.

- Fruit that received only Captan cover sprays (3C-6C) had similar amounts of brown rot as non-treated trees. This result emphasizes the importance of the preharvest fungicide applications. However, this treatment may have had lower disease levels if the bloom, shuck split, and earlier cover sprays had been applied.

- No treatment controlled brown rot to an acceptable level, including the standard Indar, which normally provides excellent control. As indicated above, this lack of adequate brown rot control may be related to absence of earlier sprays in the program, which are important for management of early season blossom blight, latent brown rot infection prior to pit hardening, and peach scab. Fruit from all treatments were observed to have a high level of peach scab. Severe scab infection can result in epidermal cracking during the preharvest period, thereby increasing the possibility of infection by *M. fructicola*.

- Further study is needed to determine if brown rot control improves with microthiol sulfur (and perhaps Oxidate) when applied after a full season program.

TABLE 1. Brown Rot on Jerseyglo Peach

			Brown rot incidence (% Fruit inf)[1]		
Treatment[2]	Rate / A	Timing	Harvest	3-dph	6-dph
Nontreated Control	--------	--------	24.8 a	66.5 a	91.4 a
Captan 80WDG Indar 75WSP + Latron B-1956	3.75 lb 2.0 oz	3C-6C 21, 12, 4 DPH	10.2 bcd	34.8 bc	61.4 b
Captan 80WDG Serenade 10 WP	3.75 lb 10.0 lb	3C-6C 21, 12, 4 DPH	17.8 ab	53.1 abc	78.1 ab
Captan 80WDG Microthiol Special 80WP	3.75 lb 20.0 lb	3C-6C 21, 12, 4 DPH	6.9 d	33.4 c	54.9 b
Captan 80WDG Oxidate	3.75 lb 128 fl oz	3C-6C 21, 12, 4 DPH	7.0 cd	43.2 abc	75.5 ab
Captan 80WDG	3.75 lb	3C-6C	16.0 abc	64.1 ab	88.8 a

[1] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, $K=100$).
[2] No fungicide was applied on any treatment tree prior to the 3C spray; insect control, however, was full season.

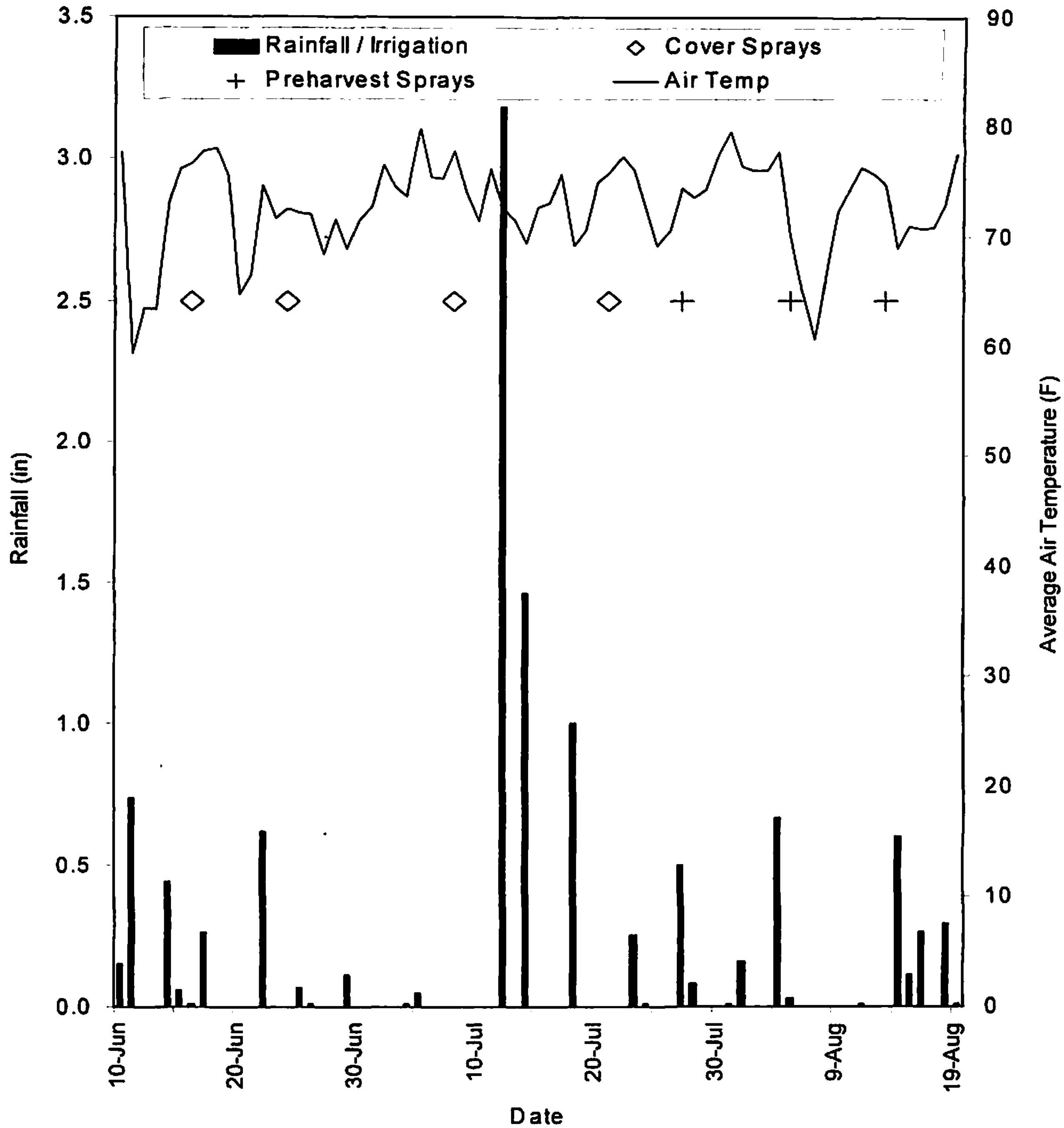

Figure 1. Rainfall, air temperature, and fungicide application timing on 'Jerseyglo' peach during the 2004 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. Diamond and + symbols represent application timing for 3st through 6th cover (3C-6C) and the preharvest sprays (PH), respectively.

CONTROL OF ALTERNARIA BLOTCH

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Fungicide treatments were applied with an airblast sprayer calibrated to deliver 225 gpa at 175 psi. Each treatment was applied to two groups of five Oregon Spur Delicious trees. Data were taken from the second and fourth trees in each group. All treatments, including the nonsprayed control were sprayed approximately weekly with Nova 40W at 5.0 oz/acre beginning at green tip (26 Mar) and continuing through petal fall. Fungicide treatments were begun on 20 May and subsequent sprays were made on 3 and 17 Jun; 1, 16 and 29 Jul; and 13 and 26 Aug. Treatments for the control of Alternaria blotch except the Captan + Prophyt treatment were initiated at third cover (3C). The Captan + Prophyt treatment was initiated at second cover (2C). The incidence and severity of Alternaria blotch was determined on 13 Jul by examining all leaves on four terminals selected arbitrarily from each replication. In order to determine if treatments targeted to the control of Alternaria had any effect on other summer diseases of apples, 25 fruit were arbitrarily selected and picked from each replication at harvest on 9 Sep and examined for the presence of diseases.

The period after petal fall was very conducive for Alternaria blotch with 14 days with measurable precipitation in May, 18 in Jun and 10 until 13 Jul when records were taken. The wet weather continued until harvest with an additional 27 days with rain. First symptoms of Alternaria blotch were observed in early Jun. About 20% fewer leaves were affected in treatments that included Omega, BAS516 and Prophyt although the treatments were not significantly different from all others except the control. Disease severity did not differ greatly among treatments either, but disease severity in treatments with Omega, BAS516, Prophyt and Tanos + Captan was numerically less. Some treatments applied for the control of Alternaria blotch also provided good commercial control of sooty blotch and flyspeck. Sooty blotch and flyspeck disease severity in the Omega and Captan + Prophyt treatments was less than 3% compared to 77% in the nonsprayed control. Sooty blotch and flyspeck incidence was also numerically less in the treatment with Omega than other treatments. The poorest control of sooty blotch and flyspeck was obtained in the treatment with Tanos + Cuprofix Disperss.

Treatment and rate per acre	Alternaria blotch		Sooty blotch and flyspeck		
			Incidence		
	Incidence	Severity[z]	Sooty blotch	Flyspeck	Severity[y]
Captan 50W 6 lb 2C; Flint 50WG 2 oz 3C-4C; Captan 50W 6 lb +Topsin 70WP 8 oz 5C; Flint 50WG 2 oz 6C; Captan 50W 6 lb + Topsin M 70WP 8 oz 7C; Flint 50WG 2 oz 8C	70.3ab[x]	1.27ab	80.0ab	45.6c	6.7bc
Captan 50W 6 lb 2C; BAS516 14.5 oz 3C-4C; Captan 50W 6lb + Topsin 70WP 8 oz 5C; BAS516 UD14.5 oz 6C; Captan 50W 6 lb +Topsin 70W 8 oz 7C; BAS516 UD 14.5 oz 8C	42.5b	1.06c	71.0bc	11.0de	7.7bc
Captan 50W 6 lb 2C; Tanos DF 8 oz + Captan 50W 3.0 lb 3C-4C; Captan 50W 6 lb + Topsin 70WP 8 oz 5C; Tanos DF 8 oz + Captan 50W 3 lb 6C; Captan 50W 6 lb + Topsin M 70WP 8 oz 7C; Tanos DF 8 oz + Captan 50W 3 lb 8C	61.4ab	1.06c	80.0ab	28.0cd	5.7c
Captan 50W 6 lb 2C; Tanos DF 8 oz + Cuprofix Disperss 8 oz 3C-4C; Captan 50W 6 lb + Topsin 70 WP 8 oz 5C; Tanos DF + 8 oz Cuprofix Disperss 8 oz 6C; Captan 50W 6 lb + Topsin 70WP 8 oz 7C; Tanos DF 8 oz + Cuprofix Disperss 8 oz 8C	70.2ab	1.19bc	94.0ab	64.8b	12.1b
Captan 50W 6 lb + Prophyt 3 qt 2-6C	43.8b	1.05c	50.0c	33.0c	2.8c
Captan 50W 6 lb 2C; Omega 500F 1 pt 3C-4C; Captan 50W 6 lb + Topsin M 70WP 8 oz 5C; Omega 500F 1 pt 6C; Captan 50W 6 lb + Topsin M 70WP 8 oz 7C; Omega 500F 1 pt 8C	44.3b	1.11bc	48.0c	8.0e	2.6c
Check	86.4a	1.42a	100.0a	90.4a	77.0a

[z] Severity of Alternaria blotch: 0 = no lesions/leaf; 1 = 1-3% leaf surface area covered with lesions; 2 = 4-6%; 3 = 7-12% 4 = 13-25%

[y] Percent surface area covered with sooty blotch or flyspeck.

[x] Means within the same column followed by the same letter are not significantly different at P = 0.05 as determined by the Waller-Duncan k-ratio t-test.

NEW FUNGICIDES FOR POSTHARVEST DISEASE CONTROL ON APPLES

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The objective of this experiment was to determine effectiveness of various fungicides for controlling *Penicillium expansum* in stored apples when (i) the fungicides were mixed in clean water and applied immediately after mixing, (ii) fungicides were mixed in clean water and held for 72 hr prior to treating fruit, and (iii) fungicides were mixed in water containing soil and organic matter and were then held for 72 hr prior to treating fruit. Fungicide solutions used for postharvest treatments are often reused on successive days, and the fungicide solutions gradually accumulate soil and organic matter from the apple bins that are being drenched with fungicide. Loss of activity when fungicides are held in clean water would indicate that the fungicides gradually break down in water. Loss of activity when fungicides are mixed with soil and organic matter could indicate that the fungicides are bound to organic matter.

Empire apples were harvested on 8 Oct from two different orchards at the Hudson Valley Lab and were held at 40° F until the experiment was initiated. On 13 Oct, apples to be treated with clean water immediately after mixing (0-hr) were wounded on a single hemisphere using a large cork fitted with three finishing nails spaced about three-eighth in. apart in a triangular pattern. Wounds created on the fruit were approximately one-eighth in. deep by one-sixteenth in. in diameter. Wounded apples were held at ca. 65° F until they were inoculated and treated on 14 Oct. An inoculum stock solution was prepared on 14 Oct by washing spores from 16 day old plates of a benzimidazole-sensitive isolate of *P. expansum* (P-99) growing on potato dextrose agar. The spore density of the stock solution was determined using a hemacytometer. Apples were inoculated by submersion for 30 seconds in a spore suspension containing 10,000 spores/ml. After inoculation, fruit were allowed to dry approximately 1 hr before fungicide treatments were applied. Fungicides were mixed in 15 gal of water in 30-gal plastic garbage cans. Fruit were treated by submersing baskets of fruit into the fungicide solution for 30 sec. After treatment, apples were allowed to dry approximately 2 hours before they were placed on spring cushion trays in fiberboard boxes and were moved to storage at 36 °F. Each treatment was replicated four times using 25 apples per replicate, with two replicates derived from fruit from one orchard and the other two replicates from the other orchard. Mean firmness of fruit used for replicates 1 & 2 was 17.4 lb whereas fruit used for replicates 3 & 4 had a mean firmness of 18.8 lb at the time that fruit were treated. The fungicide solutions used for treatments on 14 Oct were retained and reused to treat another set of fruit on 17 Oct. A set of "dirty-water" fungicide solutions were also prepared on 14 Oct and were used for treatments applied on 17 Oct. These solutions contained the same concentrations of fungicides as the clean-water tanks, but 2000 g of orchard soil plus 247 grams of peat moss were added to the 15 gal of water in each tank. The fungicide solutions were held at 61 °C during the interval between mixing and the 72-hr applications. Fungicide solutions in both the clean water and the dirty water tanks were agitated three times per day by using small brooms to circulate the water and to resuspend any sediment. Apples that were inoculated and treated on 17 Oct were removed from storage on 16 Oct and were wounded, inoculated, treated and stored as described for the 0-hr fruit. Inoculum for the 72-hr inoculations was derived from a fresh stock solution that was prepared on 17 Oct. Temperatures during storage were monitored with Hobo H8 Pro Series Temperature Recorders (Onset Computer Corp., 470 MacArthur Blvd., Bourne, MA 02532) that were packed with apples in the fiberboard storage boxes. Because of a refrigeration malfunction on 15 Feb 2004, temperatures of the stored fruit gradually increased from 36°F to a high of 57°F on 23 Feb when the refrigeration was repaired, then gradually dropped back to 36 °F over the next 48 hours. Fruit were removed from storage on 3 Mar (after 113 days of cold storage), were held at ca. 56°F for the next 7 days to provide a shelf life test, and were then re-evaluated for a final time.

Fruit were evaluated on four dates (Table 1), and fruit were considered decayed if infections occurred at any of the three wound sites that were present on each apple. The two higher rates of Pristine were included only in the 0-hr clean water trial. All of the other treatments were included in all three trials (0-hr clean, 72-hr clean, 72-hr dirty), and two-way analyses were used to compare the 10 fungicide treatments across the three treatment regimes. Data from the two-way analyses are presented only for the final evaluation on 10 March (Table 2). Pristine and Penbotec provided excellent control of *P. expansum* in this trial, even at the lowest rates tested. The 4-oz rate of Scholar is only half of the recommended rate, and it failed to provide adequate control in this trial. In all previous trials, Scholar used at 4 oz/100 gal was just as effective as higher rates, but in this trial the 4-oz rate was insufficient. We could not detect any rate effects for Pristine or Penbotec in this trial. All of the tested rates provided equivalent control and were significantly better than the half-rate of Scholar. The over-all incidence of decay (grand means shown at the bottom of the data columns) was greater for 72-hr clean and 72-hr dirty water than for 0-hr clean water (Table 2). Because this was true for the controls as well as many of the fungicide treatments, we cannot attribute the difference to breakdown of the fungicides during the holding period. Instead, it seems likely that the spore suspension used for the 72-hr inoculations was slightly more effective than the one used for the 0-hr inoculations, despite the fact that we attempted to produce spore suspensions of identical densities. No phytotoxicity was noted on any of the treated fruit.

Table 1.

Material and rate of formulated product per 100 gal of drench solution	% Empire fruit with blue mold in the 0-hr, clean water trial			
	16 Jan (91 days @ 36 °F)	17 Feb (123 days @ 36 °F)	3 Mar (138 days varied temp.)	10 Mar (after shelf-life test)
Control	48.2 c*	61.3 b	70.4 c	75.5 d
Mertect 340 F 16 fl oz	1.0 ab	1.0 a	2.0 ab	4.0 b
Scholar 50W 4 oz	3.0 b	3.0 a	8.0 b	19.0 c
Pristine 38WDG 16.7 oz	0.0 a	0.0 a	1.0 a	2.0 ab
Pristine 38WDG 33.7 oz	0.0 a	0.0 a	1.0 a	1.0 ab
Pristine 38WDG 67.4 oz	0.0 a	0.0 a	0.0 a	0.0 a
Penbotec 40% 8 fl oz	1.0 ab	1.0 a	1.0 a	1.0 ab
Penbotec 40% 16 fl oz	0.0 a	0.0 a	0.0 a	0.0 a
Penbotec 40% 24 fl oz	0.0 a	0.0 a	0.0 a	0.0 a
Penbotec 40% 32 fl oz	0.0 a	0.0 a	0.0 a	0.0 a
Penbotec 40% 16 fl oz + Shield DPA 15% 86 fl oz ..+ Optical (calcium) 1.35 gal	0.0 a	0.0 a	0.0 a	0.0 a
Penbotec 40% 32 fl oz + Shield DPA 15% 86 fl oz ..+ Optical (calcium) 1.35 gal	0.0 a	0.0 a	0.0 a	0.0 a

*Means within columns followed by the same small letter at not significantly different (Fisher's Protected LSD Test, $P \leq 0.05$).

Table 2.

Material and rate of formulated product per 100 gal of drench	% Empire fruit with blue mold on 10 March			
	Clean water 0 hr	Clean water 72 hrs	Soiled water 72 hrs	Grand means for material
Control	75.5 c*	97.0 d	83.0 c	85.1 e
Mertect 340 F 16 fl oz	4.0 a	8.0 b	23.0 b	11.7 c
Scholar 50W 4 oz	19.0 b	27.0 c	22.0 b	22.7 d
Pristine 38WDG 16.8 oz	2.0 a	4.0 ab	5.0 a	3.7 b
Penbotec 40% 8 fl oz	1.0 a	2.0 ab	3.0 a	2.0 ab
Penbotec 40% 16 fl oz	0.0 a	1.0 a	1.0 a	0.7 a
Penbotec 40% 24 fl oz	0.0 a	1.0 a	0.0 a	0.3 a
Penbotec 40% 32 fl oz	0.0 a	0.0 a	1.0 a	0.3 a
Penbotec 40% 16 fl oz + Shield DPA 15% 86 fl oz ...+ Optical (calcium) 1.35 gal	0.0 a	1.0 a	1.0 a	0.7 a
Penbotec 40% 32 fl oz + Shield DPA 15% 86 fl oz ...+ Optical (calcium) 1.35 gal	0.0 a	1.0 a	0.0 a	0.3 a
Grand means for condition	10.1 A	14.2 B	13.9 B	

*Means within columns followed by the same small letter at not significantly different as determined by applying Fisher's Protected LSD Test ($P \leq 0.05$) to results from a two-way analysis of three water quality/timing factors applied to 10 different fungicide treatments. In the two way analysis, P-values for effects of fungicide, water quality/timing, and the interaction effect were <0.001, 0.005, and 0.169, respectively.

TIMING SUMMER FUNGICIDES FOR APPLES IN THE NORTHEAST

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Three field trials were conducted during 2004 to evaluate the performance of fungicides applied to control flyspeck, sooty blotch, and summer fruit decays. In all of the trials, individual treatments were replicated four times in a randomized block design and fungicides were sprayed to drip using a handgun and a high-pressure sprayer set at 200 psi. Leaf wetting was recorded with a DeWitt leaf wetness recorder, and all wetting periods regardless of duration and including dew periods were included in wetting-hour accumulations. Other details of the individual treatments are noted below.

Trial #1: Treatments were compared in a 7-yr-old orchard of trees on MM.111 rootstocks with M.9 interstems. The control trees used for this experiment did not receive any fungicides all year. However, all other trees in the block were sprayed with contact fungicides (Penncozeb, Polyram, Microthiol Disperss, and/or Captan) from 16 Apr through 24 May to control apple scab, rust diseases, and powdery mildew. Fungicide treatments for were applied 8, 24 Jun, 15, 29 Jul, and 17 Aug. Copper fungicides (Cuprofix Disperss and Kocide) were not applied until mid-July and were alternated with Captan in an effort to minimize phytotoxicity. Copper phytotoxicity on McIntosh was evaluated by harvesting available fruit (mean of 40 fruit/tree, range = 7-55) on 11 Aug and observing fruit for blackened lenticels. Development of flyspeck was monitored by examining twenty-five arbitrarily selected Golden Delicious fruit per tree on 23 Aug and 3, 14, 22 Sep without removing the fruit from the trees. Fifty Golden Delicious fruit were harvested from each tree on 27 Sep and were held at ambient temperature until the final disease evaluation was completed on 29 Sep. Rainfall during a storm on 21-22 Aug totaled 2.15 in. and presumably removed most of the fungicide residues remaining from the 17 Aug spray. Counting from 22 Aug, the totals for accumulated hours of leaf wetting were 164, 233, and 270 hr for the 14, 22, and 27 Sep observation dates, respectively.

Incidence of flyspeck on control fruit was 66% on 23 Aug and 98% on 3 Sep. No flyspeck was detected in any of the fungicide-treated plots on 23 Aug or 3 Sep except that 2% of fruit in the plots treated with Cuprofix had flyspeck on both of those observation dates (data not shown). By 22 Sep, flyspeck incidence was higher in both of the treatments involving copper fungicides than in the Topsin M + Captan standard or than in treatments involving strobilurin fungicides. Incidence of flyspeck increased rapidly between 22 and 27 Sep at the same time that accumulated wetting, counting from the rains of 22 Aug, reached the 270 hr incubation period required for flyspeck to appear on fruit. Fruit treated with Pristine had the least amount of flyspeck, sooty blotch, and fruit rots at harvest, but Pristine did not differ significantly from the Topsin M + Captan standard for control of any of those diseases. Fruit from trees treated with Topsin M alone, TD-2407-02, Captan, Flint, Cuprofix disperses, or Kocide had more flyspeck on 27 Sep than fruit treated with Pristine or with Topsin M + Captan, and the same trend was evident for sooty blotch. Treatments involving Cuprofix Disperss or Kocide 2000 caused lenticel blackening on 90 and 95% of McIntosh fruit and on 91 and 94% of Golden Delicious fruit, respectively. Treatments had no effect on the incidence of fruit russetting for either cultivar. Results from this trial show that copper fungicides are less effective against flyspeck and sooty blotch than several of the other fungicides, and that even when applied only twice during mid to late summer, copper fungicides can cause phytotoxicity to fruit. Pristine demonstrated rain-fastness and residual activity equal to or better than that of the Topsin M + Captan standard.

By 27 Sep, sooty blotch was evident on a high proportion of fruit in all treatments. Sooty blotch usually appears only after virtually all fungicide residues are exhausted. Because fungicide residues that fail to control flyspeck often continue to suppress sooty blotch, we usually see flyspeck emerge before sooty blotch in sprayed orchards. The fact that sooty blotch was present in all treatments in this trial indicates that none of these treatments, not even Pristine, had active residues remaining on fruit in September. However, the fact that sooty blotch was more prevalent than flyspeck in many treatments suggests that, in the absence of fungicide residues, sooty blotch develops more rapidly than does flyspeck. Any fungicide residues that survived the rains of 21-22 Aug were removed by subsequent rains on 30 Aug (0.23 in.), 8-9 Sep (2.12 in.), and 17-18 Sep (2.90 in.). We could not determine which of these rains contributed most to the sooty blotch that was evident on fruit by 27 Sep.

Trial 1:	% Golden Delicious fruit with				
	flyspeck			sooty blotch	fruit rot
	14 Sep[z]	22 Sep[z]	27 Sep[y]	27 Sep[y]	27 Sep[y]
Control	100.0 d[x]	100.0 c	100.0 e	100.0 d	78.6 c
Topsin M 70W 3.3 oz	2.0 abc	2.0 a	35.2 bc	74.0 abc	19.7 b
TD-2407-02 70DG 3.3 oz	1.0 ab	9.0 ab	52.2 cd	83.6 cd	20.5 b
Captan 80W 10 oz	1.0 ab	11.0 ab	64.2 d	77.0 bcd	12.8 ab
Topsin M 70W 4 oz + Captan 80W 10 oz	0.0 a	3.0 a	26.8 ab	55.2 ab	10.6 ab
Flint 50WDG 0.67 oz	4.0 bc	5.0 a	49.5 cd	78.0 bc	13.0 ab
Sovran 50WDG 1.33 oz	0.0 a	9.3 a	31.0 bc	50.0 ab	15.0 ab
Pristine 38WDG 4.8 oz	0.0 a	2.0 a	8.1 a	48.6 a	3.8 a
Captan 80W 10 oz alternating with Cuprofix Disperss 37W 1 lb[w]	8.0 c	21.3 b	51.0 cd	98.0 cd	12.7 ab
Captan 80W 10 oz alternating with Kocide 2000 54W 1 lb[w]	6.0 c	24.0 b	72.7 d	78.5 cd	9.9 ab

[z] On-tree evaluations of 25 arbitrarily selected fruit per tree.

[y] Data from 50 fruit per tree evaluated after harvest.

[y] 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 data analyses, but arithmetic means are reported.

[w] Captan was applied 8, 24 Jun and 29 Jul. Copper fungicides (Cuprofix Disperss and Kocide) were applied 15 Jul and 17 Aug.

Trial #2: Fungicides were evaluated for their effectiveness against flyspeck, sooty blotch, and summer fruit rots by applying summer treatments to plots where other fungicides had been applied on 8, 16, 25 Apr and 5 May to control scab, mildew, and rust diseases. Because the same summer fungicide programs were sometimes used following more than one early-season treatment, the treatments reported here were replicated either 4, 8, 12 or 16 times as noted in the table. Each replicate contained one tree of each cultivar on M.9 rootstocks. Treatments listed in the table were applied on 14 May (petal fall), 16 Jun, and 14 Aug. In addition, all plots except controls were sprayed with Captan 80W 10 oz + Bayleton 50W 1.5 oz on 25 May and with Captan 80W 10 oz on 1 & 24 July. Control plots did not receive any fungicide throughout the entire growing season. The number of wetting hours that occurred during the seven intervals between fungicide applications on 14, 25 May, 16 Jun, 1, 25 Jul, 14 Aug, and harvest dates of 14, 21 Sep were 66, 87, 36, 143, 140, 252, and 65, respectively, and accumulated rainfall for those same intervals was 1.1, 1.4, 2.1, 3.8, 3.7, 5.0, and 3.0. Fruit were evaluated by harvesting 50 fruit from each tree on 14 Sep (Redcort) or 21 Sep (Golden Delicious) and examining fruit for any signs of sooty blotch or flyspeck or symptoms of fruit decays. Redcort fruit were evaluated for diseases immediately after harvest. Golden Delicious fruit were initially held at ambient temperature in a storage building, were moved to 40 °F storage on 2 Oct, and were the held at 40 °F until evaluations were completed between on 10 Nov.

None of the fungicides provided acceptable control of flyspeck in this trial, but different factors accounted for flyspeck development on Redcort as compared to Golden Delicious. On Redcort, many of the infections occurred near the stem end of fruits and may have resulted from incomplete spray coverage in contact areas between fruits. By calculating backward for 270 hr of accumulated wetting prior to 14 Sep when Redcorts were harvested, we know that flyspeck infections evident on Redcort fruit at harvest must have been initiated prior to 12 Aug. Captan applied on 24 Jul was weathered by 1.25 in. rain between 28 Jul and 1 Aug, and that was followed by an additional 85 hr of wetting between 1 and 14 Aug when the last treatment sprays were applied. On Golden Delicious, post-infection activity from sprays applied on 14 Aug probably controlled most of the flyspeck infections initiated between 24 Jul and 14 Aug, but infections on the clustered Redcort fruit were not completely controlled because of limited spray coverage within the fruit clusters. The fact that Sovran resulted in less flyspeck (numerically) than other treatments on Redcort might indicate that Sovran redistributed slightly better than other fungicides to the areas within fruit clusters during the rains following the 14 Aug application.

Some of the flyspeck present on Golden Delicious fruit when they were evaluated in November probably developed after harvest when fruit were stored at ambient temperature for 11 days due to lack of cooler space. When harvested on 21 Sep, Golden Delicious fruit had been exposed to 238 hr of accumulated wetting counting from 22 Aug, the date when rains following the last fungicide application had presumably removed most fungicide residue. We specifically harvested these fruit on 21 Sep, about two weeks earlier than normal harvest, because we knew that flyspeck from late August infections would begin appearing on fruit after 270 hr of accumulated wetting following loss of fungicide protection and we wanted a measure of fungicide effectiveness prior to the point of complete fungicide wash-off. However, we did not consider the possibility that infections would continue to develop following harvest. Because of the delay between harvest and fruit evaluation, results on Golden Delicious here are comparable to those in Trial 1 where flyspeck developed following loss of all fungicide residues even though fruit in this trial were harvested earlier.

In this trial, Pristine again provided the best protection against flyspeck. Residual protection of Pristine was evident in the sooty blotch evaluations. Incidence of sooty blotch in this trial was lower than in Trial 1 because fruit were harvested earlier and sooty blotch did not develop during the holding period after harvest whereas flyspeck did. The fact that Pristine provided better control than any of the other fungicides is a clear indication of superior residual activity. All of the fungicides provided equivalent control of summer fruit rots (mostly black rot and white rot caused by *Botryosphaeria obtusa* and *B. dothidea*, respectively.)

Trial 2:		% fruit infected				
		flyspeck		sooty blotch	summer fruit rots	
Material and rate of formulated product per 100 gal*	Number of repli-cations	Redcort 14 Sep	Golden Del. 21 Sep	Golden Del. 21 Sep	Redcort 14 Sep	Golden D. 21 Sep
Control	4	100.0 e**	98.5 d	95.6 d	16.1 b	61.4 b
Captan 80W 1 lb	12	72.8 d	66.4 c	29.1 c	0.7 a	5.3 a
Captan 80W 1 lb (+ Topsin M 70W 3 oz 14 Aug only)	8	65.5 cd	43.4 ab	12.8 b	2.0 a	5.3 a
Pristine 38WDG 4.8 oz	4	41.5 ab	25.8 a	0.5 a	0.0 a	1.4 a
Sovran 50WDG 1.33 oz	4	30.5 a	58.8 bc	9.1 b	1.0 a	4.3 a
Flint 50WDG 0.67 oz	16	58.8 bc	67.4 c	17.4 b	1.5 a	4.7 a

*Test fungicides were applied 14 May, 16 Jun, and 14 Aug. In addition, all treatments except the control were sprayed with Captan 80W 10 oz + Bayleton 50W 1.5 oz on 25 May and with Captan 80W 10 oz on 1 & 24 July.
**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 data analyses, but arithmetic means are reported.

Trial 3: The objective of this trial was to determine if fungicides applied beginning at 300-350 accumulated hours of leaf wetting (AHLW) after petal fall can provide adequate control of flyspeck, sooty blotch, and summer fruit rots. We hypothesized that in orchards where early-season diseases are well-controlled, no summer fungicides should be needed until flyspeck conidia begin blowing into orchards from adjacent woodlots and hedgerows, that immigration of flyspeck conidia begins after ca. 270 AHLW from petal fall, and that the fungicides included in this test might provide post-infection activity against flyspeck infections initiated within 100 AHLW prior to the time the fungicides are applied. If the 100 AHLW of post-infection activity is added to the 270 AHLW threshold for inoculum availability, then sprays applied prior to 370 AHLW from petal fall should control flyspeck in orchards left unsprayed during June and early July. Trees in the test block were on M.9 rootstocks and were planted in 1995 in a hilltop location with good air drainage. Early-season diseases were controlled by applying Dithane 75DF at 3 lb/A on 20, 29 Apr, 14, 24, 30 May using an air blast sprayer calibrated to deliver 100 gal of water/A. No other fungicides were applied until the test fungicides were applied on 20 July (309 AHLW from petal fall). Test fungicides were applied to drip using a handgun and a high-pressure sprayer set at 200 psi. The same treatments were repeated on 29 Jul. Topsin M 70W 1 lb/A + Captan 50W 3 lb/A were applied to all plots with an air blast sprayer on 11 Aug (436 AHLW from petal fall) and again on 17 Aug, and Topsin M alone (1 lb/A) was similarly applied to all plots on 25 Aug.

Fungicide treatments applied on 20 and 29 Jul did not differ in their abilities to protect fruit from flyspeck and sooty blotch, whereas control fruit that were sprayed with Topsin M + Captan beginning on 11 Aug had significantly more disease. The incidence of flyspeck was much higher on Redcort than on Golden Delicious. Many of the infections on Redcort occurred near the stem end of fruits and may have resulted from incomplete spray coverage on clustered fruit during August when heavy rains would have removed residues from earlier fungicide sprays. None of the treatments provided complete control of summer fruit rots on Golden Delicious. The higher incidence of fruit rots in the control compared to fungicide-treatments provides evidence that a significant number of fruit became infected between 20 Jul when the treatments were applied and 11 Aug when all plots including controls were sprayed with Topsin M + Captan. It is possible that some of the fruit rot infections that developed in the fungicide treatments were initiated before the fungicides were applied on 20 Jul. However, it is equally likely that fruit infection in the fungicide treatments resulted from infections that occurred shortly before harvest. More than 5 in. of rain fell between 9 and 18 Sep. That rain would have removed all fungicide residues from the last spray and allowed time for fruit to develop black rot or white rot infections before it was harvested on 6 Oct. The fact that flyspeck on Golden Delicious was well-controlled by sprays initiated after 309 AHLW from petal fall provides support for our hypothesis that early summer sprays are not essential for controlling flyspeck. However, more work is required to determine if omitting sprays during June and early July contributes to a higher incidence of summer fruit decays under the environmental conditions encountered in northeastern United States. Further work is also needed to determine if timing of late summer fungicides should be adjusted for years and varieties with clustered fruit as compared to cases where well-thinned fruit allow more complete spray coverage during late summer.

Trial 3: Material and rate of formulated product per 100 gal[z]	% fruit infected: flyspeck		% fruit infected: Golden Delicious[x]	
	Redcort[y]	Golden Del.[x]	Sooty blotch	fruit rot
Control	51.5 b[w]	15.5 b	14.5 b	17.0 c
Topsin M 70W 4 oz	24.5 a	1.0 a	1.0 a	7.5 b
Pristine 38WDG 4.8 oz	19.5 a	1.5 a	3.0 a	4.0 a
Sovran 50WDG 1.33 oz	25.5 a	1.5 a	4.0 a	4.0 ab
Flint 50WDG 0.67 oz	21.5 a	0.5 a	2.5 a	6.0 ab

[z] Treatments were applied on 20 and 29 Jul. Thereafter, all of the plots including the controls were sprayed with Topsin M 70W 1 lb/A + Captan 50W 3 lb/A on 11 & 17 Aug and Topsin M 70W 1 lb/A alone on 25 Aug.
[y] Data was collected from 50 fruit per tree on 20 Sep 2004.
[x] Data was collected from 50 fruit per tree on 6 Oct 2004.
[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 data analyses, but arithmetic means are reported.

Conclusions: In Trial 1 as well as in similar trials from previous years, flyspeck has consistently appeared on fruit following 270 hr of accumulated wetting counting from the time that fungicide residues were exhausted by heavy rains. Results from Trial 1 showed that none of the fungicides, with the possible exception of Pristine, remained effective against flyspeck following 2.15 inches of rain. This is valuable information because it allows us to tell growers that they will need to respray orchards if they receive more than two inches of rain after their last spray in blocks that are still more than 30 days from harvest. (The 30 day-to-harvest rule is based on the assumption that, even during a wet harvest season such as we had in 2003, at least 30 days will be required to accumulate the 270 hr of wetting required for development of flyspeck symptoms.) The results from Trial 3 verified that, under New York conditions, summer diseases can be effectively controlled even if fungicide sprays are omitted from about second cover until the time that wetting accumulations total 300 hr counting from petal fall.