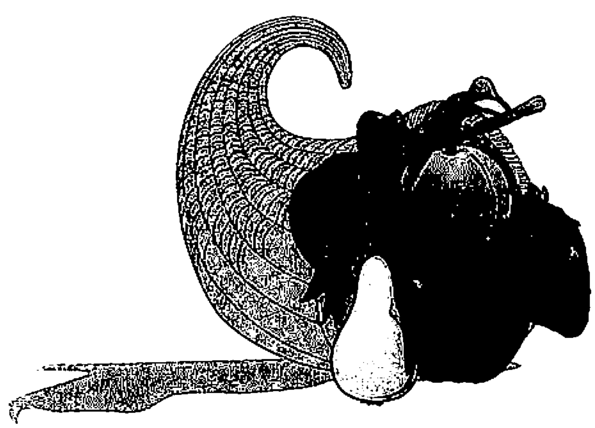
PROCEEDINGS

81st

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE



November 17 & 18, 2005

WINCHESTER, VIRGINIA

(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the

Cumberland-Shenandoah

Fruit Workers Conference

81st Annual Meeting

November 17th and 18th, 2005
Winchester Holiday Inn
Winchester, VA

Conference Chair
Tracy C. Leskey
United States Department of Agriculture
Agricultural Research Service
Appalachian Fruit Research Station

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List of Participants

Name	Affiliation
Agnello, Art	NYS-AES
Atanassov, Atanas	Rutgers
Baugher, Tara	Penn State Ext
Bergh, Chris	VA Tech
Biddinger, David	Penn State
Black, Robert	Catoctin Mountain Orchard
Breth, Deborah	Cornell CES
Brown, Mark	AFRS-ARS-USDA
Callahan, Tom	Adams County Nursery
Carroll, Juliet	NYS-AES
Chevalier, Jim	Bayer CropScience
Combs, David	NYS-AES
Crim, V. Larry	AFRS-ARS-USDA
Dell, Larry	United Agri Products
DeMarsay, Anne	Rutgers-Marucci Ctr
Erickson, Mary Anne	Certis
Foster, Kathleen	Rutgers
Frank, Daniel	VA Tech
Glenn, Mike	AFRS-ARS-USDA
Gundrum, Patty	AFRS-ARS-USDA
Gut, Larry	Michigan State
Halbrendt, Noemi	Penn State
Hancock, Torri	AFRS-ARS-USDA
Hanlin, Bill	NC Coop. Ext.
Heuser Gale, Wanda	Summit Tree Sales, Inc.
Hogmire, Henry	WVU
Hott, Chris	AFRS-ARS-USDA
Hull, Larry	Penn State FREC
Jentsch, Peter	Cornell Hudson Valley Lab
Krawczyk, Greg	Penn State
Lachance, Michael	VA Tech
Lalancette, Norman	Rutgers
Leahy, Kathleen	Polaris
Lehman, Bryan	Penn State
Leskey, Tracy	AFRS-ARS-USDA
Lesser, Katy	Penn State
Marston, Cyndi	VA Tech
McArtney, Steve	NCSU

List of Participants, cont.

Millay, Tom	AFRS-ARS-USDA
Miller, Stephen	AFRS-ARS-USDA
Myers, Clayton	AFRS-ARS-USDA
Newell, Michael	UMD WREC
Orr, Mark	George S. Orr & Sons Orchard
Pfeiffer, Doug	VA Tech
Polk, Dean	Rutgers
Reissig, Harvey	NYS-AES
Rosenberger, David	Cornell Hudson Valley Lab
Rothwell, Nikki	Michigan State
Rucker, Ann	Rutgers
Shearer, Peter	Rutgers AREC
Short, Brent	AFRS-ARS-USDA
Stamm, Greg	CBC America
Travis, James	Penn State
Tworkoski, Thomas	AFRS-ARS-USDA
Villanueva, Raul	NCSU
Walgenbach, Jim	NCSU
Wright, Starker	AFRS-ARS-USDA
Yoder, Keith	VA Tech
Yuan, Rongcai	VA Tech
Zhang, Xing	VA Tech

81st Annual Cumberland-Shenandoah Fruit Workers Conference

November 17th & 18th, 2005

Winchester, VA

Thursday, November 17

8:00-9:00 **Registration**

9:00-9:30 **Call of the States**

9:30-10:15 **General Session-Panel Discussion**

Current Challenges Facing the Tree Fruit Industry in the Eastern US

Panel Members:

Robert Black, Fruit Grower	Catoctin Mountain Orchard
Tom Callahan, Nursery Industry	Adams County Nursery
Larry Dell, Consultant	United Agri Products
Wanda Heuser Gale, Nursery Industry	Summit Tree Sales, Inc.
Mark Orr, Fruit Grower	George S. Orr & Sons Orchard

Moderators:

Tracy Leskey, Research Entomologist	USDA-ARS-AFRS
Stephen Miller, Research Horticulturist	USDA-ARS-AFRS

10:15-10:30 **Break**

10:30-12:00 **Panel Discussion, continued**

12:00-1:00 **Lunch**

1:00-5:00 **Concurrent Sessions (Entomology, Horticulture, Plant Pathology)**

5:30-7:30 **Mixer** (Sponsored by Bayer, DuPont, and Cerexagri)

Friday, November 18

8:30-9:30 **Business Meeting**

9:00-12:00 Concurrent Sessions (Entomology, Horticulture, Plant Pathology)

Thursday afternoon
Entomology-Main Ballroom

1:00-1:15 **Field experience with codling moth/oriental fruit moth mating disruption using micro flakes MD materials.** Greg Krawczyk and Larry A. Hull. Penn State, Biglerville, PA

1:15-1:30 **Avenues for improving codling moth mating disruption.** Larry Gut, Luascz Stelinski, and James Miller. Michigan State, East Lansing, MI

1:30-1:45 **Testing codling moth DA lures in New York, 2005.** Harvey Reissig and C. Smith. Cornell, Geneva, NY

1:45-2:00 **Use of mating disruption and Cyd-X to manage codling moth in Pennsylvania apple.** Larry Hull and Greg Krawczyk. Penn State, Biglerville, PA

2:00-2:15 **Management of oriental fruit moth in apples using different pheromone dispenser technologies in combination with in-season fruit inspection.** Art Agnello and Harvey Reissig. Cornell, Geneva, NY

2:15-2:30 **Toxicity of insecticides to codling moth and oriental fruit moth.** Jim Walgenbach and Raul Villaneuva. NC State, Fletcher, NC

2:30-2:45 **Two new pests of tree fruit in West Virginia.** Mark Brown and Robb Alleman. AFRS, Kearneysville, WV

2:45-3:00 **Conservation and augmentation of the predatory mite, *Typhlodromus pyri*, in Pennsylvania apple orchards.** David Biddinger, Larry Hull, and Greg Krawczyk. Penn State, Biglerville, PA

3:00-3:15 **BREAK**

3:15-3:30 **Searching for insect resistance traits in *Malus* germplasm: preliminary observations.** Clayton Myers, AFRS, Kearneysville, WV; Harvey Reissig, Cornell, Geneva, NY; and Tracy Leskey, AFRS, Kearneysville, WV

3:30-3:45 **Progress in mating disruption of oriental beetle in highbush blueberries.** Dean Polk, J.D. Barry, R. Holdcraft, and C.R. Rodriguez. Rutgers, Cream Ridge, NJ

3:45-4:00 **Capture of dogwood borer in pheromone traps deployed in managed and native habitats in five eastern states.** Chris Bergh, VA Tech, Winchester, VA; Tracy Leskey, AFRS, Kearneysville, WV; Jim Walgenbach, NC State, Fletcher, NC; Bill Klingeman, U of TN, Knoxville, TN; Dave Kain, Cornell, Geneva, NY; and Aijun Zhang, BARC, Beltsville, MD

4:00-4:15 **Organic management of arthropod pests on apple in West Virginia.** Henry Hogmire. WVU, Kearneysville, WV

4:15-4:30 **Pheromone trapping of the brown marmorated stink bug.** Peter Shearer, Rutgers, Bridgeton, NJ; Ashot Khrimian, Jeff Aldrich, Anne Nielson, George Hamilton, and Ann Rucker.

4:30-4:45 **Impact of prevailing temperatures on captures of plum curculio in odor-baited traps.** Tracy Leskey, AFRS, Kearneysville, WV; and Aijun Zhang, BARC, Beltsville, MD

4:45-5:00 **Tart cherry integrated orchard management (RAMP) project in Michigan** Nikki Rothwell and Andrea Biasi-Combs. Michigan State, Traverse City, MI

Friday morning
Entomology-Main Ballroom

9:30-9:45 **Trac software makes spray record-keeping & reporting easier.** Juliet Carroll. Cornell, Geneva, NY

9:45-10:00 **Impact of reduced-risk insecticides on European red mite and predatory mite interactions.** Raul Villanueva and Jim Walgenbach, NC State, Fletcher, NC

10-10:15 **Current progress in developing a fixed-spray application system for high-density apple plantings.** Art Agnello. Cornell, Geneva, NY

10:15-10:30 **Effect of insecticide, water volume, and method of application on internal Lepidoptera management in apple.** Larry Hull, Greg Krawczyk, and David Biddinger. Penn State, Biglerville, PA

10:30-10:45 **Seasonal applications of E2Y45 against peach arthropods.** Peter Shearer, Ann Rucker, Atanas Atanassov. Rutgers, Bridgeton, NJ

10:45-11 **Results of 4-year risk avoidance and mitigation program (RAMP) project on peaches in New Jersey.** Atanas Atanassov, Peter Shearer, and Ann Rucker. Rutgers, Bridgeton, NJ

11-11:15 **Analysis of Wolbachia strains and re-evaluation of the success of cross-strain mating in plum curculio in eastern North America.** Xing Zhang, J. Tu, and Doug Pfeiffer. VA Tech, Blacksburg, VA

11:15-11:30 **Combining codling moth Granulosis virus with mating disruption for internal Lepidoptera in apple.** Doug Pfeiffer, A. K. Wallingford, C. Laub, W. Mays, X. Xing, K. Love. VA Tech, Blacksburg, VA

11:30-12 Additional Papers and General Discussion

Thursday afternoon
<u>Plant Pathology-Large Board Room</u>

1:00-1:20 **Comparisons of fungicides for full season management of peach diseases.** Norman Lalancette, Kathleen Foster, and E. Murday. Rutgers, Bridgeton, NJ

1:20-1:40 **Organic alternatives for apple disease control in Pennsylvania, 2005** James Travis, Noemi Halbrendt, and Bryan Lehman. Penn State, Biglerville, PA

1:40-2:00 **Control of fireblight with antibiotics, protective fungicides and biological materials in 2005.** Keith Yoder. VA Tech, Winchester, VA

2:00-2:20 **New tools for managing blueberry anthracnose: a progress report.** Anne DeMarsay, and Peter Oudemans. Rutgers, Chatsworth, NJ

2:20-2:40 **Disease observations on grapes in 2005.** James Travis, Noemi Halbrendt, and Bryan Lehman. Penn State, Biglerville, PA

2:40-3:00 **Inoculum sources for *P. expansum* and implications for controlling blue mold decay of apples.** David Rosenberger and A.L. Rugh. Cornell, Highland, NY

3:00-3:15 **BREAK**

3:15-3:25 **Bacterial spot of stone fruit: cultivar susceptibility, bactericide efficacy, and time of fruit infection.** Norman Lalancette, Kathleen Foster, and J. Frecon. Rutgers, Bridgeton, NJ

3:25-3:45 **Highlights of apple fungicide testing in 2005.** Keith Yoder. VA Tech, Winchester, VA

3:45-4:05 **Post-infection control of flyspeck with new fungicides.** David Rosenberger and F.W. Meyer. Cornell, Highland, NY

4:05-4:25 **Combinations of bactericides and fungicides for fire blight and summer disease management on apple.** Norman Lalancette, Kathleen Foster, and R. Winzenried. Rutgers, Bridgeton, NJ

4:25-4:45 **Post-infection control of apple scab with Syllit, Vangard, and Scala.** David Rosenberger and F.W. Meyer. Cornell, Highland, NY

4:45-5:00 **General Discussion**

Friday morning
<u>Plant Pathology-Large Board Room</u>

9:30-12:00 **Additional Papers and General Discussion**

Thursday afternoon
<u>Horticulture-Small Board Room</u>

1:00-1:20	**Efficacy and mode of action of bloom thinners of apple.** Steven McArtney. NC State, Fletcher, NC
1:20-1:40	**Potential chemical thinners for the 'GoldRush' apple cultivar.** Stephen Miller. AFRS, Kearneysville, WV.
1:40-2:00	**Effects of 1-methylcyclopropane, aminoethyoxyvinylglycine, and naphthaleneacetic acid on preharvest drop of "Golden Supreme' and 'Golden Delicious' apples.** Rongcai Yuan, Ross Byers, and David Carbaugh. VA Tech, Winchester, VA
2:00-2:20	**Thinning pillar growth habit peach trees with a spiked-drum shaker or chemical bloom thinners.** Stephen Miller, Donald Peterson, Tom Tworkoski, and Ralph Scorza. AFRS, Kearneysville, WV
2:20-3:00	**General Discussion**
3:00-3:15	**BREAK**
3:15-3:25	**Rootstock effect on growth of apple scion with different growth habits.** Tom Tworkoski and Stephen Miller. AFRS, Kearneysville, WV
3:25-3:45	**Three successive years of Apogee® on young 'Nittany' apple trees on M.9 rootstock.** Stephen Miller. AFRS, Kearneysville, WV
3:45-5:00	**Additional Papers and General Discussion**

Friday morning
<u>Horticulture-Small Board Room</u>

9:30-12:00 **Additional Papers and General Discussion**

Business and Financial

81st Annual Cumberland-Shenandoah Fruit Workers Conference

Program Highlights and Business Meeting

The USDA-ARS Appalachian Fruit Research Station hosted the 81st Annual Cumberland-Shenandoah Fruit Workers Conference at the Holiday Inn in Winchester, Virginia on November 17-18, 2005. There were 60 registered participants and 40 papers presented. Registration was $50 and was intended to cover the cost of the meeting rooms, lunch, breaks, and publication of the Proceedings. Tracy Leskey served as general chair and secretary, while Steve Miller continued his role as treasurer. Mark Brown and Chris Bergh served as moderators for the Entomology sessions. Keith Yoder and Steve Miller served as moderators for the Plant Pathology and Horticulture sessions, respectively. Clayton Myers provided technical support.

The meeting began at 9:00AM on Thursday with a "Call of the States" that included a brief report on the crop, weather, and pest conditions for each state during the 2005 growing season. This was followed by a Panel Discussion during the General Session. The Discussion was entitled "Current Challenges Facing the Tree Fruit Industry in the Eastern United States." Panel guests included Robert Black, a fruit grower from Catoctin Mountain Orchard, Tom Callahan, a nursery industry specialist from Adams County Nursery, Larry Dell, a crop consultant from United Agri Products, Wanda Heuser Gale, a nursery industry specialist from Summit Tree Sales, Inc. and Mark Orr, a fruit grower from George Orr & Sons Orchard. Steve Miller and Tracy Leskey moderated the session. Topics discussed included land use pressures, marketing, labor issues, crop protection, and access to information. After lunch, concurrent sessions in Entomology, Plant Pathology, and Horticulture began and continued through Friday morning. A Social was held on Thursday evening, which was sponsored by Cerexagri, DuPont, and Bayer.

The business meeting was called to order by Tracy Leskey on Friday at 8:30AM. A change of venue for the meeting was strongly encouraged based on loss of space at the Holiday Inn resulting in lack of acceptable meeting rooms for Concurrent Sessions. Also discussed was raising the registration fee due to financial concerns. The group approved raising the registration fee to $60. On-site registration was raised to $75 to encourage participants to register and pay early, therefore providing the Treasurer with more cash in hand to pay bills up front. Finally, it was suggested that more time be left during concurrent sessions for discussion. Several years ago the suggestion was made to limit speakers to a single talk to allow more time for discussion. However, based on the number of talks in Plant Pathology and Horticulture sessions, this has not been an issue. Only in the Entomology session have the number of talks increased to the point where they fill the entire meeting program. It was decided that it be left up to the 2006 Chairperson to best structure concurrent sessions in 2006. Steve Miller gave the treasurer's report. Total income in 2004 was $3500, and together with a balance preceding the 2004 Meeting of $1,250.13 and $0.20 interest, total assets were $4,750.12. Expenses associated with the 2004 Meeting were $3,747.77 for room rental, luncheon, publication of the Proceedings and postage expenses. With additional interest, the balance of the CSFWC was $1,005.39 as of November 16, 2005 and was $4005.39 after adding in 2005 paid registrations. Tracy Leskey thanked Steve Miller for his continued service as Treasurer.

The 2006 CSFWC will be held on November 16-17. Pennsylvania will host the meeting, with Larry Hull serving as General Chairperson.

Respectfully Submitted,
Tracy Leskey, General Chair, Secretary — Steve Miller, Treasurer

Financial Report

2004/2005 Cumberland-Shenandoah Fruit Workers Conference

Balance Preceding the 2004 Meeting (Dec. 1) -	**$1,250.13**

Income (2004/2005) –

Receipts from registration (70)	**3,500.00**
Interest on Account, Dec 2004	**0.20**
Total Assets (Dec. 3, 2004)	**$4,750.13**

Expenses (2004-2005)–

Room rental, luncheon, etc. for 2004 meeting, Jimmy's Holiday Inn	**$2,297.78**
Proceedings, 2004 (copy, bind, etc.)	**1,248.90**
Laminate covers	**103.60**
Postage and meeting costs	**97.49**
Total Expenses (2004-'05)	**$3,747.77**

Additional Income (2004)

Interest on Account(Jan,2005-Oct. '05)	**2.83**
Balance as of 11/16/05	**$1,005.39**
Paid Registrations, '05 (60)	**$3,000.00**
Balance as of 11/18/05	**$4,005.39**

Facilities & Food Costs: Cost - Cost per attendee

1997 - $1,617.15 - $23.43	2001 - $2,453.93 - $28.53
1998 - $1,624.40 - $28.00	2002 - $2,055.61 - $28.95
1999 - $1,916.78 - $26.25	2003 - $1,876.73 - $36.80
2000 - $2,134.64 - $31.86	2004 - $2,297.78 - $32.83

Proceeding Publication Costs:

1997 - $946.58	2001 - $1,481.17
1998 - $867.55	2002 - $999.60
1999 - $888.77	2003 - $804.64
2000 - $1,461.67	2004 - $1,352.50

CSFWC Registrations	**Meeting Hosts**
2005 - 60	2006 - Pennsylvania
2004 - 70	2007 - West Virginia
2003 - 50	2008 - New Jersey/SC
2002 - 71	2009 - Virginia
2001 - 86	2010 - Maryland
2000 - 67	2011 - North Carolina
1999 - 73	2012 - USDA
1998 - 58	2013 - Pennsylvania
1997 - 69(?)	2014 – West Virginia

Total Meeting Costs - Cost per attendee

1997 $2,563.73 - $37.15	2002 $3,055.21 - $43.03
1998 $2,491.95 - $42.96	2003 $2,841.22 - $56.82
1999 $2,805.55 - $38.43	2004 $3,747.77 - $53.54
2000 $3,596.31 - $53.67	2005 $(3,700)est. - $(61.66)est.
2001 $3,935.10 - $45.76	

Call of the States

Call of states- Maryland (primarily eastern parts of the state)

Between May and September we recorded over 30 days of temperatures greater than 90°F. This is in sharp contrast to the 3 days above 90°F in 2004. Precipitation was slightly above the seasonal average, however, as always, one or two events made up the bulk of the monthly totals.

Excellent pollination conditions led to heavy crop loads for peach, apple and Asian pear. High quality, large yields were achieved with aggressive fruit thinning. Maryblight predicted four fireblight infection periods during bloom and sprays applied based on this model prevented any serious fireblight outbreaks. Sporadic reports of fireblight were reported throughout the state.

Despite what seemed like hot/dry weather during a good portion of the growing season, no serious mite outbreaks occurred. There was some serious fruit cracking in late season Goldrush apple prior to acceptable maturity.

Bacterial spot on peach was the worse ever at WYE even on varieties regarded as somewhat resistant. And it was widely reported throughout the state if growers were not on a preventive spray program.

Strawberry plasticulture yields were greater than the historic state average yields. This was due in large part to the mild Fall 2004, and absence of late winter/early Spring freezes.
Botrytis was a problem (even with a good spray program) in vigorous varieties that were planted to close together.

Wine grapes had no major (but the usual) disease epidemics. Warm and somewhat dry Fall conditions allowed fruit to hang and mature longer then in many years past.

Michael J. Newell
Wye Research Center
Queenstown MD

Call of the States – New Jersey Report 2005

David Schmitt, Dean Polk, Rutgers Cooperative Research and Extension

Approximate bloom dates in southern counties were: full bloom in peaches 4/17 and full bloom in apples 4/28. The growing season began cool and wet, and remained so until early June. Early and midsummer established a pattern of timely rains and "normal" temperatures. Late July and August consisted of several short heat waves and dry conditions. This pattern continues into Mid-October when a mini drought was broken by 7-10" of rain over a one week period.

Our peach crop was one of the best in recent memory with perfect growing conditions, fruit of outstanding quality, and a strong market. Secondary insect pests such as plant bugs, San Jose scale and plum curculio remain our biggest pest control challenges. This is mainly due to the loss and increased restrictions on O.P. insecticides. Disease control was excellent overall. A few orchards had difficulty with bacterial spot and anthracnose but control was still acceptable. Over the past 5 years anthracnose and peach scab have become more widespread appearing in nearly all orchards. The higher incidence of anthracnose seems tied to the increased planting of newer varieties that appear to be very susceptible. Many of the white peaches such as Klondike and Sugar Giant are highly susceptible. Yellow-fleshed varieties such as Harrow beauty and PF-27 also show high incidence of the disease. Most growers are still getting excellent scab control with currently available materials, however an increased potential for widespread outbreaks is troubling.

This past season was a difficult year for apples. As in peaches, we are experiencing difficulty controlling plum curculio and San Jose scale. Two South Jersey orchards have had control failures with O.P.'s against codling moth. We have also noticed a trend toward increased trap captures in other blocks. Stink bug has also become a key pest in some orchards. Most injury is occurring late season, when many effective materials cannot be used due to pre-harvest restrictions. Mutsu, the Delicious cultivars, and Fuji seem most affected. Mite pressure was low until mid-to late summer when populations exploded in some blocks and were difficult to control. Disease pressure was high in 2005 with summer diseases very prevalent in post harvest samples. Summer and late season strobilurin applications appear to have provided superior control compared to Captan/Topsin combinations. Rots are only slightly higher where strobilurins were used. Fire blight was nearly non-existent in 2005 after a widespread epidemic in 2004. The greatest threat to apple growers in Southern New Jersey is continued poor market conditions and increases in pest control and labor costs.

Blueberry growers experienced overall favorable growing conditions. However, a warmer than normal start to the season made some pickings for early season varieties overlap with pickings for mid season varieties, mostly Duke overlapping with Bluecrop. This combined with an overall labor shortage, led to fewer hand harvests and an increase in machine harvesting for the frozen process market. Prices held for both markets, but labor continues to be an issue for many hand harvested crops in New Jersey.

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE
Call of the States Report – New York 2005
Art Agnello - NYS Agric. Expt. Sta., Geneva

For once, NY had a growing season that was more like 'the ones we used to have' than any in the past several years, and although keeping the trees covered and the pests under control was considerably less complicated than during the shower-heavy 2003 and 2004 seasons, the hot and dry conditions presented their own kinds of challenges in terms of arthropod management.

It's a little difficult to recall from this vantage point, but we actually started out with a relatively slow, cool and rainy spring, which had us "behind normal" until well into June, when a brief period of warmer temperatures came in during the fruit set period. Similar to last year, this had the positive effect 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 it also gave **plum curculio** enough steam to progress through its oviposition period in fairly short order, so that most locations were able to get by with just the petal fall and 1st cover applications to obtain sufficient protection.

Living up to its reputation as a master of elusiveness, **obliquebanded leafroller** appeared to be very scarce during its overwintered and early 1st summer broods, as a number of orchard inspections around the state turned up extremely low numbers. Nevertheless, harvest evaluations revealed that quite a few orchards concealed marginally damaging populations that caused the typical "late OBLR" damage we're so accustomed to seeing in NY. The **internal worm (oriental fruit moth, codling moth, etc.)** populations once again were on the upswing in the state this year, with notably high moth catches and some definite fruit damage showing up in the traditional high-pressure spots. Particularly troubling is the fact that codling moth seems to be getting more common than it has previously been. We may be seeing the end of our "CM escape" phase, which distinguished us from our neighbors in Michigan and Pennsylvania; this will mean that more alternative CM control measures (such as mating disruption and use of newer chemistry and CM virus) may need to be considered in NYS during the next years.

Apple maggot activity was also back to its more typical strength this year -- some high populations evident in eastern NY, particularly in the Hudson Valley, and quite a few western NY locations -- on the whole, about what we would expect given the favorable climatic conditions. **European red mite** did manage to cause its share of problems eventually, although for some reason not as severely as we expected, and **twospotted spider mite,** which loves this kind of summer weather, also seemed to be fairly limited. **Woolly apple aphid** was evident early once again; this is of particular interest, since we are still lacking any very effective tactics to use against it. Other sometimes sporadic summer pests were also troublesome, depending on the specific locality: **pear psylla** and **potato leafhopper, stink bugs,** and **San Jose scale** all generated their share of attention in one area of the state or another.

Finally, a few regular pests were apparently around, but in relatively low numbers: **Comstock mealybug, white apple leafhopper** and **tarnished plant bug.**

Pennsylvania State Report for CSFWC, 2005.
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Horticulture:

The 2005 growing season started early. Following a relatively mild winter, temperatures soared in mid-April, stimulating rapid bud development and early bloom. In Adams County, Loring peach blossoms opened on 4/13. We had 80% full bloom on early apple varieties and king bloom on mid-season varieties on 4/19. Temperatures then cooled significantly, resulting in an extended bloom period. Two weeks later, Yorks and Goldens were still in full bloom, coinciding nicely with the annual Apple Blossom Festival at the South Mtn. Fairgrounds. Short windows of good pollination weather (warm temperatures and low winds) occurred throughout the bloom window, resulting in a broad range of fruit sizes for growers to contemplate while determining when to apply post-bloom thinners. The relatively cool temperatures, with daily highs in the 50s and 60s continued until the end of May. These temperatures were sub-optimal for chemical thinner activity, and this, combined with the heavy bloom and heavy initial set, resulted in a heavy crop for most PA acreage.

Parts of northern and central PA experienced a very dry summer, and southern PA was dry from mid- July to early Sept. Many growers were concerned about fruit size. Much of the state received heavy rains from the remnants of Hurricane Katrina, effectively ending the prospects of drought.

The peach crop was excellent in terms of yield and quality, and this combined with a smaller national crop resulted in a satisfactory peach marketing season. Apple harvest was about a week later than average, likely due to the cool spring weather. Apple fruit size was better than anticipated, resulting in high yields. Fruit quality was generally good, however we had more stem end cracking of Gala, and more preharvest drop of susceptible varieties than was desirable. Some portion of these problems can be attributed to mixed fruit maturity on the tree, a result of the protracted pollination period. Another portion can be attributed to the dry spell followed by abundant rain. There were also reports of increased bitter pit and calcium related disorders, as would be expected in a season with uneven rainfall and good fruit size. Fruit finish was especially clean, most notably on Golden Delicious. In some cases fruit red color was compromised by warm temperatures for early season varieties. Growers struggled to finish the harvest in good order due to a shortage of harvest labor and in some cases, bins.

Entomology:

From entomological perspective the 2005 season was almost typical for Pennsylvania fruit growers. The biofix for OFM was established on April 17 (exactly the same date as during the 2004 season), for CM on May 09 (a week later than during 2004), for TABM on May 14, and for OBLR on June 05 (two weeks later than in 2004).

Call of the States Report – Virginia 2005

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Horticulture

Temperatures in May were below normal with mean maximum and minimum temperatures of about 70 and 46 °F, respectively, in Winchester. Low temperature affected apple fruit thinning. Low temperature in early May also resulted in some frost injury. Apple fruit matured about one week later than normal due to low spring temperature. Extremely dry weather in September and high humidity in October contributed to fruit cracking in 'Stayman' apples. Prices for processing apples were very poor again and are not keeping pace with production costs. The weather was favorable for pollination, fertilization, and fruit growth of peaches, nectarines and cherries. The peach crop was good.

Plant Pathology

Apple scab remained a prominent problem. We had generally heavy inoculum carry-over and the most significant primary infection period occurred 22-23 Apr, with lesions seen 10 May. Numerous secondary infection periods with wet May; also lingering questions about fungicide effectiveness/ resistance. There was an unusually long period for cedar rust gall activity (2 months), from early April to early June, because of shorter wetting periods, resulting in a higher than usual amount of foliar infection. Some quince rust infection occurred but most blossoms and fruit were no longer susceptible during the heaviest rust wetting periods. Powdery mildew had plenty of opportunity for secondary infection (*36 infection days total through mid-June compared to 22 in '04*). Mildew will continue to be a control problem on susceptible cultivars with less use of SI fungicides due to scab resistance. It was and average fireblight year; lack of wetting at critical times reduced potential threats.

Accumulation of wetting hours related to sooty blotch and flyspeck was delayed in '05 because of the late petal fall date, and ended as the second lowest total since 1994; still these diseases were easy to find in commercial orchards and test plots, particularly on poorly protected trees at lower elevations. Indicators of potential apple rot activity in the test plots included some frogeye leafspot and rots in trees, near cicada-killed shoots (from '04), fruit mummies and sunburn injury. There is still potential for rot development in storage. Alternaria leaf blotch on Red Delicious, first reported in Valley (in Shenandoah county) in '04, was again evident this year but not much expansion in area affected. So far we have not confirmed it to be at our AREC.

On peach and nectarine, several commercial cases of peach mildew and rusty spot were noted, a result of the drier "mildew weather" early in 2005. We had typical brown rot pressure this year; we have effective fungicides if people use them. There seem to be more recent concerns with bacterial spot than in previous years.

Entomology

While the occurrence of oriental fruit moth biofix was within typical limits (April 11), the cool and wet weather that prevailed during the latter part of April and May prolonged its first flight and delayed codling moth biofix (May 8) by about one week, relative to a typical season. As has been the case in recent years, high overwintering populations of oriental fruit moth translated to very large trap captures during first flight.

The extension damage done by the Brood X periodical cicada in 2004, and greater use of pyrethroids for their control, did not translate to increased abundance of woolly apple aphid populations in 2005, and "woollies" were actually rather scarce in most orchards. Rosy apple aphids were detectable in some orchards, but did not occur at outbreak levels equivalent to those in 2003. Spirea aphids, leafhoppers and damage from leafminers was very low early in the season, although leafhoppers increased to high levels in many orchards by harvest. Climatic conditions early in the season were unsuitable for the rapid increase of mites, and mite problems were within typical limits.

Despite the initial detection of European apple sawfly in northern Virginia several years ago, damage from this pest does not appear to be increasing and its distribution shows no signs of rapidly expanding. The extensive late-season damage caused by stink bugs in 2004 did not recur in 2005, although it was certainly at detectable levels in many orchards at harvest. Leafrollers damage at harvest was within typical limits in most orchards.

The major problem in this area continues to be sustained pressure from oriental fruit moth. Its abundance and distribution appear to be increasing, and growers who previously have not had problems are now finding infested fruit at harvest. Codling moth is likely contributing to some degree, and may be increasing. However, the hot and dry conditions that prevailed through August and September appear to have accelerated the development of oriental fruit moth populations and resulted in trap counts that greatly exceeding threshold through most of September. Some growers reported spraying Yorks and Romes in mid-September, later than they had ever done before.

Call of States – West Virginia, 2005

Alan Biggs, Henry Hogmire, and Stephen Miller

Horticulture

A "normal" winter with slightly below normal temperatures for March delayed bud activity and resulted in a late bloom on tree fruit crops. After buds began to swell and open in the second week of April, the region experienced the typical cool down and several nights of light frost, but nothing severe. By most accounts the conditions for pollination were poor, with temperatures below 70°F and windy most days during full bloom. Despite some concern, the heavy bloom in the area set a heavy crop and many apples required thinning. Unlike the previous two growing seasons when an over abundance of moisture led to numerous pest problems, rainfall this year from April through September was below normal. The few sweet cherry growers in the area harvested a very high quality crop with no cracking and very little brown rot. Golden Delicious responded to the dry conditions with some of the smoothest Goldens in many years. The peach crop was above levels of recent years and of very high quality. The acreage planted to apples and peaches continues to decline in West Virginia and most remaining growers are diversifying to small fruits to supplement their cash flow during the early part of the growing season. Fresh local sales continue to increase, especially in apples, as growers move from low-density plantings and cultivars traditionally associated with processing to higher density plantings and a wider selection of cultivars. Mother Nature tried to catch up on the year's below normal moisture levels in October with over 6 inches received in many orchards. West Virginia's tree fruit industry has taken a "Y" in its long and historic road as evidenced by the hot topic at most grower meetings - the price of land and where the next housing/industrial development is likely to begin!

Plant Pathology

The 2005 growing season came in on the heels of two of the wettest growing seasons in recent history. Accordingly, disease inoculum was plentiful and plant disease management played an important role for most fruit producers in West Virginia. But the wet weather arrived in only small amounts, with only seven infection periods in April and May and a total of 21 for the entire season. Apple scab was again the disease with the most widespread incidence and severity in 2005, although it was well-managed in most locations. Fire blight was generally sporadic in its occurrence and incidence was low. Incidence of cedar-apple rust and apple powdery mildew were moderate to heavy in some locations. At the WVU-KTFREC, unsprayed trees of Golden Delicious and Rome had over 50% leaves infected with cedar-apple rust this year – the highest incidence ever recorded there. Growers were well-prepared for summer disease control, and because of the relatively dry weather this summer were able to manage effectively the summer rots and fruit blemish fungi.

Entomology

Internal worms (codling moth, Oriental fruit moth) continue to be the most troublesome pest complex for West Virginia growers in terms of fruit injury and loss. Although both species are responsible, injury from codling moth has increased. Most internal worm injury is occurring after mid-July. Warm temperatures this summer resulted in the completion of an entire third generation egg hatch of codling moth from mid-August through late September. Pheromone trap counts of Oriental fruit moth (4th and 5th flights) were especially high (over 100/week) in quite a few orchards during this same time period. Rosy apple aphid was more problematic than last year, but not as abundant as in 2003. More cases of poor performance of pyrethroids against this pest were observed, whereas neonicotinoids (Actara, Assail, Calypso, Provado) performed very well. In general, incidence of spirea aphids, leafhoppers and leafminers was very low in most orchards. In spite of hot temperatures during July and August, populations of European red mites requiring control were not as numerous as expected. Japanese beetles were quite abundant over a prolonged period for the second year in a row. Incidence of fruit injury from leafrollers (tufted apple bud moth, variegated leafroller, redbanded leafroller) was generally low throughout the area.

Entomology

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AVENUES FOR IMPROVING CODLING MOTH MATING DISRUPTION

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Mating disruption has been shown to be a feasible control tactic for the codling moth, *C. pomonella* L.. An estimated 200,000 acres worldwide were treated with a codling moth disruption product in 2004 (Gut et al., 2004). Further adoption of this promising approach has been impeded, however, by the difficulty encountered in controlling moderate to high population densities. To minimize the risk of failure, apple and pear growers typically have applied companion insecticides to reduce pest densities. Broad-spectrum insecticides have been the key materials used to reduce pest densities to low levels in disrupted blocks, as they kill both adults and larvae. The US-EPA has restricted or eliminated most of the insecticides that growers have historically relied on for codling moth control. Some alternative insecticide chemistries have recently been registered for control of this pest. An insect growth regulator, novaluron, and the neonicotinoids, thiacloprid and acetamiprid, are three of the most promising options. However, the targets of the newer insecticide chemistries are primarily the larvae. But, the window of opportunity for killing larvae is the brief time between egg hatch and entry into the apple fruit. These new compounds have little or no activity against adults. In addition, the new products are more expensive than the older ones that are being eliminated. In the absence of inexpensive and broadly acting insecticides, the use of mating disruption is likely to decline. Indeed, at least a 10% reduction in the acreage treated with pheromones for control of codling moth was recorded in Washington State over the past two years (Gut et al., 2004). To be economically viable in the future mating disruption needs to be effective against higher population densities; in many instances, it may need to provide control as a stand-alone program.

At present, pheromone-based mating disruption of codling moth is largely achieved through hand-application of reservoir-type release devices at rates of at least 250 sources per ha. The highest recommended deployment rates are usually limited to 500-1000 dispensers/ha, mainly for economic reasons, including costs of labor for hand-application. Typical levels of disruption of *C. pomonella* by such hand-applied macro-dispensers can range from 60-98 % as measured by inhibition of monitoring traps deployed in the interior of treated plots, depending on moth density and insecticide inputs (Gut and Brunner, 1998; Gut et al, unpublished data). In our experience with the industry standard (Isomate-C Plus) dispensers at two/tree (1000/ha), codling moth disruption of 90% or greater requires companion insecticides to reduce populations to very low densities, where monitoring traps catch only ca. 0.5 - 3 moths / trap / whole growing season (Gut et al. unpublished).

Mating disruption for codling moth is at a juncture where its efficacy and reliability needs to be significantly improved if it is to maintain or increase its share of the pest-control market. Apple and pear growers are concerned about the occurrence of unacceptably high levels of codling moth damage in orchards under previously effective mating disruption regimes using hand-applied, reservoir dispensers. Part of the reason may be that some growers under economic stress have been halving the recommended density of dispensers. However, even growers faithfully following recommended protocols that once worked well are seeing less positive outcomes. The pressing concern is that, as insecticide usage decreases in orchards, densities of moths do not periodically get severely depressed so as to remain for extended periods within pest-density ranges at which mating disruption can be effective as currently practiced. More potent disruptive formulations are sorely needed in management of fruit pests. The next generation of disruption formulations needs to surpass the formulations currently on the market.

Over the past few years we have been exploring ways of raising the bar and achieving "high-performance mating disruption of CM" that should be consistently effective even under high moth densities with limited insecticide inputs. The foundation for this work is a series of studies examining the mechanisms underlying pheromone-based mating disruption in tortricid moth pests of fruit. Collectively, they support false-plume following to pheromone dispensers as an important, if not essential, component of communicational disruption of tortricid moths in the field. Four main lines of evidence have led to this conclusion. Disruption of CM is density-dependent. Under high population densities, disruption increases as a function of increasing density of pheromone release sites. Effective mating disruption using high dosage dispensers occurs in the field despite overall atmospheric concentrations not reaching levels high enough to desensitize moths by adaptation or habituation (Judd et al., 2005). Moreover, males are attracted to high-dosage dispensers in the field. If the nightly observations made at a single polyethylene-tube dispenser reflect what is taking place at the majority of dispensers in a treated plot, then direct competition by sources of sex-attractant would decrease the time available for males to find females.

Finally, the theoretical properties of competitive-attraction phenomena (Miller et al., 2006) have proved consistent with the majority of results obtained in the field. Miller et al. (2006) built on the groundwork laid by Kipling (1979 et ante), who employed standard probability theory to the problem of pest annihilation by the tactic of trapping-out males. For disruption by competitive attraction, a graphical plot of visitation rate to one attractant source (on the y-axis) against density of synthetic pheromone dispensers (on the x-axis) produces a concave profile (true for any inverse function). Male visitation rate initially falls sharply with small incremental increases in dispenser density. However, the additional declines in visitation rate become progressively smaller as dispenser density continues to increase; approach to zero is asymptotic. Plotting 1 / male visitation rate to a given attractant source on the y-axis against dispenser density on the x-axis yields a straight line with positive slope. Plotting male visitation rate to a given attractant source on the y-axis against (dispenser density x visitation rate) on the x-axis yields a straight line with negative slope. Non-competitive phenomena were found not to share this set of properties. Outcomes for simulations of mating disruption by purely non-competitive mechanisms. e.g., pure camouflage or desensitization (adaptation or habituation) were largely straight lines on non-transformed graphical axes in plots of disruptive effect vs. dispenser density and curved lines on both transformed plots (Miller et al., 2006). Of 13 published disruption profiles the authors were able to locate, 11 were a better fit to the predictions of competitive attraction than a non-competitive disruption mechanism (Miller et al., 2006). The reverse was true for 2 cases, where pheromone release rate per dispenser was extraordinarily high; neither of these two cases involved a commercialized product.

If competitive attraction plays a major role in achieving mating disruption, the following practical implications should guide us in developing high performance approaches and formulations: 1) distribution should be uniform rather than clumped, 2) dispenser density should be high, and 3) attractiveness should be competitive with females. Based on these guiding principles, we have explored three means of improving codling moth mating disruption, an "ultra low volume" application of microencapsulated pheromone, a wax disruption formulation that could be applied as small drops at high densities, and a novel dispenser that co-releases both codlemone and the kairomone pear ester, (ethyl (E,Z)-2,4-decadienoate).

Microencapsulated pheromone. Recently, an "ultra low volume" application of microencapsulated pheromone (CheckMate CM-F, Suterra LLC, Bend, OR, USA) that is ca. 10 times more concentrated than the standard air-blast application method was shown to significantly improve disruption of codling moth using microencapsulated pheromone (Knight and Larsen, 2004). In a laboratory flight-tunnel study, we attempted to uncover some of the mechanisms that might mediate disruption of codling moth exposed to CheckMate CM-F (Suterra LLC) applied in a concentrated or dilute manner (Stelinski et al., 2005a). The two treatments of CheckMate CM-F evaluated consisted of the label-recommended field rate of 50 g A.I. / ha diluted in: 1) a standard 1000 liters of water (low concentration; 0.05 g / L), and 2) a low volume of 100 liters of water (high concentration; 0.5 g / L). Treatments were applied to wax-paper strips (Figure 1) at 0.06 ml of solution per cm^2. The mean number of microcapsules adhering to treated wax-paper strips in the high concentration treatment (397.6) was sevenfold greater than the number (57.3) counted on wax-paper strips treated with the low concentration treatment. Both low- and high-concentration treatments prevented anemotactic orientation of male codling to an adjacent 0.1 mg codlemone lure for up to 24 h after application. These moths flew out of the release cages, but exhibited erratic and short flights not restricted to any plume and ending at the tunnel walls or floor. This occurred with ca. 60 and 400 microcapsules per wax-paper strip in the low- and high-concentration treatments, releasing codlemone at ca. 0.15 and 1.5 µg / h, respectively. After 2 d of aging, the low-concentration treatment no longer interfered with ability of males to find the codlemone lure. However, the numbers of males contacting the lure was significantly lowered for up to 6 d with the high-concentration treatment relative to the control and low-concentration treatments. The high-concentration treatment no longer impeded normal orientational flight after 2 – 6 d of aging; but, it diverted males from the codlemone lure by causing them to land on the adjacent treated wax-paper strips. This occurred at a release rate of ca. 0.7 µg / h codlemone from ca. 400 microcapsules per wax-paper strip distributed as clumps of ca. 30 microcapsules / 14 mm^2. We suggest that an initial but short-lived disruption mechanism like camouflage is followed by a longer period of false-plume-following to clumps of microcapsules. The low-volume, concentrated application method for disseminating pheromone microcapsules warrants further investigation for codling moth, as well as for other pests because this approach may improve efficacy without the need for increasing field application rate.

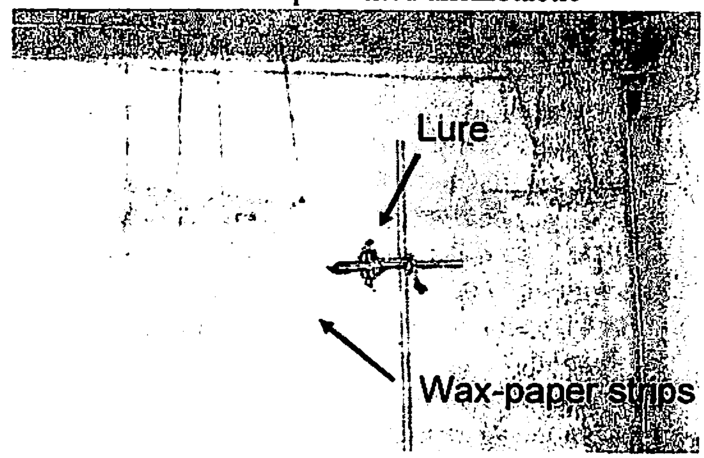

Figure 1. Positioning of wax strips and an attractive lure in the flight tunnel.

Wax drops. The development a disruptive formulation that could be applied as small drops at high densities was achieved through refinement of a paraffin-wax formulation (de Lame, 2003). Our first tests of this approach targeted Oriental fruit moth, *G. molesta* and the outcome was rewarding. Hand-applied paraffin wax drops (0.1 ml) containing 5 % pheromone and deployed at 30 and 100 per tree (8,200 and 27,300 / ha) completely disrupted mating of Oriental fruit moth under heavy population densities as measured by tethered female moths and disrupted orientation of feral males to optimally-baited traps above 99 % relative to control plots (Stelinski et al. 2005b). In addition, the level of mating disruption using high-application densities of wax drops was superior to that with label-recommended applications of Isomate M-Rosso dispensers, which resulted in ca. 17 % mating of tethered virgin females. Furthermore, the application of 8,200 wax drops per ha (30 / tree) required less total pheromone (99 g of pheromone / ha / per season) compared with Isomate M-Rosso ropes at 500 per ha (199 g of pheromone / ha / season). Extensive field observations revealed that male Oriental fruit moth briefly (< 30 s) approached within 130 cm of wax drops. Although some individuals approached within 10 cm, the majority (75 %) remained 20-60 cm away from drops. In summary, paraffin-wax drops were an effective dispenser for mating disruption of high population densities of Oriental fruit moth (catch in control plots averaged 40-100 males / trap / week). Such dispensers are inexpensive and easy to produce, consisting mostly of paraffin wax and water (de Lame, 2003). The higher application densities of wax drops tested produced the best results, probably because these treatments created the highest level of competitive attraction between dispensers and feral female Oriental fruit moth.

Early in 2005, we collaborated with MSU Agriculture Engineer R. Lederbuhr in producing a tractor-mounted mechanized applicator capable of precisely deploying up to 100 wax drops per tree and covering one ha in 25 min. A hydraulic piston precisely meters the emulsified wax formulation through a high-pressure hose running up a maneuverable boom positioning a spinning-cup dispenser spun by a hydraulic motor. The number and size of holes at the bottom of the side-walls of the spinning cup, in conjunction with its rpm's, govern droplet size and number delivered per time. Adjusting the pitch, yaw, and elevation of the spinning cup optimizes deposition of drops onto the target trees. About 70 % of dispensed drops were caught within apple trees during the spring application when the foliage had not yet flushed. Efficiency of deposition was even better for the 2nd and 3rd applications of the season. A 2005 test with very high populations of Oriental fruit moth yielded 100 % disruption of tethered female mating and 99 % disruption of pheromone traps with machine-applied wax drops during the spring generation of moth flight. But during hot summer months, excellent disruption lasted not quite ten days, because of insufficient droplet size (0.05 ml) to prolong pheromone release at the hot temperatures. We are currently working on increasing droplet size so as to provide generation-long release of pheromone against Oriental fruit moth.

Wax-drop technology maximally exploits competitive attraction because of the high density of pheromone point sources applied. It uses pheromone judiciously compared with reservoir-type dispensers that deploy more pheromone per ha per season than wax drops and achieve poorer disruption. Finally, machine application vastly speeds up application time (ca. 4-10 X's faster) and lowers demand for hand labor.

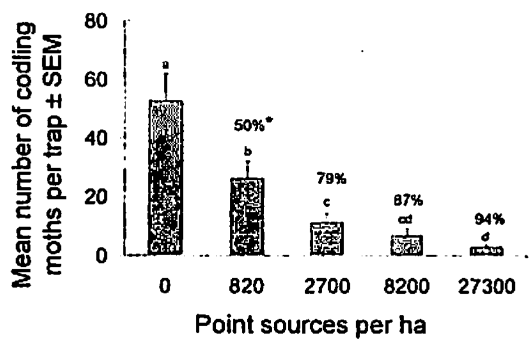

Fig. 2: Captures of male codling moths in traps baited with 1.0 mg codlemone lures in replicated 16 tree

In 2004, we tested a hand-applied wax-drop formulation against a high population of codling moth. It was very disruptive (Fig. 1), but for only two weeks. Ninety four percent inhibition of male codling moth catch in traps was achieved with 27,300 drops / ha (100 / tree). Disruption of actual mating using tethered virgin females has yet to be determined. Loss of efficacy after 14 d may have been due to: 1) drop in codlemone release rate below that required to disrupt well, or 2) codlemone degradation. The field life of this given formulation is insufficient, as it would require too many applications per season (3-4 is judged the maximum affordable). Future efforts to extend the longevity of codling moth wax drops will focus on adding antioxidants to limit pheromone degradation.

During the 2005 field season, we were invited by Trécé Inc. to test their novel dispenser that co-releases both codlemone and the kairomone pear ester (ethyl (E,Z)-2,4-decadienoate) (Fig. 3 A; next page). This dispenser is made from rubbery PVC polymer and has been formulated to release codlemone alone, pear ester alone, or both compounds simultaneously. We evaluated the two-component PVC formulation during the second codling moth generation in 2005. Treatments were applied to 16 tree (0.07 ha) plots replicated five times. The results from Trécé dispensers releasing both codlemone and pear ester were exciting; disruption was substantially better than that by Isomate-C Plus dispensers, the industry standard for the past 15 years (Fig. 3 B,C). Mean captures of moths and mating of tethered virgin females in Fig. 3 B, C were statistically compared by analysis of variance and separation of pairs of means for each sampling date to show efficacy changes over time. For the first 4 wks of this test, inhibition of moth catch in pheromone traps was substantially better for Trécé dispensers releasing both codlemone and pear ester than for Isomate-C Plus dispensers releasing just pheromone. Moreover, mating of tethered virgin females under high moth densities was completely disrupted in plots treated with Trécé dispensers (Fig. 3 C). Mating in Isomate-C Plus treated plots averaged ca.15% during this same period (Fig. 3 C). This is the first time we have been able to achieve complete disruption of codling moth mating under high pest pressure. However, the high degree of efficacy achieved with Trécé dispensers lasted only four weeks. For the remainder of the season, effectiveness of Trécé dispensers was similar to that of Isomate-C Plus. The Trécé PVC dispenser contains an equivalent amount of codling moth pheromone to that in Isomate-C Plus dispensers. The content of PE was somewhat higher. However, based on our release-rate studies of both compounds from paraffin wax, the PE volatilizes ca. 3 times faster than codlemone, suggesting that depletion of PE after 4 wks of deployment was responsible for the abrupt decrease in efficacy for Trécé dispensers after 4 wks in the field. Other hypotheses that need to be ruled out by direct evidence are that: 1) the release rate and active ingredients may not have fallen below threshold, but something else changed in the orchard environment, or 2) A breakdown of codlemone or PE occurred with concurrent buildup of antagonists such as codlemone acetate that rendered dispensers unattractive after 4 wks. Unfortunately, during this first test, PVC dispensers releasing codlemone only were not available for comparison, however this initial test of efficacy relative to that of Isomate-C Plus suggests that this pear-ester plant volatile dramatically improved disruption of codling moth.

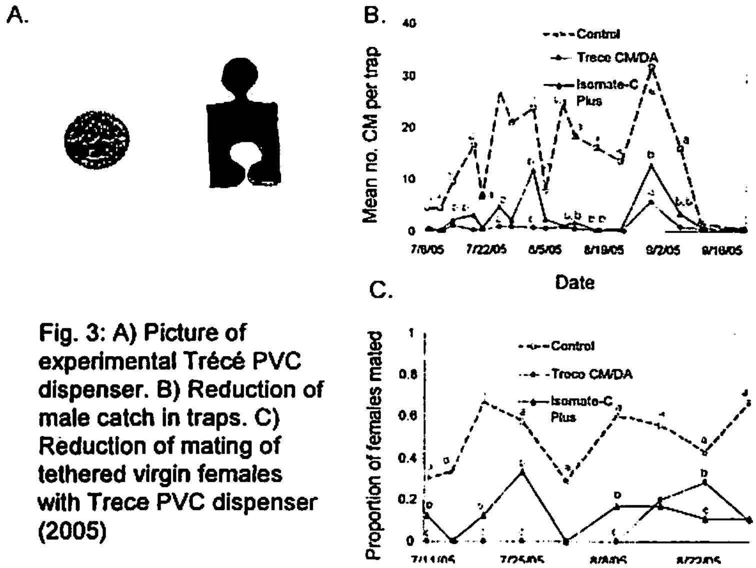

Fig. 3: A) Picture of experimental Trécé PVC dispenser. B) Reduction of male catch in traps. C) Reduction of mating of tethered virgin females with Trece PVC dispenser (2005)

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TESTING CODLING MOTH DA LURES IN NY APPLE ORCHARDS, 2005

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The pear ester kairomone (ethyl (2E, 4Z)-2,4-decadienoate) has been used in west coast apple growing regions as a lure in sticky traps to capture both male and female codling moths. More recently, it has been tested in combination with the codling moth sex pheromone in commercial orchards and this combination attractant captured significantly more moths than a standard sex pheromone lure. Because of the attractiveness of this compound in capturing female moths in west coast apple orchards, it has been extremely useful in monitoring orchards treated with pheromones for mating disruption to detect females that can then be dissected to determine whether or not they are mated to assess the efficacy of the disruption programs.

Unfortunately, DA lures have generally not been as effective when initially tested as lures in apple orchards in certain locations, such as apple production regions in the Eastern United States. In NY during the 2002 growing season, standard CM lures and DA lures were initially tested in 8 NY orchards involved in the RAMP project in 5 acre adjacent plots, one treated with standard pheromone ties for mating disruption, and the other treated only with reduced-risk insecticides. The CM pheromone traps captured and average of 4.5, and 10 moths/season, respectively, in the mating disrupted and non-disrupted plots. The DA lures captured an average of less than 1.0 moths/season and only a few of these were females. The 8 test orchards were fairly representative of "typical" orchards in NY that usually are not severely damaged by internal lepidoptera. Therefore, the populations in these orchards, as indicated by the relatively low captures in the non-disrupted plots, are considerably lower than those found in most apple orchards in western apple production regions.

The objectives of research conducted in NY apple in 2005 were to test different rates of DA alone and in combination with different rates of pheromones in undisrupted orchards that were more heavily infested with CM.. This work was designed to determine if DA lures are more effective in attracting moths from higher density populations.

MATERIALS AND METHODS

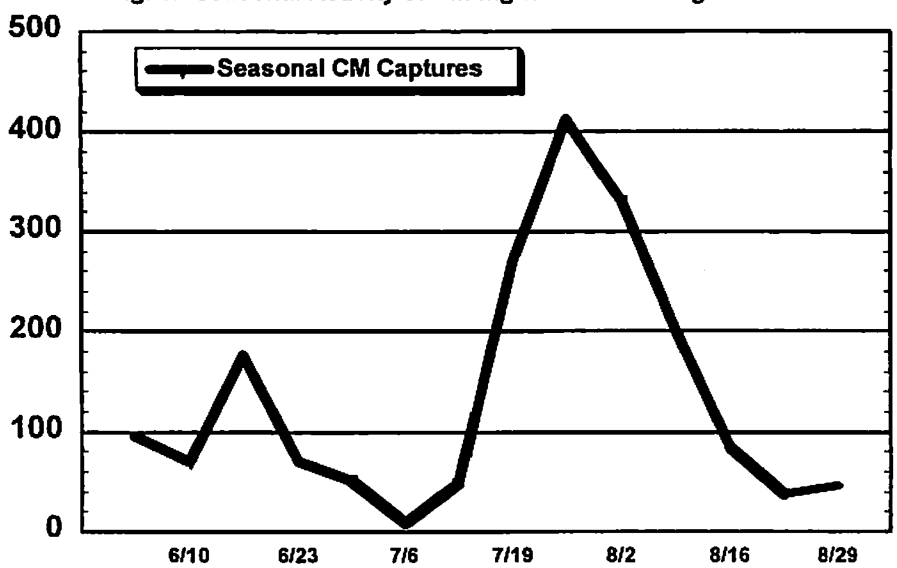
The different types of lures were tested in Delta Pherocon VI traps. Treatments were replicated 10 times in a RCB design. Traps were separated by ca. 25 m. Five replications were deployed in an unsprayed research orchard at Geneva, NY and five were put out in an organic apple orchard in Niagara County, NY. The traps were checked once/week.

During the first flight of CM, from June 3-July 26, the following treatments were tested: 3 mg DA, 15 mg DA, 40 mg DA, 3.0 mg CM pheromone, 3.0 mg DA + 3.0 mg CM pheromone, 0.1 mg CM pheromone + 3.0 mg DA. A different set of treatments was tested during the second flight of CM from August 2-September 1: 3.0 mg DA + 3.0 mg CM pheromone, 0.3 mg DA gray, 0.3 mg DA + 0.3 mg CM pheromone, 0.3 mg CM pheromone grap, 0.3 mg DA + 3.0 mg CM pheromone, 3.0 mg CM pheromone.

RESULTS AND DISCUSSION

The seasonal pattern of trap catches is shown below in Figure 1. The peak activity for the first flight occurred about the middle of June and the peak catches for the second generation of CM

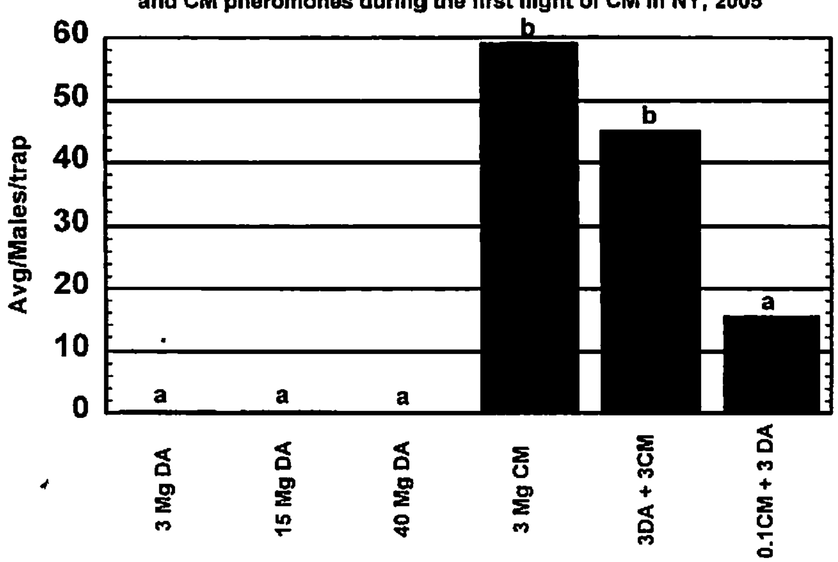
Fig. 1. Seasonal Activity of CM flights in NY during 2005



occurred during the last week in July

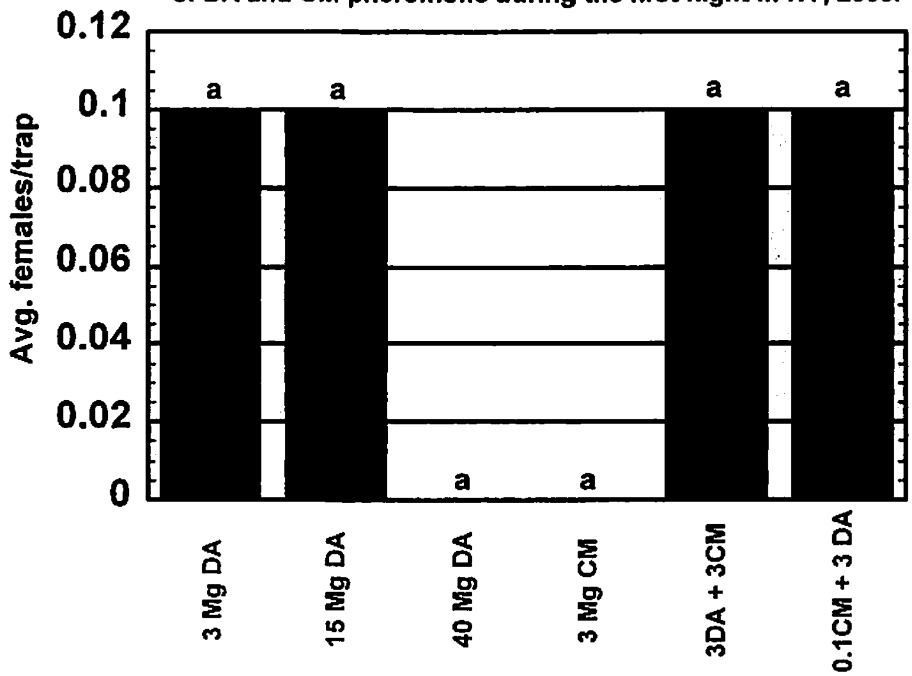
During the first flight of CM, the treatments of various rates of DA alone captured virtually no males (Fig. 2). The 3.0 mg of CM pheromone treatment captured more males than the combination lure of 3.0 mg DA + 3.0 mg CM, but the difference between the two treatments was not significant. The combination of 3.0 mg DA + 0.1 mg CM pheromone caught significantly fewer males than the two most effective treatments.

Fig. 2. Captures of males in the different treatmentsof DA and CM pheromones during the first flight of CM in NY, 2005



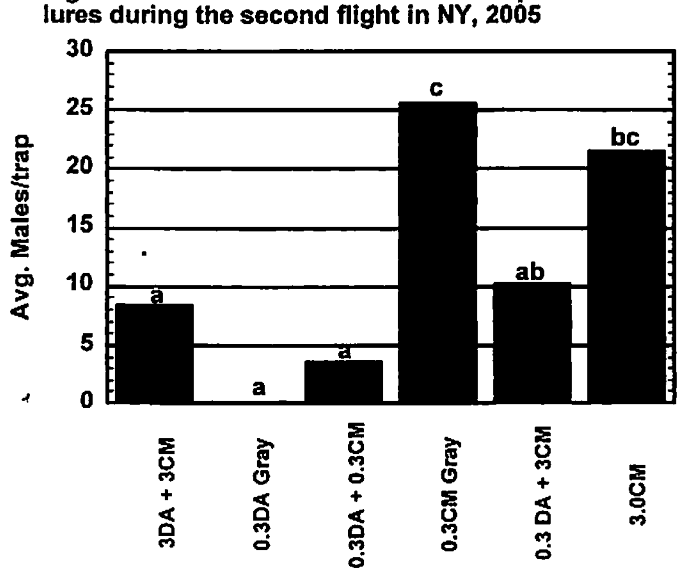
Very few female CM were captured in any of the treatments tested during the first flight of CM (Avg. <0.1/trap) and the differences among treatments were not statistically significant (Fig. 3).

Fig. 3. Captures of female CM in the different treatments of DA and CM pheromone during the first flight in NY, 2005.



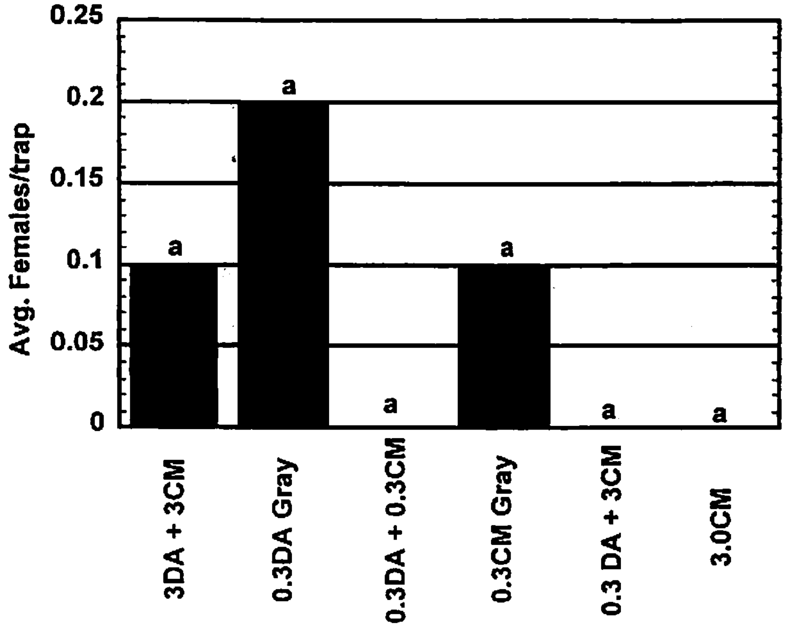
During the second flight of CM, the two concentrations of CM pheromone alone caught the most males, and the difference between these two treatments was not significantly different (Fig. 4). All of the combination lures captured fewer moths than the pheromone alone treatments and some of these differences were statistically significant. The low rate of DA alone only captured a few males during the flight.

Fig. 4. Catches of CM males in DA and pheromone lures during the second flight in NY, 2005



There were no statistical differences in catches of CM females among treatments during the second flight of CM and only a few females were captured even in the most effective treatment 0.3 DA, in which catches/trap averaged only 0.2 moths during the entire flight.

Fig. 5. Catches of CM females in DA & pheromone lures during the second flight in NY, 2005



In conclusion, none of the range of dosages of DA tested alone (0.3-40 mg) were attractive to either CM males or females throughout the season. The combination lures of DA + pheromone were no more attractive to males than pheromones alone. Interestingly, some of the combination treatments of DA + pheromone captured significantly fewer CM males than the pheromone alone. The reasons for the variable performance of the DA and combination lures in different geographical locations are currently not known. It is possible that some of the following variables associated with different apple production locations could influence the response of moths to DA: Differences in population densities; climactic variables such as day and nigh time temperatures, solar radiation, relative humidity, etc; interactions of the DA volatile with plant host differences such as cultivars, tree size, etc.; sensory differences of geographically different CM host races. Further research should be done to investigate this phenomenon.

MANAGEMENT OF ORIENTAL FRUIT MOTH IN APPLES USING DIFFERENT PHEROMONE DISPENSER TECHNOLOGIES AND IN-SEASON FRUIT DAMAGE INSPECTION
2005

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This trial was conducted in mixed plantings of fresh and processing apples on five commercial farms in Wayne, Orleans and Niagara Counties, NY. A low-density pheromone "packet" dispenser, a sprayable plastic micro-flake, and a standard "twist-tie" dispenser were compared for efficacy in managing the internal-feeding Lepidoptera species, oriental fruit moth (OFM), *Grapholita molesta*, when applied against the 2nd and 3rd generations of this pest. Apple varieties included Gala, Rome, Golden Delicious, Red Delicious, Ida Red, Mutsu, Ben Davis, 20-Ounce and McIntosh.

Materials & Methods

In 2005, OFM management programs were tested in five "moderate-risk" commercial orchards, using three different pheromone dispensing technologies, as well as a modified fruit sampling procedure to assess the need and timing for special pesticide sprays directed against the 2nd and subsequent generation of this species. The pheromone treatments used were: 1) Isomate-M plastic ties; 2) MSTRS OFM high-yield, low-density pheromone packets; 3) Hercon Disrupt Micro-Flake OFM, a sprayable plastic laminate, all applied against the 2nd and subsequent generations of OFM. In five additional "moderate-risk" commercial orchards, growers applied their conventional pest management programs (including one orchard where pheromones were used), and the fruit sampling procedure was used to determine the need for specific additional internal worm treatments based on the occurrence of new fruit feeding. In all cases, growers managed the first generation of OFM with their conventional pesticide applications that were directed primarily against plum curculio and obliquebanded leafroller occurring at and immediately following petal fall.

The Isomate-M 100 (CBC America Corp., Commack, NY) was a polyethylene rope (or "tie") containing 232.1 mg of OFM pheromone blend (88.5 : 5.7 : 1.0% of Z:E8-12:OAc : Z8-12:OH), deployed at a rate of 250 ties per ha (100 per acre).

A pheromone packet treatment, using "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 27.4 m (90 ft) between dispensers, resulting in densities between 12.4–20 per ha (5.0–8.0 per acre). A pole+hoop applicator was used to position the dispensers in the top one-third of the tree canopy. Deployment of both of the above dispensers took place from 17–21 June. At one orchard, however—Knapp, an organic block—the MSTRS treatment was deployed in a second plot on 10 July, in place of the Disrupt Micro-Flake treatment, which was not organically certified.

The Disrupt Micro-Flake OFM (Hercon Environmental, Emigsville, PA) was a 3 x 3 mm solid matrix laminate chip impregnated with 7.83 : 0.51 : 0.08% Z:E8-12:OAc : Z8-12:OH, applied at a rate of 70.8 g a.i. per ha (28.67 g a.i. per acre), or 852 g of flakes per ha (12.2 oz of flakes per acre) using a modified leaf blower mounted on an ATV travelling at 8–10 mph down the rows. The flakes were stuck to the tree foliage using a mixture (9.35 liters per ha; 1 gal per acre) of acrylic sticker and guar gum thickener applied as they were blown from the machine. All the Micro-Flake treatments were applied on 7–8 July.

Pheromone treatment efficacy in depressing adult male trap catch was monitored by using 4 Pherocon IIB traps per plot (2 at the row ends and 2 in the plot interior), each baited with a standard Scentry oriental fruit moth lure, and checked weekly from 9 May to 29 August. In addition, 2 traps each for codling moth (CM), *Cydia pomonella*, and lesser appleworm (LAW), *Grapholita prunivora*, were placed in the interior of each plot and also monitored weekly, to maintain information on background levels of these other potentially damaging pests in the event that unanticipated fruit injury was detected at harvest. Lures in all traps were changed in mid-July.

The fruit sampling protocol consisted of weekly on-tree fruit inspections conducted from mid-July through August, comprising 300 fruits per plot (20 on each of 15 trees) during the first week and 100 fruits per plot (10 on each of 10 trees) on subsequent weeks, for each of the 2nd and 3rd generations, to detect the initial occurrence of any OFM larval fruit damage in time to curtail further infestation. Whenever an inspection session resulted in detection of at least one damaged fruit, the grower or his consultant was notified so that they could determine whether a special spray of a selective pesticide was needed for control of internal Lepidoptera.

Results

Trap catches of OFM were generally suppressed to low levels in all pheromone treatment plots during the mid- and late summer, although some breakthrough captures did occur, so trap shutdown was not absolute in all cases (Fig. 1). Two plots with notable OFM catches were the Isomate and Micro-Flake treatments at the Bittner site. These plots were located near a non-disrupted organic apple planting with a high OFM population, so it is possible that immigration from that block was too severe to be completely disrupted by the pheromone treatments in our plots. The Bittner site also recorded a relatively high CM catch during the first flight in June. Trap catches in the insecticide-treated plots differed among the sites, with some farms at or near zero for both species all season, and others catching relatively large moth numbers (Fig. 2). The highest numbers of OFM and CM were caught at DeBadts and Kast, respectively, but the Russell site had relatively large catches of both species. Interestingly, if the proposed trap catch thresholds of 10 OFM and 5 CM/trap/week had been used as a basis for making control sprays, our management recommendations would have been much more conservative than they were using the evidence of fruit-feeding damage.

The fruit sampling procedure was convenient to implement, requiring 10–15 min per plot, and seemed to effectively allow detection of low-level infestations at a very early stage, so that the growers could be notified of any extra needed control measures in a timely fashion. Incidence of fruit injury was extremely low except for the Knapp (organic) site, which was the only pheromone plot location where more than 1 damaged fruit was detected per sampling bout (Table 1). No damaged fruits were found during the 8 weekly samples in any of the Isomate plots; damage was detected 3 times each in any MSTRS and Hercon flake plots plots. In the insecticide-treated plots, damaged fruit was found during only one of these sessions, near the end of August. The high incidence of in-season fruit damage seen at the Knapp site was a result of high endemic pressure, of mostly OFM, plus the organic management regimen, which consisted of kaolin clay and B.t. for the 1st generation, and Cyd-X (codling moth granulosis virus) applied 4 times against the summer generations (20 July, at 5 oz/A; and 4, 20, 31 Aug, at 3 oz/A).

Our notifications to the growers of finding fruit damage during the season did not always result in a decision to apply an extra spray for internal worm control. The 2 such occasions at the Oakes site happened to correspond with the grower's scheduled applications of materials (i.e., Spintor and Assail) against other pests that also had some activity against OFM. Because of the farm's pest history, the Knapp orchard was on a preventive Cyd-X schedule, which was anticipated to have some effectiveness against OFM, so the grower was not relying on our reports for his spray decisions. At the Bittner site, a spray was applied for internal worms in all the pheromone plots, even though damage was found in only one treatment on 1 Aug, because of the grower's concern about the orchard's proximity to undisrupted moth populations.

Fruit damage caused by internal-feeding Lepidoptera at harvest was very low in all treatments at 3 of the 5 pheromone disruption sites (Table 2). At the Bittner site, the Isomate plot sustained approximately 10% fruit damage, although its proximity to a nondisrupted organic planting with a high population could have been a contributing factor. Additionally, the 1st generation CM we detected was not being disrupted, and damage from this species was likely included in the harvest evaluation, as no effort was made to distinguish between OFM and CM damage. The Knapp organic site had previously suffered relatively high fruit damage the previous season. Damage in all the treatments here ranged from 7–17% damage, which the grower indicated was acceptable for the organic processing market, and a measurable improvement over the previous season. No appreciable internal Lepidoptera feeding damage occurred in any of the 5 insecticide-treated plots.

Although the pheromone treatments tested were generally a useful component of the OFM management programs in these orchards, some factors can be identified as potentially contributing to less than perfect fruit quality: Plot size was not large enough to overcome the possibility of immigration by mated females; OFM population pressure was sometimes too high to be effectively disrupted by the pheromone treatments; the pheromones were applied only against 2nd and subsequent generations, leaving the potential for the 1st generation to contribute to fruit damage. More research should be done in future seasons and more locations to continue to test the effectiveness and reliability of the fruit damage inspection system. Nevertheless, it may be difficult to convince growers that any level of damage from internal Lepidoptera is acceptable in their orchards.

Acknowledgments

Thanks are due to J. Bittner, D. Bartleson, R. DeBadts, T. Kast, S. Knapp, D. Oakes, C. Pettit, and P. Russell for allowing these trials to be conducted on their farms; to M. Burlee, J. Eve, J. Misiti, and R. Paddock for coordinating the setup and maintenance of the plots and communications with the growers; to Dorothy and Dianne Mitchell, Rachel Mussack and Rachel Falkey for field assistance in plot establishment and data collection, and for T. Baker and J. Meneley (AgBio, Inc.), P. MacLean (Hercon Environmental), and G. Stamm (CBC America) for their cooperation in providing and helping to apply the pheromone products; and M. Dimock (Certis USA) for donating the Cyd-X used in this study. This work was partially funded by a grant from the NY Apple Research and Development Program and Motts (Cadbury Schweppes).

Table 1. Detection of worm-infested apples during summer fruit inspection dates in pheromone- and insecticide-treated plots, 2005.

	No. fruit inspected	300	100	100	300	100	100	100	100
Site	**Treatment**	**7/13**	**7/16**	**7/25**	**8/1**	**8/8**	**8/15**	**8/23**	**8/29**
Bittner	Isomate	0	0	0	0	0	0	0	0
	MSTRS	0	0	0	1	0	0	0	1
	Hercon Flake	0	0	0	0	0	0	0	0
Oakes	Isomate	0	0	0	0	0	0	0	0
	MSTRS	0	0	0	0	1	0	0	0
	Hercon Flake	0	0	1	0	0	0	0	0
DeBadts	Isomate	0	0	0	0	0	0	0	0
	MSTRS	0	0	0	0	0	0	0	0
	Hercon Flake	0	0	0	1	0	1	0	0
Bartleson	Isomate	0	0	0	0	0	0	0	0
	MSTRS	0	0	0	0	0	0	0	0
	Hercon Flake	0	0	0	0	0	0	0	0
Knapp	Isomate	3	4	4	0	1	1	4	1
	MSTRS-1	34	14	5	16	5	3	15	4
	MSTRS-2	6	5	2	3	1	1	3	1
Russell	Insecticide Std	0	0	0	0	0	0	0	0
Oakes	Insecticide Std	0	0	0	0	0	0	0	0
Pettit	Insecticide Std	0	0	0	0	0	0	0	0
Kast	Insecticide Std	0	0	0	0	0	0	3	0
DeBadts	Insecticide Std	0	0	0	0	0	0	0	0

Table 2. Percent deep (internal) and sting (surface) fruit injury[1] at harvest in pheromone- and insecticide-treated plots, 2005.

Site	Treatment	Deep	Sting	Clean
Bittner	Isomate	9.3 b	0.3 b	90.4 b
	MSTRS	2.0 a	0.1 ab	97.9 a
	Hercon Flake	1.0 a	0.0 a	99.0 a
Oakes	Isomate	0.1 a	0.1 a	99.8 b
	MSTRS	1.6 b	0.2 a	98.2 ab
	Hercon Flake	0.6 a	0.1 a	99.3 b
	Insecticide Std	1.6 b	0.2 a	98.2 a
DeBadts	Isomate	0.0 a	0.0 a	100.0 a
	MSTRS	0.0 a	0.0 a	100.0 a
	Hercon Flake	0.0 a	0.0 a	100.0 a
	Insecticide Std	0.0 a	0.0 a	100.0 a
Bartleson	Isomate	0.1 a	0.0 a	99.9 a
	MSTRS	0.1 a	0.1 a	99.8 a
	Hercon Flake	0.0 a	0.0 a	100.0 a
Knapp	Isomate	7.2 a	0.6 a	92.2 a
	MSTRS-1	15.6 b	2.1 a	82.3 b
	MSTRS-2	6.0 a	0.9 a	93.1 a
Russell	Insecticide Std	0.2	0.0	99.8
Pettit	Insecticide Std	0.0	0.0	100.0
Kast	Insecticide Std	0.2	0.1	99.7

[1]Within a site, values in the same column followed by the same letter are not significantly different at P=0.05 level (Fisher's protected lsd test).

Fig. 1. Pheromone trap catches (lines), in-season fruit infestation detection (asterisks) and harvest fruit damage (bars) in five WNY orchards receiving pheromone treatments against 2nd-3rd generation OFM, 2005

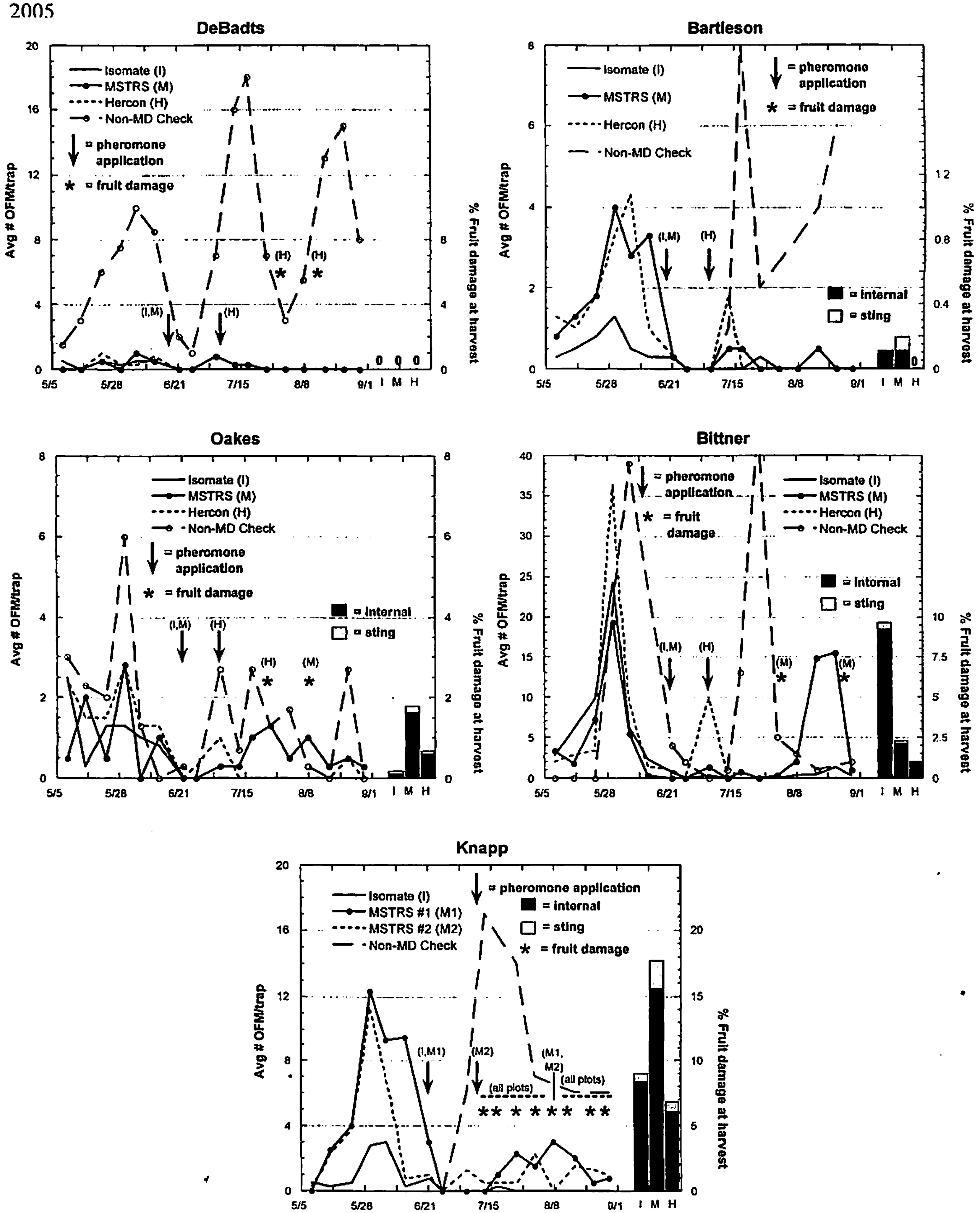
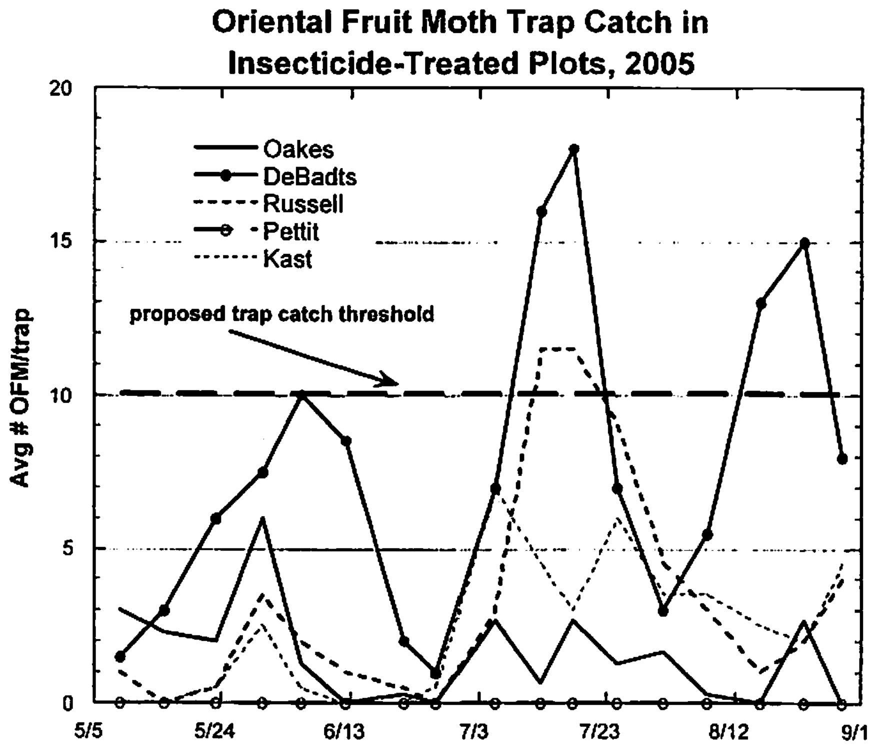
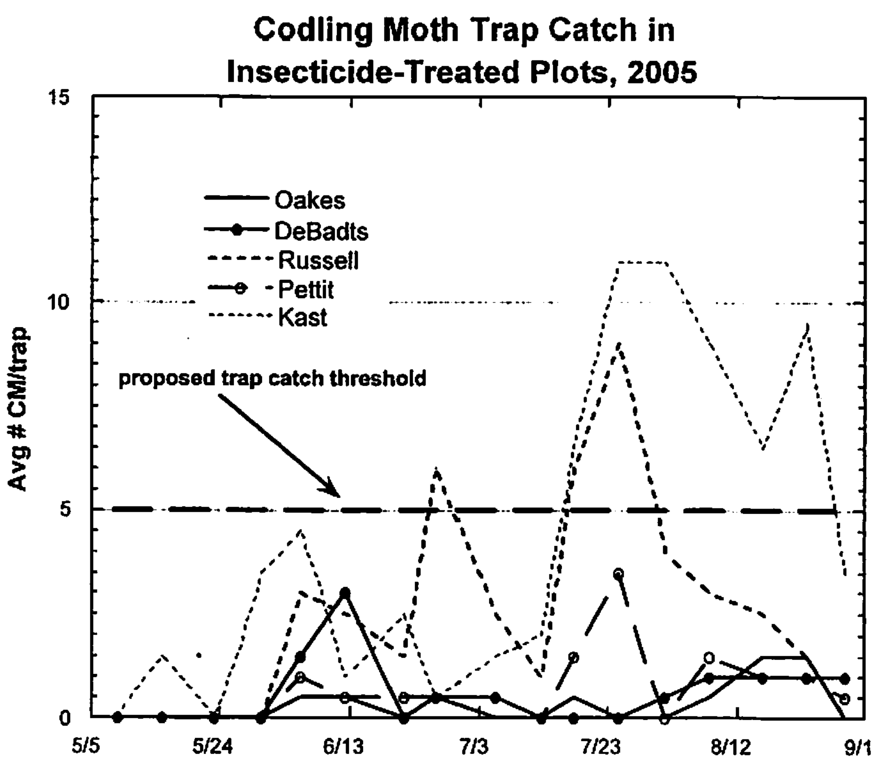


Fig. 2. Pheromone trap catches of oriental fruit moth and codling moth in standard insecticide-treated plots, WNY 2005.





TWO NEW ORCHARD PESTS IN WEST VIRGINIA

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Pear sawfly, *Hoplocampa brevis* (Klug) (Hymenoptera: Tenthredinidae). This sawfly is a close relative of the apple sawfly, previously reported to be present in West Virginia in 2001, and is similar in appearance and biology. The pear sawfly was first reported to be in North America in 1964 in eastern Canada, but was later identified from a museum specimen that was collected in Newburgh, NY in 1953. A survey conducted in 1966 reported pear sawfly to be in RI, CT, NY, PA and MD. We first noticed pear sawfly in pear orchards at the Appalachian Fruit Research Station in 2003, and specimens were confirmed to be *H. brevis* by David R. Smith (USDA, ARS, Systematic Entomology Lab) in 2005. Adult sawflies have a short flight, about 10 days, during late pear bloom, laying eggs in the calyx of young fruit. The egg stage lasts 1 to 13 days and the larvae complete development in about 20 days feeding on 2 or 3 pear fruitlets. The larvae bore into the center of the fruit, entering and exiting fruit near the calyx. Unlike apple sawfly damage, all damaged pears appear to abort leaving no evidence of damage at harvest. Adult pear sawfly is slightly smaller than the apple sawfly (4-5 mm compared to 6-7 mm in length, respectively) and has some slight coloration differences. The major difference is in host preference, only rarely will apple sawfly be found in pear or will pear sawfly be found in apple.

Peach Root Weevil, *Myllocerus hilleri* Faust (Coleoptera: Curculionidae, Otiorhynchinae). This subfamily also contains such serious pests as black vine weevil and strawberry root weevil. *M. hilleri* was listed in a checklist published in 1962 as occurring in CT, DC, MD, PA and VA. The first specimen collected in WV was at the Appalachian Fruit Research Station in 1983 (identified by D. R. Whitehead, reconfirmed by Steven Lingafelter from specimens collected in 2005; USDA, ARS, Systematic Entomology Lab), and recently it has been reported in TN. The weevil is native to Korea and Japan and there is no available literature on its biology in English. The following details were determined by lab, greenhouse and field trials in 2005. The adult weevil will feed on foliage of all rosaceous plants that have been tested, but there is a preference for peach and pear foliage. It appears to overwinter as adults, becoming active in peach orchards at full bloom (10 April 2005). There are at least 2 generations per year, probably 3. Eggs are laid on the soil surface and larvae feed on small peach roots (feeding on pear roots has not been investigated). Although in our unsprayed peach orchard there has been considerable foliage feeding and more than 100 adults emerging in a 0.1 m^2 emergence trap under one 4-year-old peach tree, there seems to be no obvious adverse effects on tree vigor.

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Biological Mite Control Through the Distribution & Conservation of the Predatory Mite, *Typhlodromus pyri*

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Introduction and Historical Background Data

Pennsylvania and other Mid-Atlantic states had an international reputation as a model system for the biological control of mites in apple for almost 30 years, starting in the 1970s. The small, black ladybug, *Stethorus punctum*, was documented to reduce miticide use by 50% during this time and saved apple growers millions of dollars (Biddinger & Hull 1995, Biddinger et al. 2005). OP resistance and the high mobility of the adults allowed this predator to survive toxic pesticide programs of OPs and the carbamate, methomyl, that were targeted to the main pest of this period, the tufted apple bud moth (*Platynota idaeusalis*). While requiring larger spider mite populations than predaceous mites in order to sustain itself, *Stethorus* could fly to new trees in search of higher mite populations when food declined. The only other mite natural enemies of European red mite and two-spotted spider mite that have proven to give effective biological control of mites are the predatory mites of the Phytoseiidae. Predator mites, however, are not mobile and require a constant presence on each tree to give consistent and effective mite control. Thus, they are more susceptible to local extinctions due to lack of prey from miticide applications or from toxic materials such as methomyl or pyrethroids applied for leafrollers or codling moth. Such local extinctions may occur from even a single spray and afterwards some species of predatory mites may take 2-3 years or more to re-establish in an orchard, providing, of course, that further applications of toxic materials are not 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). The chitin synthesis type of IGRs, (e.g. Rimon) are known to be ovicidal (Biddinger & Hull 1995). 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.

For many years, during the early development of mite IPM programs, the phytoseiid mite predator, *Neoseiulus fallacis* (formerly *Amblyseius fallacis*), was promoted as the most effective biological control agent for ERM in eastern apple production. In recent years, however, it has been shown that *A. fallacis* gives only 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 *N. fallacis* are identical in appearance but based on its shorter generation time, higher oviposition and prey consumption rates, *N. fallacis* would appear on paper to be the more effective biological control agent of spider mites. However, the most important advantage that *T. pyri* has over *N. 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 and *T. pyri* can not only survive for long periods on this diet, but also unlike many other predatory mites, it can also reproduce on it. *N. 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 *N. fallacis* often does not become re-established as an effective control agent for spider mites until July or August, whereas *T. pyri* is 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 *N. fallacis* and was thought to be most effective during cooler spring and fall months. Because of this, *T. pyri* was thought to only range in the apple production areas of western NY, the Hudson Valley and New England, but not 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.

It was something of a surprise when in 2003 & 2004, when *T. pyri* was identified in high numbers in the majority of 20 commercial apple orchards surveyed. 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* in many orchards. A three year grant from the Pennsylvania Department of Agriculture had the following objectives and progress towards those objectives is outlined below.

Objective 1: Survey predatory mites throughout the major fruit growing regions of Pennsylvania.

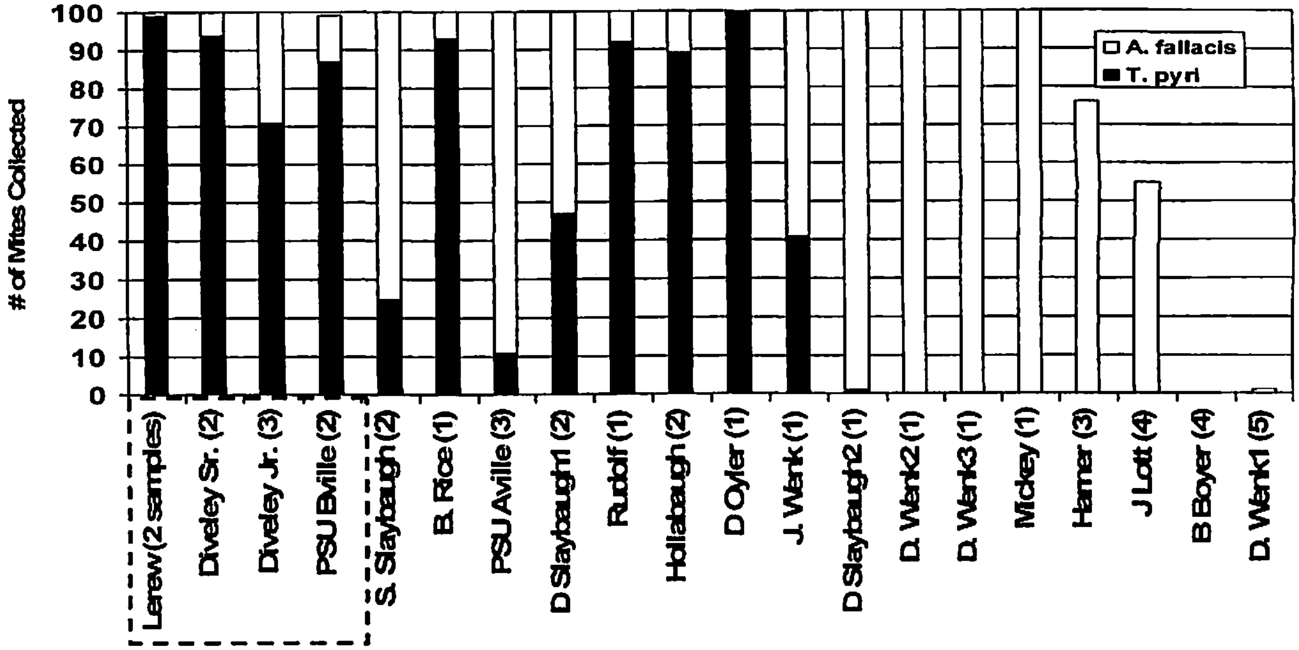
In addition to the original 20 grower sites surveyed in the initial grant from the Apple Marketing Board, an additional 8 sites have been surveyed so far in 2005. The majority of the original survey sites were with apple growers participating in a 4-year RAMP study of reduced risk pesticide orchard pest management. This was because the conditions for *T. pyri* to become established appeared to be highest in blocks using only reduced risk pesticides. We have since found that old orchards with very large standard sized trees also appear to be more likely to harbor *T. pyri*. The most likely explanation is that inadequate spray coverage in very large trees with abundant shoot growth allow refugia from even the more toxic insecticide residues and a steady food source of phytophagous mites even when miticides are sprayed. Another good source of *T. pyri* appears to be some of the apple insecticide research plots at the Penn State University Fruit Research and Extension Center.

Five of the 8 new sites from 2005 are from new blocks with RAMP cooperators who are familiar with *T. pyri* from their interactions with the Penn State researchers during the RAMP study. The remaining 3 cooperators requested to be part of the survey after hearing extension presentations on *T. pyri* at the recent PSU Grower Field Day and during the winter Penn State Fruit School Course by the PI's. Most of the efforts to date have concentrated on conservation of *T. pyri* in existing sites (Objective 2), introduction of *T. pyri* into sites where they are absent (Objective 3), and general grower education (Objective 5).

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

From the original 2003-4 survey of 20 orchards, we found 12 orchards with detectable levels of *T. pyri.* We have identified 1 university and 3 grower orchards with high levels of *T. pyri* (Fig. 1) that can serve as "Seed Orchards" and have obtained the cooperation of the owners for Penn State personnel to transfer shoots and spurs with *T. pyri* to sites where they do not exist or exist at undetectable levels. Examining the pesticide histories of the survey sites with and without *T. pyri* has shown a correlation with the use certain insecticide and miticides at sites where *T. pyri* and other Phytoseiid predatory mites are absent. Methomyl, pyrethroids and diazinon appear to be extremely toxic to *T. pyri* and the use of a single application of any of these compounds appears to eliminate *T. pyri* for several seasons. Working with growers to conserve *T. pyri* where it has already been found has been a top priority this season, especially in the 4 "seed orchards" that are critical to Objective 3. Testing of other insecticides and miticides on *T. pyri* populations in grower orchards has begun and protocols for laboratory testing of populations next season are being developed.

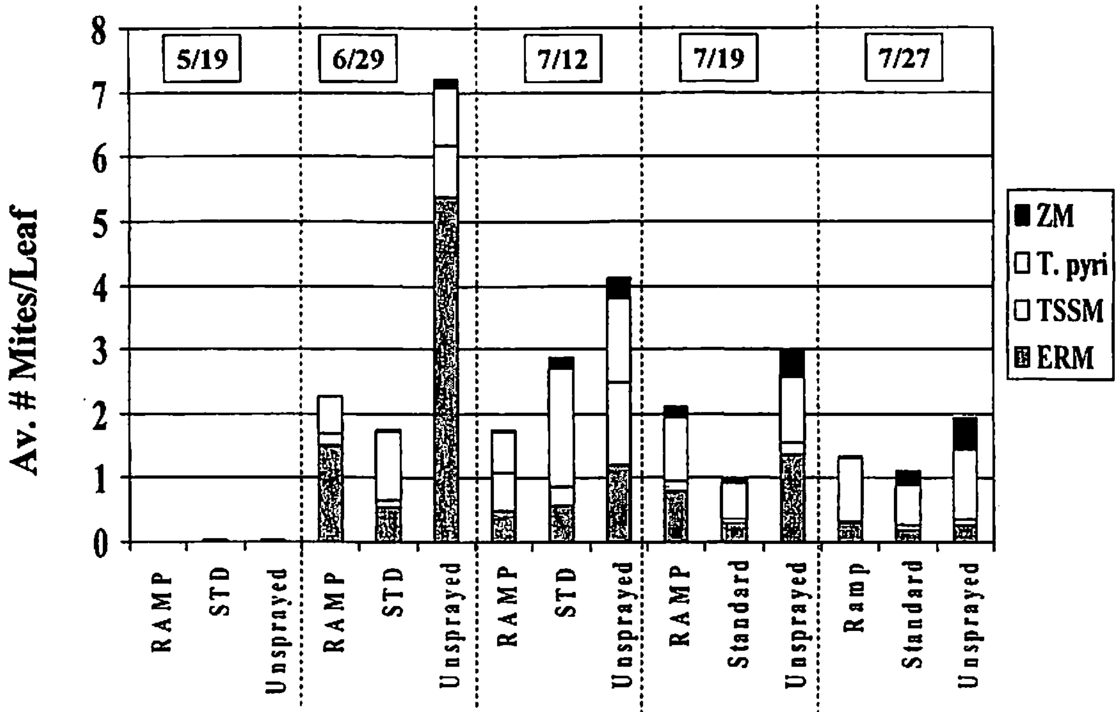
Fig. 1 - PA Predatory Mite Survey 2003-4



"Seed Sites" ***Supported by Apple Marketing Board/SHAP 2004**

One of the impediments to establishing and implementing biological mite control in apple using *T. pyri* was a concern that this more northern species of predatory mite was not tolerant of the higher summer temperatures in Pennsylvania and other mid-Atlantic states. One published laboratory study showed large reductions in prey consumption and fecundity at temperatures over 80° F. We are currently monitoring populations of *T. pyri* and their prey in several grower orchards throughout the season to determine if biological mite control can be achieved with *T. pyri* alone during the hot summer months. A tentative predator/prey ratio of 1:10 had been established in New York and New England, but only for the spring and fall. Our monitoring should show whether this 1:10 predator prey ratio is valid all season under Pennsylvania weather conditions. Initial results indicate that *T. pyri* is active during the hot summer months in Pennsylvania and that they are able to prevent the increase of phytophagous pest mites during the summer months (Fig. 2).

Fig. 2 RAMP 2005 Mite Data – Lerew Orchards



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

Of the 20 apple orchards surveyed originally for *T. pyri* (Fig. 1), it was absent or at undetectable levels in at least 8 orchards. This survey was undoubtedly biased by sampling the 7 orchards managed with the 'soft' pesticides of reduced risk pesticide RAMP programs over a 3 year period, but in at least 2 of these RAMP locations *T. pyri* has never increased in numbers by themselves. It was apparent in some locations that a natural process of succession in biological mite control would be too slow and that the introduction or augmentative releases of *T. pyri* would have to be made from outside sources (the 'seed orchards"). Therefore, releases were made into these two 'sterile' RAMP sites and into other orchards that had been determined to lack adequate numbers of the predator. Introductions were made through the movement of blossoms and shoots cut from the seed orchards and transplanted at a rate of 2 blossoms or shoots on every 3rd tree (approximately 100 shoots/A) at 9 different locations. A total of 12 relocations were made to a total of 62 acres (Table 1). It was determined that relocation took approximately 1.5 hour/person to cut and transfer shoots for each acre where *T. pyri* is being established, exclusive of travel time.

Table 1. *T. pyri* introduction or augmentation sites in Pennsylvania apple orchards through July 2005.

Block	County	Date	Source	Acreage
Boyer RAMP	Bedford	5/27, 6/14	Diveley Sr. Greening Bl.	5
D. Slaybaugh RAMP	Adams	5/26	Diveley Sr. Greening Bl.	10
D. Slaybaugh IPM, Adams Co.	Adams	6/1, 6/7	Diveley Sr. Greening Bl.	10
S. Slaybaugh RAMP	Adams	6/7	Lerew RAMP Bl.	6
S. Slaybaugh IPM	Adams	6/2, 6/7	Diveley Sr. Greening Bl.	7
D. Wenk RAMP	Adams	5/24	Lerew RAMP Bl.	5
D. Wenk Weaner Mtn.	Adams	5/24	Diveley Sr. Greening Bl.	7
J. Wenk Trellis Bl.	Adams	6/10	Lerew RAMP Bl.	7
Harner Farms RAMP	Centre	7/20	Lerew RAMP Bl.	5
		Transfers: 12		**Total: 62 acres**

Preliminary data indicate that detectable levels of *T. pyri* could be found in some of these 'sterile' orchards only 2 months after the initial introductions. The site shown is a RAMP site that has been intensively monitored for 3 seasons with no evidence of *T. pyri* and hardly any predatory mites of any species even though it has chronic pest mite problems and has required a miticide application almost every season (Fig.3). The site has a history of intensive methomyl use and predatory mites were apparently unable to re-establish themselves naturally within the 3-year time frame even with only reduced risk pesticides being used. We introduced *T. pyri* into this orchard in May and they were detected in significant numbers by July 12 (Fig. 4). This establishment was much quicker than previously anticipated and a second count was made the next day just to be certain. Although there is a mixture of the less effective *Amblyseius fallacis* (which probably moved up into the trees from the ground cover) and *T. pyri*, 80% of the predatory mites recovered were *T. pyri* (Fig. 5). It appears that there was some dispersal into the standard grower block as substantial numbers of *T. pyri* were recovered even though only the RAMP block was seeded with shoot transfers. These almost certainly had to result from our May introduction. Predator to prey ratios were well above the 1:10 ratios in the seeded RAMP block (Fig. 6), and approached it in the standard block so that for the first time in 4 years of monitoring nether block needed to be treated with miticides. Rapid establishment and relatively low labor investments should help ensure widespread grower acceptance of the *T. pyri* program.

Fig. 3 RAMP Mite Data – D. Wenk

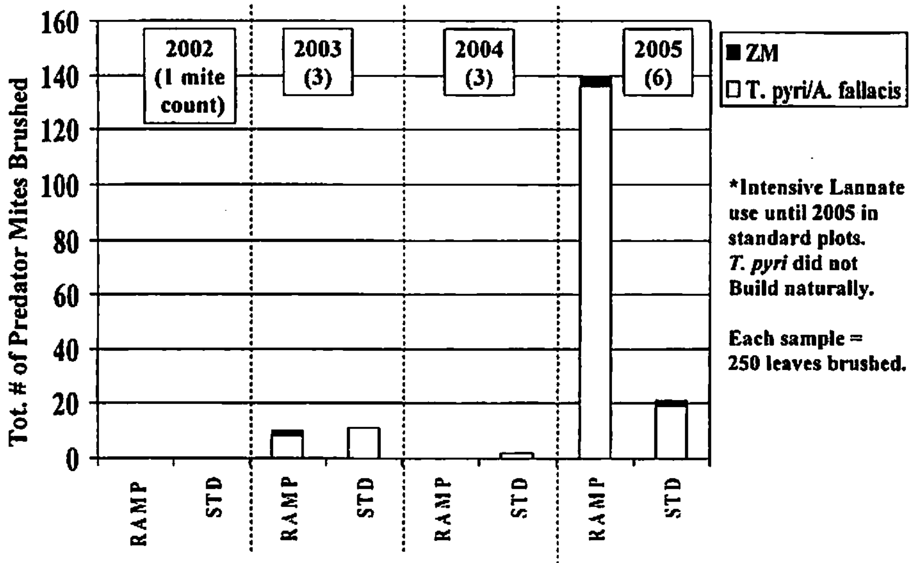


Fig. 4 RAMP 2005 Mite Data – D. Wenk

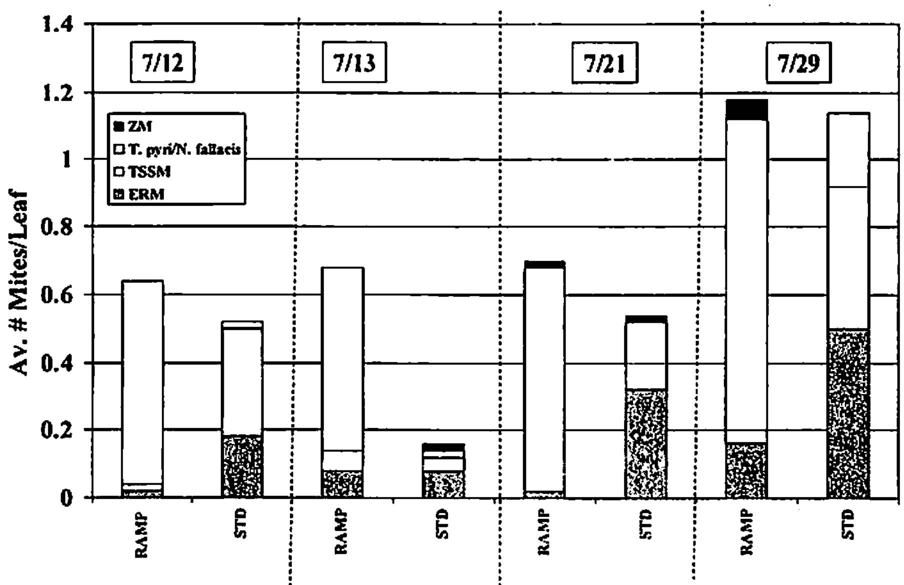


Fig. 5 Slide-Mounted Predatory Mites 2004-5 – D. Wenk

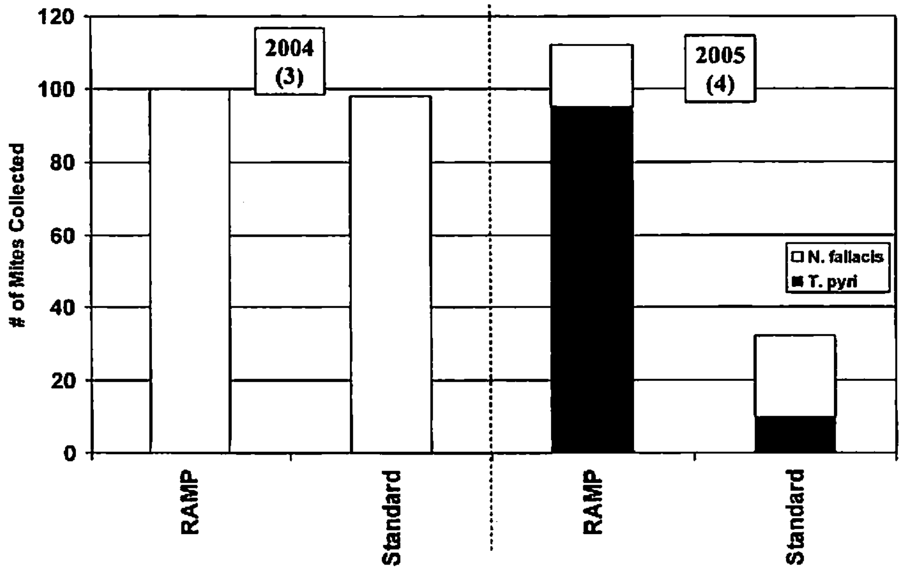
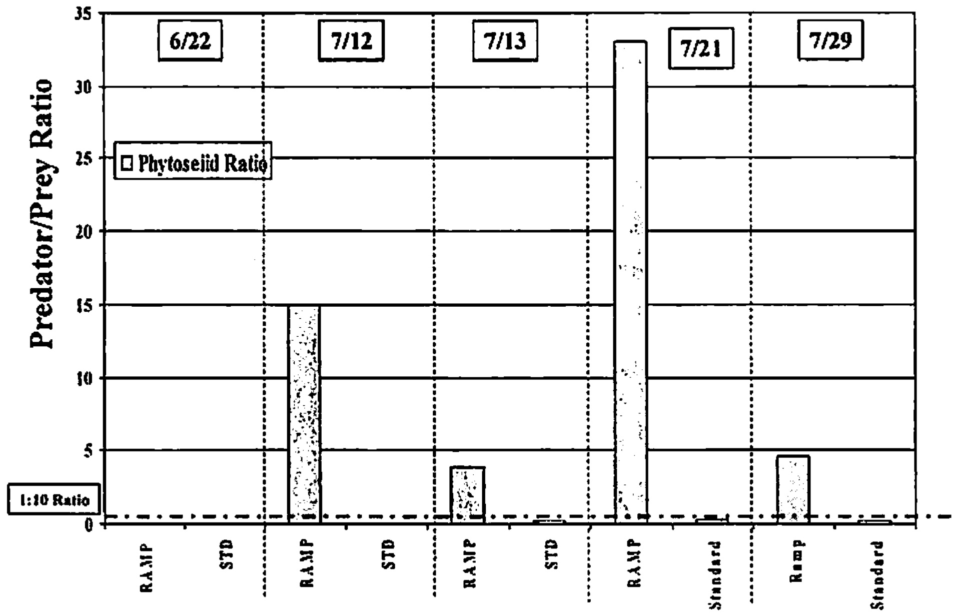


Fig. 6 Mite Predator To Pest Prey Ratios – D. Wenk 2005



Objective 4: Evaluation of success.

Only 6 months into the grant, it is too early to declare successes in any of the objectives. Initial interest and participation of growers has been very positive considering the high cost of miticides and the rapid development of resistance. Some growers wish to retain the option of using pyrethroids as emergency sprays for codling moth and Oriental fruit moth control and are not yet convinced of the long-term sustainability and reliability of this biological control agent. Initial comparisons of orchards with *T. pyri* to those without, indicate a savings to Pennsylvania apple growers of over $600,000 a year with almost 1 ton less miticide active ingredient being applied each year.

A set of recommendations was submitted in June of this year to the USDA Natural Resources & Conservation Service AMA (Agricultural Management Assistance) Program to incorporate mite biological control as a part of the IPM program objectives. It has been accepted and is already partially compensating grower for the initial cost related to the mite introduction/conservation and scouting. The current compensation rate is $6/acre for up to 3 years, but it has been recommended based on the efficiency and labor costs determine in 2005, that compensation be increased to $20/acre.

Conclusions

While still very early to make strong conclusions, the apparent ease of introduction of *T. pyri* into orchards and the relatively low labor cost involved, make the grower implementation part of this project much easier than originally anticipated. The ease of introduction in our few study orchards may not be indicative of all orchards, but the initial results are very positive. The initiation of the AMA program to at least partially compensate growers for *T. pyri* introduction or conservation is a crucial step in getting growers off the very expensive miticide 'treadmill' and back to a biological mite control program. Such a program should be much more effective and reliable than even the well-known *Stethorus punctum* program of the 1975-95. Establishing the effectiveness of *T. pyri* in the hot summer months and whether a predator/prey ratio of 1 phytoseiid mite to every 10 pest mites is valid all season long will be crucial in establishing economic thresholds that would almost completely eliminate miticide use.

PROGRESS IN MATING DISRUPTION OF ORIENTAL BEETLE IN HIGHBUSH BLUEBERRIES

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Earlier work by Shridhar Polavarapu demonstrated the feasibility of using pheromone mediated mating disruption for control of the oriental beetle in highbush blueberries. However, load rates of 1g ai per dispenser are too expensive for commercial use. Therefore, as part of a reduced risk project in highbush blueberries, mating disruption work is being continued with the objective of reducing pheromone load rates, thereby reducing costs. This work was carried out on a 500 acre farm in Atlantic County, NJ. All plots were placed throughout all of the 'Duke' cultivar at Atlantic Blueberry Co. in Mays Landing, NJ. All mating disruption plots contained plastic 'bubble' dispensers (ChemTica Internacional TA, San Jose, Costa Rica), loaded with .5 or .1 g of oriental beetle sex pheromone (Bedoukian Research Inc., Danbury, CT). Plots were 1 ha each (2.47 ac), with 4 treatments of 1) Low - .1g ai/dispenser with 20 dispensers per acre (2g ai/acre), 2) Medium - .1g ai/dispenser with 40 dispensers per acre (4g ai/acre), 3) High - .5g ai/dispenser with 20 dispensers per acre (10g ai/acre), and 4) untreated control. Plots were replicated 3 times in a randomized complete block design, which included untreated buffer rows of at least 200' between treatments, and 500'or more between blocks. Dispensers were attached to an outside blueberry cane, within the row orientation, with a wire twist tie, about 20 cm above the soil surface. The adult flight was monitored with Japanese Beetle can traps (Great Lakes IPM, Vestaburg, MI), baited with 300µg of (Z)-7-tetradecon-2-one lures, placed 3 traps per plot to monitor trap shut-down. Traps were placed on wire hangers so the bottom of the can was just off ground level. Traps were placed in plots on 6/6 with pre-treatment counts taken on 6/13 and 6/16. Pheromone dispensers were placed in plots on 6/16 just after traps were monitored. Traps were monitored once per week until 8/25, and lures were changed on 7/15. Successful trap shut-down is the first measure of success in a mating disruption program, since this data mimics the success or failure of males finding unmated females. Traps placed in a mating disrupted area should catch no to very low levels of the target insect. The 2005 data (Figure 1 and Table 1) indicates that all treatments were equally effective in maintaining trap shut-down.

Oriental beetle larvae were also collected during the spring, reared to adults and sexed to collect virgin females. Virgin females were used as a second method to test the effectiveness of mating disruption treatments. Estimates of actual mating activity replaces data that could be gathered by the destructive sampling of commercial blueberry bushes for the presence of resulting larvae. In preparation for adult placement, oriental beetle larvae were collected from the Rutgers University Research Farm in Adelphia, NJ, and placed in individual clear plastic 1oz cups (Jet Plastica Industries, Inc., Hatfield, PA) with Pro-mix BX (Premier Horticulture Inc., Quakertown, PA) and perennial rye grass. After eclosion, females were separated from males. For each treatment replicate 2-3 virgin females were placed in each of 4-5 cage-pots, located near the center of each plot, and were retrieved after 1-3 days. Cages were placed on July 6, 12, 19, and 22. After retrieval, cages were returned to the laboratory where data was taken to include: the number of females recovered, and the number of males per cage. Individual females were placed in 1oz plastic cups with moist soil and checked for eggs once per week for 3 weeks. Resulting eggs (usually after 7-10 days) were incubated at 25°C and checked biweekly for development and hatching for up to 3 weeks. When adults died, they were held 10 °C. Immediately after death, all females in cages without males were dissected for the presence of eggs, and eggs incubated as above. Females with males that had not laid eggs were also dissected, and any eggs removed as above. For any female's egg cluster in which at least 1 egg hatched, the cluster was classified "viable" resulting from a fertilized female.

The percentage of females recovered from all treatments was not significantly different (P=.05). For all practical purposes, males were recovered only from control cages. An average of 0.08 ± 0.08 males/cage was found in all treatments as opposed to an average of 3.67 ± 0.96 in the control. Practically all fertile eggs resulted from females found with males in cages (mated females) in the controls. One male was found in one treatment cage (medium rate) on the second deployment. Eggs dissected from 1 female in a low treatment cage (no males) did hatch, inferring that there was a male that probably escaped. Data indicates that all treatments were equally effective in shutting down pheromone communication.

Figure 1. 2005 Seasonal trap capture of Oriental beetle adult males in mating disruption plots.

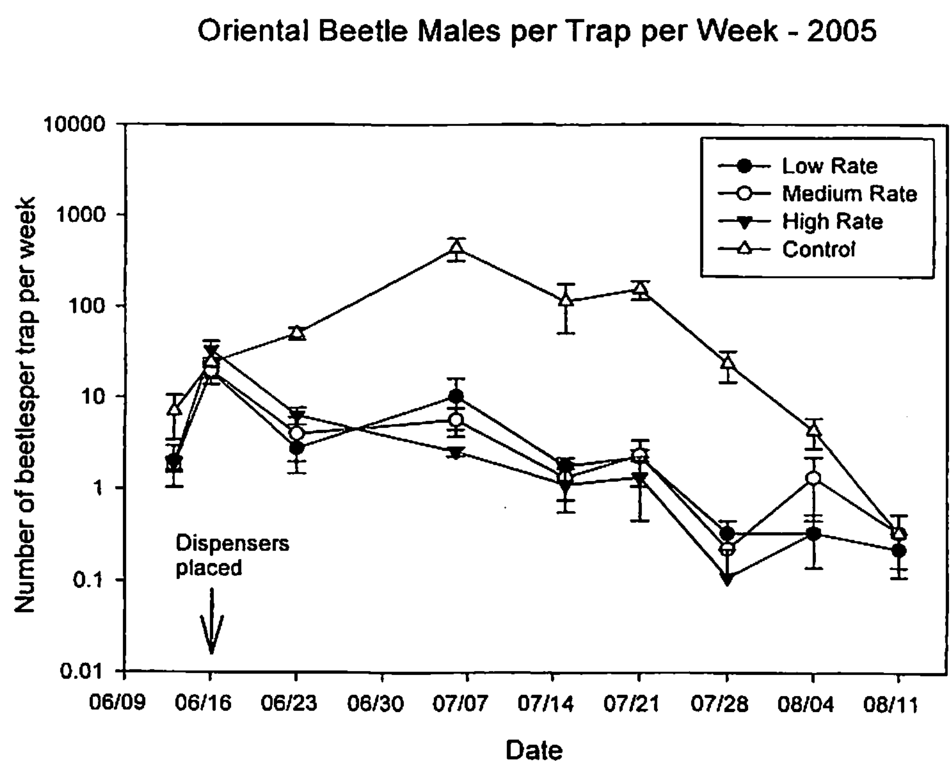


Table 1. Numbers of oriental beetles per trap per week

Date[1]	Treatment				Statistics		
	Low	Medium	High	Control	F	df	P
13-Jun	2.0 ± 1.0	1.8 ± 0.3	1.9 ± 0.3	7.0 ± 3.6	1.52	3,8	0.282
16-Jun	18.9 ± 5.0	19.7 ± 3.5	33.4 ± 8.3	24.2 ± 2.8	1.41	3,8	0.3106
23-Jun	2.8 ± 1.3b	4.0 ± 2.0b	6.3 ± 1.3b	50.7 ± 7.6a	29.98	3,8	0.0001
6-Jul	10.3 ± 5.9b	5.7 ± 1.9b	2.6 ± 0.3b	441.7 ± 120.2a	38.7	3,8	< 0.0001
15-Jul	1.8 ± 0.4b	1.3 ± 0.6b	1.1 ± 0.6b	115.4 ± 64.0a	9.63	3,8	0.0049
21-Jul	2.2 ± 1.2b	2.3 ± 0.3b	1.3 ± 0.9b	156.2 ± 36.0a	46.02	3,8	< 0.0001
28-Jul	0.3 ± 0.0b	0.2 ± 0.2b	0.1 ± 0.1b	23.4 ± 8.8a	21.83	3,8	0.0003
4-Aug	0.3 ± 0.2b	1.3 ± 0.9a	0.3 ± 0.2b	4.3 ± 1.6a	3.74	3,8	0.0601

Means followed by the same letter within a row are not significantly different (Fisher's LSD, P=0.05).

[1] Number of beetles per trap per week on date listed, except count on 6/16 for 3 days.

Table 2. Number of males finding virgin females in cages.

Virgin female deployments, 2005 summary							
Deployment	Date Set	Date Retr	Trt	Rate/A & Total g/A	# Cages / Trt	# Females / Trt	# Males finding Females
1st deployment	6-Jul	7-Jul	Control	0	12	24	21
			Low	0.1 g dispensers @ 20/acre - 2	12	24	0
			Medium	0.1 g dispensers @ 40/acre - 4	12	24	0
			High	0.5 g dispensers @ 20/acre - 10	12	24	0
2nd deployment	12-Jul	14-Jul	Control	0	15	45	17
			Low	0.1 g dispensers @ 20/acre - 2	15	45	0
			Medium	0.1 g dispensers @ 40/acre - 4	15	45	1
			High	0.5 g dispensers @ 20/acre - 10	15	45	0
3rd deployment	19-Jul	21-Jul	Control	0	15	45	5
			Low	0.1 g dispensers @ 20/acre - 2	15	45	0
			Medium	0.1 g dispensers @ 40/acre - 4	15	45	0
			High	0.5 g dispensers @ 20/acre - 10	15	45	0
4th deployment	22-Jul	25-Jul	Control	0	12	24	1
			Low	0.1 g dispensers @ 20/acre - 2	12	24	0
			Medium	0.1 g dispensers @ 40/acre - 4	12	24	0
			High	0.5 g dispensers @ 20/acre - 10	12	24	0

Table 3. Percent females recovered in cages.

Dep.*	Cages in Rep.	Treatment Control	High	Low	Med
1	1	77.78	77.78	100.00	66.67
1	2	77.78	100.00	66.67	77.78
1	3	88.89	100.00	100.00	100.00
2	1	33.33	60.00	80.00	80.00
2	2	26.67	53.33	73.33	73.33
2	3	80.00	60.00	73.33	73.33
3	1	60.00	73.33	53.33	66.67
3	2	66.67	53.33	60.00	93.33
3	3	40.00	73.33	86.67	33.33
4	1	50.00	62.50	100.00	75.00
4	2	0.00	37.50	75.00	50.00
4	3	75.00	75.00	62.50	62.50
	Avg	56.34	68.84	77.57	71.00
	SE±	7.74	5.34	4.67	5.12

*=Deployment

Table 4. Males recovered per cage.

Dep.*	Cages in Rep.	Treatment Control	High	Low	Med
1	1	4	0	0	0
1	2	10	0	0	0
1	3	7	0	0	0
2	1	6	0	0	1
2	2	3	0	0	0
2	3	8	0	0	0
3	1	2	0	0	0
3	2	1	0	0	0
3	3	2	0	0	0
4	1	0	0	0	0
4	2	0	0	0	0
4	3	1	0	0	0
	Avg	3.67	0.00	0.00	0.08
	SE±	0.96	0.00	0.00	0.08

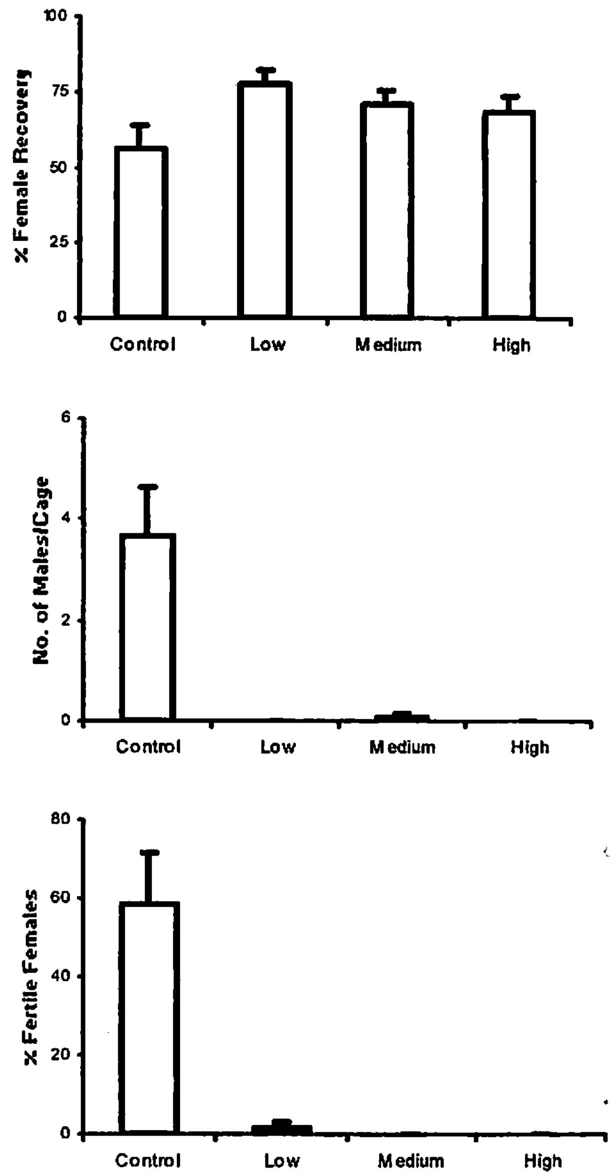
*=Deployment

Table 5. Percent fertile females

Dep.*	Treatment Control	Low	Med	High
1	100.00	0.00	0.00	0.00
1	85.71	0.00	0.00	0.00
1	62.50	0.00	0.00	0.00
2	20.00	0.00	0.00	0.00
2	25.00	0.00	0.00	0.00
2	58.33	9.09	0.00	0.00
Avg	58.59	1.52	0.00	0.00
SE±	13.02	1.52	0.00	0.00

*=Deployment

Figure 2. Female recovery, males per cage, and % fertile females.



Not for Citation or Publication
Without Consent of the Author

CAPTURE OF DOGWOOD BORER IN PHEROMONE TRAPS DEPLOYED IN MANAGED AND NATIVE HABITATS IN FIVE EASTERN STATES

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Previous studies of the seasonal flight activity and relative abundance of dogwood borer (DWB), *Synanthedon scitula* Harris (Lepidoptera: Sesiidae) in managed urban landscapes and apple orchards have relied on information from traps baited with pheromone lures that were suboptimal in their attractiveness and species-specificity (reviewed in Bergh and Leskey 2003). Researchers have reported discrepant and inconsistent results from pheromone-baited traps and have repeatedly raised the issue of poor selectivity for DWB. Identification of the trinary blend of components that comprise the DWB sex pheromone (Zhang et al. 2005) has vastly improved the sensitivity and species-specificity of pheromone trap based monitoring, and use of the new pheromone in traps deployed in apple orchards in WV, VA and NC has revealed that DWB is much more abundant than was previously understood. Leskey and Bergh (2005) showed that burr knots at the base of young apple trees propagated on size-controlling rootstocks are attacked by DWB during the first season after planting, and it is likely that apple trees are at most risk from the potentially damaging effects of DWB infestation during their early years of growth and establishment. Given the broad host range of DWB, including numerous indigenous deciduous trees, many species of woody ornamental trees and apple, DWB should be expected to utilize host plants growing in agricultural and urban settings and in native woodland habitats. Consequently, young apple orchards may be at risk from attack by DWB that originate from several different sources. Furthermore, since data from previous studies have suggested that the duration of flight, mating and egg-laying activity of DWB differs considerably according to latitude (reviewed in Bergh and Leskey 2003), the annual period of risk to apple orchards may also vary among regions within its geographical range.

The objective of this study was to use the new DWB pheromone to provide definitive information on the seasonal flight activity and relative abundance of DWB in different habitats in five eastern states, toward an improved understanding of the risk posed by this pest to young apple orchards and ornamental trees in urban settings.

Delta-style pheromone traps baited with red, rubber septa lures containing 1 mg of the trinary blend of DWB sex pheromone components were deployed in managed urban landscapes, commercial apple orchards and woodlands in NY, WV, VA, NC and TN. Sites for trapping were selected based on their relative isolation from the other habitats. With the exception of one abandoned apple orchard in TN, all orchards were under commercial production. Urban sites included three university campuses, a golf course, a municipal park, a cemetery, a residential subdivision and a National Conservation Training Center campus. Woodland sites included a nature preserve and a nature park, several unmanaged woodlots and an arboretum. In WV, VA, NC and TN, two traps were used at each of two sites per habitat, while two traps were deployed at one site per habitat in NY. Traps were suspended from available vegetation at a minimum of 1.2 m (4 ft) above the ground and placed at different locations at each site. Traps were deployed prior to the anticipated onset of moth flight and remained in the field until flight had actually or virtually ceased. The number of DWB captured in each trap was recorded at approximately weekly intervals throughout the study and the sticky liners were either cleaned of moths each week or the liner was replaced. Since lures loaded with 1 mg of this pheromone remain attractive to male DWB for many months, the same lures were used for the duration of the study.

The total number of DWB captured differed tremendously among states and among habitats within each state (Fig. 1). The vast majority of moths (67.6 - 99.1% of total) were captured in apple orchards, and DWB was more abundant in managed urban landscapes (0.8 – 29.3%) than in woodland habitats (0.1 – 3.1%). Combined data from all states revealed that captures in apple orchards exceeded those in urban landscapes and woodlands by 16- and 219-fold, respectively, and that captures at urban sites were 14-fold greater than at woodland sites.

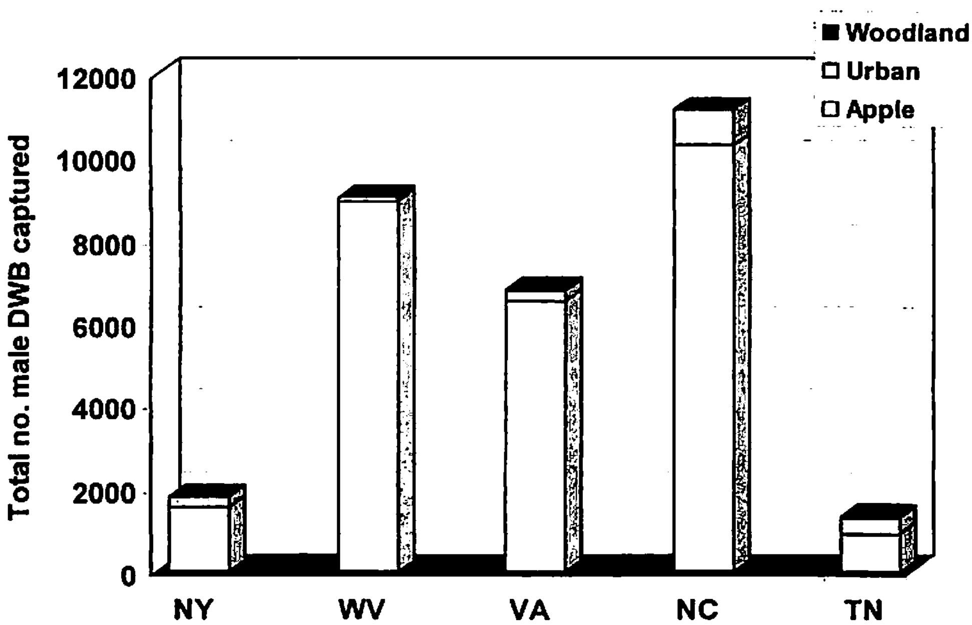

Fig. 1. The total number of male dogwood borer captured among three habitats in five eastern states, 2005.

Figure 2 shows the mean weekly moth captures in 2005. Since the specific day on which weekly captures were recorded differed among the five states, the counts are presented as occurring on Friday of each week. In apple orchards, capture of the first moth in both orchards per state occurred on 13 May in VA, NC and TN. Although the first moths were recorded on 20 May in WV, it appears that those traps may have been deployed somewhat after flight had begun, based on the relatively large counts from both orchards recorded during the first week of trapping (Fig. 1). Relative to the other states, the onset of flight was delayed by about one month in NY apple orchards (first capture on 10 June). As in orchards, the date on which the first moth was captured was identical at both urban sites in WV, VA, NC and TN. In WV, VA and NC, the onset of flight in urban landscapes was delayed by about one week, relative to apple orchards, occurring between 20 – 27 May. In NY and TN, the first capture of moths in urban landscapes occurred on the same day as in apple orchards (10 June and 13 May, respectively). In WV, VA, NC and TN, the onset of flight in woodland sites showed more variability than in apple orchards or urban sites; the date on which the first moth was captured at each woodland site differed by one to two weeks within each state. As in urban habitats, the onset of flight in woodland habitats in WV, VA and NC occurred about one week later (20 – 27 May) than in apple orchards. In NY, first capture occurred two weeks later than in apple, while in first capture in TN occurred on the same date as in the other habitats.

The duration of flight differed among the five states and among habitats within states (Fig. 3). Among states, there was a trend toward progressively longer flight durations in all habitats from north to south. There was a general trend for shortest flight durations in woodlands (mean = 17.4 ± 5.6 SD weeks), intermediate durations in urban landscapes (mean = 21 ± 3.5 SD weeks) and longest durations in apple orchards (mean = 22.2 ± 3.3 SD weeks). Differences in the flight durations among habitats were least pronounced in the two southern-most states. In NY apple orchards, the date of last moth capture (30 September) occurred from 1 to 4 weeks earlier than in the other states.

Despite large differences in the numbers of moths captured among habitats within each state, a fairly consistent feature of the data from apple orchards and urban sites were early peaks of moth capture in June or early July and later peaks that occurred in late August through early September (Fig. 2). In several orchards, however, pronounced fluctuations in weekly captures during the middle of the flight period resulted in seasonal patterns that were not strongly bimodal.

Our data on the abundance and widespread distribution of DWB in apple orchards confirm previous observations (Zhang et al. 2005, Bergh et al. in press) and raise questions about the proximate and ultimate causes underlying its prevalence on this host. Several factors may be invoked to explain this phenomenon, including relatively large acreages in monoculture, pesticide mediated disruption of biological control, and the influence of apple tissues on the performance, fitness and voltinism of DWB. Historically, DWB has been considered a univoltine species with temporally staggered cohorts that result in annual bimodal flight patterns. This widespread assertion has persisted in the literature, despite the fact that data on the developmental rate of DWB are not robust, have generally not been collected systematically and pertain only to its development on dogwood (reviewed in Bergh and Leskey 2003). In 2005, Leskey (unpublished data) provided unequivocal evidence that DWB developing on apple burr knot tissue can complete a generation (egg to adult) in a period of less than two months. Given the duration of its flight, especially in the more southern portions of its range, we believe that DWB is at least bivoltine, and possibly multivoltine, in apple orchards planted on size-controlling rootstocks and hypothesize that this may partially explain the abundance of this pest in the apple ecosystem.

In combination with our results on the rate at which new apple orchards can be infested by DWB (Leskey and Bergh 2005), these data reveal that DWB can represent a significant risk to the establishment of young orchards. It appears that new apple plantings are most likely to be infested from DWB originating from older blocks of apple in the vicinity of new blocks, and not from moths that emigrate from the landscape or adjacent woodlands. Our ongoing research will include monitoring the seasonal flight and relative abundance of DWB in 2006, using the same study sites as in 2005, and expanded investigations of the developmental rate and voltinism of DWB on apple burr knots.

This research was supported by the USDA-CSREES Southern Region IPM Competitive Grants Program.

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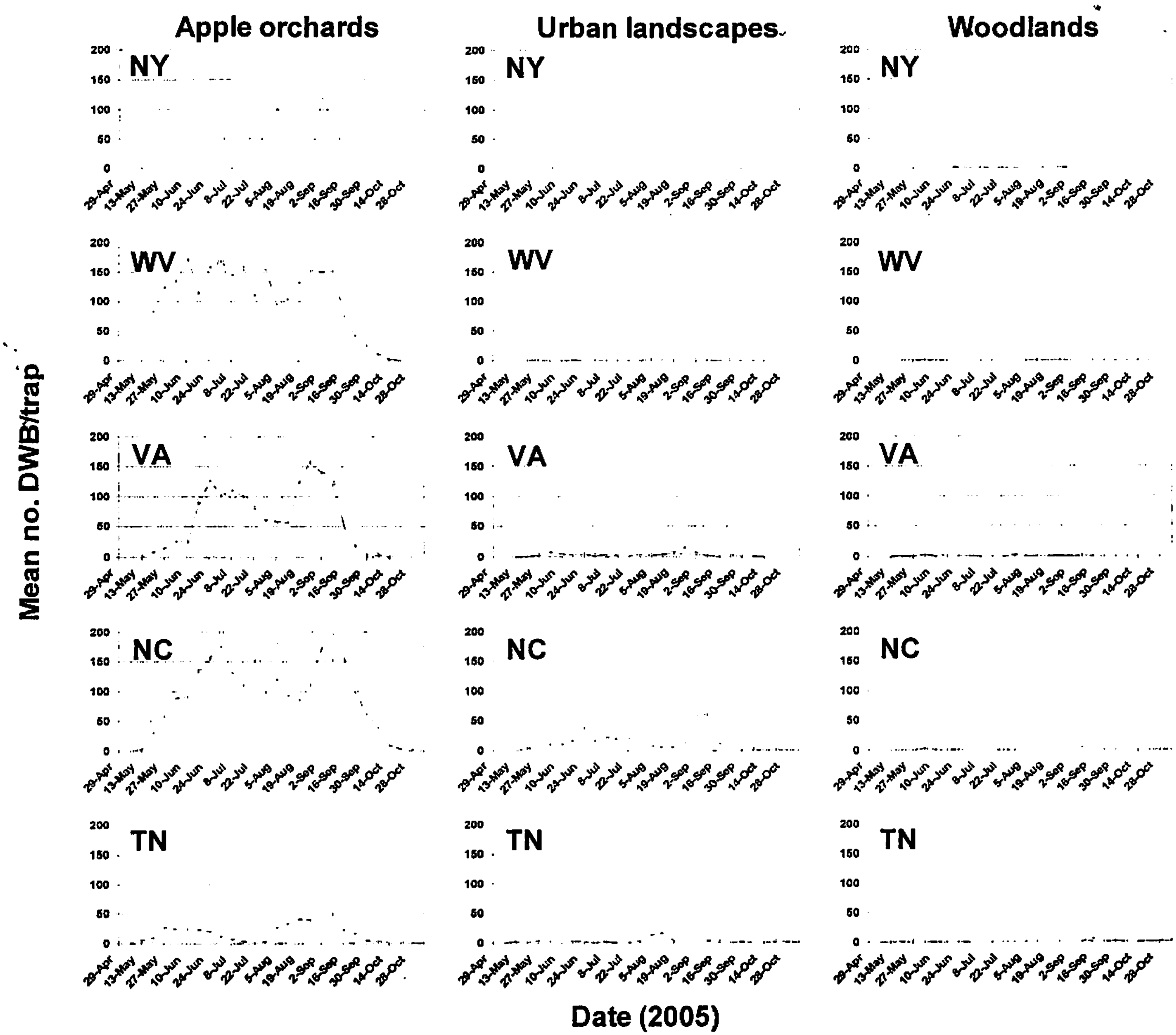

Fig. 2. Weekly captures of male dogwood borer in pheromone traps deployed in apple orchards, urban landscapes and woodland habitats in five eastern states, 2005.

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ORGANIC MANAGEMENT OF ARTHROPOD PESTS ON APPLE IN WEST VIRGINIA

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Introduction

In collaboration with faculty at Iowa State University and North Carolina State University, a three-year project funded by the USDA Risk Management Agency was initiated in 2004 to investigate the risks and feasibility of organic apple production. An orchard at the WVU Tree Fruit Research and Education Center, which had been under an alternative/IPM pest management program since establishment, was utilized to evaluate the efficacy of an organic management program for insects and diseases. This paper reports results for the organic management of arthropod pests in 2005.

Materials and Methods

This study was conducted in a 3.6 acre block of 13-yr-old trees on M.26 rootstock. The block consists of two identical 1.8 acre sections (M West and M East) equally divided among the four cultivars of 'Fuji', 'Golden Delicious', 'Liberty', and 'York'. Trees measured 10 ft. in height and 10 ft. in width and were planted at a spacing of 8 x 18 ft. Insecticides were applied as complete sprays to both sides of the trees with a Swanson DA400 airblast sprayer, which traveled at 2.6 mph and delivered a spray volume of 200 gpa for applications that included oil and Surround, and 100 gpa for all other applications.

Lepidopteran pests [codling moth, *Cydia pomonella* (L.) (CM); Oriental fruit moth, *Grapholita molesta* (Busck) (OFM); redbanded leafroller, *Argyrotaenia velutinana* Walker (RBLR); spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabr.) (STLM); and tufted apple bud moth, *Platynota idaeusalis* (Walker) (TABM)] were monitored with a single Scenturion delta trap for each species installed in the center of M West and M East. Traps were checked and insects removed weekly, with lures replaced every 6 weeks. Pest control was determined by counting arthropods or injury on 4 single-tree replications per cultivar in each section of the block. Control of rosy apple aphid, *Dysaphis plantaginea* (Passerini) (RAA) was determined by counting the number of colonies per tree. Spirea aphid, *Aphis spiraecola* Patch (SA) control was evaluated by determining the number of infested leaves on each of 10 terminals per tree. Aphid natural enemy incidence was determined on the same 10 terminals used for SA counts. Control of first generation OFM was determined by counting the number of injured terminals per tree. Up to 100 fruit were examined on each tree to determine injury by CM and OFM. Larvae were removed from injured fruit and species identified. Injury from fruit-feeding insects was determined at harvest by evaluating 50 apples for each single-tree replication that were collected on 9 Sep ('Liberty'), 19 Sep ('Golden Delicious'), and 14 Oct ('York', 'Fuji'). Internal worms were collected from harvested fruit and identified to species for each treatment.

Trap monitoring and insect data were also taken (4 single-tree replications/treatment) from conventionally managed and untreated trees in a neighboring one acre block of 27-yr-old 'Rome' trees on MM 111 rootstock.

Results and Discussion

Isomate CM/OFM provided excellent control of first generation terminal injury from OFM, with no significant difference in injury among the four cultivars (Table 1). Incidence of SA did not differ among the four cultivars, and was comparable to that in the untreated check and slightly higher than in the Conventional treatment. Aphid natural enemies did not differ among the four cultivars, but were more abundant than in the untreated check and Conventional treatment. JMS Stylet Oil and Aza-Direct provided excellent control of RAA, which was comparable to that provided by a Conventional treatment of Lorsban + Oil (Table 2). Incidence of RAA was slightly, but significantly higher on 'York' than on 'Fuji' and 'Liberty'. Fruit injury from CM & OFM in late June and in August was similar in Organic and Conventional treatments, and much lower than in the untreated check. Injury did not differ among the four Organic cultivars in late June and early August, but a significantly higher level of injury occurred on 'Golden Delicious' in late August. At harvest, fruit injury from CM & OFM on 'Fuji' was similar to that in the Conventional treatment, and significantly higher than that on the other three cultivars (Table 3). Injury from TABM & RBLR in the Organic treatment was higher on 'Fuji', 'Golden Delicious' and 'York' and lower on 'Liberty' than in the Conventional treatment. This injury differed significantly among the Organic cultivars, with the highest level on 'Fuji', followed by 'York', 'Golden Delicious' and 'Liberty'. Injury from PC was higher on all four Organic cultivars than in the Conventional treatment, with significantly more injury on 'Liberty' than on 'Fuji' and 'York'. Injury from TPB, EAS and AM was similar in Organic and Conventional treatments, however the Conventional treatment had a higher level of injury from SJS . There were no significant differences among Organic cultivars in injury from TPB, SJS and AM, however there was significantly more injury from EAS on 'Liberty' than on the other three cultivars. When compared with the Conventional treatment, percentage of clean fruit was lower for 'Fuji', similar for 'Golden Delicious' and 'York', and higher for 'Liberty'. Of the four Organic cultivars, the percentage of clean fruit was significantly higher on 'Liberty' than on 'Fuji'. A total of 23 internal worms were found in injured Organic fruit from 'Fuji' and 'York', which were identified as 21.7% CM and 78.3% OFM. This compared with only three worms (100% OFM) in the Conventional treatment and 23 worms (69.6 % CM, 30.4% OFM) in the untreated check (Table 4). There was virtually no trap capture of OFM and CM in the Organic plots as a result of mating disruption with Isomate CM/OFM (Fig. 1). Trap captures of leafrollers, especially TABM, and STLM was lower in the Organic plots (Fig. 1), most likely due to multiple applications of Entrust.

Table 1. OFM shoot injury, and incidence of SA and natural enemies in 2005.

Pest Treatment	Rate/acre	lb AI	Time of application	Cultivar	OFM injured terminals/tree 1 Jun	SA infested leaves/terminal 13 Jun	Natural enemies /10 terminals[a] 13 Jun
Organic				Fuji	0 a	3.9 a	0.3 a
JMS Stylet Oil	15.2 l	-----	5 & 12 Apr				
Isomate CM/OFM	200	-----	8 Apr	G. Delicious	0 a	3.8 a	2.1 a
Aza-Direct	947 ml	0.02	12 & 19 Apr				
Surround 95WP	75 lb	71.25	10 & 16 May	Liberty	0 a	3.7 a	1.4 a
Surround 95WP	50 lb	47.50	26 May, 26 Jul				
Entrust 80WP	85 g	0.15	8 & 23 Jun, 10 & 25 Aug	York	0.1 a	3.6 a	1.3 a
Conventional							
Lorsban 75WG	908 g	1.50+					
Oil	22.7 l	-----	13 Apr	Rome	-----	2.5	0
Guthion 50W	908 g	1.00	13 May, 1 & 13 Jun, 5 Jul				
Intrepid 2F	355 ml	0.19	21 Jun				
Rimon 0.83EC	592 ml	0.13	18 Jul, 3 & 17 Aug, 1 Sep				
Untreated check	-------	-------		Rome	-----	3.4	0

Means in a given column followed by the same letter are not significantly different (LSD, *P* ? 0.05).
[a]Includes ladybird beetle adults and larvae, minute pirate bug, and larvae of syrphid fly, green lacewing, and aphid midge.

Table 2. Incidence of RAA, and in-season fruit injury from CM and OFM in 2005.

Pest Treatment	Rate/acre	lb AI	Time of application	Cultivar	RAA colonies/tree 13 Jun	% CM and OFM fruit injury 29 Jun	1 Aug[a]	29 Aug[b]
Organic				Fuji	0 b	0.3 a	0.3 a	1.1 b
JMS Stylet Oil	15.2 l	-----	5 & 12 Apr					
Isomate CM/OFM	200	-----	8 Apr	G. Delicious	0.9 ab	0.1 a	0.4 a	3.4 a
Aza-Direct	947 ml	0.02	12 & 19 Apr					
Surround 95WP	75 lb	71.25	10 & 16 May	Liberty	0.1 b	0 a	0.3 a	0.4 b
Surround 95WP	50 lb	47.50	26 May, 26 Jul					
Entrust 80WP	85 g	0.15	8 & 23 Jun, 10 & 25 Aug	York	1.8 a	0.3 a	0.1 a	0.8 b
Conventional								
Lorsban 75WG	908 g	1.50+						
Oil	22.7 l	-----	13 Apr	Rome	0.5	0	0.3	1.3
Guthion 50W	908 g	1.00	13 May, 1 & 13 Jun, 5 Jul					
Intrepid 2F	355 ml	0.19	21 Jun					
Rimon 0.83EC	592 ml	0.13	18 Jul, 3 & 17 Aug, 1 Sep					
Untreated check	--------	-------		Rome	42.8	5.0	15.3	33.8

[a]Internal larvae found in injured fruit were identified as 100% OFM in the Organic plot, and 7% OFM, 93% CM in the Conventional/Check plot.
[b]Internal larvae found in injured fruit were identified as 68% OFM, 32% CM in the Organic plot, and 33% OFM, 67% CM in the Conventional/Check plot.

Table 3. Arthropod pest injury to fruit at harvest in 2005.

Pest Treatment	Rate/acre	lb AI	Time of application	Cultivar	Percent fruit injury by: CM & OFM	TABM & RBLR	TPB	PC	EAS	SJS	AM	Percent clean fruit
Organic				Fuji	9.5 a	25.3 a	1.5 a	6.5 b	0 b	0.3 a	0 a	59.0 b
JMS Stylet Oil	15.2 l	------	5 & 12 Apr									
Isomate CM/OFM	200	------	8 Apr	G. Delicious	4.0 b	11.8 b	1.3 a	9.5 ab	0.5 b	0 a	0 a	71.5 ab
Aza-Direct	947 ml	0.02	12 & 19 Apr									
Surround 95WP	75 lb	71.25	10 & 16 May	Liberty	0.3 b	0.5 c	0.8 a	15.3 a	3.0 a	0 a	0 a	80.3 a
Surround 95WP	50 lb	47.50	26 May, 26 Jul									
Entrust 80WP	85 g	0.15	8 & 23 Jun, 10 & 25 Aug	York	3.5 b	18.5 ab	1.0 a	4.8 b	0 b	0 a	0 a	72.5 ab
Conventional												
Lorsban 75WG	908 g	1.50+										
Oil	22.7 l	------	13 Apr	Rome	10.8	6.0	1.4	1.3	0.2	12.4	0.1	69.8
Guthion 50W	908 g	1.00	13 May, 1 & 13 Jun, 5 Jul									
Intrepid 2F	355 ml	0.19	21 Jun									
Rimon 0.83EC	592 ml	0.13	18 Jul, 3 & 17 Aug, 1 Sep									
Untreated check	---------	--------		Rome	31.2	5.5	1.1	1.9	0.4	58.6	0.4	16.4

Means in a given column followed by the same letter are not significantly different (LSD, *P* ? 0.05).

Table 4. Species of internal worms found in injured fruit at harvest in 2005.

Pest Treatment	Rate/acre	lb AI	Time of application	Cultivar	Internal worms in fruit at harvest: CM No.	CM %	OFM No.	OFM %
Organic				Fuji	3	18.8	13	81.2
JMS Stylet Oil	15.2 l	------	5 & 12 Apr					
Isomate CM/OFM	200	------	8 Apr	G. Delicious	0	0	0	0
Aza-Direct	947 ml	0.02	12 & 19 Apr					
Surround 95WP	75 lb	71.25	10 & 16 May	Liberty	0	0	0	0
Surround 95WP	50 lb	47.50	26 May, 26 Jul					
Entrust 80WP	85 g	0.15	8 & 23 Jun, 10 & 25 Aug	York	2	28.6	5	71.4
Conventional								
Lorsban 75WG	908 g	1.50+						
Oil	22.7 l	------	13 Apr	Rome	0	0	3	100
Guthion 50W	908 g	1.00	13 May, 1 & 13 Jun, 5 Jul					
Intrepid 2F	355 ml	0.19	21 Jun					
Rimon 0.83EC	592 ml	0.13	18 Jul, 3 & 17 Aug, 1 Sep					
Untreated check	---------	--------		Rome	16	69.6	7	30.4

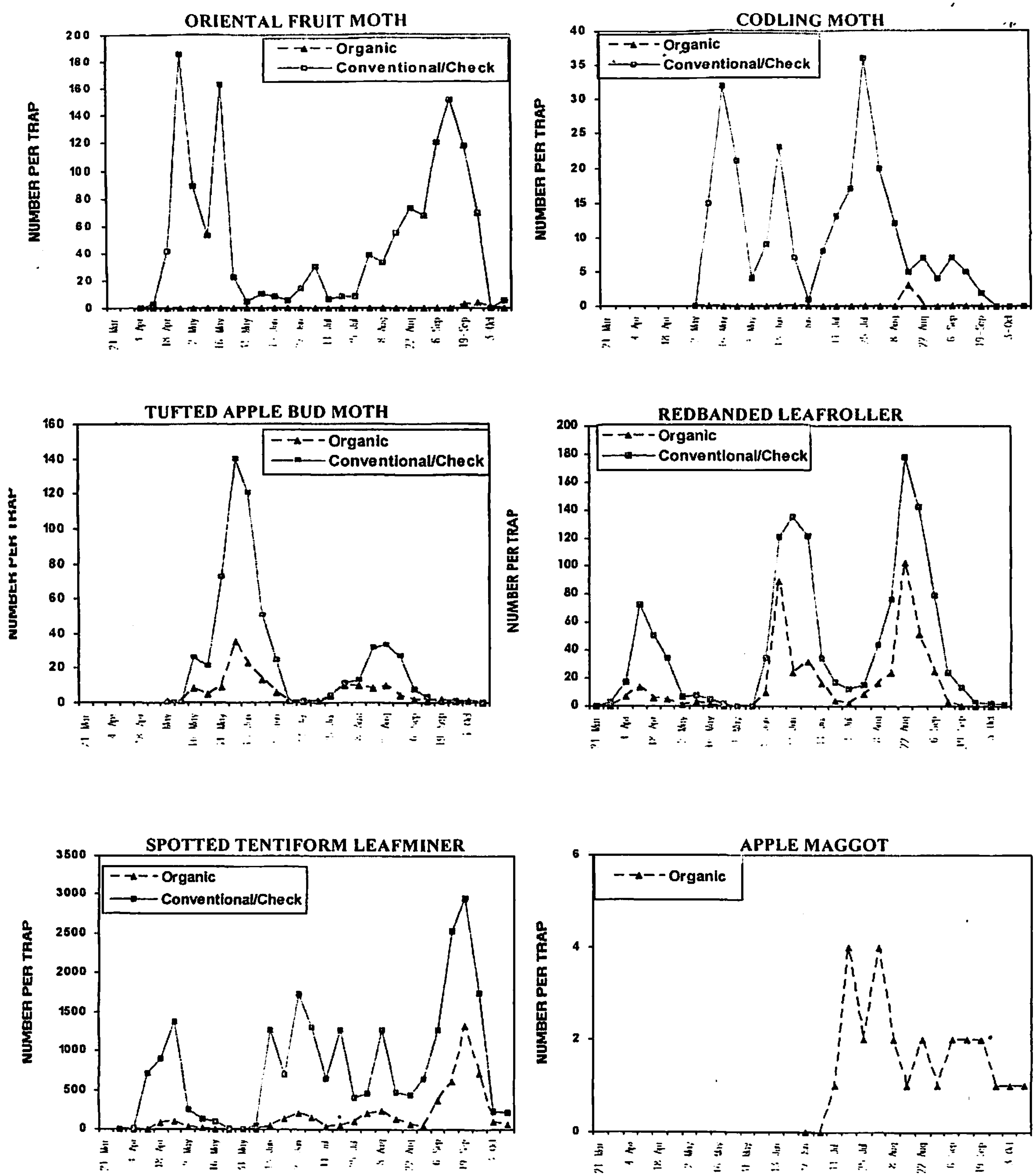

Fig. 1. Trap counts of arthropod pests in Organic and Conventional/Check blocks in 2005

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Impact of Prevailing Temperatures on Captures of Plum Curculio in Odor-Baited Traps

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In 2003-2005, we evaluated the attractiveness of novel synthetic host plant volatiles alone and in combination with the synthetic aggregation pheromone, grandisoic acid (GA) to overwintered adult plum curculio, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae) in association with black masonite pyramid traps deployed in an unsprayed apple orchards. The most attractive synthetic host plant volatiles evaluated included those identified from foliar and woody tissues of a non-fruiting Stanley plum tree (6-Tree) benzaldehyde formulated with 10% 1, 2, 4-trichlorobenzene (Ben(TCB). The most attractive bait combinations included 6-Tree + GA and Ben(TCB) + GA in 2003, and 6-Tree + Ben(TCB) + GA in 2004, which all were significantly more attractive than unbaited traps. However, in 2005, we observed no difference in captures in traps baited with these odor combinations and unbaited traps. We hypothesized that the cooler conditions experienced during the plum curculio trapping period in 2005 reduced the release rate of synthetic odor baits to the point where they were no longer perceptible to foraging plum curculios. Average daytime temperatures for 2003, 2004, and 2005 were 15.88°C, 20.59°C, and 13.61°C. Gravimetric studies revealed that release rates for GA, 6-Tree, and BEN(TCB) were reduced by ~35-50% in 2005 compared to 2004. Based on analyses of field data collected between 2003-2005, we have found that there is a significant relationship between temperature and captures in odor-baited traps and that the threshold for plum curculio activity associated with baited traps is between 12-14°C. Only at temperature above this threshold do we see benefit of lures associated with traps. This temperature threshold is higher than that associated with plum curculio activity in the field, and therefore helps explain some of the variability associated with trap captures and reason for their poor predictive abilities. In the future, we want to explore better release vehicles for synthetic lures and investigate the hypothesis that at higher release rates more plum curculio will respond to odor-baited traps, even at lower temperatures.

Reduced Risk Tart Cherry Orchard Management Strategies for U.S. Tart Cherry Production

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The overall goal of the project is to implement economically viable and environmentally sound pest management and production systems that significantly reduce reliance on broad spectrum pesticides while meeting high standards for processed tart cherries. We have brought together a team of entomologists, pathologists, horticulturists, a soil microbiology expert, an agricultural economist, and an evaluation specialist to develop, deliver and evaluate tart cherry orchard management practices in Michigan, Wisconsin, and Utah. The four major thrusts of the project include biointensive IPM strategies, stakeholder input, IPM adoption, and economic evaluation.

Reduced insect management strategies included 'softer' pesticide chemistries to control cherry insects, such as cherry fruit fly (CFF) and plum curculio (PC). We conducted trials on nine farms across the state with two ten-acre blocks; one block was managed with a conventional program with organophosphates (OP's) and one block with a reduced risk strategy, which included spinosad, indoxacarb, thiamethoxam, and imidacloprid. In 2004 and 2005, we found no larvae in fruit at harvest, but orchards with heavy CFF pressure may need a post-harvest insecticide application. In addition to determining efficacy of these new chemicals, growers are concerned with the translaminar modes of action of these insecticides and potential residues. To determine residues in fruit, we collected tart cherries directly off the shaker at harvest, and fruit from the cooling pad after they had been in water for 3 hours; cherries were sent in for residue testing, and analysis is currently underway.

Mites are another concern in the tart cherry system, and one that growers found of utmost importance in the hot dry year of 2005. In the RAMP program, thiamethoxam, one of the reduced risk insecticides in the neonicotinoid class, has been shown to 'flare' plant parasitic mites in apple systems. Results from 2005 do not suggest that neonicotinoids flare two-spotted spider mites in cherry. We also investigated mite distribution in the tree canopy throughout the growing season and found early season mites in high numbers on the inside of the canopy and even distribution throughout the canopy by mid-August. The optimal miticide application procedure is a spray needs to be applied every row, rather than every other row.

The pathology objectives for the study are to evaluate reduced-risk fungicide spray programs on different cultivars, to determine the physical modes of action of fungicides on *Blumeriella jaapii* (cherry leaf spot (CLS)) and to survey commercial orchards for fungicide-resistant (DMI) *B. jaapii*. A 2004 survey showed extensive CLS resistance to DMI's around the state. Based on this survey, we have incorporated copper compounds into fungicide spray programs to control CLS in 2005 at two on-farm sites. Copper showed effectiveness against CLS. However, growers are concerned with tank-mixing copper and lime with insecticides, and a laboratory study found COCS did not affect insecticide efficacy against PC. Further studies will add lime to the tank mixes.

Economics of the RAMP projects have not proven as successful as the effectiveness of new products. The insecticide costs for the 2004 RAMP blocks are on average 2.5x or $51.00/acre more than the conventional blocks. This economic hurdle is one that will be difficult for growers to confront and for project researchers to overcome as the study continues.

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TRAC SOFTWARE MAKES SPRAY RECORD-KEEPING AND REPORTING EASIER

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Abstract:
Trac© software (copyright 2003-2005 Cornell University), an Excel-based record-keeping and reporting software program, enables fruit farmers to easily maintain and report accurate crop protection records that are, 1) vital to their market edge, when increasingly competitive global markets demand detailed pesticide records and product traceability, and 2) critical to their integrated pest management practices, especially when faced with pest or disease control failures and severe outbreaks. In 2005, Trac software was upgraded for apple and grape and new Trac software was created for all other fruit crops commonly grown in New York. Trac Software support materials were created including a Software Manual, a Frequently Asked Questions website, and a training workshop module.

Introduction:

Issue - Fruit farmers face increasing need to produce crop protection and production records on demand. The Environmental Protection Agency Worker Protection Standard (EPA-WPS), processors, marketers, etc, require pesticide records and each has a different reporting form, required either by law or to market the crop. This necessitates that farmers fill out several different forms when marketing their crop, making record-keeping an unnecessarily burdensome task. In an expanding and increasingly competitive global market, farmers with the ability to produce detailed crop production records, including pesticide spray records, will have a competitive edge. As more consumers actively seek products with eco-labels, those grown without pesticides, those produced in an environmentally sound manner, or those produced under sustainable practices, the onus will be on the farmer, processor, and marketer to show auditors that such practices were indeed used. Furthermore, accurate crop protection and production records are critically important to the farmer, particularly when pest or disease control failures or severe outbreaks occur. Computerized records would allow farmers to easily search and judge pest management practices in light of such pest control failures or severe pest pressure.

Response - The apple farmers requested that record-keeping software be developed to generate the various pesticide spray record forms required by processors, buyers, and brokers, to aid in their record-keeping and market access requirements. The grape juice processors requested that similar software be developed for their grape farmers. Funds were secured from several sources to support software development in Microsoft Excel, a common spreadsheet program. In 2003, TracApple software was released for beta testing and in 2004 TracGrape software was released. A software license agreement was prepared and the software was copyrighted by Cornell University. Canandaigua Wine distributed 165 copies of the software to grape farmers they have contracts with. Each year the software is revised with pesticide registration updates and software improvements. In 2005, TracPear, TracBerry, TracStoneFruit, and TracCherry were released. Farmers using Trac software enter their data once and it automatically fills out the report forms of all the major fruit processors and buyers in the Northeast. Very simply, the user fills in the blanks on data entry worksheets. Trac software has drop-down lists for pesticides and pests, saving time and preventing typographical errors. The software also generates drop-down lists specific to the user's farm business. When a pesticide trade name is selected from the drop down list the program automatically fills in the EPA registration number, restricted entry interval, pre-harvest interval, and calculates the earliest harvest date.

Objectives:

1. Upgrade TracApple and TracGrape and develop Trac software for other fruit crops.
2. Publish, online and in print, supporting information for Trac Software.
3. Conduct Trac workshops, presentations and exhibits.

Procedures:

1. Upgrade TracApple and TracGrape and develop Trac software for other fruit crops.

Following the release of the beta test version of TracApple 2003 software, grower input on its improvement was solicited at meetings, exhibits, and an email survey. It became clear that growers found the Excel-based software easy to use. Some of the comments from the 2003 survey follow:

"It was a big improvement over the other software I bought in the past."

"We would like to use it in 2004 and are going to order the 2004 program."

"We just got started with it, had some computer problems, but intend to use (it) more fully this year - want to get (the) 2004 version set to go."

TracApple 2004 was upgraded and released in February 2004 with the following new features:

A. New reports automatically generated from entered data:
    a. EPA Worker Protection Standard Central Posting form.
    b. EUREPGAP-compliant pesticide usages report form.
    c. Knouse Foods processor form.
B. Improved SprayData worksheet:
    a. Earliest harvestable date calculated automatically.
    b. Chemical costs calculated automatically for each spray applied.
    c. Easier spray rate calculations.
    d. Weather tracking columns.
C. Improved ChemTable worksheet:
    a. Accessible and easily viewed for quick reference.
    b. Space for additional, user-defined chemicals.
    c. Columns to record unit costs of chemicals to enable cost calculations.
D. Improved BloomHarvest worksheet includes a harvest Tracking Number column.

E. A new FertData worksheet generates a EUREPGAP-compliant fertilization record.

In May of 2004, TracGrape 2004 was released in collaboration with the major grape juice processors in New York. It was based on the TracApple 2004 version improvements listed above. The processor report forms specific to the grape industry were included in TracGrape (Canandaigua Wine, Cliffstar Corporation, Westfield Maid, Carriage House Co. Inc., Growers Cooperative Grape Juice Co., Meier's Wine Cellars Inc., and Mogen David Wine Co.) Canandaigua Wine distributed 165 copies of the CD to their growers. Cliffstar Corporation sent letters to their growers announcing the availability of TracGrape software.

The major focus of our effort in 2004 was in the development of 2005 Trac Software for all other fruit crops commonly grown in New York. Along with this effort, TracApple and TracGrape were upgraded for 2005. TracPear was developed and released on the TracApple 2005 CD. TracBerry was developed and covers strawberry, raspberry, blackberry, blueberry, currant and gooseberry. TracBerry is distributed on its own CD. TracCherry (sweet & tart cherry) and TracStoneFruit (peach, nectarine, apricot and plum) were included on the TracStoneFruit CD.

The most challenging part of developing these Software programs is in maintaining and updating the chemical information for each crop. This effort is supported by the Pest Management Guidelines (Agnello 2005, Pritts and Bushway 2005, Weigle and Muza 2005) and by faculty and staff involved in contributing to these publications. Trac software is disclosed for copyright via the Cornell Research Foundation and is protected by a software license agreement developed in conjunction with Cornell University Council. Language regarding the use of pesticides and the use of the software as it relates to pesticides is cleared through the Pesticide Management Education Program. Availability of Trac software is announced through Extension newsletters, trade magazines, Extension-sponsored grower meetings, the New York Fruit & Vegetable Expo, and via email to all Trac software recipients.

2. Write and publish supporting information for Trac Software.

A convenient Trac software tri-fold brochure with order form details information about the software and its cost. Information describing Trac software was published online at www.nysipm.cornell.edu/trac/. The web pages contain detailed information about each Trac Software program, an order form, the "Getting Started" instructions, tips for using Excel and Trac, and a complete Trac Software Manual. The Manual is also included as a pdf file on the CDs of the 2005 versions of Trac Software.

Based on records of technical support inquiries on Trac Software, a set of Frequently Asked Questions (FAQs) and answers was written and published online. Twenty-seven questions with comprehensive answers about Trac Software were written, covering everything from the basics of copying and pasting information to filtering and sorting data in Excel to generate customized reports specific to any farm business.

3. Conduct Trac workshops, presentations and exhibits.

In 2004, eight presentations, four exhibits, and one workshop on Trac Software were conducted across New York and in Ontario, Canada. In addition, a grant from the New York Farm Viability Institute was secured to develop a computer-training module for apple growers in conjunction with Finger Lakes Community College, Canandaigua, NY and KM Davies apple storage, Williamson, NY. Under this grant, four hands-on TracApple training sessions were conducted, reaching approximately 40 apple growers.

Results and discussion:

Impact – Trac has effectively streamlined the burdensome task of record-keeping and reporting for apple and grape farmers. In 2004, 126 copies of TracApple and 307 copies of TracGrape were distributed to interested farmers in New York and also in 17 other states and two Canadian provinces. Apple growers using TracApple were able to generate their yearly pesticide records within 24 hours of the exhaustive Eurepgap certification audits and sail through this portion of the audit. One grape juice processor reported saving up to 25 percent in the time it takes them to process their grape growers' records when those records are generated with TracGrape. Development of TracGrape in conjunction with Canandaigua Wine enabled them to devise a report form for their grower contracts. Growers using the software state that it is easy to use and manipulate their crop production and crop protection data in Trac. Trac software costs $20 to purchase, compared to other farm-related software that costs much more and is more complicated to learn, Trac software provides a simple answer to bringing more farmers into the computer age and digitizing New York's agricultural industry. Growers that are able to easily access computer records of pesticide and fertilizer applications and compare practices from year to year, tracking costs and harvests, will be better able to manage their farm businesses, make more informed IPM decisions, all of which will provide a solid foundation for farm sustainability.

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Impact of Reduced-Risk Insecticides on European Red Mite and Predatory Mite Interactions

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The European red mite (ERM) *Panonychus ulmi* (Koch) (Acari: Tetranychidae) and the apple rust mite (ARM) *Aculus schlechtendali* (Nalepa) (Acari: Eriophyidae) are pests of apple orchards in western North Carolina. While the ARM is the most abundant phytophagous mite in NC apples, the ERM is the most damaging. ARM damage is generally insignificant, and these mites can be a supplementary food source for natural enemies when spider mite populations are low. ERM populations are most intense from June to the end of August. Previous research has revealed that ERM population flare-ups are often associated with the adverse effects of certain insecticides. These effects included increase of spider mite fecundity (hormoligosis) (Luckey 1968) and/or high mortality or repellency of insecticides to natural enemies (phytoseiid and stigmaeid mites or the coccinellid *Stethorus* sp.). Spider mite outbreaks were detected with older, broad-spectrum insecticides such as DDT (Hamilton and Cleveland 1957), and toxicity or repellency to natural enemies was observed with synthetic pyrethroids (Penman *et al.* 1986). In addition, hormoligosis was demonstrated in the twospotted spider mite, *Tetranychus urticae* Koch, with the reduced risk insecticide imidacloprid (James and Price 2002). The objective of this study was to evaluate population changes of phytophagous and predacious mites in response to selected reduced risk insecticides in apple orchards.

Materials and Methods

This study was conducted in a 'Delicious' apple orchard in Dana (Henderson Co.), NC. Part of this orchard was under a conventional insecticide program and the remainder under a reduced-risk (RR) pest management program. These insecticide management programs had been applied for the last four years. Five out of six treatments were distributed in a single row in the conventional part, where each treated block had 3 trees with a buffer tree separating treatments. The sixth treatment was in the RR part of the orchard. Each treatment was replicated 4 times. Three RR insecticides were evaluated, including Assail® 70 WP (acetamiprid, Dupont) at 2.5 oz/Acre, SpinTor® 2SC (spinosad, Dow AgroSciences) at 6.0 oz/Acre, and Rimon® 0.83EC (novaluron, Chemtura) at 30.0 oz/Acre, as well as the pyrethroid Danitol® 2.4EC (fenpropathrin, Valent) at 18 oz/Acre, the organophosphate Guthion® 50WP (azinphosmethyl, Bayer) at 2.0 lbs/Acre and the contiguous RR orchard. Insecticide rates represented field label rates indicated by manufacturers. Spray dates were 3 and 17 June, and 6 and 30 July 2005. Guthion was applied only once on 21 July to all treatments. All sprays were applied with an airblast sprayer delivering materials at 101 GPA. Ten leaves were collected from the middle sample tree at weekly intervals from 26 May to 13 September. Leaves were returned to the laboratory where they were placed through a mite brushing machine and the number of ERM eggs, nymphs and females as well as phytoseiids, stigmaeids and ARM were counted with the aid of a dissecting stereoscopes. Data were transformed using $\sqrt{X+0.5}$, and then subjected to a two-way ANOVA. Means were compared using Fisher's LSD test ($P < 0.05$) (Statistica™, StatSoft Inc., Tulsa, OK).

Results and Discussion

The mean (±SEM) number of ERM eggs, nymphs and females, ARM, motile phytoseiids and stigmaeids, and significant differences among treatments are shown on Tables 1, 2, 3, 4, 5, and 6, respectively. The insecticide-miticide Danitol significantly reduced all stages of ERM, as well as ARM and phytoseiids below those in all treatments except Assail. In previous studies (Villanueva and Walgenbach 2004) similar effects of Danitol on the ERM were observed, and this corresponds with the repellency and toxicity of pyrethroids to phytoseiids (Penman *et al.* 1986, Hall and Thacker 1993). Assail did not flare up ERM populations, despite the fact that phytoseiid populations were low. These results are in contrast to those of Beers *et al.* (2005), who reported that Assail sprays resulted in 4.6 times more spider mites (both *P. ulmi* and *T. urticae*) than organophosphate insecticides in apples. In addition, Carter (2003) also observed spider mite flare-ups due to Assail in Canada, whereas Villanueva and Walgenbach (2005) found that Assail was moderately toxic to the phytoseiid *Neoseiulus fallacis.*

Spintor did not affect ERM, ARM or phytoseiids compared to the OP- and RR-based treatments; however, by 9 August the phytoseiid numbers found in this treatment were >1.8/leaf, the highest phytoseiid numbers recorded during this study. In laboratory assays spinosad was toxic to TSSM and phytoseiids when they were confined to spinosad-treated leaves (Villanueva and Walgenbach 2005, Villanueva and Walgenbach in review). Villanueva and Walgenbach (in review) also found that Spintor did not affect ERM in field or laboratory studies. In this study, Rimon had the highest number of ERM and the lowest counts of phytoseiids for most of the season. In addition, the increase in phytoseiid populations in the Rimon treatment lagged by approximately 2 weeks compared to the OP- and RR- treatments. By the end of August, however, more phytoseiids were found in the Rimon treatment compared to the RR- or OP- treatments, which may have been due to the high ERM populations in this treatment and very low populations in the latter treatments. Although this late-season increase in phytoseiid populations was probably too late to control mites in the present season, it may contribute to suppression of the overwintering ERM population by consumption of overwintering eggs. Hilton and VanBuskirk (2002) did not report TSSM flare ups with novaluron in pears, and it is unknown whether this insecticides adverse affects are confined to ERM.

An ERM outbreak in the RR treatment by late June and early July appeared to be rapidly controlled by phytoseiids in the reduced risk treatment, while in the OP-based treatment no ERM outbreak was observed at this time. In the RR and OP-treatments, phytoseiids were present in high numbers when all ERM instars were present from 6 July to mid August. It is probable that this phytoseiid population had developed resistance to organophosphate insecticides, as phytoseiid numbers were not reduced by the Guthion spray on 21 July in the Assail, Spintor, OP- or RR-based plots. Similar results were also reported in Washington State (Beers *et al.* 2005).

The stigmaeid species found in this orchard was identified as *Agistemus fleschneri* Summers, which was also reported as the most prevalent stigmaeid in the mountains of NC by Shaffer and Rock (1983). In many northern and western areas of the USA, *Zetzellia mali* (Ewing) is the most prevalent stigmaeid species in apple orchards, which was previously reported to be in this area, although numbers were not provided (Farrier *et al.* 1980). A further conclusion with this predacious species is not possible due to its low numbers recorded in all treatments in 2005.

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Table 1. Mean (±SEM) number of ERM eggs per 10 leaves. Means within rows followed by different letters are significantly different by Fisher's LSD (df = 5,15; $P < 0.05$).

Date	Assail	Spintor	Rimon	Danitol	OP-based	Red. Risk	F (*P*)
26-May	0.5 ± 0.3 **a**	3.5 ± 1.3 **ab**	0.8 ± 0.5 **a**	1.5 ± 0.5 **a**	2.5 ± 1.6 **a**	7.0 ± 2.7 **b**	3.24 (*0.03*)
9-Jun	6.8 ± 3.1	28.5 ± 9.0	17.5 ± 11.3	11.3 ± 3.1	4.0 ± 1.7	15.3 ± 4.6	2.43 (*0.08*)
15-Jun	4.8 ± 2.9	11.5 ± 10.8	12.0 ± 11.3	5.8 ± 3.5	5.0 ± 2.1	82.3 ± 49.3	1.20 (*0.35*)
23-Jun	15.5 ± 7.9 **a**	41.8 ± 25.9 **a**	8.3 ± 7.3 **a**	10.5 ± 3.4 **a**	23.8 ± 12.0 **a**	125.8 ± 73.1 **b**	3.72 (*0.02*)
28-Jun	9.5 ± 3.1 **a**	97.8 ± 52.5 **b**	80.8 ± 42.1 **b**	13.3 ± 5.1 **a**	41.0 ± 13.5 **ab**	203.5 ± 69.7 **c**	5.85 (*0.003*)
6-Jul	2.5 ± 0.9 **a**	159.3 ± 95.0 **bcd**	151.5 ± 82.9 **cd**	17.0 ± 7.2 **ab**	58.0 ± 22.6 **abc**	297.3 ± 90.2 **d**	5.95 (*0.003*)
13-Jul	17.5 ± 10.3	48.3 ± 22.9	89.5 ± 63.4	8.3 ± 3.6	66.8 ± 27.0	63.5 ± 3.8	2.00 (*0.13*)
20-Jul	81.3 ± 62.9 **a**	404.5 ± 255.0 **a**	112.3 ± 24.4 **a**	37.3 ± 12.1 **a**	199.0 ± 78.3 **a**	1222.0 ± 713.1 **b**	5.54 (*0.004*)
28-Jul	110.3 ± 63.6	866.8 ± 735.6	1076.3 ± 566.1	345.3 ± 234.6	626.5 ± 302.7	498.3 ± 241.1	1.01 (*0.44*)
4-Aug	168.5 ±70.3 **a**	647.0 ± 362.6 **ab**	1395.0 ± 376.5 **c**	222.0 ± 90.2 **a**	433.8 ± 114.5 **ab**	764.0 ± 172.7 **bc**	4.45 (*0.01*)
9-Aug	209.8 ± 119.4 **ab**	693.0 ± 271.4 **c**	1316.0 ± 191.6 **d**	74.3 ± 22.5 **a**	689.8 ± 367.4 **c**	473.8 ± 207.4 **bc**	9.74 (*<0.001*)
17-Aug	75.3 ± 45.8 **a**	254.5 ± 101.8 **bc**	1491.5 ± 251.5 **d**	86.5 ± 45.7 **ab**	255.5 ± 64.6 **c**	210.8 ± 60.1 **abc**	25.16 (*<0.001*)
24-Aug	67.5 ± 34.5	490.0 ± 218.3	830.0 ± 312.6	60.8 ± 14.5	307.0 ± 156.8	368.5 ± 201.0	2.82 (*0.05*)
1-Sep	26.5 ± 9.9 **ab**	115.0 ± 74.2 **b**	259.3 ± 31.7 **c**	16.0 ± 4.2 **a**	41.8 ± 13.7 **ab**	58.5 ± 17.2 **ab**	7.81 (*<0.001*)
13-Sep	75.3 ± 49.2 **a**	44.8 ± 11.3 **a**	311.0 ±170.3 **b**	24.3 ± 6.2 **a**	104.0 ± 46.5 **ab**	38.0 ± 12.9 **a**	3.05 (*0.04*)

Table 2. Mean (±SEM) number of ERM nymphs per 10 leaves. Means within rows followed by different letters are significantly different by Fisher's LSD (df = 5,15; $P < 0.05$).

Date	Assail	Spintor	Rimon	Danitol	OP-based	Red. Risk	F (*P*)
26-May	0.3 ± 0.3	0.3 ± 0.3	1.0 ± 1.0	0.3 ± 0.3	1.0 ± 0.7	0.8 ± 0.5	0.39 (*0.84*)
9-Jun	0.8 ± 0.3	1.3 ± 0.5	1.3 ± 0.6	1.3 ± 0.6	2.0 ± 1.1	4.8 ± 2.1	2.13 (*0.11*)
15-Jun	0.8 ± 0.5	9.5 ± 2.8	1.0 ± 0.4	0.0	3.3 ± 1.0	24.0 ± 15.0	2.71 (*0.06*)
23-Jun	4.8 ± 2.2 **a**	8.5 ± 5.1 **a**	3.0 ± 1.2 **a**	0.8 ± 0.5 **a**	5.5 ± 3.7 **a**	40.3 ± 24.9 **b**	3.84 (*0.01*)
28-Jun	4.3 ± 1.8 **ab**	20.8 ± 10.6 **b**	25.0 ± 14.6 **b**	1.0 ± 0.4 **a**	7.8 ± 2.5 **ab**	62.0 ± 21.1 **c**	7.17 (*0.001*)
6-Jul	3.5 ± 2.6 **ab**	35.3 ± 21.0 **bc**	42.0 ± 25.3 **cd**	0.5 ± 0.3 **a**	10.0 ± 2.6 **abc**	84.5 ± 27.9 **d**	6.48 (*0.002*)
13-Jul	3.3 ± 1.7	20.8 ± 16.1	22.3 ± 16.1	0.5 ± 0.3	26.5 ± 9.6	9.0 ± 2.6	1.96 (*0.14*)
20-Jul	6.3 ± 3.5 **ab**	55.8 ± 10.9 **bc**	21.3 ± 10.9 **ab**	1.5 ± 0.9 **a**	43.5 ± 25.4 **bc**	84.3 ± 38.3 **c**	4.69 (*0.008*)
28-Jul	19.8 ± 10.9	39.3 ± 8.6	137.3 ± 8.6	30.5 ± 13.8	88.0 ± 42.0	224.5 ± 179.7	1.38 (*0.28*)
4-Aug	2.3 ± 2.3 **a**	43.5 ± 37.3 **a**	111.0 ± 37.3 **b**	1.8 ± 1.0 **a**	25.5 ± 18.9 **a**	13.0 ± 6.0 **a**	5.19 (*0.005*)
9-Aug	9.3 ± 3.6 **a**	95.0 ± 393.1 **a**	683.8 ± 393.1 **b**	4.5 ± 2.7 **a**	32.8 ± 20.2 **a**	17.0 ± 6.3 **a**	8.28 (*<0.001*)
17-Aug	1.5 ± 1.0 **a**	5.3 ± 40.0 **a**	115.3 ± 40.0 **b**	1.0 ± 0.7 **a**	4.5 ± 2.9 **a**	0.5 ± 0.5 **a**	20.45 (*<0.001*)
24-Aug	1.3 ± 0.9	10.0 ± 24.7	62.8 ± 24.7	1.8 ± 1.1	20.8 ± 16.9	9.5 ± 4.9	2.31 (*0.09*)
1-Sep	0.3 ± 0.3 **a**	0.5 ± 1.0 **a**	2.8 ± 1.0 **b**	0.0 **a**	0.8 ± 0.8 **a**	0.3 ± 0.3 **a**	3.47 (*0.02*)
13-Sep	0.0 **a**	0.3 ± 0.9 **a**	2.3 ± 0.9 **b**	0.0 **a**	0.0 **a**	0.0 **a**	6.73 (*0.001*)

Table 3. Mean (±SEM) number of ERM females per 10 leaves. Means within rows followed by different letters are significantly different by Fisher's LSD (df = 5,15; $P < 0.05$).

Date	Assail	Spintor	Rimon	Danitol	OP-based	Red. Risk	F (*P*)
26-May	0.0	0.0	0.0	0.0	0.0	0.3 ± 0.3	1.0 (*0.45*)
9-Jun	0.5 ± 0.3	1.3 ± 0.5	1.3 ± 0.6	1.3 ± 0.6	2.0 ± 1.1	4.8 ± 2.1	1.87 (*0.15*)
15-Jun	0.8 ± 0.8	6.5 ± 3.0	1.5 ± 1.0	0.3 ± 0.3	2.5 ± 1.0	4.8 ± 2.9	1.97 (*0.14*)
23-Jun	0.5 ± 0.3 a	3.3 ± 1.6 ab	2.8 ± 1.6 a	0.0 a	0.3 ± 0.3 a	11.0 ± 6.0 b	4.06 (*0.01*)
28-Jun	0.0 a	0.5 ± 0.3 ab	1.8 ± 0.6 b	0.0 a	0.8 ± 0.5 ab	12.5 ± 3.0 c	23.59 (*<0.001*)
6-Jul	0.3 ± 0.3 a	4.0 ± 2.1 a	5.3 ± 2.2 a	1.5 ± 1.2 a	3.3 ± 0.9 a	17.5 ± 8.2 b	4.38 (*0.01*)
13-Jul	4.5 ± 2.7	14.5 ± 9.7	16.5 ± 11.1	0.5 ± 0.3	15.8 ± 5.5	4.3 ± 1.8	1.76 (*0.17*)
20-Jul	5.0 ± 3.4 ab	28.3 ± 17.7 b	23.3 ± 14.7 ab	3.8 ± 2.2 a	20.8 ± 10.5 ab	71.3 ± 36.6 c	5.24 (*0.005*)
28-Jul	18.3 ± 10.6	14.0 ± 4.2	108.5 ± 51.4	36.3 ± 22.8	45.3 ± 15.6	65.3 ± 38.9	1.49 (*0.24*)
4-Aug	8.0 ± 4.2 ab	56.5 ± 41.2 b	152.0 ± 39.1 c	4.3 ± 1.3 a	26.0 ± 14.6 ab	24.8 ±4.9 ab	7.89 (*<0.001*)
9-Aug	8.3 ± 5.1 ab	110.5 ± 97.0 b	207.5 ± 60.5 c	4.8 ± 2.2 a	27.3 ± 19.7 ab	4.8 ± 1.9 a	7.35 (*0.001*)
17-Aug	0.3 ± 0.3 a	5.5 ± 5.2 a	85.3 ± 28.6 b	1.0 ± 0.7 a	2.8 ± 1.4 a	0.0 a	31.37 (*<0.001*)
24-Aug	0.3 ± 0.3 a	1.0 ± 0.4 a	22.3 ± 10.0 b	0.3 ± 0.3 a	3.0 ± 2.7 a	1.3 ± 0.8 a	3.49 (*0.02*)
1-Sep	0.0	0.0	0.5 ± 0.3	0.0	0.5 ± 0.5	0.0	1.47 (*0.25*)
13-Sep	0.0	0.0	0.3 ± 0.3	0.0	0.0	0.0	1.0 (*0.45*)

Table 4. Mean (±SEM) number of ARM per 10 leaves. Means within rows followed by different letters are significantly different by Fisher's LSD (df = 5,15; $P < 0.05$).

Date	Assail	Spintor	Rimon	Danitol	OP-based	Red. Risk	F (*P*)
26-May	0.0	0.8 ± 0.5	0.3 ± 0.3	0.8 ± 0.5	0.0	0.5 ± 0.3	1.07 (*0.41*)
9-Jun	3.0 ± 1.0	1.0 ± 0.4	8.0 ± 6.7	2.8 ± 1.1	5.0 ±2.4	1.5 ± 1.5	0.80 (*0.56*)
15-Jun	6.0 ±3.1	9.5 ± 3.7	23.3 ± 8.4	5.5 ± 2.4	4.0 ± 1.1	7.5 ± 1.4	2.62 (*0.07*)
23-Jun	28.3 ±10.8	8.8 ± 2.2	11.3 ± 2.3	7.5 ± 0.6	10.8 ± 3.1	6.5 ± 2.9	2.02 (*0.13*)
28-Jun	71.0 ±16.4 c	41.5 ± 10.5 abc	21.5 ± 3.2 ab	11.5 ± 1.3 a	44.8 ± 13.7 bc	71.0 ± 22.4 c	3.93 (*0.01*)
6-Jul	113.3 ± 18.9 c	65.5 ± 24.5 abc	26.8 ± 4.0 ab	17.3 ± 4.8 a	83.0 ± 28.6 bc	133.3 ± 44.3 c	4.19 (*0.01*)
13-Jul	28.3 ± 10.6 c	8.5 ± 4.1 abc	2.3 ± 0.9 ab	3.8 ± 2.3 a	45.8 ± 11.4 bc	23.5 ± 4.3 c	9.75 (*<0.001*)
20-Jul	268.0 ± 99.6 b	101.3 ± 44.3 ab	35.5 ± 18.6 a	37.5 ± 27.0 a	105.8 ± 47.8 ab	262.0 ± 141.7 b	3.61 (*0.02*)
28-Jul	93.0 ± 37.9	43.3 ± 21.2	26.8 ± 4.4	26.3 ± 20.3	65.8 ± 26.4	96.3 ± 29.2	1.44 (*0.26*)
4-Aug	50.8 ± 10.4 b	16.5 ± 6.8 a	23.0 ± 11.1 a	11.0 ± 1.9 a	47.0 ± 12.2 b	64.3 ± 16.4 b	7.30 (*0.001*)
9-Aug	35.8 ± 9.7	22.5 ± 10.5	13.8 ± 5.5	11.0 ± 2.8	23.5 ± 7.0	63.3 ± 33.9	2.24 (*0.1*)
17-Aug	28.8 ± 11.3 c	11.5 ± 1.5 bc	10.5 ± 3.0 ab	2.8 ± 0.6 a	12.8 ± 2.8 bc	20.8 ± 1.5 bc	4.59 (*0.009*)
24-Aug	10.5 ± 2.9 a	25.0 ± 9.1 b	8.3 ± 3.3 a	6.0 ± 1.5 a	15.8 ± 2.4 ab	50.5 ± 6.3 c	10.84 (*<0.001*)
1-Sep	-	-	-	-	-	-	
13-Sep	-	-	-	-	-	-	

Table 5. Mean (±SEM) number of phytoseiids per10 leaves. Means within rows followed by different letters are significantly different by Fisher's LSD (df = 5,15; $P < 0.05$).

Date	Assail	Spintor	Rimon	Danitol	OP-based	Red. Risk	F (*P*)
26-May	0.0	0.0	0.0	0.0	0.0	0.0	-
9-Jun	0.8 ± 0.8	0.5 ± 0.5	0.3 ± 0.3	0.5 ± 0.5	0.0	0.0	0.54 (*0.73*)
15-Jun	0.3 ±0.3	0.5 ± 0.5	0.3 ± 0.3	0.3 ± 0.3	0.3 ± 0.3	0.0	0.24 (*0.93*)
23-Jun	0.0	0.0	0.0	0.0	0.0	0.0	-
28-Jun	0.5 ± 0.5	0.0	0.0	0.0	0.3 ± 0.3	0.5 ± 0.5	0.63 (*0.67*)
6-Jul	1.3 ± 0.5	1.5 ± 0.9	0.3 ± 0.3	0.0	1.0 ± 0.4	1.3 ± 0.5	1.67 (*0.20*)
13-Jul	2.3 ± 1.1	0.0	0.0	0.8 ± 0.8	2.8 ± 1.0	3.5 ± 2.8	2.00 (*0.13*)
20-Jul	0.5 ± 0.3 **a**	1.3 ± 0.5 **a**	0.0 **a**	0.3 ± 0.3 **a**	7.3 ± .0 **b**	1.5 ± 1.0 **a**	4.16 (*0.01*)
28-Jul	5.8 ± 1.3 **bc**	12.0 ± 2.7 **c**	0.8 ± 0.3 **a**	4.8 ± 0.8 **b**	10.5 ± 4.0 **bc**	10.5 ± 2.7 **bc**	6.54 (*0.002*)
4-Aug	9.8 ± 2.9 **bc**	12.0 ± 3.7 **bc**	4.0 ± 1.1 **ab**	1.3 ± 0.3 **a**	18.8 ± 2.9 **c**	12.5 ± 5.0 **bc**	5.39 (*0.004*)
9-Aug	7.8 ± 1.1 **ab**	18.3 ± 7.5 **b**	6.0 ± 0.7 **ab**	1.8 ± 0.3 **a**	13.0 ± 5.2 **b**	15.5 ± 6.3 **b**	3.02 (*0.04*)
17-Aug	4.3 ± 1.5	8.3 ± 2.5	14.3 ± 3.4	2.5 ± 0.6	6.5 ± 1.6	6.3 ± 2.2	2.74 (*0.06*)
24-Aug	3.5 ± 0.9	15.0 ± 6.7	13.3 ± 6.3	2.5 ± 1.3	11.0 ± 5.1	4.3 ± 2.0	1.52 (*0.23*)
1-Sep	3.0 ± 1.5	6.3 ± 1.3	6.5 ± 1.7	2.0 ± 0.7	5.0 ± 1.8	6.5 ± 0.9	2.20 (*0.10*)
13-Sep	2.0 ± 1.2	3.5 ± 1.3	3.3 ± 1.7	1.5 ± 0.9	3.5 ± 1.2	1.8 ± 1.1	0.44 (*0.80*)

Table 6. Mean (±SEM) number of stigmaeids per 10 leaves. Means within rows followed by different letters are significantly different by Fisher's LSD (df = 5,15; $P < 0.05$).

Date	Assail	Spintor	Rimon	Danitol	OP-based	Red. Risk	F (*P*)
26-May	0.0	0.0	0.0	0.0	0.0	0.0	-
9-Jun	0.0	0.0	0.0	0.0	0.0	0.0	-
15-Jun	0.0	0.0	0.0	0.0	0.0	0.3 ± 0.3	1.0 (*0.45*)
23-Jun	0.0	0.0	0.0	0.0	0.0	1.0 ± 1.0	1.0 (*0.45*)
28-Jun	0.0	0.0	0.0	0.0	0.0	0.3 ± 0.3	1.0 (*0.45*)
6-Jul	0.0	0.0 **a**	0.5 ± 0.3 **b**	0.0 **a**	0.0 **a**	0.0 **a**	3.0 (*0.04*)
13-Jul	0.0	0.0	0.0	0.0	0.0	0.3 ± 0.3	1.0 (*0.45*)
20-Jul	0.3 ± 0.3	0.3 ± 0.3	0.0	0.0	0.8 ± 0.5	1.5 ± 1.5	0.83 (*0.54*)
28-Jul	0.3 ± 0.3	1.8 ± 1.1	0.3 ± 0.3	0.5 ± 0.3	1.5 ± 0.6	0.8 ± 0.3	1.15 (*0.37*)
4-Aug	0.0	0.5 ± 0.3	0.8 ± 0.5	0.0	1.8 ± 1.8	0.5 ± 0.5	0.57 (*0.72*)
9-Aug	0.5 ± 0.5	1.0 ± 0.7	0.5 ± 0.5	0.3 ± 0.3	0.5 ± 0.5	0.5 ± 0.3	0.21 (*0.95*)
17-Aug	0.3 ± 0.3	0.8 ± 0.8	0.0	0.0	0.5 ± 0.5	0.3 ± 0.3	0.46 (*0.79*)
24-Aug	0.8 ± 0.8	3.0 ± 3.0	5.8 ± 5.4	0.0	3.0 ± 2.0	0.3 ± 0.3	0.73 (*0.61*)
1-Sep	1.0 ± 0.7	3.3 ± 1.7	1.0 ± 0.6	0.0	1.3 ± 0.8	0.5 ± 0.5	1.52 (*0.24*)
13-Sep	0.3 ± 0.3	0.8 ± 0.5	0.5 ± 0.3	0.0	0.3 ± 0.3	0.0	1.39 (*0.28*)

CURRENT PROGRESS IN DEVELOPING A FIXED-SPRAY APPLICATION SYTEM FOR HIGH-DENSITY PLANTINGS
2005

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The application of pesticides to fruit throughout the Northeastern US, as in the rest of the world, gives rise to concern, primarily due to inaccurate application, which often results in high residues and environmental pollution. Inaccuracy, due to over/under application, may result in high levels of disease or insect activity. Air and water pollution is a major concern due to pesticide drift. There is also a growing concern for food safety and accountability among consumers who purchase fruit. Surveys of fruit growers of New York, based upon stakeholder input, show that evaluation of sprayers, sprayer management and fruit coverage issues are a research priority in tree fruits and apples in particular. Priorities developed by members of the Northeastern IPM Fruit Working Group include sprayer and pesticide application resources (evaluations, calibration, best use patterns, etc.).

Direct injection sprayers have been developed by many researchers for boom sprayers in conventional field crops, but only one paper, Tennes et al. (1976) has been published in their application to fruit crops where they used four direct injection pumps inside a trailed tunnel sprayer. Direct injection sprayers offer the operator many advantages, including reduced environmental pollution and operator contamination (Landers 1992, 1997). Injection sprayers eliminate tank rinsing and allow rapid changes in dose rate. The main tank of the sprayer holds clean water only. Pesticide is injected into the water flow via a piston or a peristaltic pump and the resultant mix flows through the pipes to the nozzles. A manual or electronic controller adjusts the pesticide injection pump according to changes in operating requirements, e.g., changes in application rate and pesticide required.

A fixed spraying system was devised at NYS Agric. Expt. Station, Geneva, and preliminary trials were conducted to measure its efficiency at applying pesticides and controlling insects and diseases. Spraylines were fixed to metal conduit poles at three different heights and fitted with Netafim DAN 7000 sprinkler nozzles. Preliminary trials were conducted in two blocks each of Red Delicious and Empire apples on M.9 dwarfing stock located in a research orchard at this experiment station (Agnello et al. 1999). Tracer solution, using micronutrients, was used to monitor spray deposition and a conventional airblast sprayer was connected, via a hose, to the spraylines passing through the trees. The fixed line system orchard blocks were compared with blocks treated with a conventional airblast sprayer. The scope of the preliminary trials was small, but results over two years showed control of diseases and insect pests such as plum curculio was equal to that obtained with a conventional airblast sprayer.

In 2005, a pesticide application system was devised, similar to a fixed irrigation system, in a larger scale, 0.9-acre block of dwarf super-spindle Gala apple trees in a cooperating grower's orchard in Wolcott, NY. Two 3/4-inch plastic pipes (laterals) were positioned through the canopy of the apple trees, following the top support wire at 8 feet and the bottom wire at 3.5 feet above the ground. Small emitters, Netafim DAN 7000 series, with an 8 mm orifice and flat pattern spreader (Netafim, Fresno, CA) were installed at 6-foot intervals along the length of the pipe. A 2-inch main pipe was run along the junction of the rows to a central filling position. Pipe diameters were calculated based upon a hydraulic analysis computer program devised by W. Shayya for irrigation purposes.

A trailed application unit was constructed using a 300 gal water tank and a gasoline-driven centrifugal pump producing a flow of 90 gallons/minute at 36 psi. Two DOSMATIC A80-2.5% proportional injection pumps (Dosmatic USA, Carrollton, TX) were fitted into the water flow line after the pump. The water-driven pumps were fitted with super corrosive transfer (SCT) kits to avoid damage to the pump seals from solvents in the pesticides. The pumps dispense pesticide at a known rate into the water stream in the spray pipeline, the injection rate being adjustable from 0.2–2.5% or 1:500 to 1:40. The resultant mix was then pumped along the main pipe to the laterals within the tree canopy. This arrangement was used to apply the grower's standard mixture of insecticides and fungicides in July-Aug 2005, for the final three crop protectant sprays of the season. Although the system was functional, a number of engineering challenges and anomalies were encountered that need to be addressed to optimize and improve system performance in order to facilitate grower acceptance and implementation on a commercial scale.

Following are some of the specific objectives we hope to address in the coming season to improve the operation of this system on a commercial scale:

1. Refine and optimize the engineering elements of a pesticide application system of tubing and nozzles fixed into the canopy of high-density apple trees.

The engineering challenges in this project have been numerous, but not unsurmountable. To prevent excessive pressure loss in this larger scale trial, we minimized pipe runs and branch points, and opted for a high and low lateral line, with careful analysis of the hydraulic flows provided by an irrigation engineer, W. Shayya, SUNY-Morrisville. Another hydraulic concern was overcome by using a mobile pumping unit. Originally, we had intended to use a central pumping station, but hydraulic flow limitations and costs were a concern. The mobile unit can be transported from one block of trees to another.

A conventional airblast sprayer, used as the pumping station, suffers from a tank of mixed pesticide and water, plus operating at too a high pressure. To overcome the problems of tank rinsing and pump pressures, we chose a direct injection unit. A water-driven injection pump and gasoline-powered centrifugal water pump allows the system to be independent of tractors and PTO drive lines. The unit could, if desired, be pulled and operated with a pick-up truck. A 12 volt electricity supply is required for the pesticide mixing reservoir fitted below the intake of the injection pump.

The large internal volume of a mains/lateral pipeline system through a block of apple trees presents many problems, such a filling and emptying the pipe. The direct injection pump allows us to fill the pipes with clean water for one minute, then inject pesticides for one minute and then purge the pesticide laden water out with a clean water for a further minute.

As so many emitters are required, traditional sprayer nozzles, nozzle bodies and anti-drip check valves would be prohibitively expensive. Micro-emitters are used in greenhouse irrigation systems and produce small droplets. Droplet size was of concern, so the micro-emitters were tested at OARDC (Wooster, OH) using an Aerometrics PDPA 1-D laser system. The VMD at 4 bar was 310 micron (Downer 2004). This is larger than we might choose, but is the smallest emitter available. Initial field trials over two seasons have shown extremely good pest control with these emitters.

Specific goals of the trial in refining and improving the engineering aspects of the fixed sprayline will involve using accepted procedures to optimize:

- The deposition characteristics of the emitters, employing computer-aided image analysis of deposition patterns on water-sensitive cards

- The uniformity of pesticide concentrations from nozzle to nozzle, using tracer dyes and individual catch tubes on sequential nozzles to obtain comparative samples of solution all along the length of the sprayline
- The uniformity of pesticide concentrations with changes in dose level, by running a series of pesticide injection trials employing different initial input concentrations and assessing readings in the final effluent
- The system response time during filling and application of products, through repeated time trials using a range of pesticide materials representative of the grower's typical spray program
- The use of a purge mode to rinse the sprayline, comparing the relative merits of a water rinse as opposed to an alternative using compressed air
- The injection pump characteristics, consisting of examining the pump's operational limits under a testable range of candidate injection rates and spray durations.

The reliability of the components of the fixed sprayline system over a number of seasons will be evaluated by observing the system's performance throughout the course of this project, which was initiated during the 2004 season.

2. Determine the physical aspects of spray deposition and distribution patterns in the tree canopy achieved, as well as pesticide drift and off-target deposition, using a fixed spray system, compared with a conventional airblast sprayer.

At different times during the growing season, physical measurements of the spray deposition and distribution patterns within the orchard canopy and via off-site drift will be taken using water-sensitive cards and strips located at set distances from the trees. The strips and cards will be analyzed using a scanner and computer software program to calulate the proportion of the target areas contacted by the spray.

3. Evaluate pest control efficacy and economics of use with each type of application method.

The seasonal standard pesticide schedule of sprays will be applied through this system in one-half of the orchard, and, for comparison, the remaining half will be managed using the same pesticide schedule, materials and rates, but applied by the grower cooperator using a standard orchard airblast sprayer. Because some time will be needed at the start of the spray season to complete the system's design and operational improvements, it may be necessary to start the pest control efficacy comparison with the petal fall sprays; this will miss the apple scab primary infection period, which occurs pre-bloom, but will still allow enough time to assess management levels of secondary scab, plus all the remaining diseases and arthropod pests normally present during the growing season. Pest incidence and damage will be assessed in multiple randomly selected orchard sites throughout the season and at harvest, using standard research-based sampling procedures (Agnello et al. 1999) to evaluate both direct (fruit-feeding or -attacking) and indirect (foliar) pests, including insects, mites, and disease pathogens.

To assess the relative economics of using a fixed spray system for applying pesticides, a budget will be constructed to take into consideration the set costs (i.e., mobile pumping unit: tank, primary pump, pesticide injection pump, flowmeter, mixing reservoir, etc.) and the variable per-acre construction costs (supply mains, lateral lines, nozzles, support hardware, etc.) of the equipment. Records will be kept of time and labor requirements for system construction and individual spray sessions, and an estimated cost will be formulated for both the expense of constructing this system and the costs of use for each application and on a season-long basis. This will be compared against the set material and labor costs of operating a conventional tractor-pulled airblast sprayer. Costs of both application methods will be amortized over a best estimate of the respective equipment life on a commercial scale.

While this system would not be intended for all planting systems, it could be used in many of the newer high-density blocks where airblast sprayers are not the most suitable or required application method. Because drift and off-target deposition would be reduced with this method, adjacent properties and their occupants would secondarily benefit from lowered risk.

Spraying an entire orchard using a fixed system could have several advantages that *would justify* initial establishment costs and reduce pesticide-associated risks. Spray drift would be minimized without sacrificing adequate crop protection. Pesticide application could be a much more efficient process, achievable in a fraction of the time of tractor spraying, during shorter windows of acceptable spraying conditions, and at times of the year (i.e., early season) when ground conditions may make it impractical to drive through the orchard. Because multiple sprays and re-sprays would be much easier, this enhanced efficiency would make it more practical to use lower rates of pesticides and more "least-toxic" alternative or organically approved materials that have relatively short residual effectiveness, such as botanicals, microbials, oils, soaps, or insect growth regulators. To the extent that alternative pest management programs would be more realistic options in such plantings, such a system could favor growing fruit profitably for organic or niche specialty markets in selected blocks.

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EFFECT OF INSECTICIDE, WATER VOLUME AND METHOD OF APPLICATION ON THE INTERNAL FEEDING LEPIDOPTERAN COMPLEX IN APPLES – 2005

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Introduction

Large numbers of truck loads of fruit from the mid-Atlantic region destined for the processing markets in Pennsylvania have been rejected at harvest over the past eight years due the presence of live internal fruit feeding lepidopteran larvae – the codling moth (CM), *Cydia pomonella* L, and the Oriental fruit moth (OFM), *Grapholita molesta (Busck)*. The majority of the load rejections were for OFM (i.e., ≈ 63%). A number of reasons (e.g., insecticide resistance, choice of chemicals, water volume, low use rates of chemicals, cessation of spraying too early in August, etc.) have been cited for this outbreak of rejected loads of fruit. Another reason often cited by the authors is the use of the alternate row middle (ARM) method of application to apply insecticides to orchards. This method of application is very common throughout Pennsylvania and other mid-Atlantic states. The system of spraying was recommended back in the 1960's for various reasons, one of which was to promote the use of IPM by allowing for better survival of mite natural enemies on the unsprayed side of trees. This method of application was very successful over the years, not only in promoting conservation biological control of spider mites, but also in the overall reduction of pesticide use. However, since the vast majority of eggs from both OFM and CM are deposited on or near fruit and the larvae penetrate developing fruit within 24 hrs of egg hatch, coverage of fruit is extremely important for successful control of this pest complex. Insecticide residues on the offside of trees sprayed using the ARM method are usually less than optimal, due to such factors as sprayer capacity, canopy density, interval between sprays, the residual activity of the insecticide, etc., and the ability of OFM and CM larvae to enter fruit may be greatly enhanced with this spray method. Therefore, the authors designed a study to evaluate three factors – the efficacy of various types of insecticide chemistries, water volume, and method of application (alternate row middle [ARM] vs. complete [both middles] sprays), for their impact on controlling both OFM and CM in apples during 2005.

Materials and Methods

All treatments were applied to replicated 12-15 tree plots (four times) in a randomized complete block design. Each plot consisted of either 3 rows x 4 or 5 trees per row with each row consisting of alternating trees of 'Golden Delicious' and 'Yorking' trees. These trees were planted to a spacing of 18 x 25 ft, were 13-14 ft in height and 10-11 ft in width and were 26 years old. The trees were trained to a modified central leader system and pruned annually. The various insecticide x water volume x method of application treatments were applied with a Friend Airmaster '309' calibrated to deliver either 50 or 100 gallons per acre (GPA) as complete sprays or 50% of these volumes when applying the ARM application schedule of insecticides. All treatments were applied at a tractor speed of 2.4 mph and the dates of applications are listed in Table 1. A routine schedule of fungicides (Topsin M 85DF and Ziram 76WDF) was maintained throughout the experiment. An assessment of internal fruit injury by CM and OFM was made before the study (22 Jul) was initiated by sampling 100 random fruit ('Golden Delicious') per tree *in situ* on the two center trees in each plot and determining the number of fruit showing evidence of frass. A harvest evaluation of fruit exhibiting frass on both 'Golden Delicious' (23 Sep) and Yorking' (14 Oct) fruit was conducted in a similar fashion except that 225 fruit per tree on two center trees in each plot were randomly examined *in situ*. In addition, 50 dropped fruit per cultivar per plot were examined for internal worm presence. All apples showing the presence of frass at harvest were collected and examined for the presence of live larvae. All larvae collected during the evaluation process were identified to species. Adult flight of both OFM and CM were measured by the placement two and one sex pheromone monitoring traps for OFM and CM, respectively, in the orchard block. Traps were checked twice per week and lures and traps bottoms were changed monthly. OFM adult flight was high during the study while CM flight was very low (Fig. 1).

Results and Discussion

For 'Golden Delicious' data at harvest, all chemical treatments allowed significantly fewer fruit with frass than the untreated check (Table 1). Rimon (ARM/100 GPA) was the most effective treatment, followed by Imidan (ARM/100 GPA) and Assail (complete/50 GPA) (Table 1). There was no comparable complete/100 GPA treatment for Rimon. There was no difference in the percentage of apples with frass for the factor – method of application (ARM vs. complete) when averaged across chemical and method of application treatments. There was a statistical difference for the factor – water volume (50 and 100 GPA) with the higher volume treatments resulting in 52% less frass injury (means = 0.83% vs. 1.74% for the 100 vs. 50 GPA, respectively). For 'Yorking,' all chemical treatments resulted in fewer apples with frass, while again the Rimon treatment (ARM/100 GPA) was the most effective treatment for preventing injured fruit (Table 1). Only both Assail treatments at 100 GPA (ARM / complete) were less effective than the Rimon treatment (ARM/100 GPA). There was no difference across all treatments for method of application or GPA. When the data for both 'Golden Delicious' and 'Yorking' was combined and reanalyzed, some similar results were found. The Rimon treatment (ARM/100 GPA) was the most effective treatment while the Assail (ARM/50 GPA) and the Imidan (complete/50 GPA) treatments allowed the most fruit injury from the CM/OFM pest complex (Table 1). For the data from both cultivars, there was no difference across all treatments for method of application, but for the water volume, 100 GPA was more effective than 50 GPA in the prevention of fruit injured by internal feeding larvae. Of the larvae collected from fruit, 322 were identified as OFM and only 2 larvae were CM (Table 2). The least number of live larvae (5) was collected from the Rimon (ARM/100 GPA) treatment while the highest number of live larvae (32) was collected from the Imidan (ARM/50 GPA) (Table 2). Overall, it appears that Rimon was the most effective treatment when applied at 100 GPA. In addition, all chemical treatments applied at 100 GPA are more effective in preventing injury from internal feeding larvae than those applied at 50 GPA. There was no consistent effect of method of application on the efficacy across all chemical insecticides to support the contention by the authors that complete sprays are more effective in reducing internal worm injury than ARM sprays under the orchard conditions and days between applications for the types of insecticides and water volumes tested in this study.

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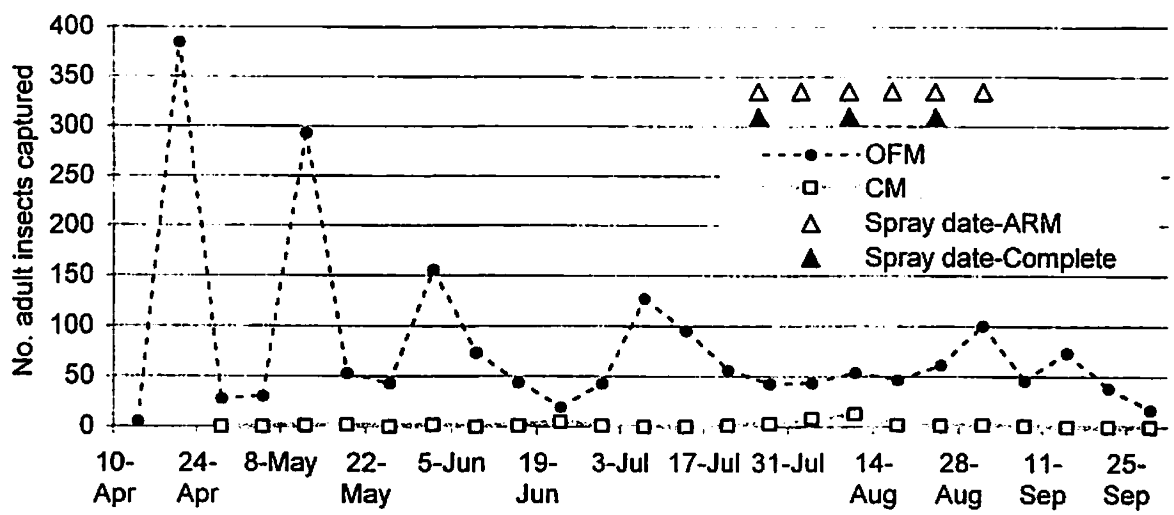

Fig. 1. **Sex pheromone trap capture of adult OFM and CM in the study designed to evaluate insecticide efficiency, water volume and method of application, Arendtsville, PA – 2005.**

Table 1. Efficacy of insecticide chemistry, method of application and water volume on internal fruit feeding Lepidoptera control in apples, Arendtsville, PA – 2005.

Treatment	Amt/A	lb AI	Applic. Combined method (GPA)	Dates of application	% apples with frass			
					22 Jul	23 Sep[1]	14 Oct[2]	G & Y[3]
Imidan 70W	1362.0 g	2.1	Complete (100)	26 Jul, 10 & 24 Aug	0.1 a	0.9 abc	1.9 ab	1.4 abc
Imidan 70W	1362.0 g	2.1	ARM (100)	26 Jul, 2, 10, 17 & 24 Aug, 1 Sep	0.1 a	0.7 ab	1.3 ab	1.0 ab
Assail 70W +	71.0 g	0.1094	Complete (100)					
Stylet Oil	1892.0 ml	0.5%		26 Jul, 10 & 24 Aug	0.0 a	1.1 a-d	2.2 b	1.7 bc
Assail 70W +	71.0 g	0.1094	ARM (100)					
Stylet Oil	1892.0 ml	0.5%		26 Jul, 2, 10, 17 & 24 Aug, 1 Sep	0.5 a	1.2 a-d	2.2 b	1.7 bc
Rimon 0.83EC	590.0 ml	0.129	ARM (100)	26 Jul, 2, 10, 17 & 24 Aug, 1 Sep	0.0 a	0.4 a	1.2 a	0.8 a
Imidan 70W	1362.0 g	2.1	Complete (50)	26 Jul, 10 & 24 Aug	0.0 a	2.5 e	1.6 ab	2.1 c
Imidan 70W	1362.0 g	2.1	ARM (50)	26 Jul, 2, 10, 17 & 24 Aug, 1 Sep	0.0 a	1.7 cde	1.6 ab	1.7 bc
Assail 70W +	71.0 g	0.1094	Complete (50)					
Stylet Oil	1892.0 ml	0.5%		26 Jul, 10 & 24 Aug	0.1 a	0.9 ab	2.2 ab	1.5 bc
Assail 70W +	71.0 g	0.1094	ARM (50)					
Stylet Oil	1892.0 ml	0.5%		26 Jul, 2, 10, 17 & 24 Aug, 1 Sep	0.0 a	2.2 de	1.7 ab	2.0 c
Rimon 0.83EC	590.0 ml	0.129	Complete (50)	26 Jul, 10 & 24 Aug	0.8 a	1.4 b-e	1.5 ab	1.4 abc
Rimon 0.83EC	590.0 ml	0.129	ARM (50)	26 Jul, 2, 10, 17 & 24 Aug, 1 Sep	0.3 a	1.8 b-e	1.4 ab	1.6 bc
Untreated check	--	--	--		0.3 a	6.3 f	4.2 c	5.2 d

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

1 No. fruit sampled per treatment (Golden Delicious) was 2,000 apples.

2 No. fruit samples per treatment (Yorking) was 2,000 apples.

3 Combined Golden Delicious and Yorking samples (4,000 apples/treatment)

Table 2. Species of larvae found in two cultivars of fruit in the study designed to evaluate the factors of insecticide chemistry, method of application and water volume on internal fruit feeding Lepidoptera control in apples, Arendtsville, PA – 2005.

Treatment	Amt/A	Applic. method (GPA)		No. (%) internal larvae in fruit: Golden Delicious CM	Golden Delicious OFM	York CM	York OFM
Imidan 70W	1362.0 g	Complete (100)	....	0 (0)	2 (100)	0 (0)	15 (100)
Imidan 70W	1362.0 g	ARM (100)	....	0 (0)	1 (100)	0 (0)	6 (100)
Assail 70W + Stylet Oil	71.0 g 1892.0 ml	Complete (100)	....	0 (0)	4 (100)	0 (0)	18 (100)
Assail 70W + Stylet Oil	71.0 g 1892.0 ml	ARM (100)	....	1 (7)	14 (93)	0 (0)	14 (100)
Rimon 0.83EC	590.0 ml	ARM (100)	....	0 (0)	0 (0)	0 (0)	5 (100)
Imidan 70W	1362.0 g	Complete (50)	....	0 (0)	17 (100)	0 (0)	10 (100)
Imidan 70W	1362.0 g	ARM (50)	....	0 (0)	25 (100)	0 (0)	7 (100)
Assail 70W + Stylet Oil	71.0 g 1892.0 ml	Complete (50)	....	0 (0)	2 (100)	0 (0)	17 (100)
Assail 70W + Stylet Oil	71.0 g 1892.0 ml	ARM (50)	....	1 (4)	22 (96)	0 (0)	3 (100)
Rimon 0.83EC	590.0 ml	Complete (50)	....	0 (0)	8 (100)	0 (0)	3 (100)
Rimon 0.83EC	590.0 ml	ARM (50)	....	0 (0)	6 (100)	0 (0)	3 (100)
Untreated check	--	---	....	0 (0)	70 (100)	3 (6)	50 (94)

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RESULTS OF 4-YEAR RISK AVOIDANCE AND MITIGATION PROGRAM (RAMP) PROJECT ON PEACHES IN NEW JERSEY

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Introduction

A 4-year Risk Avoidance and Mitigation Program (RAMP) project on peaches was completed in 2005. It integrated 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 and OP-replacement 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 (OP), carbamates, and pyrethroid insecticides. Levels of beneficial fauna abundance were also compared.

Materials and Methods

This study was conducted in eight commercial orchards (seven orchards in 2005) in Cumberland County (sites 1 - 4) and Camden County (sites 5 - 8), New Jersey (Table 1). The study sites were approximately 10–40 acres in size (Table 1). Each study site was divided into 2 blocks and 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 120 - 140 acres.
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 deployed. 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. One or two counts per generation were conducted. 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 and LPTB exuviae were counted two and three times per season, respectively. 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.

In RAMP blocks, various mating disruption products were used against OFM, LPTB, and PTB (Table 2). Reduced-risk and OP-replacement insecticides were used to control other pests (Table 2). Most pesticides and sprayable pheromones were applied with air blast sprayers as alternate-row-middle sprays 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, PTB, and LPTB significantly reduced numbers of males captured in pheromone baited traps with an exception of 2004 PTB and 2005 OFM (Table 3). In 2004 and 2005, OFM mating disruption was used sparingly because of very low pest pressure in the previous two years. There were no differences in the number of TABM males captured in pheromone baited traps between the RAMP and conventional programs (Table 3).

Trace amounts of damaged shoots were detected during the season 2002 and 2003. Then in 2004 and 2005 this injury slightly increased but still there were no differences in the number of damaged shoots between the programs (Table 4). OFM shoot injury increases were mostly observed early in the season before mating disruption was applied or late in the season especially in orchards without mating disruption. There were no differences in CF insect abundance in sweep samples between the treatments with an exception of year 2004 (Table 4).

Trace amounts of OFM damaged fruit were observed in both programs (Table 5). There were no differences in the amount of OFM fruit injury between treatments during the harvest assessments (Table 5). CF insect control was satisfactory in both programs with an exception of year 2002. There were no differences in CF damaged fruit between the RAMP and conventional treatments (Table 5). In 2002, early season control of PC with Asana was not satisfactory and growers were advised to use organophosphates. More damaged fruit were found in the conventional blocks when compared with the RAMP blocks (Table 5). Early season control of PC with Avaunt (2003 – 2005) and Actara (2004 – 2005) was satisfactory in the RAMP orchards (Table 5). A few scars and larvae infested fruit were detected in the RAMP and conventional orchards. PC control was equivalent for both pest management programs. 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 (Table 5). SJS damaged fruit were only detected in both programs blocks at harvest in 2002 and 2004. In 2004, even though damage was high in one RAMP block, there were no differences between treatments (Table 6). Lacewing pupae contaminated fruit in fruit stem ends occurred in both treatments but no differences were observed (Table 6).

There were no differences in the number of PTB and LPTB exuviae between either programs with an exception of 2005 PTB exuviae (Table 7).

High percentages of clean fruit, free from insect damage, were observed at harvest (Table 8). More clean fruit were observed in the RAMP blocks when compared with conventional blocks in 2003 but there were no difference the other years (Table 8).

The following Neuroptera species were observed: *Chrysoperla rufilabris* (Burmeister), *Ch. plorabunda* (Fitch) (Chrysopidae), *Micromus posticus* (Walker), and *M. subanticus* (Walker) (Hemerobiidae). There were no differences in Neuroptera numbers between treatments with an exception of year 2002 (Fig. 1A).

The following Coccinellidae species were observed: *Coccinella septempunctata* L., *Harmonia axyridis* (Pallas), *Adalia bipunctata* L., *Coleomegilla maculata* De Geer, and *Hippodamia converges* (Guerin-Meneville). Coccinellids were more abundant in the RAMP orchards when compared with the conventional blocks with an exception of year 2003 (Fig. 1B).

Anthocoridae adults and nymphs were at low levels and no differences were found between both treatments with an exception of year 2002 when more individuals were observed in the RAMP orchards (Fig. 1C). There were no differences in adult Syrphid flies numbers observed in the RAMP and conventional orchards (Fig. 1D). The observed Hymenoptera parasitoids belonged to Aphidiidae, Ichneumonidae, and Braconidae. There were no differences in their numbers between both treatments (Fig. 1E). There were no differences in the numbers of ants between both treatments (Fig. 1F). Spiders were in approximately equal numbers with an exception of 2005 when they were more abundant in the RAMP orchards when compared with conventional blocks (Fig. 1G).

Overall, similar numbers of all natural enemies were observed in both programs in years 2003 and 2004 (Fig. 1H). In years 2002 and 2005, overall natural enemies were less abundant and predominated in the RAMP orchards over conventional blocks (Fig. 1H).

The amounts of organophosphorus and carbamate insecticides used in RAMP blocks were significantly reduced in the RAMP blocks were significantly less when compared with conventional blocks (Fig. 2). In 2002, an average of two OP sprays were applied against early season PC in RAMP blocks because no effective OP alternatives were available. OP sprays applied to RAMP blocks in 2003 – 2005 were inadvertent sprays applied to single blocks prebloom, early season, or after harvest.

Mating disruption techniques, reduced risk, and OP-replacement insecticides are expensive products and significantly increased costs of the RAMP program when compared with the conventional program that predominantly used less expensive organophosphate, carbamate, and pyrethroid insecticides (Fig. 3).

Conclusions

Mating disruption, reduced risk, and OP-replacement insecticides provided control of major arthropod pests that was equivalent to growers organophosphorus- and carbamate-based spray programs. Overall fruit quality in the RAMP sites was as good or better than the conventional blocks. The exclusion organophosphorus insecticides from RAMP blocks may explain the increase of SJS fruit injury during this study. With an exception of 2002 and 2005, substituting reduced-risk pest management products for OP's, carbamates, and pyrethroids did not result in an increase of natural enemies. One major drawback is that the arthropod management costs of the RAMP programs are the 2.1 - 2.7 times higher than conventional costs.

Acknowledgement

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Table 1. Study sites

		Approximate acreage	
Site	Variety	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	6.2
8	Encore	9.5	4.6

Table 2. Product used in the RAMP Program: 2002-2005

Product	Rate / Acre	Unit	Target insect(s)
3M-MEC-OFM	0.5, 1.0, 1.5, 5.5	oz	OFM
Suterra Checkmate OFM	1.3 or 1.5	oz	OFM
Isomate M 100	100	ties	OFM
Isomate M Rosso	200	ties	OFM
PTB 3M Sprayable	2.0 or 4.0	oz	PTB, LPTB
Isomate – P	100	ties	PTB, LPTB
Isomate – L	100 or 200	ties	PTB, LPTB
Asana .66XL	6.0 or 8.0	oz	PC, OFM, CF
Avaunt 30WDG (EUP)	6.0	oz	PC, OFM
Provado 1.6F	5.0 or 6.0	oz	GPA, JB, GJB
Intrepid 2F	8.0, 10.0, or 12.0	oz	OFM, leafrollers
Actara 25WDG	4.0	oz	PC, GPA
Warrior 1S	4.0 or 5.0	oz	CF, OFM, leafrollers
Esteem 35WP	5.0	oz	Scales
Centaur 70DF	34.5	oz	Scales
Dormant oil	2.0	gal	Scales. Mites

Table 3. Average number of males OFM, TABM, PTB, and LPTB captured: 2002-2005

	Mean number ± se of males per trap per season			
	OFM[1]		TABM[2]	
Year	RAMP	Conv.	RAMP	Conv.
2002	0.6 ± 0.6 b	121.9 ± 47.6a	150.8 ± 69.7a	142.3 ± 37.2a
2003	7.3 ± 3.0b	31.2 ± 11.4a	91.5 ± 39.3a	77.1 ± 17.9a
2004	14.6 ± 41.1b	142.2 ± 42.8a	89.9 ± 25.4a	138.6 ± 21.2a
2005	40.6 ± 23.6a	141.1 ± 70.5a	67.2 ± 10.4a	98.8 ± 23.0a

For each pest and year means in a row followed by the same letter are not significantly different (Anova; P > 0.05)

[1]OFM (2002: $F_{1,7} = 6.52$; $P = 0.03$; 2003: $F_{1,7} = 6.88$; $P = 0.03$; 2004: $F_{1,7} = 8.29$; $P = 0.02$; 2005: $F_{1,6} = 4.73$; $P = 0.07$). [2]TABM(2002: $F_{1,7} = 0.02$; $P = 0.89$; 2003: $F_{1,7} = 0.35$; $P = 0.57$; 2004: $F_{1,7} = 2.55$; $P = 0.16$; 2005: $F_{1,6} = 4.90$; $P = 0.07$

Table 3 (Cont.). Average number of males OFM, TABM, PTB, and LPTB captured: 2002-2005

	Mean number ± se of males per trap per season			
	PTB[3]		LPTB[4]	
Year	RAMP	Conv.	RAMP	Conv.
2002	0.0 ± 0.0b	14.0 ± 3.9a	0.0 ± 0.0b	169.6 ± 38.2a
2003	0.0 ± 0.0b	13.3 ± 6.0a	0.1 ± 0.1b	136.3 ± 43.3a
2004	0.6 ± 0.2a	1.1 ± 0.4a	4.6 ± 2.2b	321.2 ± 67.7a
2005	0.0 ± 0.0b	2.5 ± 1.0a	5.4 ± 2.4b	353.7 ± 70.3a

For each pest and year means in a row followed by the same letter are not significantly different (Anova; P > 0.05)

[3]PTB (2002: $F_{1,7} = 12.77$; $P = 0.00$; 2003: $F_{1,7} = 17.99$; $P = 0.00$; 2004: $F_{1,7} = 1.75$; $P = 0.22$; 2005: $F_{1,6} = 7.31$; $P = 0.04$). [4]LPTB (2002: $F_{1,7} = 19.71$; $P = 0.00$; 2003: $F_{1,7} = 9.89$; $P = 0.01$; 2004: $F_{1,7} = 21.63$; $P = 0.00$; 2005: $F_{1,6} = 23.36$; $P = 0.03$)

Table 4. Average number of OFM damaged shoots and average seasonal number of CF insects: 2002-2005

	Mean number ± se of damaged shoots		Mean number ± se per 100 sweeps	
	OFM		CF	
Year	RAMP	Conv.	RAMP	Conv.
2002	0.1 ± 0.1a	0.1 ± 0.0a	3.9 ± 1.8a	3.0 ± 1.0a
2003	0.1 ± 0.0a	0.1 ± 0.0a	3.2 ± 1.1a	2.0 ± 0.7a
2004	0.5 ± 0.2a	0.4 ± 0.1a	4.3 ± 1.4b	5.6 ± 1.1a
2005	0.9 ± 0.4a	0.7 ± 0.2a	0.7 ± 0.3a	1.0 ± 0.2a

For each pest and year means in a row followed by the same letter are not significantly different (Anova; P > 0.05)

OFM (2002: $F_{1,7} = 0.90$; $P = 0.37$; 2003: $F_{1,7} = 0.18$; $P = 0.68$; 2004: $F_{1,7} = 0.59$; $P = 0.46$; 2005: $F_{1,6} = 0.62$; $P = 0.4$). CF (2002: $F_{1,7} = 0.70$; $P = 0.36$; 2003: $F_{1,7} = 1.07$; $P = 0.34$; 2004: $F_{1,7} = 5.83$; $P = 0.046$; 2005: $F_{1,6} = 2.00$; $P = 0.21$)

Table 5. Average percent of OFM, CF, PC, and TABM fruit injury at harvest: 2002-2005

	Mean percent ± se of damaged fruit			
	OFM[1]		CF[2]	
Year	RAMP	Conv.	RAMP	Conv.
2002	0.04 ± 0.0a	0.03 ± 0.0a	4.0 ± 0.7a	3.6 ± 1.5a
2003	0.0 ± 0.0a	0.1 ± 0.1a	0.8 ± 0.2a	1.0 ± 0.2a
2004	0.1 ± 0.0a	0.1 ± 0.0a	0.9 ± 0.1a	0.7 ± 0.1a
2005	0.1 ± 0.0a	0.0 ± 0.0a	0.1 ± 0.0a	0.0 ± 0.0a

For each pest and year means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

[1]OFM (2002: $F_{1,7} = 2.33$; $P = 0.17$; 2003: $F_{1,7} = 4.20$; $P = 0.08$; 2004: $F_{1,7} = 0.44$; $P = 0.53$; 2005: $F_{1,6} = 2.39$; $P = 0.17$). [2]CF (2002: $F_{1,7} = 0.19$; $P = 0.67$; 2003: $F_{1,7} = 1.04$; $P = 0.34$; 2004: $F_{1,7} = 0.86$; $P = 0.38$; 2005: $F_{1,6} = 0.80$; $P = 0.41$)

Table 5 (Cont.). Average percent of OFM, CF, PC, and TABM fruit injury at harvest: 2002-2005

	Mean percent ± se of damaged fruit			
	PC[3]		TABM[4]	
Year	RAMP	Conv.	RAMP	Conv.
2002	1.6 ± 0.4b	2.7 ± 0.4a	0.04 ± 0.03a	0.0 ± 0.0a
2003	0.4 ± 0.1a	0.8 ± 0.4a	0.0 ± 0.0a	0.04 ± 0.03a
2004	0.8 ± 0.4a	0.5 ± 0.3a	0.3 ± 0.2a	0.4 ± 0.1a
2005	0.1 ± 0.1a	0.3 ± 0.1a	0.1 ± 0.1a	0.1 ± 0.1a

For each pest and year means within a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

[3]PC (2002: $F_{1,7} = 7.10$; $P = 0.03$; 2003: $F_{1,7} = 1.15$; $P = 0.32$; 2004: $F_{1,7} = 4.51$; $P = 0.07$; 2005: $F_{1,6} = 0.37$; $P = 0.56$). [4]TABM (2002: $F_{1,7} = 2.33$; $P = 0.17$; 2003: $F_{1,7} = 2.33$; $P = 0.17$; 2004: $F_{1,7} = 0.28$; $P = 0.61$; 2005: $F_{1,6} = 0.00$; $P = 1.00$)

Table 6. Average percent of SJS and LWG fruit injury at harvest: 2002 - 2005

	Mean ± se percent of damaged fruit		Mean ± se percent of contaminated fruit	
	SJS		LWG	
Year	RAMP	Conv.	RAMP	Conv.
2002	0.1 ± 0.1a	0.1 ± 0.1a	0.8 ± 0.2a	1.0 ± 0.5a
2003	0.0 ± 0.0a	0.0 ± 0.0a	0.8 ± 0.3a	1.3 ± 0.4a
2004	2.1 ± 1.7a	0.0 ± 0.0a	1.2 ± 0.4a	1.4 ± 0.4a
2005	0.0 ± 0.0a	0.0 ± 0.0a	1.2 ± 0.4a	1.2 ± 0.4a

For each pest and year means in a row followed by the same letter are not significantly different (Anova; $P > 0.05$).

SJS (2002: $F_{1,7} = 0.05$; $P = 0.84$; 2003: $F_{1,7} =$ **; 2004: $F_{1,7} = 1.60$; $P = 0.27$; 2005: $F_{1,6} =$ **).
LWG (2002: $F_{1,7} = 0.29$; $P = 0.61$; 2003: $F_{1,7} = 5.03$; $P = 0.06$; 2004: $F_{1,7} = 0.27$; $P = 0.62$; 2005: $F_{1,6} = 0.00$; $P = 1.00$)

Table 7. Average number of PTB and LPTB exuviae per tree: 2002 - 2005

	Mean number ± se exuviae per tree			
	PTB		LPTB	
Year	RAMP	Conv	RAMP	Conv
2002	0.03 ± 0.01a	0.04 ± 0.01a	0.1 ± 0.0a	0.1 ± 0.0a
2003	0.01 ± 0.00a	0.01 ± 0.01a	0.1 ± 0.0a	0.1 ± 0.0a
2004	0.01 ± 0.01a	0.00 ± 0.00a	0.2 ± 0.1a	0.3 ± 0.1a
2005	0.00 ± 0.00b	0.02 ± 0.01a	0.2 ± 0.0a	0.7 ± 0.3a

For each pest and year means in a column followed by the same letter are not significantly different (Anova; $P > 0.05$).

PTB (2002: $F_{1,7} = 3.33$; $P = 0.1$; 2003: $F_{1,7} = 0.30$; $P = 0.59$; 2004: $F_{1,7} = 1.34$; $P = 0.28$; 2005: $F_{1,6} = 6.39$; $P = 0.04$). LPTB (2002: $F_{1,7} = 0.00$; $P = 0.94$; 2003: $F_{1,7} = 0.38$; $P = 0.55$; 2004: $F_{1,7} = 3.31$; $P = 0.11$; 2005: $F_{1,6} = 3.93$; $P = 0.09$)

Table 8. Average percent clean fruit at harvest: 2002 – 2005

	Average percent ± se of clean fruit	
Year	RAMP	Conv.
2002	93.0 ± 1.1a	93.1 ± 2.1a
2003	97.8 ± 0.5a	95.8 ± 0.4b
2004	93.4 ± 2.0a	95.3 ± 1.0a
2005	97.2 ± 0.6a	97.2 ± 0.6a

Means in a row followed by the same letter are not significantly different (Anova; $P > 0.05$)
2002: $F_{1,7} = 0.01$; $P = 0.94$; 2003: $F_{1,7} = 8.27$; $P = 0.02$;
2004: $F_{1,7} = 1.39$; $P = 0.27$; 2005: $F_{1,6} = 0.00$; $P = 0.98$

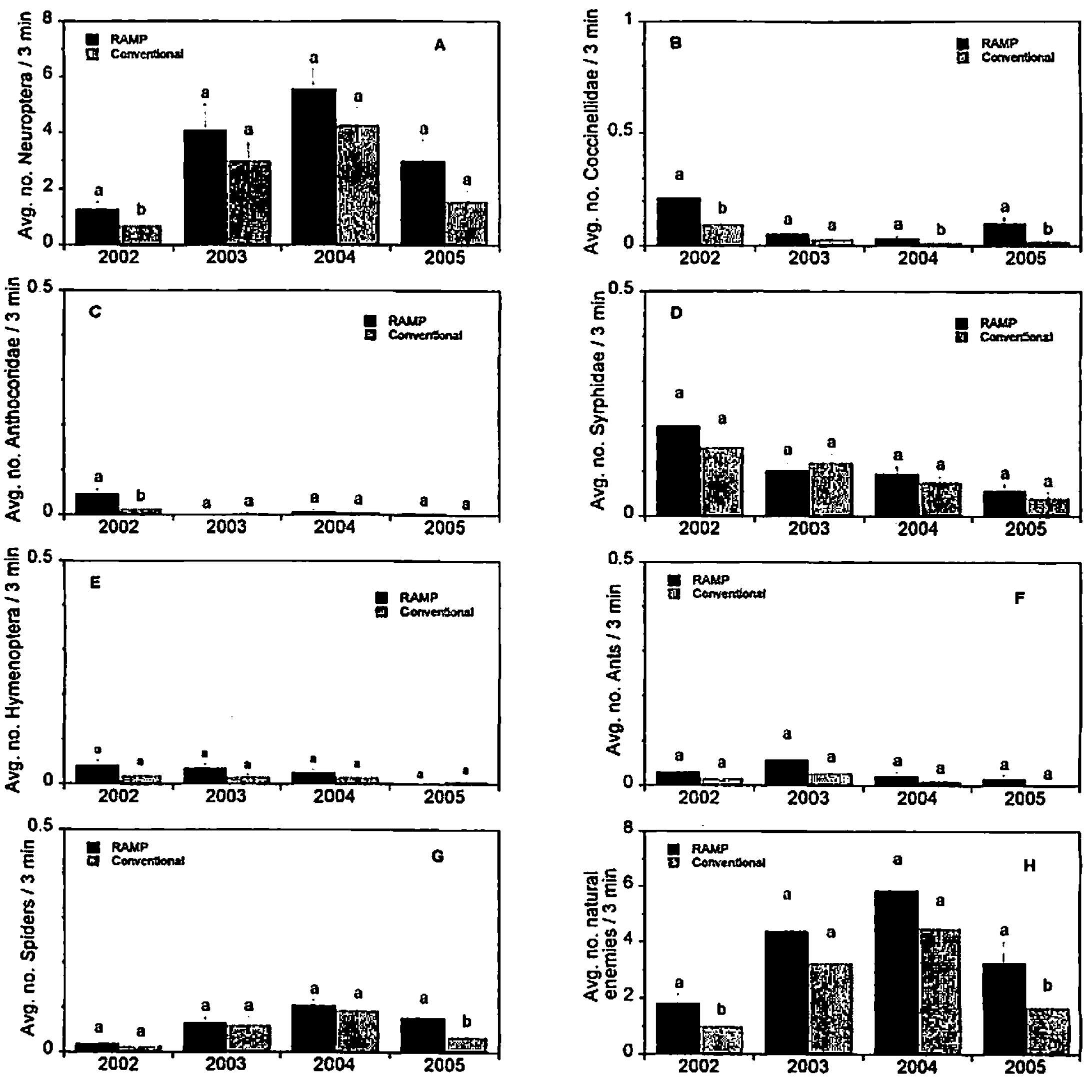

Fig. 1. Average seasonal number of natural enemies observed per 3-min per tree: 2002 – 2005. Neuroptera eggs, larvae, and adults (A); Coccinellidae adults (B); Anthocoridae adults and nymphs (C); Syrphidae adults (D); Hymenoptera adults (E); Ants adults (F); Spiders adults and nymphs (G); Total natural enemies (H)

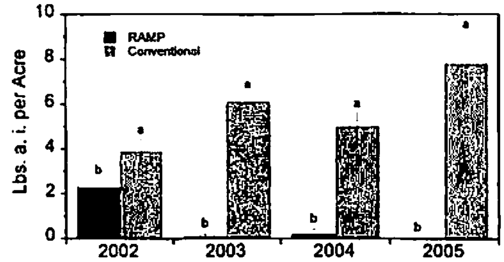

Fig. 2. Average amt of organophosphorus and carbamate insecticides applied in RAMP and conventional orchards: 2002 – 2005

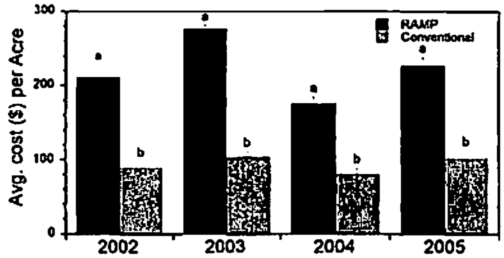

Fig. 3. Cost ($) per A of RAMP and conventional arthropod management programs: 2002 – 2005

Analysis of *Wolbachia* strains and re-evaluation of the success of cross-strain mating in plum curculio in eastern North America

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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, two factorial experiments were implemented to re-evaluate the mating in an approximate north and south transect of the range of plum curculio in various geographic populations and in within northern strain populations. For *Wolbachia* strain analysis, PCR of *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. Trade barriers 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:

I. Analysis of *Wolbachia* strains
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 or VBI). 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.

RFLP typing

To detect superinfection, three restriction endonucleases: BccI, BstF5I and AciI (specific restriction site on wCne1, wCne2 and wCne3, respectively) were used to digest PCR products.

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).

II. Re-evaluation of the success of cross-strain mating

Experiment design

Experiment I: 3x3 two factorial (maternal origin and paternal origin) design. Levels: Three locations: Geneva, NY; Amherst, MA and Cream Ridge, NJ. Twenty pairs within each combination were used.

Experiment II: 4x4 two factorial (maternal origin and paternal origin) design. Levels: Four locations: Geneva, NY; Quincy, FL; Blacksburg, VA and Kearneysville, WV. Twenty pairs within each combination were used.

Experimental procedure

Mated females were placed with uninfested thinning apples and then the success of oviposition was quantified. Apples were changed every two days and were held for 5 days to determine if eggs hatched successfully.

Variance analysis

ANOVA was done for each treatment factor and means were tested using LSD in experiment I combination. ANOVA was also done for each treatment factor and means were tested using LSD and, then the effect within each factor was compared by using HSD test because two main factors effects were both significant and the interaction of the two factors was also significant in experiment II combination.

Results:

I. Analysis of *Wolbachia* strains

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	8
Geneva, NY	Apple	10
Bridgeton, NJ	Nectarine	8
Chatsworth, NJ	Blueberry	5
Kearneysville, WV	Peach, plum	14
Washington, VA	Apple	3
Troutville, VA	Apple	6
Blacksburg, VA	Pear, plum	6
Kentland, VA	Apple	6
Clemson, SC	Peach	1
Byron, GA	Peach, plum	8
Quincy, FL	Peach	12
	Total:	87

Cloning and DNA Sequencing

All samples were found to be infected by *Wolbachia*. Three distinct sequences were produced: wCne1 (593bp), wCne2 (593bp) and wCne3 (590bp). wCne1 and wCne2 are 97% identical and they are both 84% identical with wCne3. Using a 97.5% cut off for same reference group, wCne1 can be as a new reference group. wCne2 is 99% identical with wNag1 (*Orius nagaii*). wCne3 is 100% identical with wDes (*Dacus destillatoria*). Figure 1 is a summary map of *Wolbachia* strain distribution in this study.

RFLP typing

According to PCR-RFLP analysis, 18 samples were double infected by wCne1 and wCne2. Table 2 is the distribution table for *Wolbachia* strain infection.

Strains	# of Samples (%)
wCne1	12 (13.8%)
wCne2	20 (23.0%)
wCne3	37 (42.5%)
wCne1+2	18 (20.7%)
Total	87 (100%)

Table 2. A distribution table of *Wolbachia* strain infection.

Phylogenetic Analysis

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

II. Re-evaluation of the success of cross-strain mating

There are 9 combinations (n=20) in experiment I. There are 16 combinations (n=20) in experiment II. Table 3 shows the percent fertility for each experiment I combination. Table 4 shows the percent fertility for each experiment II combination.

Within the northern strain, the geographic origin of paternal curculios (the paternal effect) had no significant effect on fertility (Table 3). New Jersey females show a lower fertility than New York and Massachusetts females. There was no significant interaction between the maternal and paternal factors. From Table 4, two main factors effects are both significant (Maternal factor, $P<0.0001$; Paternal factor, $P<0.0001$) and the interaction of the two factors is also significant ($P<0.0001$). Therefore, the effect within each factor was compared by using HSD test. Table 5 shows those significant comparisons within the two factors (values with the same letter are not significantly different).

Table 3 Mating success among populations within each geographical strain. All values are expressed as percentage of egg hatched (fertility) in each treatment. ANOVA was done for each treatment factor and means were tested using LSD.

Hatched%	Female			
Male	NY	MA	NJ	Paternal**
NY	97	95.66	94.19	95.62 **A**
MA	99.02	98.81	93.18	97.00 **A**
NJ	98.51	98.49	97.23	98.08 **A**
Maternal*	98.18 **A**	97.65 **A**	94.87 **B**	96.90

* Maternal factor, P = 0.0112, values followed by the same letter are not significantly different.
** Paternal factor, P = 0.8565, values followed by the same letter are not significantly different.

Table 4 Mating success among populations of each geographical strain. All values are expressed as percentage of egg hatched (fertility) in each treatment. ANOVA was done for each treatment factor and means were tested using LSD.

% Hatch	Female			
Male	NY	VA	FL	WV
NY	97.67	92.95	93.96	85.9
VA	92.71	97.35	85.7	80.76
FL	93.24	72.95	99.09	62.9
WV	60.21	21.19	93.21	85.7

Maternal factor, P<0.0001, Paternal factor, P<0.0001, Maternal * paternal, P<0.0001.

Table 5 Mating success among populations of each geographical strain. All values are expressed as percentage of egg hatched (fertility) in each treatment. ANOVA was done for each treatment factor and means were tested using HSD.

Hatched%	Female			
Male	NY	VA	FL	WV
NY	97.67 A A	92.95 A A	93.96 A	85.9 B
VA	92.71 A	97.35 A	85.7	80.76
FL	93.24 A A	72.95 B B	99.09 A	62.9 B
WV	60.21 B B	21.19 B B	93.21 A	85.7 A

Conclusion and Discussion

Current results suggest that *Wolbachia* strains approximate the distribution of PC strains: the northern PC strain is infected with wCne1 and wCne2 strains in B group, the southern strain is infected with wCne3 strain in A group and the mid-Atlantic region is the convergence area. wCne1 and wCne2 cause either single or double infection, but wCne3 is always present as a single infection in this study. The superinfection ratio is quite low (20.7%). WV and FL PC populations may be mixed by northern and southern strains. Comparing with the results of mating experiments between northern and southern PC strains (data not show here), the partial reproductive incompatibility may due to different *Wolbachia* strain infection. In future research, the strains of *Wolbachia* associated with the populations of plum curculio could be used to develop an assay to differentiate between the univoltine and multivoltine strains of plum curculio.

From cross-mating experiment, a rough unidirectional incompatibility was revealed: there is low fertility in West Virginia males mated with New York and Virginia females; West Virginia females have normal fertility mated with New York and Virginia males. The Florida population shows a different pattern: males have a lower fertility with Virginia and West Virginia females and females are compatible with all males from each population. The incompatibility between two plum curculio strains could be due to different, incompatible *Wolbachia* infections.

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Fig 1. *Wolbachia* strains distribution map

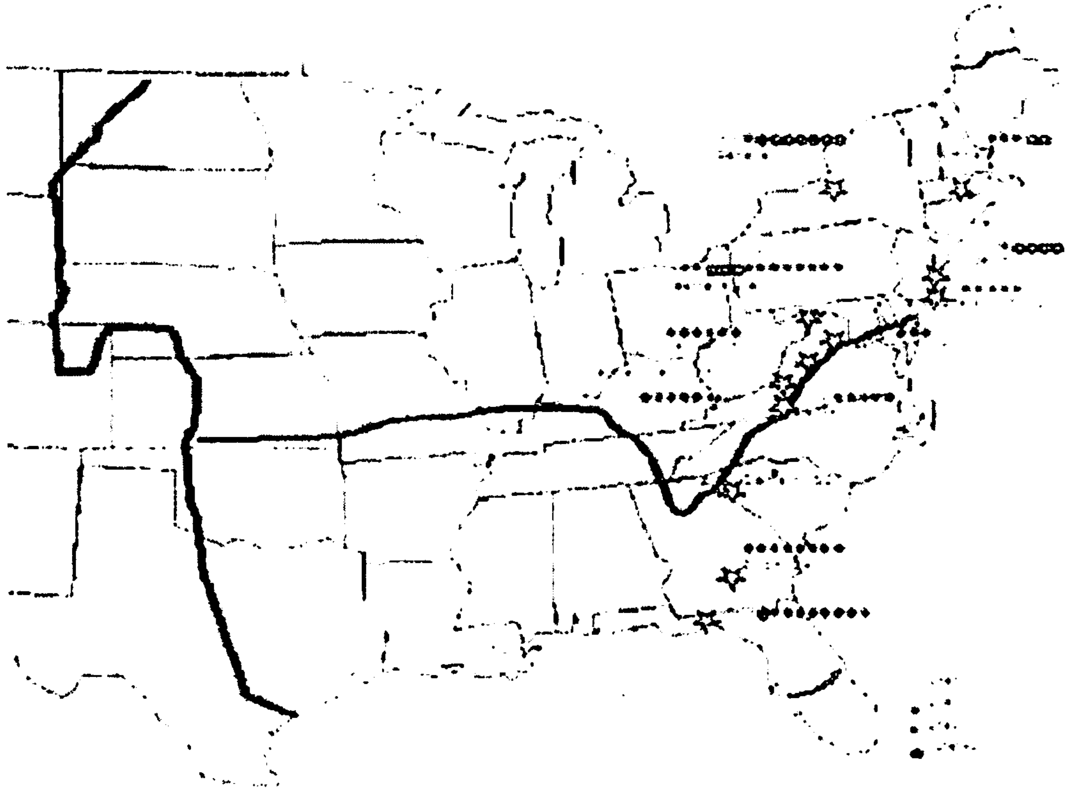
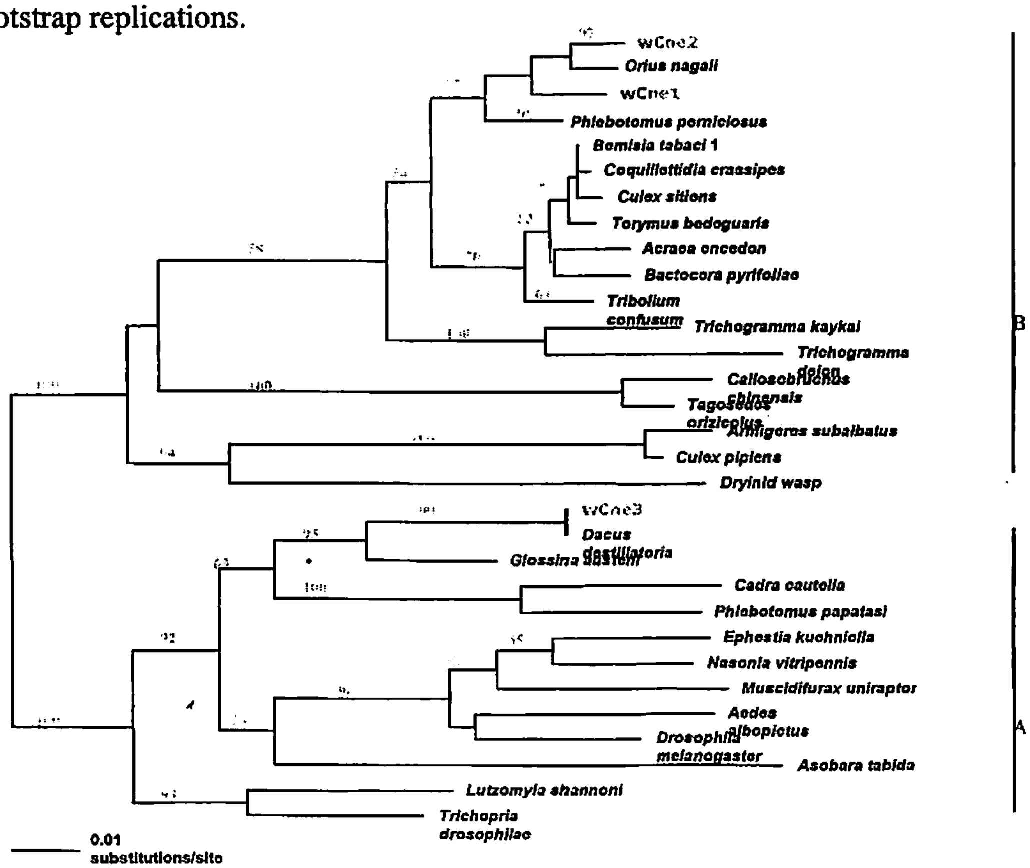


Fig 2. Phylogenetic tree of *Wolbachia* based on the wsp sequences. *Wolbachia* strains are named by host insect species. The tree has been constructed by the Neighbour Joining algorithm using the Kimura distance and midpoint rooted. Numbers on the nodes indicate percentage of 500 bootstrap replications.



Combining codling moth granulosis virus with mating disruption for internal Lepidoptera in apple

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I. Introduction: Codling moth (CM), *Cydia pomonella* (L.), has been the subject of mating disruption in Virginia since 1987. 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. 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/OFM-TT), sprayable laminate flake dispensers and Cyd-X (codling moth granulovirus).

II. Materials and Methods: Mating disruption research was carried out in two orchards in 2005, one in northern and one in central Virginia. These orchards had the following characteristics:

- **Rappahannock** – 2005 was the third year of MD; severe problems with internal feeders (for past three years have worked with timing, pesticide chemistry, and calibration issues; have improved situation, but insufficient progress). Last 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. Damage was reduced relative to recent years.
- **Albemarle** – by 2005, had been in MD program for several years; 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.

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. ShinEtsu combination ropes were used (CM/OFM-TT); CM/OFM-TT ropes were applied on 3 May. Hercon laminate flakes were sprayed to foliage on 4 May, and in late July. A heavy rain followed soon after the second flake application was complete. Cyd-X was applied on 24 May to seven of the rows in each pheromone treatment and again in August (6 fl oz/A).

Albemarle County: Sections of an apple orchard composed primarily of 'Delicious' trees at Miller School, Albemarle County, were treated with rope and flake 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, rope-style dispenser (CM/OFM-) was used (500/ha (200/A) on 3 May) (ca 10 A (4 ha)). In section B, Hercon laminate flakes were sprayed to foliage on 4 May. Section C was a conventionally treated control. Azinphosmethyl was applied at first cover (5/24). 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. No injury was detected at the Rappahannock orchard on 3 May. Harvest sample fruit were collected on 1 Sep at Rappahannock and 6 Sep at Albemarle. At that time, 300 fruit were picked from the edge and center of each block at Albemarle (for a total of 600 fruit per pheromone treatment), and 300 from the center of each plot at Rappahannock, and were returned to Blacksburg for examination.

II. Results and Discussion:

Flight data: In the Albemarle County orchard, no males of either species were trapped after the first week post-placement. In the Rappahannock orchard, no males of either species were collected in the ropes treatment. In the flakes treatment, 3 CM and 12 OFM were collected between 14 and 29 Jul.

Damage data: On 11 Jul, 2% internal feeder injury was detected in the ropes treatment (400 fruit), 2% in the flakes treatment, 0.25% in the ropes plus Cyd-X, and 0% in the flakes plus Cyd-X treatment. Harvest sample fruit were collected on 1 Sep at Rappahannock and 6 Sep at Albemarle. 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. Examination on collected fruit is pending. Initial examination showed very low injury at Albemarle with higher levels in Rappahannock.

Summary: Both mating disruption preparation were effective at low to moderate population pressure, though showed control problems at high population pressure. Addition of Cyd-X improved control.

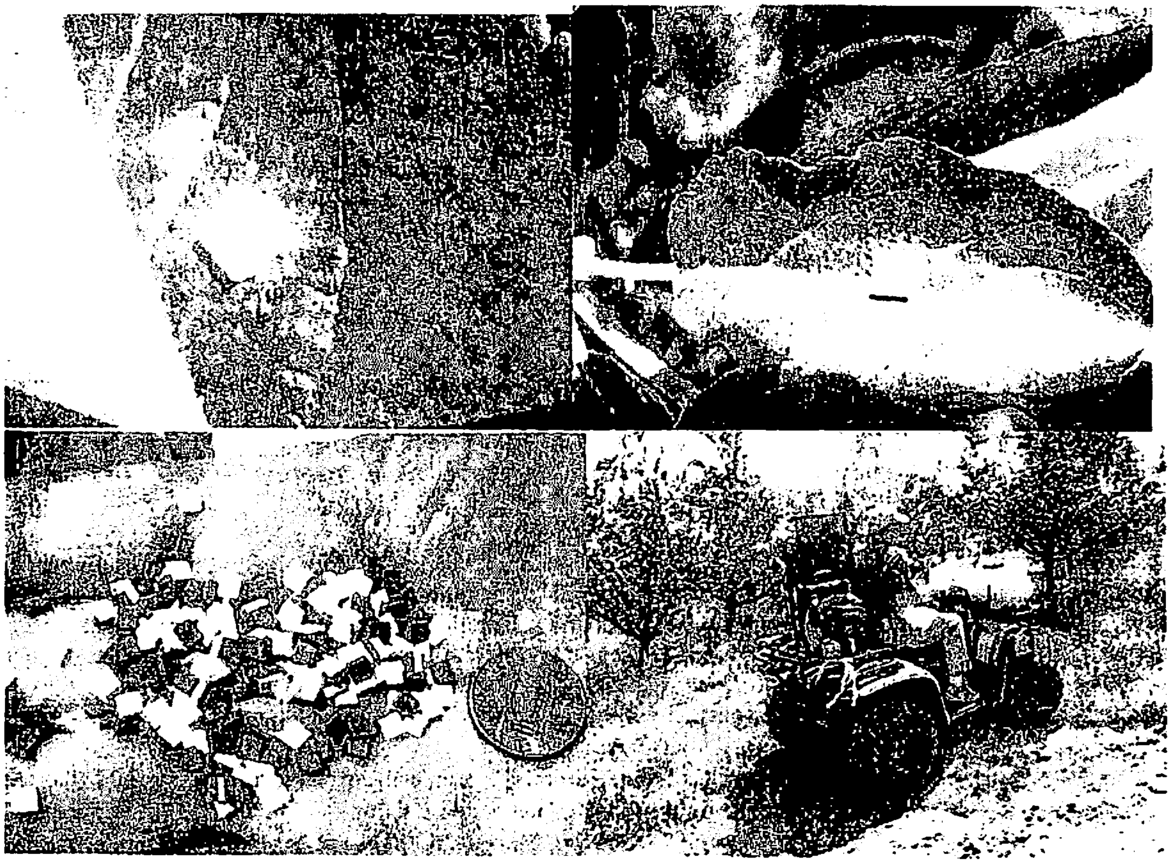

Fig. 1. Laminate flake for codling moth (upper left), oriental fruit moth (upper right), combined (lower left), and blower application (lower right).

Exploring mating disruption and entomopathogenic nematodes for control of grape root borer in southwestern Virginia - 2005

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

II. Materials and Methods: Mating disruption research was carried out in a vineyard in Patrick County over three seasons. Ropes were placed on 17 Jul 2003, 6 Jul 2004, and 26 Jul 2005. Rope style dispensers were obtained from CBC America, containing a blend designed for mating disruption of the currant clearwing, *Synanthedon tipuliformis* Clerck (Isonet Z): (*E,Z*)-2,13-octadecadien-1-yl acetate (100)
(Z)-13-octadecadien-1-yl acetate (5) (Priesner et al. 1986). The GRB pheromone blend has been described as (E,Z)-2,13-ODDA (99), (Z,Z)-3,13-ODDA (1) (Snow et al. 1986). Ropes were applied to vineyard trellis posts at the rate of 494/ha (200/A). The area treated was 2.4 ha (6 A). On 17 and 20 Aug 2005, 30 vines were examined for the presence of GRB exuviae.

The nematode treatment was applied on 30 Jun 2005. The soil surface was wet from a rainfall the previous night. A bucket with the bottom removed was placed around each treated vine trunk, and was supplied with 18.9 liters (5 gal) of water with nematodes at a nominal $0.13x10^6$/liter ($0.5x10^6$/gal). After the treatment, the soil was saturated with water to a depth of at least 0.6 m (2 ft). On 13 Jul, treated vines were pulled from the ground using a lift attached to a tractor. Rootstocks and large roots were examined for the presence of live GRB larvae.

III. Results:
Mating disruption: In the pheromone-treated block, there were 0.17 exuviae per vine, compared with 0.30 exuviae per vine in the untreated control. The fact that pupal counts were 43% lower in the disruption block is probably a conservative estimate of the degree of control provided by mating disruption. In the control, exuviae were found in the interior of the block, while in the pheromone-treated section, most exuviae found were in the vineyard edge.

Nematodes: There was no reduction in larval numbers in the nematode-treated vines relative to the control. This nematode typically causes infected larvae to assume a reddish color; no such discolored larvae were seen in any of the vines. It was concluded that a simple drench will not get nematodes to larvae in sufficient densities to cause infection, since most larvae are hidden within roots and rootstock.

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Plant Pathology

Comparison of Fungicides for
Full Season Management of Peach Diseases

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Fungicides of different chemistry were examined in various combinations for their efficacy against the full spectrum of peach diseases encountered during the growing season. Flint and Pristine were applied at petal fall to examine their influence on peach scab development as well as rusty spot control. A pre-harvest application program consisting of Elite, Pristine, and Indar was compared to the standard Indar and experimental V-10135 for brown and rhizopus rot control. USF2010 (trifloxystrobin + tebuconazole), GEM 500SC (trifloxystrobin), and Endura (boscalid) were examined for full season control against all diseases.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2005 growing season. The test block consisted of an orchard of 9-year-old 'Jerseyglo' peach planted at 25 ft x 25 ft spacing.

Treatments were replicated four times in a randomized complete block design with single tree plots. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used for applications.

Fungicide applications were made on the following dates and tree growth stages: 13 Apr (P, pink); 20 Apr (B, bloom); 29 Apr (PF, petal fall); 9 May (SS, shuck split); and 17, 31 May, 11, 24 Jun, 7, 20 Jul, 1 Aug (1C-7C, 1st through 7th cover). During the ripening period from mid August through early September, three pre-harvest sprays for fruit rot control were applied on 15, 23 Aug and 1 Sep (18, 10, 1 DPH, days preharvest). All trees in the block received Ziram 76DF at 6.0 lb/A on April 3rd for leaf curl control. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Overall, the growing season was very dry (Fig. 1). Rainfall for May, June, and August was far below average with 2.22, 2.36, and 1.52 inches verses 4.07, 3.37, and 4.18 inches, respectively, for the 30 year average. Rainfall for July and April was slightly above average; however, the vast majority of the rain fell in the first ten days in both months. The number of rain days with >0.10 in accumulation each month were: Apr, 6; May, 2; Jun, 6; Jul, 9 and Aug, 5. Air temperatures were near average in April, June, and July, but they were below average in May and a little above average in August. Average temperatures for this growing season were: Apr, 53.7°F; May, 57.5°F; Jun, 72.4°F; Jul, 76.2°F and Aug, 76.2°F.

For the most part, conditions were unfavorable for blossom blight due low temperatures and/or lack of rain during the susceptible stages of pink and bloom. The long dry periods that started in early May and lasted through 2C (May 31) were favorable for rusty spot development.

The conditions were conducive for scab due to a large amount of inoculum (twig lesions) and several wetting periods from shuck split (9 May) to 40 days preharvest (22 Jul). The number of rain days with >0.10 inch accumulation following each spray were: P, 0; B, 2; PF, 2; SS, 0; 1C, 1; 2C, 3; 3C, 0; 4C, 6; 5C, 3; 6C, 3 and 7C, 2. The lack of rain in the second half of August while fruit were ripening and most susceptible was very unfavorable for brown rot development. The number of rain days following each pre-harvest spray was: 18 DPH, 3; 10 DPH, 0 and 1 DPH, 0.

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 7 Jun by examining a total of 28-43 shoots on four branches on each tree. Two nonsprayed trees from each replication were examined. Rusty spot (*Podosphaera leucotricha*) was evaluated on 22 Jun by examining 40 fruit per tree. Scab (*Fusicladosporium carpophilum*) was evaluated at harvest on 2 Sept by examining 40 fruit per tree. Brown rot (*M. fructicola*), Rhizopus rot (*Rhizopus* spp.), Anthracnose rot (*Colletotrichum gloeosporioides / acutatum*), and other rots were evaluated at harvest on 2 Sep by examining all fruit on four or more branches per replicate tree; either a minimum of 100 fruit/tree were examined or all fruit for trees with less than 100 fruit. For post-harvest evaluations, 40 healthy, mature fruit (w/o visible symptoms) were harvested from each tree and placed on benches in two shaded greenhouses (ave. air temp. = 68 and 70.7°F). Brown rot, Rhizopus rot, Anthracnose rot, and other rots were assessed at 3 and 6 days postharvest (dph). For some replicates, low fruit set resulted in small sample sizes; in these cases, all healthy available fruit were used.

RESULTS AND DISCUSSION

Blossom Blight. Non-sprayed trees had less than 0.5% canker incidence. Because of the very low canker incidence, no assessment was performed on the treated trees. Although overwintering mummies were present in the trees, cold winter temperatures may have reduced fungal survival and therefore inoculum production during bloom. Lack of rain during much of the susceptible period (pink and bloom) may have also accounted for the low infection. There were a few wetting periods after bloom, but temperatures during these periods were well below optimum and probably limited spore germination.

Rusty Spot. Non-sprayed control trees had 40.6% infected fruit and an average severity of 0.59 lesions per fruit. All treatments except Endura 70WG significantly reduced disease incidence and severity when applied at the critical period for susceptibility for rusty spot between petal fall and second cover (Table 1). GEM was the most effective treatment (86.2% control), but not significantly better than the standard Nova program (72.2% control). Programs that substituted either Flint or Pristine for Nova at petal fall provided control at similar levels to the standard full Nova program. USF2010 provided 56.9% control and was less effective than GEM. Fruit from all treatments except Endura did not differ significantly in the severity of rusty spot.

Scab. A combination of high inoculum (twig lesions) and 14 rainy periods (> 0.10 in) from SS to 40 days before harvest resulted in extremely high disease pressure for scab. Control trees had 100% incidence of infection with the vast majority of fruit having >10 lesions. By harvest, many non-treated fruit were covered by large areas of coalescing lesions (Table 2). All treatments except Endura significantly reduced scab incidence. One of the three standard scab treatments (Bravo at SS and Captan for 1C through 6C) provided the best control (63.7%)

and had significantly lower overall scab incidence than the other two standards. One possible reason for this difference may be that Pristine applied at PF provided some additional residual control on fruit or anti-sporulant effect on twig lesions. This phenomenon was not observed when Flint was applied at PF, even though Flint has previously demonstrated significant anti-sporulant activity.

All treatments provided significant control of scab severity. The control treatment had 94.9% fruit with >10 lesions. The Endura treatment had 72.8% fruit with >10 lesions which was significantly more than all other treatments. GEM, USF2010, and two of the three standard treatments yielded the lowest severity. The other standard treatment differed significantly only from GEM, which had the fewest fruit with >10 lesions. Although none of the treatments provided acceptable control, scab 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 Bravo / Captan program.

Brown Rot. Disease pressure during the pre-harvest period was light as indicated by the relatively low incidence of rot in the non-treated control trees (Table 3). All treatments except Endura provided significant control of brown rot at harvest. The most effective treatment was the standard Indar program which provided 91.3% control. USF2010 had significantly more rot than the standard, while all other effective treatments yielded intermediate levels of control.

Post-harvest brown rot development was also limited. After three days, the non-sprayed fruit had only 14.1% infection (Table 3). Only the Indar, V-10135, and Elite/Pristine/Indar treatments yielded significantly lower disease incidence than the non-sprayed. Fruit treated with USF2010 and GEM had intermediate levels of rot; they were not significantly different from either the control or the three best treatments. At six days postharvest, none of the treatments differed significantly from the non-sprayed control. Endura had a higher incidence of infection at this time, while all other treatments had a lower incidence.

Rhizopus Rot. The amount of Rhizopus at harvest was low, ranging from 0 to 1.4% (Table 4). There were no significant differences among the treatments at harvest and three days postharvest. After 6 days incubation, all treatments had some fruit with Rhizopus. Only the Elite/Pristine/Indar treatment had significantly less Rhizopus than the non-sprayed control.

Anthracnose Rot. In general, anthracnose is not problematic in commercial orchards, but appears to be increasing over the last few years. Fruit from all treatments had the disease at harvest. Only Indar significantly reduced disease incidence from the non-sprayed. After six days incubation, Endura treated fruit had significantly higher anthracnose rot than all other treatments, including the non-sprayed control.

Other Rots. Another fruit rotting fungus, tentatively identified as a *Phomopsis* species, was observed for the first time this season. It is unknown whether this fungus acts as a pathogen or a saprophyte. This rot formed a firm, brown lesion, mostly on the suture of the fruit. Presence of black pycnidia and cirri formation in older lesions was used as positive identification. Based on the 6-dph results, all three standard programs were effective in controlling these other rots.

CONCLUSIONS

- ❖ No single treatment was highly effective against all diseases. The USF2010 and GEM programs generally did as well as the standard in controlling most diseases.

- ❖ The preharvest program of experimental V-10135 performed very well in controlling brown rot at harvest and during the postharvest incubation period. It achieved 86.4% control of brown rot at harvest vs. 91.3% for the standard Indar.

- ❖ The DMI / QoI / DMI preharvest treatment of Elite / Pristine / Indar provided brown rot control that was not significantly different from the standard. However, disease levels at harvest, 3-dph, and 6-dph were slightly higher than the standard. Thus, further testing of this combination at higher disease pressures is needed to insure that control is maintained.

- ❖ 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, USF2010, GEM, and the Pristine/Bravo/Captan treatment performed the best.

- ❖ Neither Rhizopus nor Anthracnose is a major disease; only a small percentage of the non-sprayed fruit were infected. Under these conditions, treatment separations were minimal. Nevertheless, after postharvest incubation, the Elite/Pristine/Indar treatment provided significant efficacy against Rhizopus rot.

- ❖ Endura is not planned for registration on peach, and is only included here for examination. The active ingredient of Endura is boscalid, one of the two active compounds in Pristine. Boscalid was not effective at controlling scab, but is believed to provide some brown rot control. Thus, we suspect it's inability to control brown rot in this study may have resulted from its lack of scab efficacy. Fruit severely infected with scab at harvest often crack during final swell, making it difficult for any fungicide to control brown rot. Endura-treated trees had 4.5 to 13 times more severely infected fruit (>10 scab lesions / fruit) than all other treatments.

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

Treatment	Rate / A	Timing	% Inf. Fruit[2]	# Lesions/Fruit[2]
Nontreated Control	----------------	----------------	40.6 a	0.59 a
PropiMax 3.6EC Vangard 75WP **Nova 40WP** **Nova 40WP+BravoWeatherStik 6F** **Nova 40WP+Captan 50WP** Captan 50WP Indar 75WP+Latron B-1956	4 fl oz 5 oz **4 oz** **4 oz** + 4 pt **4 oz** + 6 lb 6 lb 2 oz + 8 fl oz	P B **PF** **SS** **1C, 2C** 3C-7C 18, 10, 1 DPH	11.3 bc	0.12 b
Orbit 3.6EC Vangard 75WG **Flint 50WG** **Nova 40WP+BravoWeatherStik 6F** **Nova 40WP+Captan 50WP** Captan 50WP V-10135 20WDG	4 fl oz 5 oz **4 oz** **4 oz** + 4 pt **4 oz** + 6 lb 6 lb 1.5 lb	P B **PF** **SS** **1C, 2C** 3C-7C 18, 10, 1 DPH	7.5 bc	0.08 b
Rovral 4F Vangard 75WG **Pristine 38WG** **Nova 40WP+BravoWeatherStik 6F** **Nova 40WP+Captan 50WP** Captan 50WP Elite 45DF Pristine 38WG Indar 75WP+Latron B-1956	1.5 pt 5 oz **14.5 oz** **4 oz** + 4 pt **4 oz** + 6 lb 6 lb 6 oz 13.5 oz 2 oz + 8 fl oz	P B **PF** **SS** **1C, 2C** 3C-7C 18 DPH 10 DPH 1 DPH	7.5 bc	0.09 b
USF2010 500SC	**6 fl oz**	**P, B, PF, SS, 1C, 2C,** 3C-7C, 18, 10, 1 DPH	17.5 b	0.19 b
GEM 500SC	**3 fl oz**	**P, B, PF, SS, 1C, 2C,** 3C-7C, 18, 10, 1 DPH	5.6 c	0.06 b
Endura 70WG	**5 oz**	**P, B, PF, SS, 1C, 2C,** 3C-7C, 18, 10, 1 DPH	31.9 a	0.44 a

[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 2. Scab Incidence and Severity [1]			% Fruit [2]		
Treatment	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated Control	----------------	----------------	100.0 a	5.1 c	94.9 a
PropiMax 3.6EC Vangard 75WP Nova 40WP Nova 40WP+**BravoWeatherStik 6F** Nova 40WP+**Captan 50WP** **Captan 50WP** Indar 75WP+Latron B-1956	4 fl oz 5 oz 4 oz 4 oz + **4 pt** 4 oz + **6 lb** **6 lb** 2 oz + 8 fl oz	P B PF **SS** **1C, 2C** **3C-6C**, 7C 18, 10, 1 DPH	55.6 b	39.4 a	16.3 c
Orbit 3.6EC Vangard 75WG Flint 50WG Nova 40WP+**BravoWeatherStik 6F** Nova 40WP+**Captan 50WP** **Captan 50WP** V-10135 20WDG	4 fl oz 5 oz 4 oz 4 oz + **4 pt** 4 oz + **6 lb** **6 lb** 1.5 lb	P B PF **SS** **1C, 2C** **3C-6C**, 7C 18, 10, 1 DPH	51.6 b	38.6 a	13.0 cd
Rovral 4F Vangard 75WG Pristine 38WG Nova 40WP+**BravoWeatherStik 6F** Nova 40WP+**Captan 50WP** **Captan 50WP** Elite 45DF Pristine 38WG Indar 75WP+Latron B-1956	1.5 pt 5 oz 14.5 oz 4 oz + **4 pt** 4 oz + **6 lb** **6 lb** 6 oz 13.5 oz 2 oz + 8 fl oz	P B PF **SS** **1C, 2C** **3C-6C**, 7C 18 DPH 10 DPH 1 DPH	36.3 c	26.9 ab	9.4 cd
USF2010 500SC	**6 fl oz**	**P, B, PF, SS, 1C-6C,** 7C, 18, 10, 1 DPH	45.4 bc	33.6 ab	11.8 cd
GEM 500SC	**3 fl oz**	**P, B, PF, SS, 1C-6C,** 7C, 18, 10, 1 DPH	43.1 bc	37.5 a	5.6 d
Endura 70WG	**5 oz**	**P, B, PF, SS, 1C-6C,** 7C, 18, 10, 1 DPH	95.3 a	22.5 b	72.8 b

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

TABLE 3. Brown Rot Harvest and Post-harvest Incidence[1]			% Fruit Infected[2]		
Treatment	Rate / A	Timing	Harvest	3-dph	6-dph
Nontreated Control	----------------	----------------	24.2 a	14.1 ab	19.3 ab
PropiMax 3.6EC Vangard 75WP Nova 40WP Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP **Indar 75WP+Latron B-1956**	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C-7C **18, 10, 1 DPH**	2.1 c	3.1 c	9.4 b
Orbit 3.6EC Vangard 75WG Flint 50WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP **V-10135 20WDG**	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb **1.5 lb**	P B PF SS 1C, 2C 3C-7C **18, 10, 1 DPH**	3.3 bc	1.9 c	6.9 b
Rovral 4F Vangard 75WG Pristine 38WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP **Elite 45DF** **Pristine 38WG** **Indar 75WP+Latron B-1956**	1.5 pt 5 oz 14.5 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb **6 oz** **13.5 oz** **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C-7C **18 DPH** **10 DPH** **1 DPH**	6.6 bc	3.3 c	11.3 b
USF2010 500SC	**6 fl oz**	P, B, PF, SS, 1C-7C, **18, 10, 1 DPH**	9.4 b	4.4 abc	15.1 b
GEM 500SC	**3 fl oz**	P, B, PF, SS, 1C-7C, **18, 10, 1 DPH**	6.0 bc	3.7 bc	7.3 b
Endura 70WG	**5 oz**	P, B, PF, SS, 1C-7C, **18, 10, 1 DPH**	28.9 a	14.9 a	29.8 a

[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 4. Rhizopus Harvest and Post-harvest Incidence[1]			**% Fruit Infected**[2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	----------------	----------------	1.4 a	0.7 a	7.4 ab
PropiMax 3.6EC Vangard 75WP Nova 40WP Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP **Indar 75WP+Latron B-1956**	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C-7C **18, 10, 1 DPH**	0.6 a	0.0 a	3.1 abc
Orbit 3.6EC Vangard 75WG Flint 50WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP **V-10135 20WDG**	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb **1.5 lb**	P B PF SS 1C, 2C 3C-7C **18, 10, 1 DPH**	0.0 a	2.5 a	6.9 ab
Rovral 4F Vangard 75WG Pristine 38WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP **Elite 45DF** **Pristine 38WG** **Indar 75WP+Latron B-1956**	1.5 pt 5 oz 14.5 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb **6 oz** **13.5 oz** **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C-7C **18 DPH** **10 DPH** **1 DPH**	0.8 a	2.0 a	2.0 c
USF2010 500SC	**6 fl oz**	P, B, PF, SS, 1C-7C, **18, 10, 1 DPH**	1.1 a	2.1 a	6.1 abc
GEM 500SC	**3 fl oz**	P, B, PF, SS, 1C-7C, **18, 10, 1 DPH**	0.4 a	2.3 a	3.0 bc
Endura 70WG	**5 oz**	P, B, PF, SS, 1C-7C, **18, 10, 1 DPH**	0.8 a	0.0 a	7.5 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 ($P \le 0.05$, K=100).

TABLE 5. Anthracnose Harvest and Post-harvest Incidence[1]			% Fruit Infected[2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	---------------	---------------	5.0 a	0.0 a	0.7 b
PropiMax 3.6EC Vangard 75WP Nova 40WP Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP **Captan 50WP** **Indar 75WP+Latron B-1956**	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb **6 lb** **2 oz + 8 fl oz**	P B PF SS 1C, 2C **3C-5C, 6C, 7C** **18, 10, 1 DPH**	0.2 b	0.0 a	0.6 b
Orbit 3.6EC Vangard 75WG Flint 50WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP **Captan 50WP** **V-10135 20WDG**	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb **6 lb** **1.5 lb**	P B PF SS 1C, 2C 3C-5C, 6C, 7C **18, 10, 1 DPH**	1.4 ab	0.0 a	0.6 b
Rovral 4F Vangard 75WG Pristine 38WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP **Captan 50WP** **Elite 45DF** **Pristine 38WG** **Indar 75WP+Latron B-1956**	1.5 pt 5 oz 14.5 oz 4 oz + 4 pt 4 oz + 6 lb **6 lb** **6 oz** **13.5 oz** **2 oz + 8 fl oz**	P B PF SS 1C, 2C 3C-5C, 6C, 7C **18 DPH** **10 DPH** **1 DPH**	2.1 ab	0.0 a	0.6 b
USF2010 500SC	**6 fl oz**	P, B, PF, SS, 1C-5C, **6C, 7C, 18, 10, 1 DPH**	2.0 ab	1.4 a	2.7 b
GEM 500SC	**3 fl oz**	P, B, PF, SS, 1C-5C, **6C, 7C, 18, 10, 1 DPH**	2.5 ab	0.0 a	0.0 b
Endura 70WG	**5 oz**	P, B, PF, SS, 1C-5C, **6C, 7C, 18, 10, 1 DPH**	5.9 a	2.8 a	6.4 a

[1]Anthracnose 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).

TABLE 6. Other Rots Harvest and Post-harvest Incidence			% Fruit Infected[1]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	----------------	----------------	1.5 ab	1.7 ab	10.0 ab
PropiMax 3.6EC Vangard 75WP Nova 40WP Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP Indar 75WP+Latron B-1956	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb 2 oz + 8 fl oz	P B PF SS 1C, 2C 3C-5C, 6C, 7C 18, 10, 1 DPH	0.0 b	0.0 b	0.0 d
Orbit 3.6EC Vangard 75WG Flint 50WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP V-10135 20WDG	4 fl oz 5 oz 4 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb 1.5 lb	P B PF SS 1C, 2C 3C-5C, 6C, 7C 18, 10, 1 DPH	0.2 b	0.0 b	2.5 cd
Rovral 4F Vangard 75WG Pristine 38WG Nova 40WP+BravoWeatherStik 6F Nova 40WP+Captan 50WP Captan 50WP Elite 45DF Pristine 38WG Indar 75WP+Latron B-1956	1.5 pt 5 oz 14.5 oz 4 oz + 4 pt 4 oz + 6 lb 6 lb 6 oz 13.5 oz 2 oz + 8 fl oz	P B PF SS 1C, 2C 3C-5C, 6C, 7C 18 DPH 10 DPH 1 DPH	0.0 b	0.0 b	0.6 d
USF2010 500SC	6 fl oz	P, B, PF, SS, 1C-5C, 6C, 7C, 18, 10, 1 DPH	0.3 b	5.0 a	13.4 ab
GEM 500SC	3 fl oz	P, B, PF, SS, 1C-5C, 6C, 7C, 18, 10, 1 DPH	0.1 b	2.5 ab	6.7 bc
Endura 70WG	5 oz	P, B, PF, SS, 1C-5C, 6C, 7C, 18, 10, 1 DPH	3.2 a	0.0 b	18.7 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).

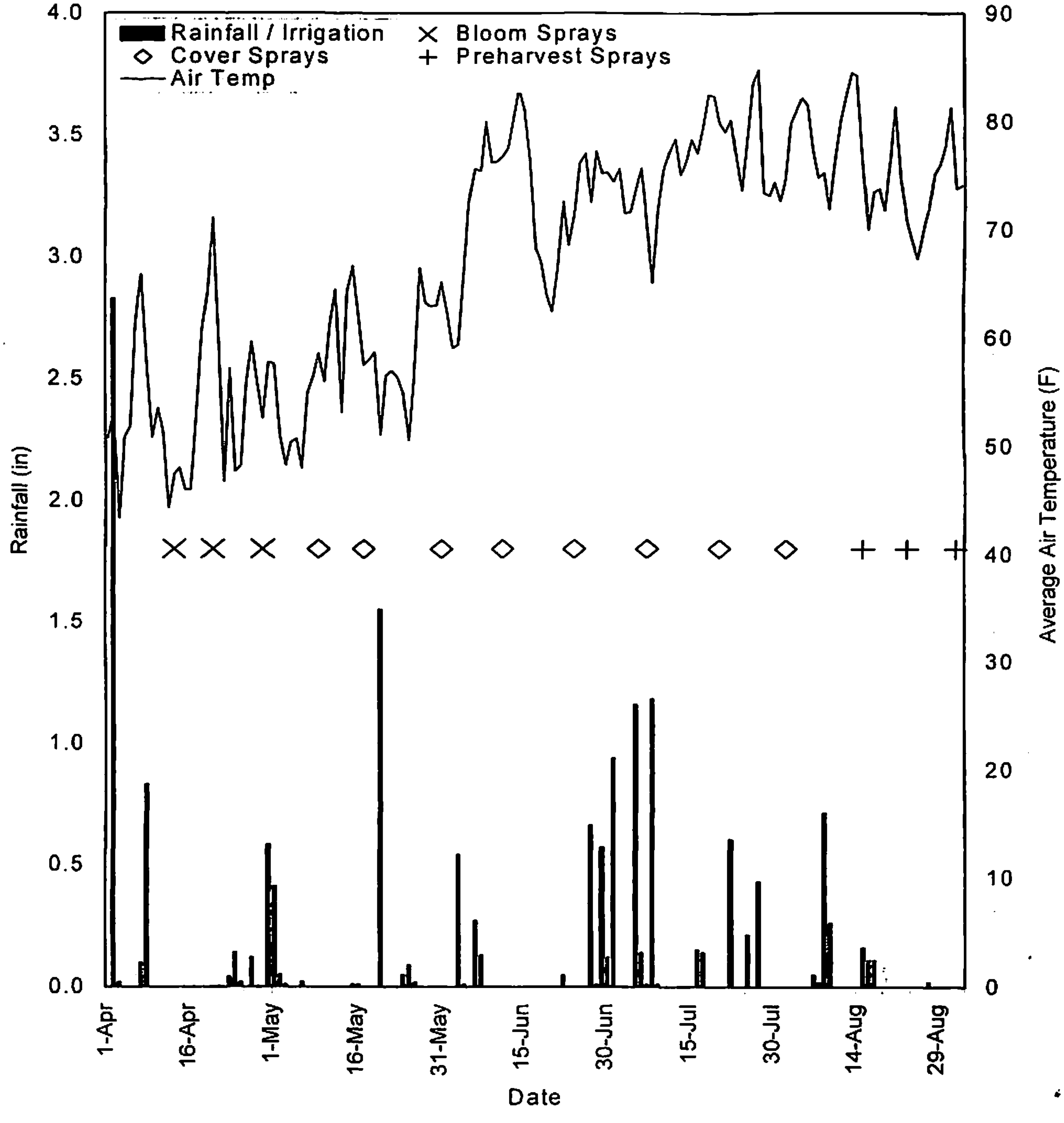

Figure 1. Rainfall, air temperature, and fungicide application timing on 'Jerseyglo' peach during the 2005 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. X, diamond, and + symbols represent application timing for bloom (P, B, PF), shuck-split through cover (SS-7C), and pre-harvest (PH) fungicide sprays, respectively.

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Without Consent of the Authors

ORGANIC ALTERNATIVES FOR APPLE DISEASE CONTROL IN PENNSYLVANIA, 2005

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A conventional fungicide program and materials approved for use in organic production were evaluated for control of apple diseases occurring in the early, middle, and late season. The test was conducted at the Penn State Fruit Research and Extension Center research orchards on mature 'Rome Beauty', 'Golden Delicious', 'Stayman', 'Cortland', and 'Red Delicious' trees on Malling 26 rootstocks spaced at 35 x 10 x 8 ft. Treatments were arranged in a randomized complete block design with 4 replications. Treatments were applied dilute with an airblast sprayer at 400 psi, which delivered 100 gal/A. Treatment applications were made on 7-14 day intervals from 14 Apr (1/2" green) to 18 Aug. Weather monitoring and primary scab infection periods were recorded with a Campbell Scientific and a Field Monitor Weather System using the Mills Modified apple scab infection model. Rainfall for April, May, June, July, August and September was 4.08", 2.50", 2.89", 4.49", 3.85" & 0.25", respectively.

Numerous scab infection periods occurred during the primary period 27 Mar to 31 May with significant accumulated infection hours. There were 4 moderate and 5 severe infection periods. Scab inoculum was high due to carry over from 2004. Powdery mildew pressure was moderate in the test site. Disease incidence on shoots was recorded by observing all leaves on 25 vegetative shoots per tree (4 replicates/treatment) on 16 May, 1 Jul and 4 Aug. Disease observations on fruit were determined at harvest 26 Sept (G. Del, R. Del & Cortland) and 5 Oct (Rome Beauty and Stayman) on 50 fruits per tree. Data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Fisher's Protected, LSD ($P \leq 0.05$).

All fungicide treatments resulted in significantly reduced fruit and leaf scab incidence and fruit severity. compared to nontreated trees. Treatments with organic alternatives: sulfur, lime sulfur and lime sulfur + Vigor Cal Phos resulted in similar levels of leaf and scab treatments with conventional /standard materials. The addition of Vigor –Cal Phos in the lime sulfur treatment did not improve the effect on scab but significantly reduced the incidence of sooty blotch and fly speck.

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APPLE (*Malus domestica* 'Idared')
Fireblight; *Erwinia amylovora*

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EVALUATION OF ANTIBIOTICS FOR BLOSSOM BLIGHT CONTROL ON IDARED APPLE, 2005:

A blossom blight test of streptomycin and gentamicin formulations was established in four randomized blocks on 23 yr-old trees. All treatments were applied to both sides of the tree on the morning of 19 Apr (50% of clusters with king bloom open) and again 27 Apr (late bloom) with a Swanson Model DA-400 airblast sprayer at the indicated gallons per acre. Four selected branches per tree, each with 30 to 50 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *E. amylovora* cells/ml, in the evening of each treatment day 19 Apr and 27 Apr. Infection data were based on counts of number of clusters 20 Apr and number of clusters with infection on inoculated branches 19 May. Maintenance materials, applied throughout the season with a commercial airblast sprayer at 100 gal per acre, included Captan, Dithane, Topsin M, Ziram, Supracide, Nova, Syllit, Captan, Flint, Supracide + oil, Imidan WSB, Assail, Lannate LV, Provado, and SpinTor. Harvest ratings of fruit russet were based on a 25-fruit sample from each tree 22 Sep.

Inoculation and weather conditions favored a strong fireblight test. Following the initial inoculation 19 Apr, a natural (MaryBlyt) infection period occurred 21 Apr. Streptomycin formulations performed as expected with all but the 12 oz per acre airblast rate giving significant suppression. The dilute application at 8 oz per 100 gal, intended to be equivalent amount to 1.5 lb per acre, gave significantly better control than Agri-Mycin 1.5 lb per acre applied airblast in 50 gal of water per acre. All gentamicin (GWN 9350) treatments gave significant fireblight suppression with no significant differences among treatments. There was no significant effect (p=0.05) on fruit finish by any treatment.

Table 1. Fireblight blossom treatments applied concentrate to Idared apples, 2005.

	Treatment and rate	Application method	% flower clusters inf.
0	No treatment	--	43.5 c
1	Agri-Mycin 17 12 oz/A + Regulaid 1 pt/ 100 gal	Airblast, 50 gpa	28.8 bc
2	Agri-Mycin 17 1.5 lb/A + Regulaid 1 pt/ 100 gal	Airblast, 50 gpa	25.3 b
3	Agri-Mycin 17 8 oz/100 gal + Regulaid 1 pt/ 100 gal	Dilute, handgun	11.2 a
4	BacMaster 1.5 lb/A + Regulaid 1 pt/ 100 gal	Airblast, 50 gpa	15.7 ab
5	***Firewall 1.5 lb/A + Regulaid 1 pt/ 100 gal***	Airblast, 50 gpa	22.9 ab
6	***GWN 9350 10W 378 g/100 gal + Regulaid 1 pt/ 100 gal in tank***	Airblast, 50 gpa	20.5 ab
7	GWN 9350 10W 1134 g/A + Regulaid 1 pt/100 gal in tank	Airblast, 50 gpa	17.0 ab
8	GWN 9350 10W 756 g/100 gal + Regulaid 1 pt/ 100 gal in tank	Airblast, 50 gpa	23.4 ab
9	GWN 9350 10W 2268 g/A + Regulaid 1 pt/100 gal in tank	Airblast, 50 gpa	16.6 ab

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

APPLE (*Malus domestica* 'Idared',
Fireblight; *Erwinia amylovora*

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Winchester, VA 22602

FIRE BLIGHT CONTROL BY BIOLOGICAL TREATMENTS ON IDARED APPLES, 2005

Treatment regimes, partially funded by the IR-4 Biopesticide Program, were evaluated for fireblight control on 23-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by border trees in the row and by border rows between treatment rows. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 450 psi. All treatments were applied in the morning of the same days, except #2, which did not receive the first and third applications. Treatments applied at: timing #1- early bloom (19 Apr); timing #2- full bloom (27 Apr); and timing #3- late bloom (3 May). Four selected branches on the east side of each tree were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *E. amylovora* cells/ml. This was done the second evening after the first and second treatment applications. Total blossom clusters on each selected branch were counted 28 Apr, and clusters with any blossoms infected were counted 4-5 May (inoculated only) and 19 May. Per cent blossom clusters infected is based on the number of clusters infected/total clusters on inoculated branches. Infection and control were assessed by counting number of clusters infected/total clusters on inoculated branches. As shown in Table 2, 18 blossoms per inoculated/non-inoculated side of each tree were sampled for presence of the organisms in BlightBan A506 (*Pseudomonas fluorescens*) and C9-1 (*Pantoea agglomerans*) formulations on selective media at late bloom 5-6 May. Maintenance materials, applied throughout the season with an airblast sprayer at 100 gal per acre, included Captan, Dithane, Flint, Nova, Syllit, Topsin M, Ziram, Assail, Supracide + oil, Imidan WSB, Lannate LV, Provado, and SpinTor. Russet was rated on a 25-fruit sample from each tree 22 Sep.

Inoculation and weather conditions favored a strong fireblight test. Following the initial inoculation 20 Apr, a natural (MaryBlyt) infection period occurred 21 Apr. Streptomycin performed as expected (Table 2). Serenade alternated with Agri-Mycin (Trt. #12) gave control comparable to three applications of Agri-Mycin (Trt. #1) and significantly better than three applications of Serenade (Trt. #11), a single application of Agri-Mycin at timing 2 (trt. #2), and BlightBan A506 alternated with Agri-Mycin (Trts. #8-10). Results suggested that trt. #2 did not control the first inoculation seven days before the streptomycin application for this treatment. There was no significant treatment effect (p=0.05) on fruit finish. In general, blossom colonization as indicated by selective media gave the expected results (Table 3). King's B medium, observed under a black light, was a reliable indicator for the presence of *Pseudomonas fluorescens* in BlightBan A506. Monitoring of blossoms on adjacent non-treated trees showed that there was movement to adjacent non-treated trees, likely facilitated by insects.

Table 2. IR-4 biopesticide fireblight blossom test

Treatment and rate/ 100 gal dilute	Applic. timing # 1	2	3	% blossom clusters infected: inoculated with *E. amylovora* 4-5 May	19 May	not inoc. with *E. a.* 19 May	Fruit russet rating (0-5)*
0 Non-treated control	--	--	--	7.7 b	31.9 cd	0 a	1.2 a
1 Agri-Mycin 17, 4 oz	X	X	X	2.3 ab	17.0 a	0.4 ab	1.4 a
2 Agri-Mycin 17, 4 oz	--	X	--	3.1 ab	32.0 cd	0.2 a	1.4 a
3 BlightBan C9-1, 10^{11} CFU/g, 7.0 oz	X	X	X	3.3 ab	30.1 b-d	0.2 a	1.5 a
4 BlightBan A506, 10^{10} CFU/g, (reg. form.), 7.0 oz	X	X	X	2.9 ab	24.2 a-c	1.2 b	1.4 a
5 BlightBan A506, 10^{11} CFU/g, (new form.), 7.0 oz	X	X	X	1.8 a	30.8 cd	0 a	1.7 a
6 C9-1, 10^{11} CFU/g, + A506, 10^{10} CFU/g comb., 7.0 oz	X	X	X	2.2 ab	33.3 d	0 a	1.7 a
7 BlightBan C9-1, 10^{11} CFU/g, 7.0 oz / Agri-Mycin 17, 4 oz	X	X	X	3.1 ab	21.6 ab	0 a	1.7 a
8 BlightBan A506, 10^{10} CFU/g, 7.0 oz / Agri-Mycin 17, 4 oz	X	X	X	2.0 ab	25.0 b-d	0.2 a	1.7 a
9 C9-1, 10^{11} CFU/g, + A506, 10^{10} CFU/g comb., 7.0 oz / Agri-Mycin 17, 4 oz	X	X	X	1.0 a	31.3 cd	0 a	1.5 a
10 BlightBan A506, 10^{11} CFU/g, (new form.), 7.0 oz / Agri-Mycin 17, 4 oz	X	X	X	3.3 ab	27.8 b-d	0 a	1.5 a
11 Serenade Max 12 oz + Biotune 1 pt	X	X	X	2.1 ab	27.5 b-d	0 a	1.5 a
12 Serenade Max 12 oz + Biotune 1 pt / Agri-Mycin 17 4 oz	X	X	X	1.2 a	15.2 a	0 a	1.5 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). * Russet rated on a scale of 0-5. (0=perfect).

Table 3. Assessment of percent organism colonization of flower stigma as indicated by imprinting on King's B and CCT media.
IR-4 biopesticide fireblight blossom test; dilute application on Idared apple, 2005. Virginia Tech AREC, Winchester

		App. timing #			% of sampled blossoms with indicated organism on selective media							
					King's B				*E. amylovora* (*E. a.*)			
					not inoculated with *E. amy.*		inoculated with *E. amy.*		not inoculated with *E. amy.*		inoculated with *E. amy.*	
	Treatment and rate/ 100 gal dilute	1	2	3	A506	C9-1	A506	C9-1	King's	CCT	King's	CCT
0	Non-treated control	--	--	--	5cd	10de	10de	3e	0b	11ab	25ab	40a
1	Agri-Mycin 17, 4 oz	X	X	X	10cd	9d	21d	19c	0b	12ab	1ab	22ab
2	Agri-Mycin 17, 4 oz	--	X	--	5cd	11d	16d	5de	5ab	38ab	1ab	38a
3	BlightBan C9-1, 10^{11} CFU/g, 7.0 oz	X	X	X	3d	87a	11de	99a	0b	28ab	11ab	32ab
4	BlightBan A506, 10^{10} CFU/g, (reg. form.), 7.0 oz	X	X	X	60a	18cd	88ab	18cd	7a	18ab	23a	26ab
5	BlightBan A506, 10^{11} CFU/g, (new form.), 7.0 oz	X	X	X	50ab	4de	84ab	12c-e	5ab	4ab	8ab	27ab
6	C9-1, 10^{11} CFU/g, + A506, 10^{10} CFU/g comb., 7.0 oz	X	X	X	58a	58b	55c	83b	0b	12ab	22a	37ab
7	BlightBan C9-1, 10^{11} CFU/g, 7.0 oz Agri-Mycin 17, 4 oz	X	 X	X	4d	87a	4e	99a	0b	30a	0b	29ab
8	BlightBan A506, 10^{10} CFU/g, 7.0 oz Agri-Mycin 17, 4 oz	X	 X	X	47ab	34bc	93a	23c	7ab	10ab	16ab	8b
9	C9-1, 10^{11} CFU/g, + A506, 10^{10} CFU/g comb., 7.0 oz Agri-Mycin 17, 4 oz	X	 X	X	25bc	51b	75bc	86b	0b	15ab	6ab	25ab
10	BlightBan A506, 10^{11} CFU/g, (new form.), 7.0 oz Agri-Mycin 17, 4 oz	X	 X	X	58a	0e	80ab	7de	5ab	1b	15ab	22ab
11	Serenade Max 12 oz + Biotune 1 pt	X	X	X	--	--	--	--	--	--	--	--
12	Serenade Max 12 oz + Biotune 1 pt Agri-Mycin 17 4 oz	X	 X	X	--	--	--	--	--	--	--	--

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

All treatments applied the same days except #2 which did not receive that first and third applications.

Treatments applied at: #1- early bloom (19 Apr); #2- full bloom (27 Apr) and #3- late bloom (3 May). Four selected branches on the east side of each test tree were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *Erwinia amylovora* cells/ml, the second evening after the first and second treatment applications. Four selected branches were left non-inoculated on the west side of each test tree for infection flower stigma colonization monitoring. Infection and control were assessed by counting number of clusters infected/total clusters on inoculated branches.

Eighteen blossoms per inoculated/ non-inoculated side of the tree were sampled for presence of the organisms in BlightBan A506 and C9-1 formulations on selective media at late bloom 5 May (Reps A-C) and 6 May (Rep D). were sampled on selective media at late bloom 5 May (Reps A-C) and 6 May (Rep D). Note: King's B medium is selective for *Pseudomonas fluorescens*, the organism present in BlightBan A506. The CCT medium is an aid in differentiating *E. amylovora* and *Pantoea agglomerans*, the antagonist in BlightBan C9-1. Treatments #11 & 12 were not sampled.

APPLE (*Malus domestica* 'Nittany')
Fireblight; *Erwinia amylovora*
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust, *Gymnosporangium juniperi- virginianae*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Rots (unidentified)
Fruit russet

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EVALUATION OF EXPERIMENTAL FUNGICIDES FOR FIREBLIGHT AND FUNGAL DISEASE MANAGEMENT ON NITTANY APPLE, 2005.

Ten treatments involving famoxate and coppers were compared on 24-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by border trees in the row. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. After an initial maintenance application to all test trees 6 Apr (Dithane 3 lb + Ziram 3 lb), test treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (1/2" green), 21 Apr (pink-early bloom), 28 Apr (pink- 50% bloom) and 9 May (late bloom-petal fall). First through 6th covers (1C-6C) applied 23 May, 7 Jun, 23 Jun, 7 Jul, 25 Jul, and 15 Aug. Fireblight protocol: Four selected branches were inoculated by spraying to wet with bacterial suspensions containing $1X10^6$ *E. amylovora* cells/ml, the evening after the second, third and fourth applications 21 Apr (pink-early bloom), 28 Apr (50% bloom), and 9 May (late bloom petal fall). Total blossom clusters on each selected branch were counted 2 May. Fireblight infection was assessed 31 May. Clusters with any symptomatic blossoms were counted as infected. Per cent infection is based on the number of clusters infected/total clusters on inoculated branches. Fireblight cluster and strikes per tree counts also include a few infected bourse shoots at clusters which did not have fireblight symptoms. Fungal disease represent 10 cluster leaf sets per tree 29 Jun; 10 shoots per tree 5 Jul; or 25 fruit per rep at harvest 29 Sep. Insecticides applied to the entire test block with the same equipment included Supracide+oil, Assail, Intrepid, Lannate LV, Imidan, Provado, and SpinTor.

This test was initially set up as a fireblight test and continued to test for broad-spectrum disease control and fruit finish. Inoculation and weather conditions favored a good fireblight test. The first inoculation was done on a day which was a natural (MaryBlyt) infection period, 21 Apr. Streptomycin performed as expected (Table 4). The most effective treatment, Dithane + Kocide, was significantly more effective than Dithane alone and equal to streptomycin (Trt. #8). DPX-JE874-431 10EC (Trt. #5) also gave significant fireblight control compared to non-treated trees. Heavy inoculum and favorable weather conditions gave a strong scab test. Dithane-related treatments provided superior control; copper and famoxate (JE-874) gave moderate but significant control. Trt #8 was noticeably weak because only Agri-Mycin was applied during bloom. Dithane also provided superior control; Kocide-related treatments were weak for rust control. Copper and famoxate-related treatments gave significant control of sooty blotch although not as effective as the standard, captan + ziram. Captan + ziram also gave the best control of flyspeck, followed by famoxate (Table 5). In general, the EC formulation was more effective than the SC for fireblight, scab, sooty blotch, and flyspeck at equivalent active ingredient rates. All copper-related treatments deleteriously affected fruit finish except Kocide in combination with Dithane.

Table 4. **Early season disease control by protectant applications on Nittany apple, 2005, Winchester, VA**

			Fireblight infection		Scab infection on leaves and fruit					Cedar	Mildew	
		Treatment	% clusters	strikes	% cluster	shoot leaves		fruit		rust, %	infection, %	
	Rate per acre	schedule	infected	/ tree	lvs inf.	% inf.	les/lf	% inf.	les/fruit	lvs inf.	leaves	area
0	No treatment	---	15.3 c	19.8 c	57 g	37 c	6.9 bc	82 e	7.2 f	11 c-e	20 c	3.1 c
1	*Kocide 2000 53.8DF 1 lb*	½" G - 6C	7.7 a-c	10.3 a-c	12 b	18 b	1.9 a	33 bc	1.9 bc	17 ef	11 ab	2.0 a-c
2	*Kocide 2000 53.8DF 9.6 oz*	½" G - 6C	7.3 a-c	9.5 a-c	19 b-d	22 b	1.6 a	35 c	1.8 bc	21 f	10 ab	1.9 ab
3	DPX-GFJ52-008 46.1WG 9.6 oz	½" G - 6C	6.3 a-c	8.5 a-c	14 bc	17 b	0.9 a	21 b	1.0 ab	8 b-d	7 a	1.3 a
4	DPX-JE874-430 50SC 6 fl oz	½" G - 6C	8.4 a-c	11.5 a-c	45 fg	39 c	7.2 c	86 e	5.4 e	8 b-d	11 a-c	2.1 bc
5	DPX-JE874-431 10EC 30 fl oz	½" G - 6C	3.7 ab	4.8 ab	32 d-f	23 b	1.2 a	51 d	3.0 cd	5 ab	9 ab	1.8 ab
6	DPX-JE874-431 10EC 6 fl oz + Kocide 2000 8 oz	½" G - 6C	5.4 a-c	7.3 a-c	27 c-e	19 b	1.2 a	43 cd	2.5 b-d	7 bc	7 a	1.3 a
7	Tanos 50WG 12 oz + Kocide 2000 53.8DF 8 oz	½" G - 6C	6.7 a-c	9.8 a-c	29 d-f	22 b	1.7 a	48 cd	3.5 d	12 de	8 ab	1.8 ab
8	Manzate 75DF 3.2 lb Agri-Mycin 17 1.25 lb Captan 80WDG 40 oz + Ziram 76DF 3 lb	½" G, 1-2C pink – PF 3C - 6C	3.6 ab	5.3 ab	44 e-g	36 c	4.5 b	55 d	2.5 cd	11 c-e	14 bc	2.4 bc
9	Dithane RSNT 75DF 3.2 lb + Kocide 2000 53.8DF 1 lb Captan 80WDG 40 oz + Ziram 76DF 3 lb	½" G - 2C 3C - 6C	2.0 a	2.8 a	3 a	8 a	0.3 a	3 a	0.1 a	16 ef	12 a-c	2.1 bc
10	Dithane RSNT 75DF 3.2 lb Captan 80WDG 40 oz + Ziram 76DF 3 lb	½" G - 2C 3C - 6C	10.4 bc	15.8 bc	2 a	5 a	0.2 a	6 a	0.2 a	2 a	12 a-c	2.2 bc

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

Disease ratings: scab on 10 cluster leaf sets per tree 29 Jun; 10 shoots per tree 5 Jul; 25 fruit per rep 29 Sep.

Test treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (1/2" green), 21 Apr (pink-early bloom), 28 Apr (pink- 50% bloom), and 9 May (late bloom-petal fall). First through 6th covers (1C-6C) applied 23 May, 7 Jun, 23 Jun, 7 Jul, 25 Jul, and 15 Aug.

Fireblight protocol: Four selected branches were inoculated by spraying to wet with bacterial suspensions containing $1X10^6$ *E. amylovora* cells/ml, the evening after the second, third and fourth applications 21 Apr (pink-early bloom), 28 Apr (50% bloom) and 9 May (late bloom petal fall). Total blossom clusters on each selected branch were counted 2 May. Fireblight infection was assessed 31 May. Clusters with any symptomatic blossoms were counted as infected. Per cent infection is based on the number of clusters infected/total clusters on inoculated branches. Fireblight cluster and strikes per tree counts also include a few infected bourse shoots at clusters which did not have fireblight symptoms.

Table 5. Late season disease control and fruit finish by protectant applications on Nittany apple, 2005.

			Fruit disease					Fruit finish rating*	
			sooty blotch		flyspeck		any		opales-
			% fruit	% area	% fruit	% area	rot, %	russet	cence
0	No treatment	---	54 e	3 g	98 c	17 e	4 ab	2.0 bc	1.4 de
1	*Kocide 2000 53.8DF 1 lb*	½" G - 6C	22 d	2 f	92 c	13 de	3 ab	3.2 e	1.8 f
2	*Kocide 2000 53.8DF 9.6 oz*	½" G - 6C	16 cd	1 c-e	84 c	13 de	1 ab	2.5 d	1.6 ef
3	DPX-GFJ52-008 46.1WG 9.6 oz	½" G - 6C	19 cd	1 d-f	95 c	15 e	4 ab	2.7 d	1.5 de
4	DPX-JE874-430 50SC 6 fl oz	½" G - 6C	16 cd	1 ef	95 c	9 b-d	0 a	1.9 bc	1.3 de
5	DPX-JE874-431 10EC 30 fl oz	½" G - 6C	3 ab	<1 a-c	65 b	6 b	0 a	1.8 bc	1.3 cd
6	DPX-JE874-431 10EC 6 fl oz + Kocide 2000 8 oz	½" G - 6C	10 bc	<1 b-d	93 c	12 c-e	0 a	2.5 d	1.4 de
7	Tanos 50WG 12 oz + Kocide 2000 53.8DF 8 oz	½" G - 6C	15 cd	1 d-f	64 b	8 bc	4 ab	2.3 cd	1.2 cd
8	Manzate 75DF 3.2 lb Agri-Mycin 17 1.25 lb Captan 80WDG 40 oz + Ziram 76DF 3 lb	½" G, 1-2C pink – PF 3C - 6C	0 a	0 a	22 a	1 a	9 b	1.5 ab	0.9 bc
9	Dithane RSNT 75DF 3.2 lb + Kocide 2000 53.8DF 1 lb Captan 80WDG 40 oz + Ziram 76DF 3 lb	½" G - 2C 3C - 6C	3 a	<1 ab	15 a	1 a	0 a	1.7 b	0.7 ab
10	Dithane RSNT 75DF 3.2 lb Captan 80WDG 40 oz + Ziram 76DF 3 lb	½" G - 2C 3C - 6C	0 a	0 a	21 a	1 a	1 ab	1.1 a	0.4 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications.
Fruit disease and finish ratings: 25 per tree 29 Sep.

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

Test treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (1/2" green), 21 Apr (pink-early bloom), 28 Apr (pink- 50% bloom), and 9 May (late bloom-petal fall). First through 6th covers (1C-6C) applied 23 May, 7 Jun, 23 Jun, 7 Jul, 25 Jul, and 15 Aug.

Maintenance sprays: Applied to all test trees. 6 Apr (Dithane 3 lb + Ziram 3 lb + Supracide 3 qt + oil 6 gal/A); 16 May (Assail 3.4 oz + Imidan 3 lb/A); 27 May (Assail 3.4 oz + Intrepid 1 pt/A); 14 Jun (Imidan 3 lb + Provado 6 fl oz/A); 23 Jun (Imidan 3 lb + Assail 2.5 oz + Provado 6 fl oz/A); 9 Jul (Imidan 3 lb +Lannate LV 3 pt + SpinTor 10 fl oz/A); 26 Jul and 16 Aug (Imidan 3 lb +Lannate LV 3 pt/A).

New Tools for Managing Blueberry Anthracnose: A Progress Report

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Anthracnose fruit rot of highbush blueberry is a postharvest disease that poses a serious threat to the marketability and shelf life of fruit grown for the fresh market. The fungal pathogen *Colletotrichum acutatum* forms latent, symptomless infections on developing blueberry fruit that progress as fruit ripen (Daykin & Milholland, 1984). Infected fruit often show no symptoms at harvest but begin to decay in storage (Stretch, 1967). Anthracnose can be controlled by multiple applications of fungicides (ziram, captan, strobilurins, or phosphonates) to developing fruit. Because there are no visible symptoms of infection in green fruit, growers cannot easily gauge the timing or number of applications needed. They rely on calendar-based spray programs to protect fruit, which may result in unnecessary applications where the risk of fruit rot is low.

A New Model for Managing Anthracnose

We are developing a phenology-based program for managing anthracnose to reduce excessive fungicide use, employing an IPM-like approach. Under such a program, recommendations on the number and timing of fungicide applications will be site specific and based on factors including cultivar susceptibility, disease pressure (the amount of primary inoculum for fruit rot from overwintering infections in the field at the beginning of the season), and the window of risk for fruit infection (the period of potential exposure to inoculum). USDA-ARS has developed a database that includes information on relative susceptibility to anthracnose fruit rot for more than 75 cultivars (Ehlenfeldt and Stretch, 2001). We have identified biological markers for disease pressure and potential inoculum exposure. *C. acutatum* infections in dormant inflorescence buds appear to be a good indicator of disease pressure. In 2002–2004, the incidence of infection in these buds in late dormancy was highly correlated with the amount of fruit rot later in the season (DeMarsay, 2005). The pathogen migrates from the outer bud scales of dormant floral buds to inner bud scales during budswell, then to developing fruit (DeMarsay and Oudemans, 2004). The proportion of fruit clusters with >5 inner bud scales can be used as a marker to define the period of potential exposure to inoculum in cultivars that shed bud scales quickly, such as 'Duke' and 'Elliott'. In cultivars such as 'Bluecrop' that tend to retain inner bud scales, the apparent age of the bud scales and fruit size may provide additional information about the likelihood that inoculum is still present (DeMarsay, 2005).

We are also testing the efficacy of applying fungicides during two critical periods in phenology outside of fruit development to break the cycle of infection. The first is the postharvest period. Inflorescence buds are the major reservoir of the overwintering *C. acutatum* infections that give rise to primary inoculum for fruit rot (DeMarsay and Oudemans, 2002). A substantial proportion of bud infections occur between harvest and the onset of dormancy, when infected fruit left in the field become overripe and sporulate during warm, humid weather (DeMarsay and Oudemans, 2005). In a preliminary trial in 2003–2004, a single fungicide application in early September was effective in reducing the incidence of overwintering *C.*

acutatum infections in dormant inflorescence buds (DeMarsay, 2005). The second critical period is bloom, when inoculum from overwintering floral bud infections is concentrated in the now-exposed inner bud scales on blossom clusters. In a preliminary trial in 2004, a single fungicide application during bloom did not significantly reduce inoculum on green fruit clusters from surviving infections, probably due to interplot interference (DeMarsay, 2005). We report here on two field-scale trials of postharvest and bloom fungicide treatments conducted in 2004–2005.

Preventing New Overwintering Infections in Buds

Materials and methods. The trial was conducted in a 3.8 A 'Bluecrop' field on a commercial farm in Atlantic County, New Jersey, using a split-plot RCBD with 6 reps. The main plots consisted of 4 fungicide regimens applied to green fruit in the spring (a control plus 3 spray schedules) as part of regular fungicide efficacy trials. The subplots received either a single postharvest spray of ziram at 4 lb./A on August 17, 2004, applied by airblast sprayer, or no further treatment. Ripe fruit samples were taken shortly before each of three commercial hand-pickings in June and July 2005 and incubated in pint clamshells (1 pint for each rep and treatment) at room temperature and 100% relative humidity to simulate commercial storage conditions. The percentage of fruit showing visible signs of *C. acutatum* infection after incubation for 7 days was used as a measure of efficacy.

Results and discussion. We used PROC FREQ in the SAS® System for Windows, release 9.1 (SAS Institute, Cary, N.C.) to perform chi-square contingency analysis because the non-normal distribution of the data precluded using split-plot analyses of variance. We also used the Cochran-Mantel-Haenszel test to analyze data across main plot treatments and pickings. This test is an extension of chi-square analysis that permits comparison of the association between an explanatory and a response variable across samples by removing the confounding influence of a stratifying variable such picking date (Stokes et al., 2000). As shown in Table 1, application of a postharvest treatment (PH) in the previous year was effective in reducing anthracnose fruit rot overall and in the 1st and 3rd pickings individually. The accuracy of data from the 2nd picking may have been compromised by a picking error in 2 reps. Postharvest treatment was most effective when the incidence of infection was high, as at 3rd picking; when in-season fungicide treatments were weaker (data not shown); or both.

		Rot (%)		Value of		Significant	Effect of
Picking	Main Trt	PH	No PH	CMH[a]	p	at p=0.05?	PH trt
1	All	0.33	1.38	20.6874	<0.0001	Yes	Less rot
2	All	6.17	3.77	20.6195	<0.0001	Yes	More rot
3	All	22.86	29.01	76.1307	<0.0001	Yes	Less rot
All	All	11.27	13.58	43.8093	<0.0001	Yes	Less rot
1 and 3	All	13.54	17.86	89.2215	<0.0001	Yes	Less rot

[a] Cochran-Mantel-Haenszel statistic

Table 1. Summary results of a postharvest fungicide trial to reduce anthracnose fruit rot by preventing *C. acutatum* infection in developing blueberry buds, 2004–2005.

Reducing Inoculum from Surviving Bud Infections

Materials and methods. Instead of repeating a single-spray trial in a larger area to avoid interplot interference, we applied the first 2 bloom/petal fall sprays in our regular fungicide efficacy trial program for 2005 and measured the incidence of *C. acutatum* infection in green fruit clusters before making the next spray. Ziram at 4 lb./A was applied on April 30 (20-30% bloom) and May 14 (petal fall) by airblast sprayer to all non-control plots in the commercial field of 'Duke' (1.1 A) and 'Bluecrop' (3.8 A) in Atlantic County, New Jersey where we conduct our regular trials. The 'Duke' trial was set up as an RCBD with 6 reps and 4 treatments (a control and 3 spray schedules). The 'Bluecrop' trial, as previously noted, used a split-plot RCBD with 6 reps, 4 main-plot treatments (a control and 3 spray schedules), and 2 subplot treatments (a postharvest ziram spray or no further treatment). On June 1, we sampled 10 shoots with fruit clusters from each treatment and rep for both cultivars, except for the non-control 'Bluecrop' plots that received a postharvest fungicide treatment in August 2004, for a total of 240 'Duke' and 300 'Bluecrop' shoots. The twigs were incubated at room temperature at 100% relative humidity and examined every 4 days for the appearance of *C. acutatum* spore masses until no new infections had appeared for a week. Each infection was confirmed by microscopic examination of conidia at 200x.

Results and discussion. We used PROC FREQ in the SAS® System for Windows, release 9.1 (SAS Institute, Cary, N.C.) to perform chi-square contingency analysis because the non-normal distribution of the data precluded use of analysis of variance. As shown in Table 2, application of 2 fungicide sprays during bloom/petal fall significantly reduced *C. acutatum* inoculum in green fruit clusters of 'Bluecrop' but not 'Duke'. In 'Bluecrop', there was almost a sixfold reduction in the incidence of *C. acutatum* infection in clusters. The incidence of infection in 'Duke' was so low that the treatment had no statistically significant effect. 'Duke' is classified as moderately susceptible to anthracnose fruit rot—34th among 76 cultivars—in USDA's database (Ehlenfeldt and Stretch, 2001), based on inoculation of fruit on potted plants. Its field resistance appears to be higher, however. 'Duke' sheds the inner bud scales on its clusters quickly relative to other cultivars, and we believe this rapid bud scale drop may play a role in the consistently low levels of *C. acutatum* infection seen in 'Duke' plantings.

	Infected clusters (%)					
Cultivar	Treated	Control	X^2	p	Significant at p=0.05?	Effect of Trt
Duke	0.19	0.26	0.0657	0.7976	No	No effect
Bluecrop	0.98	5.61	28.6961	<0.0001	Yes	↓ infection

Table 2. Summary results of bloom fungicide trial to reduce inoculum from surviving *C. acutatum* infections reaching green fruit clusters, 2005.

Acknowledgments

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DISEASE OBSERVATIONS ON GRAPES IN 2005

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Disease observations were made on wine grapes throughout the 2005 growing season in vineyards at the Pennsylvania State Fruit Research and Extension Center. Grapevine varieties consisted of *Vitis vinifera* 'Chardonnay', 'White Riesling', 'Cabernet Franc', and 'Pinot Noir', and French-American hybrids 'Chambourcin', 'Chancellor', 'Vidal Blanc', and 'Traminette'. A conventional fungicide program consisting of sulfur, Nova, Ziram, and Mancozeb was applied to all treatments. In addition, treatments to manage Botrytis bunch rot were applied to the vinifera plot, while treatments to manage downy mildew were applied to the hybrid plot. Incidence and severity of downy mildew, powdery mildew, black rot, Phomopsis, Botrytis, ripe rot, and sour rot were recorded in the plots. Disease ratings on clusters in the vinifera plot were separated by training systems (Vertical shoot positioning and Scott Henry) and by cluster location in the trellising system (upper and lower cordons of the Scott Henry training system).

Incidence of Downy Mildew, Powdery Mildew, Black rot, and Phomopsis were generally low throughout the growing season. Botrytis incidence was low and occurred sporadically on clusters throughout the vineyard. Ripe rot was found on clusters of every cultivar and the overall incidence and severity were high in the vinifera and the hybrid plot (Figure 1). Sour rot incidence and severity was particularly high on 'Pinot Noir' and 'White Riesling' but low on other cultivars. Ripe rot incidence and severity was lower on the vertical shoot positioning than on the Scott Henry training system, while disease ratings for Botrytis were higher on Vertical Shoot Positioning. Ripe rot incidence and severity was significantly higher on the lower cordon of the Scott Henry training system, while Botrytis and sour rot were generally higher on the upper cordons (Figure 2).

ACKNOWLEDGEMENTS

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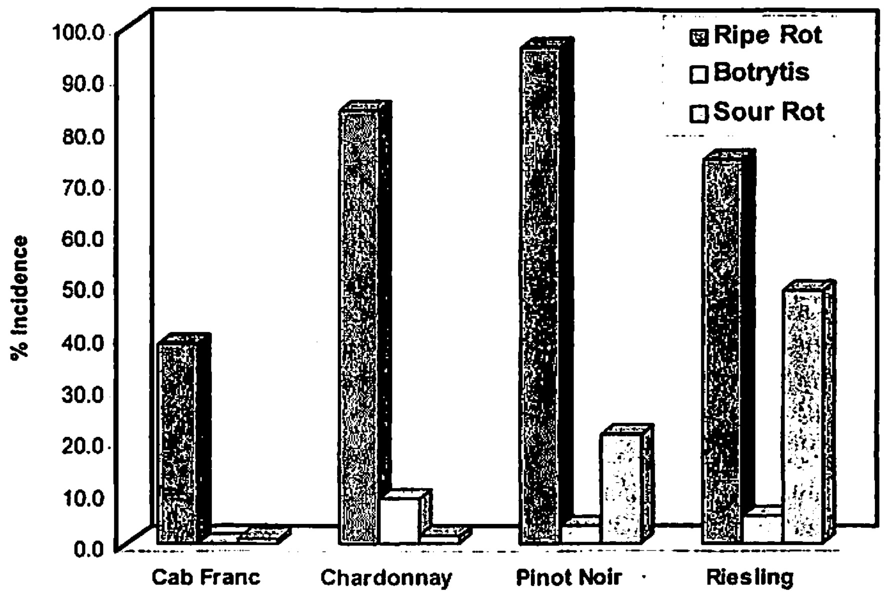

Figure 1. Incidence of Ripe Rot, Botrytis, and Sour Rot on *Vitis vinifera* 'Cabernet Franc', 'Chardonnay', 'Riesling', and 'Pinot Noir' in 2005.

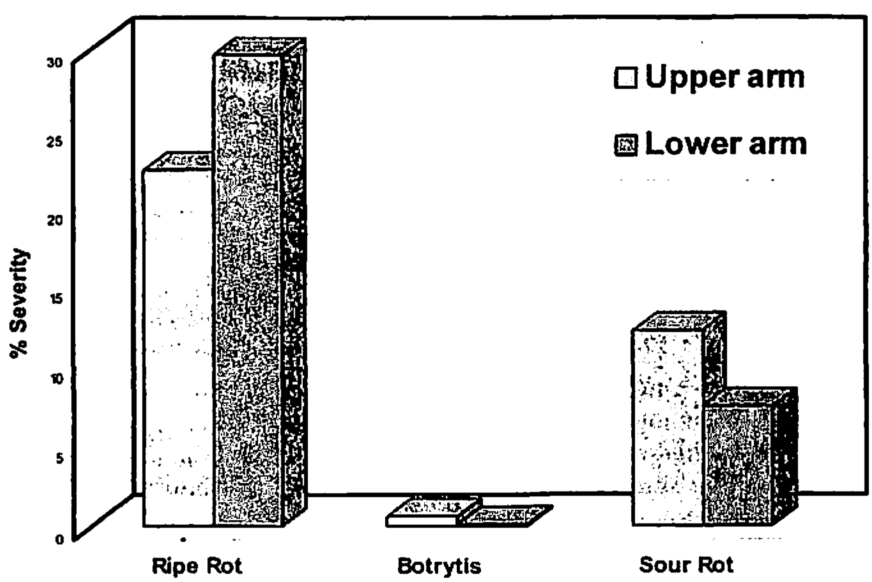

Figure 2. Severity of Ripe Rot, Botrytis, and Sour Rot on the upper and lower arms of the Scott Henry training system in 2005. Ratings were combined effects of disease severity on 'Cabernet Franc', 'Chardonnay', 'Riesling', and 'Pinot Noir'.

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INOCULUM SOURCES FOR *PENICILLIUM EXPANSUM* AND IMPLICATIONS FOR CONTROLLING BLUE MOLD DECAY OF APPLES

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Penicillium expansum causes blue mold decay of apples during postharvest storage and distribution. When first introduced, the benzimidazole fungicides thiabendazole, benomyl, and thiophanate-methyl provided excellent control of *P. expansum* when applied in postharvest drenches. Even though benzimidazole-resistant strains of *P. expansum* emerged soon after these products were introduced in the 1970's, the benzimidazole fungicides continued to provide good control of blue mold decay until the early 1990's because the fungicides were almost always applied with diphenylamine (DPA). DPA suppressed benzimidazole-resistant strains of *P. expansum*. By the mid-1990's, blue mold had become a serious problem in some storages in New York State because *P. expansum* had developed resistance to the benzimidazole-DPA combination.

Epidemiological studies were initiated in the mid-1990's to identify inoculum sources for *P. expansum* and sanitation methods that could be employed to reduce inoculum levels. Contaminated field bins were shown to carry huge quantities of inoculum from one season to the next, with some bins carrying more that 10^9 spores per bin (Table 1). Spores on contaminated bins are washed off of the bins when the filled bins are given postharvest drenches the next fall. Inoculum that accumulates in the drench solution contributes to increased decay which can result in even dirtier bins being returned to the field the next season. Sanitizing bins has been shown to remove 99% of viable conidia, but few packinghouses routinely sanitize bins because of the costs involved in doing so and questions about the economic benefits of bin sanitation.

Although field bins are recognized as a major inoculum source for *P. expansum*, no one knew the relative importance of recycled inoculum from field bins as compared to "new" inoculum originating from the field each year. The effort to sanitize field bins might be wasted if similarly large quantities of inoculum could be brought into the storage each year via contaminated apples or via soil stuck on the runners of field bins. Therefore, we initiated work to quantify populations of *P. expansum* that could be found in orchard soil and on apples at harvest time.

Table 1. Numbers of viable *Penicillium* spores per bin that were released into wash water as determined by washing bins with a portable drencher and dilution-plating sub-samples from the wash water (from Rosenberger, 2001).

Summer 1999	**Number of spores per bin recovered in wash water**[1]
Group I non-sanitized oak bins	**8.35×10^8**
Group I following fresh sanitizer wash	**1.54×10^6**
Group I washed at the end of sanitizer usefulness	**7.44×10^6**
Group II non-sanitized oak bins from another CA room	**4.25×10^8**
Summer 2000	
Wooden bins (mixed oak and other wood)	**2.23×10^9**
Plastic bins from the same storage room	**4.82×10^8**

[1]Means were derived from washing five replicates of 5 bins each in 1999 and four replicates of five bins each in 2000.

Development of a selective medium for recovering *Penicillium* species: Quantifying *P. expansum* populations in soil is difficult because of the diversity of organisms present in soils. To circumvent this problem, we developed a selective medium that could be used to isolated *P. expansum* from soil and from other environments that harbor a diverse microflora. The selective medium that we developed, DG18-P, is a modified form of DG18 agar (Hocking and Pitt, 1980). It contains 155 g glycerol, 10 g glucose, 5 g peptone, 1 g monobasic potassium phosphate, 0.5 g magnesium sulfate heptahydrate, 2 micrograms dichloran dissolved in 1 ml ethanol, 15 g agar, 0.1 g chloramphenicol, and 1.0 ml tergitol NP-10 nonionic in 1000 ml distilled water. Dichloran is added after autoclaving. This medium suppresses fast growing fungi such as *Trichoderma* and *Mucor* species and eliminates most bacteria, yeasts, and actinomycetes. When plates of DG18-P and acidified potato dextrose agar were similarly inoculated with known numbers of *P. expansum* spores, colony counts were similar on both media. DG18-P does not eliminate other species of soil-inhabiting *Penicillium*, so quantification of *P. expansum* from soil dilution plates must be based on sub-sampling and colony morphology on Czapek yeast extract agar (CYA). *P. expansum* can be readily identified on CYA due to its distinctive colony morphology and growth rate.

Quantification of *P. expansum* in orchard soils: Soils from five different apple orchards near Highland, NY, were sampled at various times in 2004 and 2005. In the four orchards that were being actively managed, soil was collected from the herbicided area beneath the tree canopy. The fifth orchard had been abandoned roughly 20 years ago and was largely overgrown with weeds, brambles and other shrubs. In each orchard, samples were collected from within the drip-line of five different trees that were separated by at least 10 meters. Soil was sampled by removing surface debris and/or cover plants with a shovel and then collecting approximately 50 cc of soil from the upper 8 cm of the soil profile at five different locations beneath each tree. The five sub-samples from each tree were mixed together, but the bulked sub-samples from each tree were evaluated separately to provide five replicate evaluations from each orchard.

Population densities of *Penicillium* species in the soils were quantified by dilution plating on DG18-P agar. One gram of soil was mixed into nine ml of water, and the soil solution was stirred for 5 min on a magnetic stirrer. The solution was allowed to settle for 60 sec, then 100 µL of soil suspension was plated onto each of 10 plates containing DG18-P medium. This process was repeated for each of the five individual samples per orchard, thereby resulting in a total of 50 soil dilution plates for each orchard evaluation. Plates were incubated at 25 °C for seven days after which all visible colonies on the plates were counted. Three arbitrarily selected colonies from each soil-dilution plate were sub-cultured onto CYA plates for species identification. In a few cases where soil dilution plates had low numbers of colonies, more than three subcultures were taken from other plates in the same replicate to bring the total number of subcultures to 30 per replicate, or 150 per orchard. Benzimidazole resistance of all 150 subcultures per orchard was determined by stab-inoculating PDA amended with 5 ppm MBC.

The relationship between the weight of the soil sampled and soil dry weight was determined by drying 4 grams of soil for 24 hr in a drying oven set at 100 °C. The ratio between original sample weight and dry weight was used to adjust counts so that the final concentration of *Penicillium* species in soil could be expressed as the number of colony-forming units (cfu) per g of dry soil.

Density of *P. expansum* in orchard soils ranged from 14 to 218 cfu/g of dry soil in the managed orchards but were roughly 10 times higher than that in the abandoned orchard (Table 2). Spore density in orchard soils were surprisingly consistent from year to year in the four orchards soils that were evaluated in both 2004 and 2005.

We assumed that even in a worst-case scenario involving wet harvest weather with soil occasionally balled into the bin runners, bins would be unlikely to carry more than 1 kg into drench solutions. Given that assumption, the contribution of orchard soils to build-up of *P. expansum* inoculum in postharvest treatment solutions is dwarfed by the inoculum that can originate with badly contaminated bins (Table 1). Contaminated bins can carry 10,000 times more inoculum than a kilogram of soil from the managed

Table 2. Preliminary results from sampling orchard soils in the Hudson Valley to determine populations of *P. expansum* and proportions of the populations that were benzimidazole-resistant.

Orchard	sampling date	cfu *Penicillium* species per g soil: all species	cfu *Penicillium* species per g soil: P. expansum	*P. expansum* as a percent of total *Penicillium* population	% *P. expansum* with benzimidazole resistance	Estimated *P. expansum* spores per bin assuming 1 kg soil/bin
A	23-Jul-04	262	33	12.6	27	33,000
A	17-Jun-05	1008	218	21.6	24	218,000
B	3-Sep-04	3,440	182	5.3	0	182,000
B	17-Jun-05	1626	186	11.4	1	186,000
C	30-Jun-04	298	14	4.7	8	14,000
C	9-Jun-05	698	46	6.5	10	46,000
D	19-Jul-05	310	40	12.9	13	40,000
E	8-Sep-04	15,268	2,137	20.6	0	2,137,000
E	16-May-05	5,447	1610	29.6	0	1,610,000

orchards that we tested and more than 1000 times more inoculum than would be contained in a kilogram of soil from the abandoned orchard we tested.

Quantification of *P. expansum* on apple fruit at harvest: To determine how much inoculum may come into storage on the surface of harvested fruit, 10 arbitrarily selected apple fruits were harvested from each of three trees in four different orchards during fall of 2005. One of the orchards was sampled on two different dates. In addition, 10 apples were collected from each of four different replicate Honeycrisp trees in experimental plots that had received three different summer fungicide regimes. In all cases, fruit were brought to the lab where they were individually washed in 500 ml of sterile distilled water containing 0.01% Tween 20. Apples were individually submersed and swirled in the wash solution for 30 sec to dislodge spores from the surfaces of the fruit. A total of 10 fruit were washed in succession, and the wash water was then filtered through a 47-mm diameter Millipore filter made up of mixed cellulose esters and having a pore size of 0.45 µm. The filter was then washed in 5 ml of sterile distilled water containing 0.01% Tween 20 by placing the filters into 25 ml glass test tubes and shaking vigorously for 10 sec. A 100 µl aliquot of the wash solution was then spread onto each of 5 plates of DG18-P agar. Plates were incubated at 25 °C for 7 days, after which all visible colonies on the plates were counted. Varying numbers of arbitrarily selected colonies from each plate were sub-cultured onto CYA plates for species identification (Table 3). Results were converted to numbers of all *Penicillium* species and numbers of *P. expansum* per fruit. The potential spore load for full field bins was calculated assuming that a field bin would hold approximately 2000 fruit.

The number of *P. expansum* spores recovered ranged from a low of about 9 to a high of 28 in the five samples taken from sprayed orchards (Orchards A-D, Table 1). In orchard A where fruit was collected from the same block of trees on both 21 September and again on 17 October, the significantly reduced population detected in the second sampling was probably attributable to the week of heavy rain that immediately preceded the second sample date. (Empire fruit were still available in this orchard on 17 October because the orchard was not harvested due to hail damage that occurred in early summer.)

The number of *P. expansum* spores detected on Honeycrisp fruit in our fungicide trial was greatly affected by the fungicide treatments (Table 3). Fruit from control trees that received their last fungicide spray (Topsin M 11 oz/A+ Ziram Granuflo 4 lb/A) on 19 July had more than twice as many *P. expansum* spores as fruit that were sprayed with Pristine fungicide (4.8 oz/100 gal) the day prior to harvest. Trees treated with Topsin M 4 oz/100 gal plus Captan 80WDG 10 oz/100 gal on the day prior to harvest had only one-sixth as many *P. expansum* spores as control trees (Table 3). *P. expansum* accounted for nearly 60% of all *Penicillium* spores on apples from control trees but only 21 and 35% of the *Penicillium* spores on fruit from the Topsin M/Captan and Pristine treatments, respectively.

Based on our limited sample in 2005, the numbers of spores that might be brought into storage on fruit surfaces is dwarfed by the inoculum previously measured on field bins.

Although additional sampling should be done in other years and locations, the accumulated evidence from measuring *P. expansum* populations on field bins, in orchard soils, and on apple fruit at harvest suggests that badly contaminated field bins are by far the most important potential source of inoculum for *P. expansum* under conditions prevalent in New York State. In the absence of effective fungicides, sanitizing contaminated field bins should reduce losses to blue mold decay in storages where decay has gradually increased from year to year. Where storage operators choose to use one of the new fungicides (pyrimethanil or fludioxonil) to control *P. expansum*, bin sanitation should reduce selection pressure for fungicide-resistant isolates and might therefore extend the useful life of these new fungicides. It may not be cost effective to sanitize all bins every year, but badly contaminated bins (i.e., those showing visible blue stains from fruit that had blue mold decay) should always be sanitized before they are returned to the orchard for refilling

Table 3. Preliminary results from washing apple fruit collected in Hudson Valley orchards to determine populations of *P. expansum* present on fruit surfaces at harvest.

Orchard	Variety/treatment	Sample date	Mean cfu/ apple	No. of sub-cultures evaluated	% of total cfu that were P. expansum	Estimated P. expansum spores/bin of 2000 apples
A	Empire	21-Sep-05	52.0	540	28.3	29,467
A	Empire	**17-Oct-05	3.0	90	10.0	600
B	Rome Beauty	21-Oct-05	15.3	315	14.6	4,478
C	Golden Delicious	21-Sep-05	5.3	180	8.9	948
D	Delicious	21-Oct-05	20.7	315	19.7	8,135
HVL-1*	Honeycrisp-control	8-Sep-05	50.0	84	59.5	59,524
HVL-2	Honeycrisp-Topsin/Capt	8-Sep-05	22.5	84	21.4	9,643
HVL-3	Honeycrisp-Pristine	8-Sep-05	36.3	84	34.5	25,030

*Samples from Hudson Valley Lab research plots left unsprayed during summer (HVL-1) or sprayed with Topsin M + Captan (HVL-2) or Pristine (HVL-3) one day prior to sampling.

** Spore numbers were presumably reduced compared to earlier sampling in the same orchard due to 13.5 inches of rainfall that occurred 7-15 October.

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Bacterial Spot of Stone Fruit: Cultivar Susceptibility, Bactericide Efficacy, and Time of Fruit Infection

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When conditions are favorable, the bacterial spot pathogen *Xanthomonas arboricola* pv. *pruni* can cause much destruction on fruit and foliage of susceptible peach and nectarine cultivars. Although leaves are susceptible for the entire growing season, fruit are considered most susceptible during the four to six week period following shuck split. Beyond this period, new infections on fruit are thought to be less likely due a decline in susceptibility as the fruit matures.

In this study, copper, antibiotic, and experimental bactericides are tested on susceptible cultivars for efficacy against bacterial spot during the early period of fruit susceptibility. Additional data were gathered at harvest to determine the extent of any new infection later in the season.

MATERIALS AND METHODS

Treatments. During the 2005 season, three experiments were performed in two horticultural test blocks, each located at a commercial orchard. Each block contained a large number of commercial and experimental peach and nectarine cultivars. The blocks were planted so that four trees of the same cultivar were adjacent to each other in a row, followed by another set of four trees of a different cultivar, and so on for each row. Each cultivar group of four trees were randomly located within the test blocks.

For each experiment, a total of four susceptible cultivars were chosen. Only those cultivars rated in past horticultural evaluations as very or extremely susceptible were selected. Experiments 1 and 2 (Exp1, Exp2) were conducted on peach cultivars located at Larchmont Orchards, while experiment 3 (Exp3) was performed on nectarine cultivars at Sunny Slope Orchards. Bactericide treatments were randomly assigned to one tree in each cultivar group. Thus, with respect to bactericide treatments, the four cultivars acted as replicate blocks. Also, this design allowed only a maximum of four treatments for each experiment, including the non-treated control.

Beginning at shuck split for the earliest cultivar, a total of five treatment applications were performed at 8- to 10-day intervals. Dates of application for all three experiments were 10, 18, 27 May, 6 Jun, and 15 Jun. At each site, bactericides were applied to run-off with a single-nozzle hand gun at 300 psi pressure. These applications provided bacterial spot protection for all cultivars during the 6-week period following shuck split. The grower at each site provided control of fungal diseases and arthropods using standard pesticides and practices, avoiding materials with bactericidal activity.

Environment. Conditions during the critical month of May were only slightly favorable for the development of bacterial spot on fruit. Rainfall and temperatures during bloom in April were about average, but temperatures during May were below normal and total rainfall only about half the 30 year average (2.22 vs 4.07 inches). June had a below average rainfall while July was slightly above average; both months had about average temperature. Thus, warmer and wetter conditions were more prevalent during late June and July, after the fruit susceptibility period. The number of rain days with >0.10 in accumulation each month were: Apr, 6; May, 2; Jun, 6; Jul, 9; and Aug, 5. Average monthly temperatures for 2005 were: Apr, 53.7°F; May, 57.5°F; Jun, 72.4°F; Jul, 76.2°F and Aug, 76.2°F.

Assessment. Bacterial spot in each experiment was assessed on 1 Jul by examining 50 fruit arbitrarily selected from each tree. The number of fruit with disease and the number of lesions per fruit were recorded. At the time of harvest for each cultivar, 50 fruit from non-treated trees were similarly assessed. No disease assessments were performed on foliage.

RESULTS AND DISCUSSION

Experiment 1. Although past records indicated all selected peach cultivars were very susceptible, disease levels were higher on Sweet Scarlet and Snow King than on Sweet Dream and Royal Lady (Table 1). Thus, bactericide treatment effects were more noticeable on these former two cultivars.

In all comparisons of treatment means for both disease incidence and severity, fruit treated with both Tenn-Cop and Kocide had less bacterial spot than the non-treated control fruit (Tables 1 and 2). Tenn-Cop provided 39.1% disease control while Kocide yielded 52.2% control. However, in none of these comparisons were any of these treatment means found to be significantly different from each other or the non-treated control.

Experiment 2. As in exp 1, only two of the four cultivars, namely August Flame and O'Henry II, were observed with significant levels of bacterial spot infection on fruit (Table1). Non-treated September Flame and experimental cultivar Burchell B16.069 had less than 5% fruit infection and lesion densities < 1.

In all treatment comparisons, fruit sprayed with the experimental compound DPX-JE874 (fomoxate) had less disease incidence and severity than non-treated fruit (Tables 1 and 2). Application of this fungicide / bactericide provided 66.7% control of bacterial spot and yielded fruit with 86.7% fewer lesions. Nevertheless, disease levels on treated fruit were not significantly less than observed on non-treated fruit. This lack of statistical significance was most likely due to inadequate disease pressure, particularly in two of the cultivar replications, thereby making it difficult to detect differences.

Experiment 3. Disease levels in this experiment were low and also quite variable. Only one of the four nectarine cultivars, Jolly Red Giant, was observed to have greater than 10% fruit infection on non-sprayed trees (Tables 1 and 2). Disease levels for Arctic Glo were consistently low, while those for Heavenly White and Arctic Sweet were often higher on treated fruit than non-treated fruit.

Fruit receiving either Cuprofix or Cuprofix alternated with FlameOut generally had higher disease incidence and severity levels than non-treated fruit. Fruit treated only with FlameOut had equal or lower levels of disease than non-treated fruit. Regardless, none of these differences among treatments were observed to be statistically significant, most likely due to the relatively low disease pressure encountered.

Time of fruit infection. Both disease incidence and severity increased on non-treated trees between mid-season on 1 Jul and harvest during late July to late August (Table 7). This increase was observed in all three experiments, although only one increase in disease incidence (exp. 1) was found to be significant. The mean increase in incidence across all three experiments, 5.7%, was not statistically significant. However, mean lesion density was observed to increase significantly by 1.46 lesions / fruit.

The data appear to support the conclusion that fruit infection can occur during the mid- to late-summer period following the initial "susceptible period". Although environmental conditions during the early susceptible period were not favorable for infection, temperature and moisture conditions were favorable during mid- to late-summer, resulting in the apparent increases in disease. Nevertheless, most comparisons of the two assessments were not significantly different. Thus, additional data are needed to make a definitive conclusion on the degree of susceptibility of fruit during this late summer period.

TABLE 1. Experiment 1 - Incidence of fruit infection (% infected fruit)

		Peach cultivar				Treatment Means [1]		
Treatment	Rate/A	Sweet Scarlet	Sweet Dream	Snow King	Royal Lady	>0 lesions	1-10 lesions	>10 lesions
Non-Sprayed	--------	22.0	2.0	20.0	2.0	11.5 a	8.5 a	3.0 a
Tenn-Cop 5E	8.0 fl oz	20.0	4.0	2.0	2.0	7.0 a	5.5 a	1.5 a
Kocide 2000 35DF	1.23 oz	12.0	2.0	8.0	0.0	5.5 a	4.0 a	1.5 a
Cultivar means		18.0	2.7	10.0	1.3			

[1] Means in the same column with the same letter do not differ significantly according to to Tukey's HSD test (α = 0.05).

TABLE 2. Experiment 1 - Severity of fruit infection (# lesions/fruit)						
		Peach cultivar				
Treatment	**Rate/A**	**Sweet Scarlet**	**Sweet Dream**	**Snow King**	**Royal Lady**	**Treatment means [1]**
Non-Sprayed	----------	2.84	0.16	1.00	0.08	**1.02 a**
Tenn-Cop 5E	8.0 fl oz	2.32	0.40	0.04	0.02	**0.70 a**
Kocide 2000 35DF	1.23 oz	1.38	0.06	0.36	0.0	**0.45 a**
Cultivar means		**2.18**	**0.21**	**0.47**	**0.03**	

[1] Means in the same column with the same letter do not differ significantly according to to Tukey's HSD test (α = 0.05).

TABLE 3. Experiment 2 - Incidence of fruit infection (% infected fruit)								
		Peach cultivar				Treatment Means [1]		
Treatment	**Rate/A**	**September Flame**	**August Flame**	**O'Henry II**	**Burchell B16.069**	**>0 lesions**	**1-10 lesions**	**>10 lesions**
Non-Sprayed	--------	4.0	14.0	32.0	4.0	**13.5 a**	**11.0 a**	**2.5 a**
DPX-JE874 10EC	30 fl oz	2.0	6.0	4.0	6.0	**4.5 a**	**4.0 a**	**0.5 a**
Cultivar means		**3.0**	**10.0**	**18.0**	**5.0**			

[1] Means in the same column with the same letter do not differ significantly according to to Tukey's HSD test (α = 0.05).

TABLE 4. Experiment 2 - Severity of fruit infection (# lesions/fruit)						
		Peach cultivar				
Treatment	Rate/A	September Flame	August Flame	O'Henry II	Burchell B16.069	Treatment means [1]
Non-Sprayed	----------	0.04	1.64	2.26	0.56	**1.13 a**
DPX-JE874 10EC	30 fl oz	0.14	0.14	0.24	0.08	**0.15 a**
Cultivar means		**0.09**	**1.78**	**2.5**	**0.64**	

[1] Means in the same column with the same letter do not differ significantly according to Tukey's HSD test ($\alpha = 0.05$).

TABLE 5. Experiment 3 - Incidence of fruit infection (% infected fruit)								
		Nectarine cultivar				Treatment Means [1]		
Treatment	Rate/A	Arctic Glo	Heavenly White	Arctic Sweet	Jolly Red Giant	>0 lesions	1-10 lesions	>10 lesions
Non-Sprayed	--------	2.0	8.0	4.0	12.0	**6.5 a**	**5.5 a**	**1.0 a**
FlameOut 17WP	1.5 lb	2.0	12.0	2.0	6.0	**5.5 a**	**5.5 a**	**0.0 a**
Cuprofix Disp. 20DF	2.15 oz	2.0	20.0	4.0	4.0	**7.0 a**	**6.5 a**	**0.5 a**
Cuprofix Disp. 20DF / FlameOut 17WP [2]	2.15 oz 1.5 lb	2.0	20.0	8.0	8.0	**9.0 a**	**7.0 a**	**2.0 a**
Cultivar means		**2.0**	**15.0**	**4.5**	**7.5**			

[1] Means in the same column with the same letter do not differ significantly according to Tukey's HSD test ($\alpha = 0.05$).
[2] Cuprofix Disperss alternated with FlameOut beginning with Cuprofix at shuck-split

TABLE 6. Experiment 3 - Severity of fruit infection (# lesions/fruit)						
		Nectarine cultivar				
Treatment	Rate/A	Arctic Glo	Heavenly White	Arctic Sweet	Jolly Red Giant	Treatment means [1]
Non-Sprayed	----------	0.02	0.36	1.04	0.38	**0.45 a**
FlameOut 17WP	1.5 lb	0.02	0.16	0.02	0.08	**0.07 a**
Cuprofix Disp. 20DF	2.15 oz	0.00	0.36	0.04	0.66	**0.27 a**
Cuprofix Disp. 20DF / FlameOut 17WP [2]	2.15 oz 1.5 lb	0.00	2.22	0.12	1.94	**1.07 a**
Cultivar means		**0.01**	**0.78**	**0.41**	**0.77**	

[1] Means in the same column with the same letter do not differ significantly according to Tukey's HSD test ($\alpha = 0.05$).
[2] Cuprofix Disperss alternated with FlameOut, beginning with Cuprofix at shuck-split.

Table 7. Comparison of Disease at Mid-Season with Disease at Harvest								
	% Infected fruit [1]				# Lesions / fruit [1]			
Assessment [2]	Exp. 1	Exp. 2	Exp. 3	Mean	Exp. 1	Exp. 2	Exp. 3	Mean
Mid-season	11.5 b	13.5 a	6.5 a	10.5 a	1.02 a	1.13 a	0.45 a	0.87 a
Harvest	18.7 a	18.1 a	11.9 a	16.2 a	1.54 a	4.63 a	0.81 a	2.33 b

[1] Means in the same column with the same letter are not significantly different according to Tukey's HSD test ($\alpha = 0.05$).
[2] Mid-season assessment performed on July 1 at ~7-weeks after shuck-split; timing of harvest assessments varied according to cultivar.

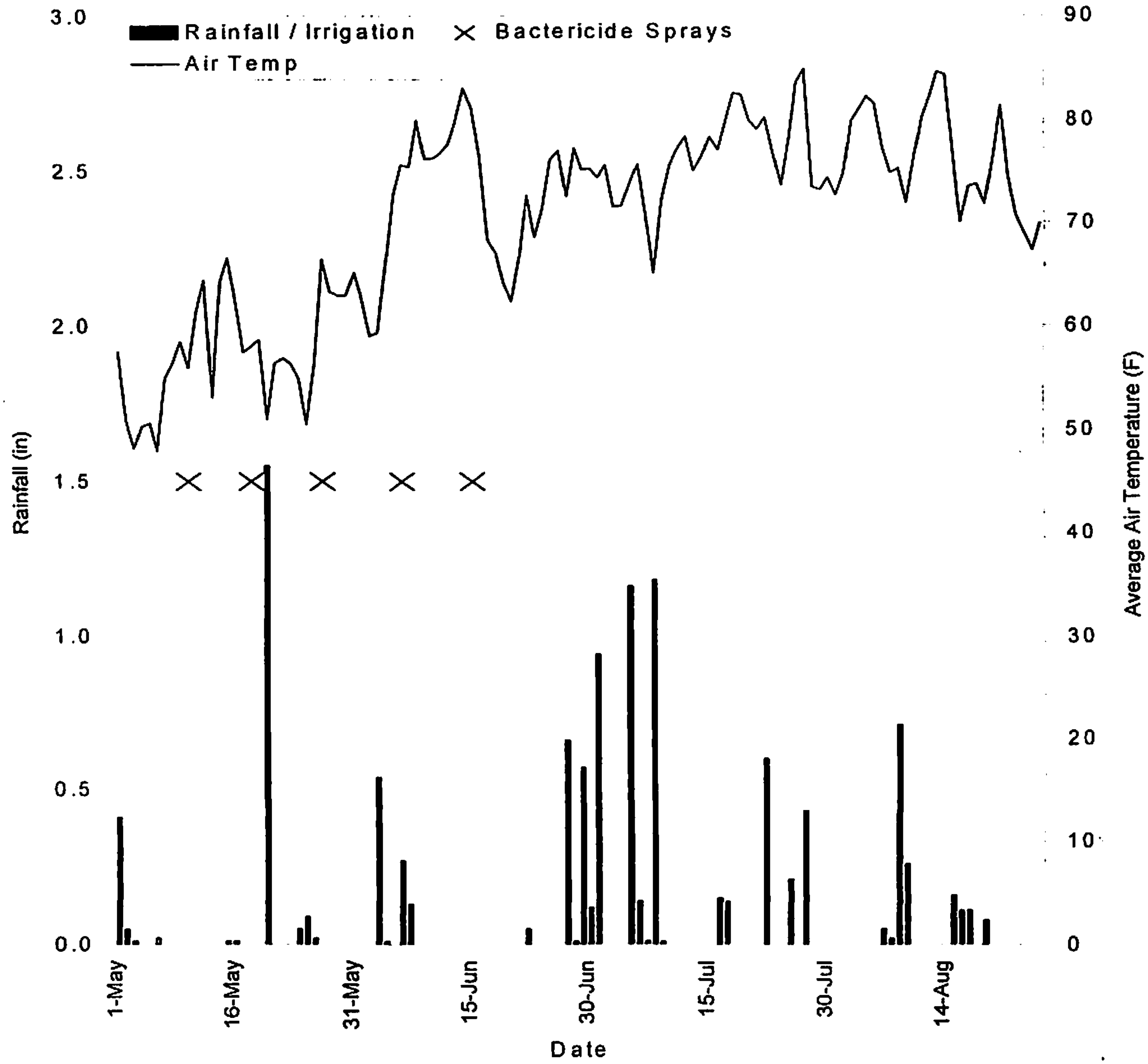

Figure 1. Rainfall, air temperature, and bactericide application timing during 2005 for three experiments conducted in peach and nectarine cultivar test blocks at Larchmont & Sunny Slope Orchards, NJ. Weather data are from Rutgers Agricultural Research and Extension Center, Bridgeton, NJ, located approximately 7-12 miles from test sites.

APPLE (*Malus domestica* 'Fuji', 'Golden Delicious')
Blue mold; *Penicillium expansum*
Bitter rot ; *Colletotrichum* spp.
White (Bot) rot; *Botryosphaeria dothidea*

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Effect of postharvest dip treatments on storage rot development in Fuji and Golden Delicious apples, 2004-05.

An experiment was conducted to test the effectiveness of Penbotec 400SC and Scholar 50W as post-harvest dip treatments on Fuji and Golden Delicious apples. Test fruit were selected from trees which had been uniformly sprayed with commercial fungicides in 2004, harvested 4 Oct '04, and placed in cold storage. For the dip test, fruit were removed from cold storage 1 Nov, and test 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. Test fruit were not directly inoculated postharvest. Each fruit was uniformly 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 4C in a regular commercial apple storage for 91 days. Samples were then further incubated 15 days (Golden Delicious) or 20 days (Fuji) at 19 C until the final ratings 18 Feb (Golden Delicious) or 23 Feb (Fuji).

Blue mold developed mostly at the wounds from inoculum typically present in the air in the commercial storage. The effectiveness of the Mertect and Mertect + captan treatments was likely reduced by the presence of benzimidazole-resistant *Penicillium* inoculum present in the storage. All rates of Scholar gave near perfect control of blue mold on both cultivars under these simulated commercial conditions. Blue mold control by Penbotec was generally good but more consistently rate responsive on Golden Delicious than on Fuji. Bitter rot and Botryosphaeria rot infections, about 90% of which occurred at the wound site in non-treated fruit, likely developed from latent infections in the orchard that apparently were not controlled by the pre-treatment sodium hypochlorite dip. All Scholar rates also gave good suppression of bitter rot and *Botryosphaeria* which developed on non-treated fruit of both cultivars after warmer temperature incubation. Treatments involving Mertect suppressed white rot infection on Fuji but were ineffective for control of latent bitter rot on both cultivars. Control of bitter rot was not improved by increased Penbotec rates. White rot control by Penbotec was inconsistent. *Alternaria*, which infected 5% of non-treated Fuji fruit, was suppressed by Scholar and Penbotec. The significant difference in the amount of Alternaria rot in fruit treated with Mertect versus Mertect + captan may have been because more wounds were infected by *Penicillium* in the Mertect treatment, leaving fewer wounds available for infection by *Alternaria*.

Table 6. Effect of postharvest dip treatments on storage rot development in Fuji apple, Winchester, VA.

	% any rot, location			% blue mold, location			% bitter rot, location			% Bot rot, location			
Treatment, rate/100 gal	any fruit	at wound	other area	any fruit	at wound	other area	any fruit	at wound	other area	any fruit	at wound	other area	Alternaria % of fruit
1 Water dip	90 d	85 e	25 b	39 e	36 e	4 a	77 e	70 de	19 b	16 cd	16 cd	1 a	5 c
2 Scholar 50W 2 oz.............	11 a	9 b	3 a	1 ab	1 ab	0 a	8 b	6 b	3 a	2 ab	2 ab	0 a	1 ab
3 Scholar 50W 4 oz.............	8 a	5 ab	3 a	1 ab	0 a	1 a	5 b	4 ab	1 a	1 a	1 a	0 a	0 a
4 Scholar 50W 8 oz.............	2 a	2 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	2 ab	2 ab	0 a	0 a
5 Penbotec 400SC 8 fl oz	41 b	34 c	18 b	0 a	0 a	0 a	33 c	26 c	16 b	10 bc	10 bc	0 a	0 a
6 Penbotec 400SC 16 fl oz	57 b	47 c	21 b	6 c	6 c	0 a	36 c	27 c	19 b	23 d	23 d	0 a	0 a
7 Penbotec 400SC 32 fl oz	39 b	31 c	18 b	3 bc	3 bc	0 a	35 c	27 c	20 b	8 bc	8 bc	0 a	0 a
8 Mertect 340F 1 pt	76 c	71 d	18 b	27 e	26 e	3 a	64 d	58 d	15 b	3 ab	3 ab	0 a	0 a
9 Mertect 340F 1 pt + Captan 50W 1 lb	90 cd	86 e	21 b	13 d	13 d	0 a	81 e	78 e	21 b	6 ab	6 ab	0 a	4 bc

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

Table 7. Effect of postharvest dip treatments on storage rot development in Golden Delicious apple, Winchester, VA.

	% any rot, location			% blue mold, location			% bitter rot, location			% Bot rot, location			
Treatment, rate/100 gal	any fruit	at wound	other area	any fruit	at wound	other area	any fruit	at wound	other area	any fruit	at wound	other area	Alternaria % of fruit
1 Water dip	92 d	92 d	14 ab	56 d	53 d	4 a	80 cd	77 d	10 ab	5 a-c	5 a	0 a	0 a
2 Scholar 50W 2 oz.............	8 a	2 a	7 ab	0 a	0 a	0 a	8 a	1 a	7 ab	1 a	1 a	0 a	0 a
3 Scholar 50W 4 oz.............	11 a	2 a	9 ab	0 a	0 a	0 a	8 a	0 a	8 ab	2 ab	2 a	0 a	1 ab
4 Scholar 50W 8 oz.............	4 a	1 a	3 a	0 a	0 a	0 a	3 a	0 a	3 a	1 a	1 a	0 a	0 a
5 Penbotec 400SC 8 fl oz	53 bc	48 bc	12 ab	5 b	4 b	1 a	30 b	25 b	10 ab	24 d	24 b	1 a	0 a
6 Penbotec 400SC 16 fl oz	35 b	30 b	13 ab	2 ab	2 ab	0 a	30 b	22 b	13 ab	6 bc	5 a	1 a	0 a
7 Penbotec 400SC 32 fl oz	67 c	51 c	23 b	1 ab	1 ab	0 a	62 c	49 c	21 b	8 c	6 a	2 a	0 a
8 Mertect 340F 1 pt	90 d	87 d	19 b	27 c	25 c	3 a	80 cd	77 d	16 b	4 a-c	4 a	0 a	0 a
9 Mertect 340F 1 pt + Captan 50W 1 lb	94 d	92 d	15 b	6 b	6 b	0 a	87 d	86 d	15 b	8 a-c	8 a	0 a	3 b

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

APPLE (*Malus domestica* 'Stayman Winesap', 'Idared', 'Ginger Gold')
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 (unidentified)

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Broad spectrum disease control by mixed fungicide schedules on Stayman, Idared, and Ginger Gold apples, 2005.

Ten treatments directed mostly at fungicide resistance management approaches and broad-spectrum control, including the newer fungicide and an experimental material, USF 2010, were tested on 19-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 2004 to stabilize mildew inoculum pressure for 2005. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Fungicide treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (TC, tight cluster); 26 Apr (bloom); 6 May (petal fall); First –5th covers (1C-5C): 23 May, 7 Jun, 21 Jun, 7 Jul, 25 Jul; 8 Aug (6C, Stayman and Idared only). Insecticides applied to the entire test block with the same equipment included Asana, Assail, Intrepid, Lannate LV, Imidan, Provado, and SpinTor. Cedar rust galls and quince cankers were placed over each Idared test tree 13 and 25 Apr, wild blackberry canes with the sooty blotch and flyspeck fungi over each Idared test tree 9 May and bitter rot mummies 25 Apr. 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 6 Jun (Stayman); or ten terminal shoots per tree 14 Jul (Stayman); 18 Jul (Idared); 20 Jul (Ginger Gold). Ginger Gold trees were harvested 31 Aug and rated 1 Sep; Stayman trees were sampled 26 Sep and Idared 27 Sep. and the 25-fruit samples were rated after storage at 1C 27 days (Idared), 22 days (Stayman). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Weather was favorable for development of most of the major diseases in 2005. Scab inoculum was at its highest in more than 28 years. SI + Dithane related treatments (#1-4) as a group were significantly weaker for scab control than Scala + Dithane, and Scala/Flint suggesting increasing resistance to SI's (Table 8). Test orchard history has shown a decline in control by Nova 4-5 oz/A over the past three years under rather consistently heavy disease pressure on foliage (Fig. 1) and fruit (Fig. 2). This year the higher (5 oz) rate of Nova gave better control than 4 oz on Stayman cluster and shoot leaves but this was not true on Idared and Ginger Gold or Stayman fruit. Flint, Flint + captan and USF2010 treatments were superior scab treatments. Scala 7 fl oz gave better scab control than 5 fl oz when combined with Dithane (Trts. #5 & 6); but was less effective than Scala 10 fl oz followed by Flint (#5). Relatively few differences in Brooks spot and rot control on Ginger Gold probably reflect the influence of the mid-season Captan + Ziram schedule for most treatments. Scala + Dithane treatments were weaker for mildew control, especially on Ginger Gold and Idared (Table 9). Flint 2 oz was equal to Nova 4 or 5 oz for foliar mildew control; Flint had less mildew on Ginger Gold fruit but Nova was significantly better on Idared. Sooty blotch and flyspeck incidence and severity (% area infected) were quite variable across the replications and control was quite variable among treatments having the similar spray schedules during the 2nd to 6th cover period whether Flint or Captan + Ziram (Table 10). Although the test was blocked for elevation, it was a year in which dramatic differences in the effect of elevation are a likely explanation for the variability phenomenon. No treatment significantly reduced fruit finish of any cultivar compared to non-treated trees.

Figure 1. 12-yr history of foliar scab control with SI + EBDC,
Stayman apple, Winchester, VA

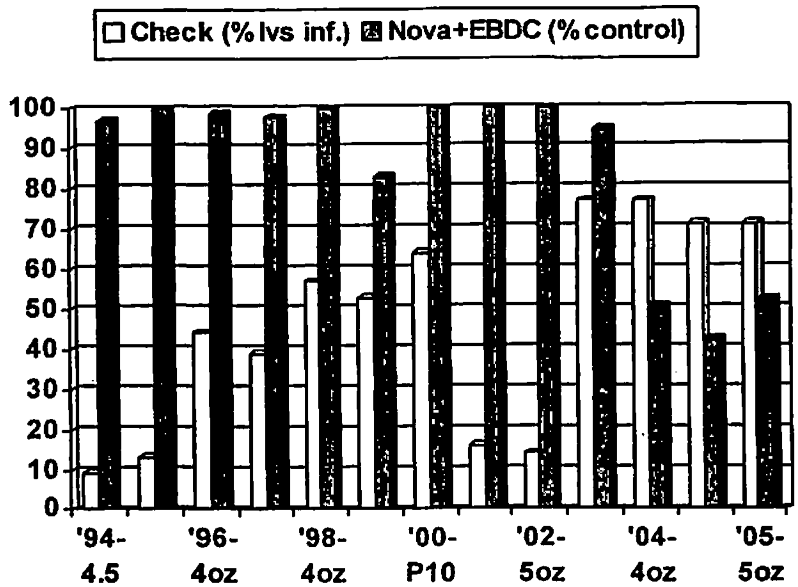

Figure 2. 12-yr history of fruit scab control with SI + EBDC
Stayman apple, Winchester, VA

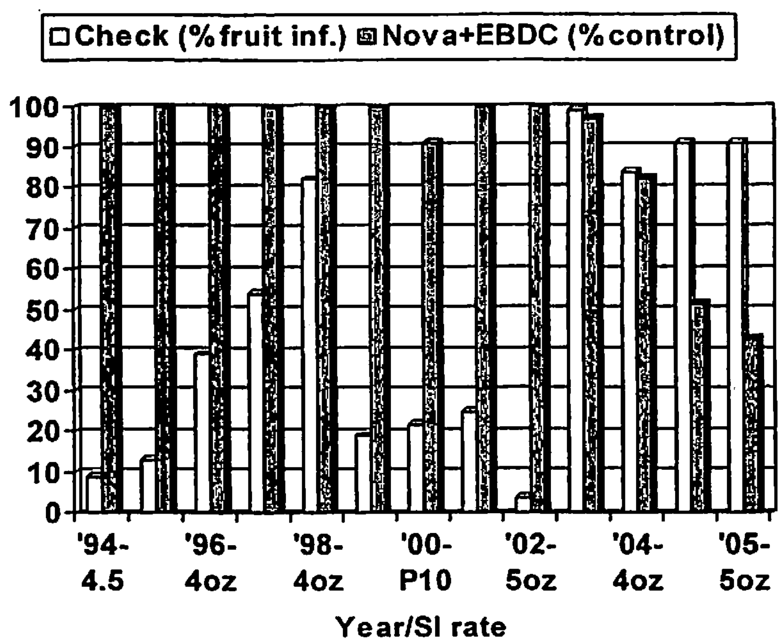

Table 8. Control of scab, Brooks spot and rots on Stayman, Idared and Ginger Gold apples, Virginia Tech AREC, Winchester, 2005

			Scab, % leaves, leaf area, or fruit infected							%Brooks spot		Ginger Gold	
			Stayman			Idared		Ginger Gold		Stay-	Ida-	% fruit	rot-
	Treatment and rate/A	Timing	cluster	shoot	fruit	shoot	fruit	shoot	fruit	man	red	rots	spots
0	No fungicide	---	49e	71f	91f	45d	89g	83d	98g	17b	24d	31d	11c
1	Nova 40W 4 oz + Dithane RSNT 75DF 3 lb	TC-1C	22d	41cd	44de	28c	22cd	71d	38f	2a	8c		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C-6C										9bc	7bc
2	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb	TC-1C	13bc	34c	52e	28c	30de	72d	23ef	1a	5a-c		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C-6C										4ab	3ab
3	Rubigan 1E 10 fl oz + Dithane RSNT 75DF 3 lb	TC-1C	20cd	47de	46e	26c	51f	67cd	36f	2a	5a-c		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C-6C										4ab	4a-c
4	Cuprofix 4 lb+ Scala 5 fl oz	TC											
	Rubigan 1E 10 fl oz + Dithane RSNT 75DF 3 lb	OC-1C	19cd	56e	59e	30c	43ef	70d	43f	0a	2a-c		
	Flint 50WG 2 oz + Dithane RSNT 75DF 3 lb	2C- 3C											
	Captan 50W 3 lb + Ziram 76DF 3 lb	4C-6C										4ab	4a-c
5	Scala 60SC 10 fl oz	TC, OC											
	Flint 50WG 2 oz	BI-1C, 5-6C	2a	13a	10bc	10b	3ab	30b	9b-d	3a	0a	12c	8bc
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C - 4C											
6	Scala 60SC 5 fl oz + Dithane RSNT 75DF 3 lb	TC - 1C	14b-d	38cd	41de	21c	19cd	50c	10c-e	1a	1ab		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C - 4C											
	Flint 50WG 2 oz	5C-6C										2a	2ab
7	Scala 60SC 7 fl oz + Dithane RSNT 75DF 3 lb	TC - 1C	11b	24b	24cd	10b	10bc	31b	13de	0a	6bc		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C - 4C											
	Flint 50WG 2 oz	5C-6C										5ab	2ab
8	USF2010 500SC 4 fl oz	TC - 1C	0a	6a	4ab	3a	1a	14a	0a	1a	2a-c		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C - 4C											
	Flint 50WG 2 oz	5C-6C										4ab	3a-c
9	Flint 50WG 2 oz	TC - 1C	0a	6a	1a	3a	0a	10a	2a-c	1a	2a-c		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C-6C										5a-c	3ab
10	Flint 50WG +Captan (64% pre-mix) 22 oz	TC - 1C	0a	8a	4ab	4a	1a	16a	1ab	1a	0a		
	Captan 50W 3 lb + Ziram 76DF 3 lb	2C-6C										1a	0a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05); four single-tree reps. Counts based on ten cluster leaf sets per rep 6 Jun (Stayman); ten shoots 14 Jul (Stayman); 18 Jul (Idared); 20 Jul (G. Gold) or post-harvest counts of 25 fruit from each of four single-tree reps.

Fungicide application dates: Fungicide treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (TC, tight cluster); 26 Apr (bloom); 6 May (petal fall); First –5th covers, all cultivars (1C-5C): 23 May, 7 Jun, 21 Jun, 7 Jul, 25 Jul; 8 Aug (6th cover 6C, Stayman and Idared only).

Table 9. Mildew and rust control on Stayman, Idared and Ginger Gold apples, Virginia Tech AREC, Winchester, 2005

			Mildew, % leaves, % leaf area, or % fruit infected									c-a rust, % lvs inf.
			Stayman			Idared			Ginger Gold			
	Treatment and rate/A	Timing	% lvs	area	fruit	% lvs	area	fruit	% lvs	area	fruit	G.Gold
0	No fungicide	---	66 f	32 d	16 b	66 c	49 c	44 g	75 e	57 d	23 d	9 c
1	Nova 40W 4 oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC-1C 2C-6C	38 b-d	6 ab	4 ab	40 ab	6 a	8 ab	54 bc	9 ab	0 a	<1 a
2	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC-1C 2C-6C	34 a-c	5 a	5 ab	38 ab	6 a	6 a	40 a	9 a	11 c	<1 a
3	Rubigan 1E 10 fl oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC-1C 2C-6C	45 de	6 ab	5 ab	46 b	10 a	15 b-d	47 ab	7 ab	2 a	<1 a
4	Cuprofix 4 lb+ Scala 5 fl oz Rubigan 1E 10 fl oz + Dithane RSNT 75DF 3 lb Flint 50WG 2 oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC OC-1C 2C- 3C 4C-6C	40 cd	5 a	5 ab	39 ab	6 a	29 d-g	50 a-c	10 b	2 ab	<1 a
5	Scala 60SC 10 fl oz Flint 50WG 2 oz Captan 50W 3 lb + Ziram 76DF 3 lb	TC, OC BI-1C, 5-6C 2C - 4C	35 b-d	4 a	7 ab	42 b	6 a	19 c-e	59 cd	6 ab	6 c	1 ab
6	Scala 60SC 5 fl oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb Flint 50WG 2 oz	TC - 1C 2C - 4C 5C-6C	53 e	21 c	4 a	63 c	49 c	34 fg	65 de	27 c	6 bc	3 b
7	Scala 60SC 7 fl oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb Flint 50WG 2 oz	TC - 1C 2C - 4C 5C-6C	52 e	12 bc	7 ab	59 c	30 b	32 e-g	72 e	29 c	5 bc	1 ab
8	USF2010 500SC 4 fl oz Captan 50W 3 lb + Ziram 76DF 3 lb Flint 50WG 2 oz	TC - 1C 2C - 4C 5C-6C	26 a	3 a	1 a	30 a	5 a	18 cd	43 a	4 a	0 a	<1 a
9	Flint 50WG 2 oz Captan 50W 3 lb + Ziram 76DF 3 lb	TC - 1C 2C-6C	35 bc	5 a	2 a	43 b	9 a	20 c-f	47 ab	8 ab	2 ab	<1 a
10	Flint 50WG +Captan (64% pre-mix) 22 oz Captan 50W 3 lb + Ziram 76DF 3 lb	TC - 1C 2C-6C	29 ab	4 a	2 a	45 b	7 a	10 a-c	50 a-c	8 ab	0 a	<1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05); four single-tree reps. Counts based on ten shoots 14 Jul (Stayman); 18 Jul (Idared); 20 Jul (G. Gold) or post-harvest counts of 25 fruit from each of four single-tree reps.

* Russet presumed to be unrelated to powdery mildew infection rated on a scale of 0-5 (0=perfect finish; 5=severe russet).

Fungicide application dates: Fungicide treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (TC, tight cluster); 26 Apr (bloom); 6 May (petal fall); First –5th covers, all cultivars (1C-5C): 23 May, 7 Jun, 21 Jun, 7 Jul, 25 Jul; 8 Aug (6th cover 6C, Stayman and Idared only).

Table 10. Evaluation of sooty blotch and fly speck control on Stayman, Idared and Ginger Gold apples, Winchester VA, 2005.

		Sooty blotch, % fruit or % fruit area infected						Flyspeck, % fruit or fruit area infected					
		Stayman		Idared		Ginger Gold		Stayman		Idared		Ginger Gold	
	Treatment, rate/A, and timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0	No fungicide	100 b	28 b	100 b	42 b	100 c	41 c	100 b	15 d	100 c	18 d	100 c	22 c
1	Nova 40W 4 oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C–6C	59 ab	4 a	48 a	4 a	41 ab	4 ab	74 a-c	6 bc	50 ab	3 a-c	77 ab	6 ab
2	Nova 40W 5 oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C–6C	57 ab	4 a	54 a	5 a	37 ab	2 a	61 ab	4 ab	50 ab	3 a-c	79 ab	6 ab
3	Rubigan 1E 10 fl oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C–6C	65 ab	6 a	66 ab	6 a	48 ab	4 ab	68 ab	5 a-c	54 b	4 bc	89 bc	8 b
4	Cuprofix 4 lb+ Scala 5 fl oz; TC Rubigan 1E 10 fl oz + Dithane 75DF 3 lb; OC-1C Flint 50WG 2 oz + Dithane 75DF 3 lb; 2C- 3C Captan 50W 3 lb + Ziram 76DF 3 lb; 4C–6C	54 a	7 a	54 a	6 a	45 ab	3 ab	45 a	3 ab	38 ab	2 a-c	52 a	4 ab
5	Scala 60SC 10 fl oz; TC, OC Flint 50WG 2 oz; Bl-1C, 5-6C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C - 4C	64 ab	8 a	71 ab	7 a	63 b	6 ab	51 ab	3 ab	19 a	1 a	57 a	3 a
6	Scala 60SC 5 fl oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C - 4C Flint 50WG 2 oz; 5C-6C	78 ab	7 a	59 a	7 a	55 ab	6 ab	78 a-c	5 a-c	30 ab	2 ab	67 ab	4 ab
7	Scala 60SC 7 fl oz + Dithane 75DF 3 lb; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C - 4C Flint 50WG 2 oz; 5C-6C	72 ab	8 a	74 ab	9 a	68 b	9 b	46 a	3 a	41 ab	2 a-c	59 a	4 ab
8	USF2010 500SC 4 fl oz; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C-4C Flint 50WG 2 oz; 5C-6C	53 a	4 a	52 a	4 a	25 ab	2 ab	69 ab	4 ab	34 ab	2 a-c	51 a	3 a
9	Flint 50WG 2 oz; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C–6C	71 ab	5 a	58 a	5 a	46 ab	3 ab	91 bc	9 c	64 b	5 c	76 ab	6 ab
10	Flint 50WG +Captan (64% pre-mix) 22 oz; TC-1C Captan 50W 3 lb + Ziram 76DF 3 lb; 2C–6C	55 a	4 a	48 a	5 a	19 a	2 a	64 ab	5 a-c	61 b	3 bc	67 ab	4 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: Fungicide treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (TC, tight cluster); 26 Apr (bloom); 6 May (petal fall); First –5th covers, all cultivars (1C-5C): 23 May, 7 Jun, 21 Jun, 7 Jul, 25 Jul; 8 Aug (6th cover 6C, Stayman and Idared only).

APPLE (*Malus domestica* 'Golden Delicious')
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*
Fly speck; *Zygophiala jamaicensis*
Rot spots (unidentified)
Fruit russet

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CONCENTRATE APPLICATIONS OF EXPERIMENTAL AND RECENTLY REGISTERED FUNGICIDES ON GOLDEN DELICIOUS APPLE, 2005.

Eleven treatments involving an experimental material and some recently registered ones, were compared on 33-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by border trees in the row, and by untreated border rows between treatment rows. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. Treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 14 Apr (TC, tight cluster); 4 May (Bl, bloom-late petal fall); First – 7th covers (1C-7C): 17 May, 1 Jun, 16 Jun, 30 Jun, 15 Jul, 1 Aug, 17 Aug.. Insecticides applied to the entire test block with the same equipment included Asana, Assail Intrepid Lannate LV, Imidan 70WSB, Provado, and Sevin XLR SpinTor. Cedar rust galls and quince rust cankers were placed over each test tree 13 and 25 Apr, bitter rot mummies 25 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi placed over each test tree 5 May. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of ten cluster leaf sets 14 Jun, shoots 23 Jun or 100 fruit for quince rust counts 15 Aug. A 25-fruit sample from each replicate tree was harvested 27 Sep and rated after 14 days' storage at 4 C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Heavy primary inoculum and three timely primary infection periods in April (7-8 Apr; 22-23 Apr; 29 Apr- 1 May) and three long secondary periods in May, resulted in a strong scab test with relatively heavy scab infection occurred on Golden Delicious leaves and fruit. An experimental compound rotated in the schedule with Manzate as indicated, significantly improved scab control on cluster and shoot leaves but was equal to Manzate on fruit. Nova 5 oz /A added little to Manzate alone (Trt. #5 vs. #6, Table 11). Flint + Manzate gave excellent control of scab on leaves and fruit. Flint + Manzate was comparable to Nova + Manzate for mildew and cedar-apple rust control but significantly weaker on quince rust. The experimental compound VA-1 was weaker than Manzate for control of sooty blotch, flyspeck, and rot suppression (Table 12). Treatments including Pristine in the late covers were strong for overall summer disease suppression. No treatment significantly increased the amount or severity of russetting and several reduced it compared to no-treated trees.

Table 11. Early season disease control on Golden Delicious; Virginia Tech AREC, Winchester, 2005.

	Treatment and rate/acre	Application schedule	Scab, % lvs or fruit inf or les/lf or fruit: clusters	shoots	les/lf	fruit	fruit les	c-a rust, % lvs inf	Quince rust (%)	Mildew: % lvs inf	% area
0	No fungicide	---	53 f	68 e	9.2 c	92 f	9.4 h	11 g	10 f	34 e	4.5 h
1	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C Bl-1C, 5C-7C	35 de	52 d	4.5 b	50 e	2.7 g	6 e-g	6 d-f	29 c-e	3.6 e-h
2	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C Bl-1C, 5C-7C	24 b-d	48 b-d	3.5 ab	43 de	1.9 f	4 b-e	9 f	28 c-e	4.2 gh
3	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C Bl-1C, 5C-7C	21 b	48 b-d	2.7 ab	31 cd	1.3 d-f	10 fg	7 ef	23 b-d	2.5 a-d
4	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C Bl-1C, 5C-7C	20 b	41 bc	2.0 ab	27 bc	0.7 bc	5 d-f	7 ef	21 bc	3.1 c-g
5	Manzate 75DF 3 lb	TC-7C	39 ef	50 d	3.2 ab	29 b-d	0.8 b-d	2 a-e	7 ef	30 de	3.5 d-h
6	Nova 40W 5 oz + Manzate 75DF 3 lb Manzate 75DF 3 lb	TC-1C 2C-7C	34 c-e	46 b-d	2.8 ab	28 bc	1.2 c-e	<1 a	<1 a	9 a	1.9 ab
7	Dithane 75DF 3 lb + Captan 80WDG 30 oz Nova 40W 5 oz + Dithane 75DF 3 lb Captan 80WDG 3.75 lb	TC-Bl 1C 2C-7C	13 b	39 b	2.3 ab	17 b	0.4 b	1 a-d	2 ab	17 b	2.4 a-c
8	Penncozeb 4F 2.25 qt + Microthiol 80DF 3 lb Penncozeb 4F 2.25 qt Topsin-M 70WDG 8 oz	TC-2C 3C-6C 7C	34 de	49 cd	4.1 b	43 de	1.7 ef	1 ab	4 b-d	20 b	2.9 c-f
9	Vangard 75WG 3oz + Manzate 75DF 3 lb Captan 80WDG 3.75 lb	TC-1C 2C-7C	22 bc	45 b-d	2.4 ab	29 b-d	0.9 cd	4 c-e	4 c-e	33 e	3.9 f-h
10	Scala 60SC 5 fl oz + Manzate 75DF 3 lb Captan 80WDG 3.75 lb Pristine 38WG 14.5 oz	TC-1C 2C-5C 6C-7C	36 e	39 b	2.0 ab	27 bc	0.7 bc	1 a-c	2 a-c	24 b-d	2.7 b-e
11	Flint 50WG 2 oz+ Manzate 75DF 3 lb Captan 80WDG 3.75 lb Pristine 38WG 14.5 oz	TC-1C 2, 3 & 5C 4, 6& 7C	1 a	8 a	0.2 a	2 a	0.1 a	2 a-d	5 de	9 a	1.8 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05); four reps. Counts of ten cluster leaf sets 14 Jun, shoots 23 Jun or 100 fruit 15 Aug.
Fungicide application dates: Airblast treatments applied to both sides of the tree on each date at 100 gal/A as follows:
14 Apr (TC, tight cluster); 4 May (Bl, bloom-late petal fall); First – 7th covers (1C-7C):17 May, 1 Jun, 16 Jun, 30 Jun, 15 Jul, 1 Aug, 17 Aug.
Maintenance applications: Applied to all test trees. 5 Apr (Asana 14.5 fl oz/A); 17 May (thinning spray: NAA 10 ppm + Sevin XLR 2 pt + Regulaid 3.4 oz + Assail 3.4 oz/A); 27 May (Assail 3.4 oz + Intrepid 1 pt/A); 10 Jun (Imidan 3 lb + Provado 6 fl oz/A); 28 Jun (Imidan 3 lb + Provado 6 fl oz/A); 9 Jul (Imidan 3 lb + Lannate LV 3 pt + Spintor 10 fl oz/A); 26 Jul and 16 Aug (Imidan 3 lb + Lannate LV 2 pt/A).
Scab infection periods through June 14: Apr 7-8; Apr 22-23; Apr 29-May 1; May 14-15 (First secondary infection period in '05); May 19-20; May 23-24; June 2-4; Jun 6-7; Jun 9-10; Jun 10-11; Jun 13-14.

Table 12. Late season disease control and fruit finish on Golden Delicious, Winchester, VA 2005.

	Treatment and rate/acre	Application schedule	Brooks spot, %	Sooty blotch % fruit	Sooty blotch % area	Flyspeck % fruit	Flyspeck % area	% any rot	% rot spots	russet rating*	% fruit X-fancy
0	No fungicide	---	4 b	100 f	14 e	100 c	18 d	26 d	21 d	2.6 a	35 b
1	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C BI-1C, 5C-7C	0 a	54 e	4 d	65 b	5 c	9 c	6 c	2.0 a	52 ab
2	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C BI-1C, 5C-7C	0 a	34 de	3 d	45 b	3 c	6 bc	5 c	2.0 a	49 ab
3	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C BI-1C, 5C-7C	1 a	42 e	3 d	49 b	4 c	6 bc	1 ab	2.0 a	56 ab
4	VA-1 (rate confidential) Manzate 75DF 3 lb/A	TC, 2-4C BI-1C, 5C-7C	0 a	19 cd	1 c	42 b	3 bc	5 bc	1 ab	1.8 a	61 ab
5	Manzate 75DF 3 lb	TC-7C	0 a	12 bc	<1 bc	11 a	<1 a	3 ab	0 a	2.1 a	57 ab
6	Nova 40W 5 oz + Manzate 75DF 3 lb Manzate 75DF 3 lb	TC-1C 2C-7C	0 a	8 a-c	<1 a-c	6 a	<1 a	3 a-c	3 bc	1.5 a	40 ab
7	Dithane 75DF 3 lb + Captan 80WDG 30 oz Nova 40W 5 oz + Dithane 75DF 3 lb Captan 80WDG 3.75 lb	TC-BI 1C 2C-7C	0 a	7 a-c	<1 a-c	17 a	1 ab	2 ab	1 ab	2.3 a	53 ab
8	Penncozeb 4F 2.25 qt + Microthiol 80DF 3 lb Penncozeb 4F 2.25 qt Topsin-M 70WDG 8 oz	TC-2C 3C-6C 7C	1 a	2 ab	<1 ab	5 a	<1 a	7 bc	1 ab	2.2 a	50 ab
9	Vangard 75WG 3oz + Manzate 75DF 3 lb Captan 80WDG 3.75 lb	TC-1C 2C-7C	0 a	3 ab	<1 a-c	11 a	<1 a	2 ab	2 a-c	1.7 a	66 ab
10	Scala 60SC 5 fl oz + Manzate 75DF 3 lb Captan 80WDG 3.75 lb Pristine 38WG 14.5 oz	TC-1C 2C-5C 6C-7C	1 a	2 ab	<1 a	4 a	<1 a	2 ab	0 a	2.1 a	52 ab
11	Flint 50WG 2 oz+ Manzate 75DF 3 lb Captan 80WDG 3.75 lb Pristine 38WG 14.5 oz	TC-1C 2, 3 & 5C 4, 6-7C	0 a	2 a	<1 a	2 a	<1 a	0 a	0 a	1.3 a	85 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05); four reps. Counts of 25 fruit from each of four single-tree reps. A 25-fruit sample from each replicate tree was harvested 27 Sep and rated after 14 days' storage at 4 C.

Fungicide application dates: Airblast treatments applied to both sides of the tree on each date at 100 gal/A as follows:
14 Apr (TC, tight cluster); 4 May (BI, bloom-late petal fall); First – 7th covers (1C-7C):17 May, 1 Jun, 16 Jun, 30 Jun, 15 Jul, 1 Aug, 17 Aug.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 28 Sep and stored at 1C 13 days before rating.

* 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* 'Jonagold')
Scab; *Venturia inaequalis*
Cedar-apple rust, *Gymnosporangium juniperi- virginianae*
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Brooks spot; *Mycosphaerella pomi*
Fruit finish

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Test of organic and biocontrols for fungal disease control on Jonagold apple, 2005.

Six treatments listed for certified organic production were evaluated for broad spectrum disease control on 14-yr-old trees. Treatments were applied dilute to the point of run-off with a single nozzle handgun in a four-replicate randomized block design as follows: 20 Apr (P, pink, trts. 1-5); 27 Apr (Bl, bloom, trts. 1-6); 6 May (PF, petal fall trts. 1-5); 16 May (1C, 1st cover, trts. 1-6); 27 May (2C, 2nd cover, trts. 1-5); 13 June (3C, 3rd cover, trts. 1-6); 28 Jun (4C, 4th cover, trts. 1-5); 12 Jul (5C, 5th cover, trts. 1-6); 26 Jul (6C, 6th cover, trts. 1-5); 10 Aug (7C, 7th cover, trts. 1-6). Cedar rust galls, quince rust cankers and bitter rot mummies were placed over each test tree 22 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each test tree 9 May. Maintenance sprays, applied separately with a commercial airblast sprayer, included Supracide + oil, Assail, Intrepid, Lannate LV, Imidan, Provado, and SpinTor and NAA + Sevin XLR (as a thinning spray). Foliar data represent counts of eight shoots from each of four single-tree reps 20 Jun or harvest counts of 25 fruit per replication 27 Sep. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The standard sulfur rates performed as expected under moderate pressures of this broad disease spectrum with the higher rate (4 lb) improving control of cedar-apple rust and flyspeck compared to the lower rate. JMS Stylet Oil gave scab, cedar rust, mildew, sooty blotch, and Brooks spot control equal to or better than sulfur 4 lb. Under heavy pressure, control of flyspeck by JMS Stylet Oil was equal to the 2 lb sulfur rate, but significantly less than the 4 lb rate. Serenade Max significantly reduced cedar-apple rust, powdery mildew, sooty blotch, flyspeck and Brooks spot, but gave only a slight suppression of scab and the level of flyspeck control was intermediate between the 2 lb and 4 lb sulfur rates. Treatment with either JMS Stylet Oil or Serenade resulted in a deleterious effect on fruit finish compared to non-treated fruit.

Table 13. Test of organic and biocontrols for fungal disease control on Jonagold, 2005.

	Disease incidence, % leaves or fruit infected								Finish rating*	
	scab		c-a rust	mildew		sooty	fly	Brooks	russet	opales-
Rate/100 gal dilute and timing	lvs	fruit	leaves	leaves	fruit	blotch	speck	spot %	rating	cence
0 No fungicide	27 b	92 c	8 c	28 c	14 c	26 c	91 f	5 bc	1.7 a	1.2 a
1 JMS Stylet Oil 1.5 gal; P-7C	18 a	45 a	<1 ab	10 ab	0 a	0 a	23 d	0 a	2.6 b	2.6 d
2 Sulfur 90W 2 lb; P-7C	24 ab	59 ab	3 b	9 ab	0 a	2 a	21 cd	0 a	1.9 ab	2.0 c
3 Sulfur 90W 4 lb; P-7C	25 ab	55 a	<1 a	7 a	0 a	0 a	1 a	1 a	2.0 ab	1.6 ab
4 Serenade Max 10W 12 oz + Biotune 1 pt; P-7C	29 b	77 b	<1 ab	13 ab	3 b	0 a	12 b	0 a	2.6 b	3.0 e
5 Serenade Max 12 oz + Biotune 1 pt; P, PF, 2, 4, 6C Sulfur 90W 4 lb; Bl, 1, 3, 5, 7C	27 b	75 b	1 ab	9 ab	6 b	0 a	13 bc	3 ab	2.1 ab	2.0 c
6 Sulfur 90W 4 lb, Bl, 1, 3, 5, 7C (when sulfur was applied in #5)	25 ab	93 c	2 b	17 bc	6 b	5 b	51 e	9 c	1.9 ab	1.9 bc

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet or opalescence).

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, 2005

Eight treatments suitable for organic or backyard fruit production were compared to a Nova/captan schedule for season-long fungal disease control and fruit finish effects on three apple cultivars. Treatments were evaluated on 17-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 2004 to allow buildup of powdery mildew inoculum. The dilute treatments were applied to the point of runoff with a single nozzle handgun at 400 psi as follows: 15 Apr (Rome ½ green, R. Del. and G. Del., TC, tight cluster); 21 Apr (Rome open cluster, OC; G. Del. OC-pink; R. Del. pink-early bloom); 27 Apr (Rome pink, G. Del. bloom; R. Del. full bloom-petal fall); 6 May (Rome full bloom; R. Del. and G. Del. petal fall). First through 8th covers (1C-8C): 16 May, 27 May, 13 Jun, 28 Jun, 12 Jul, 28 Jul, 10 Aug, and 1 Sep. Maintenance sprays, applied separately with a commercial airblast sprayer, included Asana, Assail BacMaster, NAA + Sevin XLR, Imidan, Lannate LV, Intrepid, and Provado. Cedar rust galls, quince rust cankers and bitter rot mummies were placed over each Golden Delicious test tree 25 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Golden Delicious test tree 10 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 6 Jun (Red Delicious), 8 Jun (Golden Delicious and Rome), or ten terminal shoots from each of four single-tree reps 22 Jul (Rome) and 8 Jul (Golden Del.). 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.

Heavy primary inoculum and three timely primary infection periods in April (7-8 Apr; 22-23 Apr; 29 Apr-1 May) and three long secondary periods in May, resulted in a strong scab test (Table 14). Captan alone or in combination with Nova or Immunox gave superior scab control, followed by Cuprofix then the higher rates of sulfur and Stylet Oil. Including lime sulfur with the lower rate of sulfur added little to scab control compared to sulfur alone. Myclobutanil treatments gave outstanding mildew and rust control (Table 15). Stylet oil gave partial control of cedar-apple rust and moderate mildew control, comparable to sulfur. Sooty blotch and flyspeck were best controlled by captan; Cuprofix gave fair control of sooty blotch but was weaker on flyspeck. Stylet Oil also significantly suppressed area affected by sooty blotch but had little effect on flyspeck (Table 16). Sulfur-related treatments gave partial suppression of both sooty blotch and flyspeck but were noticeably weak on Brooks spot. Captan and Cuprofix gave the best control of unidentified rots and "rot spots"; other treatments were variable in performance on one or more cultivars (Table 17). Cuprofix deleteriously affected finish of Red and Golden Delicious but not of Rome. Stylet Oil also significantly reduced finish of all three cultivars although as much as Cuprofix. Captan improved finish of Golden Delicious and Rome; sulfur improved finish of Golden Delicious.

Table 14. Scab control on Red Delicious, Golden Delicious and Rome apples, 2005

		Scab infection, % cluster or shoot leaves or fruit									
		spur leaves inf., %			G. Del. shoots		Rome shoots		% fruit scab		
Treatment, rate / 100 gal dilute	Timing	R. Del.	G. Del.	Rome	% lvs inf	lesions/lf	% lvs inf	lesions/lf	R.Del	G.Del	Rome
0 No fungicide	—	35 e	47 d	33 e	55 e	4.3 c	50 de	5.8 cd	96 f	93 e	88 e
1 JMS Stylet Oil 1 gal	TC-6C	14 d	15 c	25 d	33 cd	3.4 bc	56 e	7.4 d	77 e	80 d	74 de
2 JMS Stylet Oil 2 gal	TC-6C	8 c	7 b	19 cd	26 bc	2.6 bc	40 cd	2.8 b	55 cd	54 c	55 c
3 Yellow Jacket Sulfur 90W 3 lb	TC–6C	13 d	18 c	16 c	41 d	4.3 c	47 c-e	4.0 bc	69 de	57 c	56 c
4 Yellow Jacket Sulfur 90W 6 lb	TC–6C	9 c	14 c	14 c	36 d	3.8 c	50 de	3.8 bc	53 c	33 b	42 bc
5 Lime sulfur 4 qt + Sulfur 90W 3 lb Yellow Jacket Sulfur 90W 3 lb	TC OC-6C	13 d	18 c	17 cd	37 d	4.0 c	46 c-e	5.3 cd	65 c-e	56 c	59 cd
6 Cuprofix Disperss 20DF 12 oz	TC-6C	3 b	<1 a	14 c	23 b	1.7 ab	36 c	2.1 ab	19 b	2 a	35 b
7 Captan 50W 1.5 lb	TC- 6C	<1 a	<1 a	0 a	5 a	0.1 a	5 a	0.1 a	0 a	2 a	0 a
8 Immunox 1.55EC 50 fl oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	0 a	<1 a	1 b	2 a	0.1 a	13 b	0.3 a	1 a	3 a	3 a
9 Nova 40W 1.25 oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	0 a	0 a	0 a	3 a	0.1 a	14 b	0.4 a	0 a	0 a	1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications.
Counts of ten flower cluster leaf sets from each of four single-tree reps 6 Jun (Red Delicious), 8 Jun (Golden Delicious and Rome), or ten terminal shoots from each of four single-tree reps 22 Jul (Rome) and 8 Jul (Golden Del.).
Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 400 psi as follows: treatments were applied dilute to the point of run-off with a single nozzle handgun as follows: 15 Apr (Rome ½ green, R. Del. and G. Del., TC, tight cluster); 21 Apr (Rome open cluster, OC; G. Del. OC-pink; R. Del. pink-early bloom); 27 Apr (Rome pink, G. Del. bloom; R. Del. full bloom-petal fall); 6 May (Rome full bloom; R. Del. and G. Del. petal fall). First through 8th covers (1C-8C): 16 May, 27 May, 13 Jun, 28 Jun, 12 Jul, 28 Jul, 10 Aug, 1 Sep.

Table 15. Powdery mildew rust, rusts, and Brooks spot control on Golden Delicious and Rome Beauty apples, 2005

		Mildew, % leaves or leaf area infected					Cedar-apple rust, % leaves infected		Quince rust Golden Del.		Brooks spot (%)	
		Golden Delicious		Rome								
Treatment and rate / 100 gal dilute	Timing	% leaves	lf. area	% leaves	lf. area	fruit	G. Del.	Rome	16 Aug	harvest	G. Del.	Rome
0 No fungicide	—	44 d	8 c	71 e	31 d	14 c	15 c-e	17 b-d	5 c	4 c	6 bc	9 b
1 JMS Stylet Oil 1 gal	TC-6C	33 c	4 a-c	53 bc	7 ab	8 bc	7 bc	9 b	5 c	1 ab	3 a-c	0 a
2 JMS Stylet Oil 2 gal	TC-6C	24 b	3 ab	42 ab	4 a	3 ab	6 b	13 bc	4 c	1 ab	3 a-c	2 ab
3 Yellow Jacket Sulfur 90W 3 lb	TC--6C	29 bc	4 a-c	50 a-c	7 ab	1 a	15 c-e	19 cd	6 c	4 c	7 bc	2 ab
4 Yellow Jacket Sulfur 90W 6 lb	TC--6C	34 c	4 a-c	58 cd	11 b	1 a	14 b-d	21 cd	6 c	3 bc	10 cd	2 ab
5 Lime sulfur 4 qt + Sulfur 90W 3 lb Yellow Jacket Sulfur 90W 3 lb	TC OC-6C	 33 c	 5 bc	 49 a-c	 5 ab	2 a	 18 de	 27 d	6 c	 3 bc	22 d	4 ab
6 Cuprofix 20DF 12 oz	TC-6C	42 d	5 bc	67 de	19 c	8 bc	25 e	25 d	7 c	0 a	0 a	0 a
7 Captan 50W 1.5 lb	TC- 6C	54 e	15 d	69 de	37 d	0 a	12 b-d	17 b-d	1 b	0 a	0 a	0 a
8 Immunox 1.55EC 50 fl oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	16 a	2 ab	39 a	5 ab	0 a	<1 a	<1 a	0 a	0 a	3 ab	2 ab
9 Nova 40W 1.25 oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	13 a	2 a	40 a	6 ab	0 a	0 a	1 a	0 a	0 a	2 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications.
Count dates: ten terminal shoots from each of four single-tree reps 22 Jul (Rome) and 8 Jul (Golden Del.). Quince rust counts, 100 Golden Delicious fruit, 16 Aug.

Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 400 psi as follows: treatments were applied dilute to the point of run-off with a single nozzle handgun as follows: 15 Apr (Rome ½ green, R. Del. and G. Del., TC, tight cluster); 21 Apr (Rome open cluster, OC; G. Del. OC-pink; R. Del. pink-early bloom); 27 Apr (Rome pink, G. Del. bloom; R. Del. full bloom-petal fall); 6 May (Rome full bloom; R. Del. and G. Del. petal fall). First through 8th covers (1C-8C): 16 May, 27 May, 13 Jun, 28 Jun, 12 Jul, 28 Jul, 10 Aug, and 1 Sep.

Table 16. Evaluation of sooty blotch and fly speck 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 / 100 gal dilute	Timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0 No fungicide	---	100 d	14 e	100 d	28 e	100 d	22 e	100 e	14 d	100 d	17 e	100 e	19 d
1 JMS Stylet Oil 1 gal	TC-6C	84 c	5 cd	100 d	11 d	91 cd	8 d	100 e	15 d	100 d	17 e	100 e	17 d
2 JMS Stylet Oil 2 gal	TC-6C	58 b	4 bc	84 bc	6 b	86 cd	7 cd	100 e	13 d	99 d	13 d	100 e	18 d
3 Yellow Jacket Sulfur 90W 3 lb	TC--6C	81 c	6 d	79 b	7 bc	68 c	5 c	89 cd	6 bc	86 bc	6 a-c	81 d	7 bc
4 Yellow Jacket Sulfur 90W 6 lb	TC--6C	92 c	7 d	79 b	6 b	71 c	5 cd	85 b-d	6 c	83 bc	6 ab	82 cd	7 bc
5 Lime sulfur 4 qt + Sulfur 90W 3 lb Yellow Jacket Sulfur 90W 3 lb	TC OC-6C	89 c	7 d	97 cd	11 cd	82 c	6 cd	80 bc	5 bc	90 bc	8 bc	87 d	8 c
6 Cuprofix 20DF 12 oz	TC-6C	44 b	3 b	65 b	5 b	40 b	2 b	92 d	7 c	93 cd	9 cd	80 cd	8 c
7 Captan 50W 1.5 lb	TC- 6C	10 a	<1 a	17 a	1 a	8 a	<1 a	47 a	3 a	79 bc	6 ab	65 b	5 b
8 Immunox 1.55EC 50 fl oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	15 a	<1 a	25 a	1 a	8 a	<1 a	75 b	6 bc	74 b	6 ab	67 bc	6 bc
9 Nova 40W 1.25 oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	11 a	<1 a	24 a	2 a	8 a	<1 a	56 a	4 ab	47 a	5 a	43 a	3 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications.
Count dates: ten terminal shoots from each of four single-tree reps 22 Jul (Rome) and 8 Jul (Golden Del.). Quince rust counts, 100 Golden Delicious fruit, 16 Aug.

Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 400 psi as follows: treatments were applied dilute to the point of run-off with a single nozzle handgun as follows: 15 Apr (Rome ½ green, R. Del. and G. Del., TC, tight cluster); 21 Apr (Rome open cluster, OC; G. Del. OC-pink; R. Del. pink-early bloom); 27 Apr (Rome pink, G. Del. bloom; R. Del. full bloom-petal fall); 6 May (Rome full blooom; R. Del. and G. Del. petal fall). First through 8th covers (1C-8C): 16 May, 27 May, 13 Jun, 28 Jun, 12 Jul, 28 Jul, 10 Aug, and 1 Sep.

Table 17. 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	% of fruit with any rot: G. Del	% of fruit with any rot: R. Del	% of fruit with any rot: Rome	Russet ratings or USDA grade * Ratings (0-5): R. Del.	Russet ratings (0-5): Rome	Russet ratings (0-5): G. Del.	G. Del. % fancy/x-fcy	Opalescence rating (0-5): R. Del.	Opalescence rating (0-5): Rome
0	No fungicide	---	12 b	34 e	12 d	11 d	1.2 bc	0.9 bc	2.5 c	73 cd	1.0 ab	1.6 bc
1	JMS Stylet Oil 1 gal	TC-6C	11 b	24 de	1 ab	8 cd	1.5 cd	1.1 cd	2.9 c	57 c	1.7 c	1.6 c
2	JMS Stylet Oil 2 gal	TC-6C	5 ab	14 b-d	0 a	7 cd	1.6 d	1.2 d	3.4 d	37 b	1.6 c	2.7 d
3	Yellow Jacket Sulfur 90W 3 lb	TC--6C	3 ab	3 ab	3 b	9 cd	1.0 ab	0.7 ab	1.6 ab	94 ef	0.8 a	1.5 bc
4	Yellow Jacket Sulfur 90W 6 lb	TC--6C	8 b	16 cd	0 a	6 bc	1.2 b	0.6 a	1.8 b	83 de	1.0 ab	1.1 a
5	Lime sulfur 4 qt+ Sulfur 90W 3 lb Yellow Jacket Sulfur 90W 3 lb	TC OC-6C	13 b	17 cd	1 ab	9 cd	1.0 b	0.9 bc	1.9 b	88 e	0.9 ab	1.6 c
6	Cuprofix 20DF 12 oz	TC-6C	0 a	2 a	0 a	2 a	2.0 e	1.0 cd	4.2 e	9 a	1.4 bc	1.8 c
7	Captan 50W 1.5 lb	TC- 6C	1 a	3 a	1 ab	0 a	0.7 a	0.6 a	1.3 a	99 f	0.8 a	1.0 a
8	Immunox 1.55EC 50 fl oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	2 a	6 a-c	2 ab	0 a	0.9 ab	0.5 a	1.4 a	96 ef	0.7 a	1.3 ab
9	Nova 40W 1.25 oz + Captan 50W 12 oz Captan 50W 1.5 lb	TC-2C 3C - 6C	0 a	0 a	0 a	3 a	0.9 ab	0.5 a	1.3 a	98 f	0.8 a	0.9 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Fruit counts are means of 25-fruit samples Four single-tree replications.

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

APPLE (*Malus domestica* 'Red Delicious')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Fruit finish

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Disease control by Captan and an adjuvant on Red Delicious apples, 2005

Four treatments involving Captan and the adjuvant TM-46501 were tested for scab and summer disease control and fruit finish effects on 20-yr-old Redchief Red Delicious / MM 106 trees in a four-replicate randomized block design. Fungicide treatment rates, adjusted to tree row volume, were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 13 Apr (TC, tight cluster); 20 Apr (pink-early bloom); 1st –7th covers (1C-7C), 10 May, 27 May, 13 June, 28 June, 13 July, 3 Aug and 16 Aug. Bitter rot mummies were placed over each test tree 25 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed 10 May. Triadimefon 50DF 0.5 oz/100 gal, was applied 28 Apr for quince rust and mildew suppression. Other maintenance sprays, applied separately with a commercial airblast sprayer, included Asana, Assail, Imidan, Intrepid, Lannate LV, Provado, and SpinTor. Primary scab was counted on ten flower cluster leaf sets from each of four single-tree reps 7 Jun and all the leaves on ten shoots were rated 1 Aug. Fruit counts represent means of 25-fruit samples picked from each of four single-tree reps 27 Sep and rated 28 Sep. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Early season primary and secondary scab infection periods, inoculum pressure, and adjusted spray intervals resulted in a moderate scab test with opportunity for varying control among treatments. Although there were some evident Captan rate effects, no significant differences (p=0.05) were apparent related to inclusion of TM-46501 with Captan compared to Captan alone at the same rate. Similarly, with treatment intervals extended in the late covers to allow development of sooty blotch and flyspeck resulting in a strong residual test. There were significant differences in percent area affected related to the captan rate but none related to inclusion of TM-46501. There were no significant treatment effects on fruit finish compared to non-treated trees.

Early season disease control by Captan and an adjuvant, 2005

Treatment and rate/acre* (rate adjusted to 50% TRV)	Timing	Scab, % leaves, lesions/leaf or fruit: cluster	shoot	lesions/leaf	fruit	lesions /fruit	Mildew % lvs
0 No fungicide	---	15 b	38 c	2.4 b	52 b	2.8 b	9 a
1 Captan 80WDG 5.0 lb (2.5 lb)	TC-7C	2 a	6 ab	0.1 a	0 a	0.0 a	7 a
2 Captan 80WDG 2.5 lb (1.25 lb)	TC-7C	2 a	9 b	0.2 a	2 a	<0.1 a	4 a
3 Captan 80WDG 5.0 lb (2.5 lb) + TM-46501 8 fl oz/100 gal	TC-7C	1 a	4 a	0.1 a	0 a	0.0 a	6 a
4 Captan 80WDG 2.5 lb (1.25 lb) + TM-46501 8 fl oz/100 gal	TC-7C	1 a	10 b	0.2 a	0 a	0.0 a	5 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree reps
Counts of ten flower cluster leaf sets from each tree 7 Jun or ten shoots 1 Aug.

Summer disease control and fruit finish by Captan and an adjuvant, 2005

Treatment and rate/acre* (rate adjusted to 50% TRV)	Timing	Sooty blotch %: fruit	area	Flyspeck %: fruit	area	Finish rating (0-5)*: russet	opalescence
0 No fungicide	---	95 c	12.4 c	100 a	23 d	1.4 a	1.0 a
1 Captan 80WDG 5.0 lb (2.5 lb)	TC-7C	23 ab	1.4 ab	94 a	9.4 ab	1.1 a	0.9 a
2 Captan 80WDG 2.5 lb (1.25 lb)	TC-7C	31 b	2.0 b	98 a	13.3 c	1.1 a	0.8 a
3 Captan 80WDG 5.0 lb (2.5 lb) + TM-46501 8 fl oz/100 gal	TC-7C	16 a	1.0 a	87 a	9.3 a	1.2 a	1.0 a
4 Captan 80WDG 2.5 lb (1.25 lb) + TM-46501 8 fl oz/100 gal	TC-7C	36 b	2.2 b	98 a	13.0 bc	1.2 a	1.0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05); four reps. Counts of 25 fruit/rep 28 Sep.
* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet or opalescence).

PEACH *(Prunus persica* 'Loring')
Nectarine: (*P. persica* var. *nucipersica* 'Redgold')
Leaf curl; *Taphrina deformans*
Scab; *Cladosporium carpophilum*
Brown rot; *Monilinia fructicola*
Rusty spot; *Podosphaera leucotricha*

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Evaluation of fungicides for disease control on Loring peach and Redgold nectarine, 2005:

Several registered fungicides were compared for broad spectrum disease control on 13-yr-old trees. The test planting is composed of 3-tree sets, each including Loring peach and Redgold nectarine, which were not treated with fungicides in 2004 to allow the buildup of scab inoculum, and Redhaven peach, which were left untreated in 2005. Brown rot inoculum was standardized in the orchard by placing three mummified fruit in each test tree before bloom. 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 five replications. Applications were as follows: 31 Mar (BS, bud swell, treatments #1-3 only); 7 Apr (P, pink); 11 Apr (full bloom); 20 Apr (PF, petal fall); 3 May (SS, shuck split); 1st-4th covers, 1C-4C, 17 May, 1 Jun, 16 Jun, and 1 Jul; Pre-harvest sprays (3PH, 26 July and 1PH, 11 Aug (Loring) or 17 Aug (Redgold) were aimed at 3 weeks and 1 week before Loring harvest. Actual harvest dates were 18 Aug for Loring and 24 Aug for Redgold. Commercial insecticides, applied to the entire test block at 2-3 wk intervals with a commercial airblast sprayer, included Asana XL, Imidan WSB, Intrepid, Lannate LV, Provado, and Sevin XLR. Leaf curl incidence was rated on 25 shoots per tree 5 May. Because of heavy disease pressure on Redgold, brown rot was also counted on the tree (25 fruit/tree) 23 Aug Samples of 20 apparently rot-free fruit per replicate tree were harvested 18 Aug (Loring) and 24 Aug (Redgold), rated for rusty spot and scab, selected for uniform ripeness, and placed on fiber trays for incubation. All were incubated in polyethylene bags at ambient temperature: Loring 21-30C (mean 25.6C); Redgold 17-28C (mean 25.6C) before assessing rot development at the indicated intervals.

Following a year without fungicides on Loring, leaf curl pressure was moderately severe. Ziram, Bravo Weather Stik and Kocide 2000, applied at bud swell, gave excellent leaf curl control (Table 18). Other treatments, including Pristine, Indar, and sulfur, delayed until pink, were generally less effective but all gave significant control compared to non-treated trees. Weather during petal fall and the early cover spray period was favorable for development of rusty spot (mildew) and scab. Indar applied at pink to petal fall followed by sulfur, was an outstanding rusty spot management strategy, significantly better than all other treatment schedules, including a similar one involving Pristine/sulfur. Under strong test conditions, with more than 75% of untreated Loring and 85% of untreated Redgold fruit infected with scab, all treatments gave excellent control on Loring but control was more variable on Redgold nectarine and less effective. With timely wetting periods throughout mid-season, brown rot pressure in the test area was high as evidenced by symptoms on green nectarines and earlier ripening Redhaven trees, none of which were treated with fungicides. Because fruit rot incidence in the orchard was high, postharvest inoculation was not necessary to produce a strong test (Table 19). Pre harvest applications of Elite + Flint, Pristine, Indar, Flint (higher rate) and captan all gave excellent brown rot control on the tree and after a 4-day postharvest incubation. Indar was the most residually effective treatment on Loring; Pristine was the most residually effective treatment on Redgold nectarine. ReTain, applied 7 days to harvest to test for possible postharvest firmness, breakdown and decay effects (Trt. #7 vs. #8), had significant positive effects on brown rot after 4 days incubation on Loring and significantly more rot-free Redgold fruit after 7 days. Compared to Indar-treated fruit not receiving ReTain, ReTain-treated Loring fruit had reduced % soluble solids (SS) the day of harvest, no SS effect but increased firmness after 4 days (Table 20). Compared to Indar-treated Redgold fruit not receiving ReTain, ReTain-treated fruit had increased SS after 6 days but no significant difference in firmness throughout the monitoring period (Table 21).

Table 18. Control of leaf curl, scab, rusty spot and brown rot on Loring peach and Redgold nectarine, 2005.

			Leaf curl, % shoots inf.	Scab, % fruit inf. or lesions/fruit				Rusty spot, %	% on tree brown rot,
				Loring		Redgold			
	Treatment and rate/100 gal dilute	Timing	Loring	fruit	lesions	fruit	lesions	Loring	Redgold
0	No fungicide	---	40 f	75 b	16.4 b	85 b	17.8 b	33 c	31 e
	Kocide 2000 53.8DF 3 lb	BS	3 a-c						
1	Microfine Sulfur 90W 4 lb	BI-4C		5 a	0.2 a	27 a	2.1 a	11 b	
	Topsin-M 70W 4 oz + Captan 80WDG 10 oz	3 & 1PH							<1 ab
	Ziram 76DF 2 lb	BS	1 a						
2	Microfine Sulfur 90W 4 lb	BI-4C		10 a	0.5 a	66 ab	11.6 a	10 b	
	Captan 80WDG 20 oz	3 & 1PH							3 cd
	Bravo Weather Stik 6F 1 pt	BS	2 ab						
3	Microfine Sulfur 90W 4 lb	BI-4C		5 a	0.3 a	44 ab	7.1 a	20 bc	
	Flint 50WG 1 oz	3 & 1PH							2 b-d
	Kocide 2000 53.8DF 3 lb	pink	8 c-e						
4	Microfine Sulfur 90W 4 lb	BI-4C		4 a	0.1 a	56 ab	8.7 a	14 b	
	Elite 45DF 2 oz	3 & 1PH							<1 a-c
	Ziram 76DF 2 lb	pink	5 a-d						
5	Microfine Sulfur 90W 4 lb	BI-4C		9 a	0.8 a	50 ab	4.8 a	17 bc	
	Flint 50WG 2 oz	3 & 1PH							8 d
	Bravo Weather Stik 6F 1 pt	pink	6 b-e						
6	Microfine Sulfur 90W 4 lb	BI-4C		5 a	0.2 a	58 ab	9.4 a	11 b	
	Elite 45DF 1 oz + Flint 50WG 1 oz	3 & 1PH							2 ab
	Microfine Sulfur 90W 4 lb	P- covers	14 e	7 a	0.5 a	23 a	0.7 a	21 bc	
7	Indar 75W 1 oz+ B-1956 4 fl oz	3PH							
	Indar 1 oz + B-1956 4 fl oz + ReTain 5.85 oz	1PH							0 a
8	Microfine Sulfur 90W 4 lb	P- 4C	13 e	6 a	0.3 a	39 ab	9.7 a	18 bc	
	Indar 75W 1 oz+ B-1956 4 fl oz	3 & 1PH							<1 ab
9	Pristine 38WDG 7.25 oz	P-PF, 3 & 1PH	7 b-e						<1 a-c
	Microfine Sulfur 90W 4 lb	SS-4C		5 a	0.2 a	43 ab	4.2 a	17 bc	
10	Indar 75W 1 oz+ B-1956 4 fl oz	P-PF, 3 & 1PH	11 de						0 a
	Microfine Sulfur 90W 4 lb	SS-4C		5 a	0.3 a	37 a	2.2 a	2 a	

Averages of five single tree reps. Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Leaf curl was rated 5 May; Pre-harvest brown rot counts on Redgold, 25 fruit per tree 23 Aug. Harvest evaluations (Loring peach, 18 Aug; Redgold nectarine 24 Aug) for scab and rusty spot. Treatment dates: 31 Mar (BS, bud swell, treatments #1-3 only); 7 Apr (P, pink); 11 Apr (full bloom); 20 Apr (PF, petal fall); 3 May (SS, shuck split); 1st-4th covers, 1C-4C, 17 May, 1 Jun, 16 Jun, and 1 Jul;; Pre-harvest sprays (3PH, 26 July and 1PH, 11 Aug (Loring) or 17 Aug (Redgold) were aimed at 3 weeks and 1 week before Loring harvest. Actual harvest dates: Loring- 18 Aug; Redgold- 24 Aug. **Note**: Data are aligned with the treatment timing most likely to have affected indicated disease.

Table 19. Treatment effects on preharvest and postharvest rot development on Loring peach and Redgold nectarine, 2005.

			Loring, % of fruit with brown rot after days incubation				Redgold, % of fruit with brown rot on tree	Redgold, % of fruit with brown rot, days incubation			% fruit rot-free
	Treatment and rate/100 gal dilute	Timing	2 days	4 days	5 days	6 days	23 Aug	5 days	6 days	7 days	7 days
0	No fungicide	---	1 a	45 d	82 d	98 e	31 e	38 f	63 g	79 f	12 g
	Kocide 2000 53.8DF 3 lb	BS									
1	Microfine Sulfur 90W 4 lb	BI-4C									
	Topsin-M 70W 4 oz + Captan 80WDG 10 oz	3 & 1PH	0 a	2 ab	17 ab	49 cd	<1 ab	14 de	35 ef	53 de	40 ef
	Ziram 76DF 2 lb	BS									
2	Microfine Sulfur 90W 4 lb	BI-4C									
	Captan 80WDG 20 oz	3 & 1PH	0 a	4 ab	9 a	40 bc	3 cd	18 e	40 f	60 e	29 f
	Bravo Weather Stik 6F 1 pt	BS									
3	Microfine Sulfur 90W 4 lb	BI-4C									
	Flint 50WG 1 oz	3 & 1PH	0 a	15 c	38 c	64 d	2 b-d	12 c-e	22 de	32 bc	44 d-f
	Kocide 2000 53.8DF 3 lb	pink									
4	Microfine Sulfur 90W 4 lb	BI-4C									
	Elite 45DF 2 oz	3 & 1PH	0 a	4 a-c	16 ab	29 a-c	<1 a-c	0 a	6 a-c	18 ab	58 cd
	Ziram 76DF 2 lb	pink									
5	Microfine Sulfur 90W 4 lb	BI-4C									
	Flint 50WG 2 oz	3 & 1PH	0 a	5 bc	15 ab	36 a-c	8 d	8 b-d	25 e	38 cd	50 de
	Bravo Weather Stik 6F 1 pt	pink									
6	Microfine Sulfur 90W 4 lb	BI-4C									
	Elite 45DF 1 oz + Flint 50WG 1 oz	3 & 1PH	0 a	4 a-c	14 ab	33 a-c	2 ab	5 bc	12 cd	20 a-c	69 bc
	Microfine Sulfur 90W 4 lb	P- covers									
7	Indar 75W 1 oz+ B-1956 4 fl oz	3PH									
	Indar 1 oz + B-1956 4 fl oz + ReTain 5.85 oz	1PH	0 a	0 a	13 ab	25 ab	0 a	0 a	5 ab	12 a	83 a
8	Microfine Sulfur 90W 4 lb	P- 4C									
	Indar 75W 1 oz+ B-1956 4 fl oz	3 & 1PH	0 a	5 bc	24 bc	35 a-c	<1 ab	3 ab	7 a-c	12 a	74 b
9	Pristine 38WDG 7.25 oz	P-PF, 3 & 1PH	0 a	3 ab	14 ab	27 a-c	<1 a-c	0 a	2 a	9 a	89 a
	Microfine Sulfur 90W 4 lb	SS-4C									
10	Indar 75W 1 oz+ B-1956 4 fl oz	P-PF, 3 & 1PH	0 a	2 ab	4 a	16 a	0 a	3 ab	10 bc	13 a	76 b
	Microfine Sulfur 90W 4 lb	SS-4C									

Averages of five single tree reps. Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Leaf curl was rated 5 May; Pre-harvest brown rot counts, 25 fruit per tree 23 Aug. Harvest evaluations (Loring peach, 18 Aug; Redgold nectarine 24 Aug) for scab and rusty spot. Treatments dates: 31 Mar (BS, bud swell, treatments #1-3 only); 7 Apr (P, pink); 11 Apr (full bloom); 20 Apr (PF, petal fall); 3 May (SS, shuck split); 1st-4th covers, 1C-4C, 17 May, 1 Jun, 16 Jun, and 1 Jul; Pre-harvest sprays (3PH, 26 July and 1PH, 11 Aug (Loring) or 17 Aug (Redgold) were aimed at 3 weeks and 1 week before Loring harvest. Actual harvest dates: Loring- 18 Aug; Redgold- 24 Aug. **Note**: Data are aligned with the treatment timing most likely to have affected rots.

Table 20. Comparison of ReTain-treated Loring peach fruit for effects on firmness, and soluble solids.

	Treatment and rate/100 gal dilute	Timing	Firmness (lb) 0 days	2 days	4 days	Soluble solids (%) 0 days	2 days	4 days
0	No fungicide	---	11.a 3	2.9a	1.9b	13.a 1	11.a 3	11.a 5
7	Microfine Sulfur 90W 4 lb Indar 75W 1 oz+ B-1956 4 fl oz Indar 1 oz + B-1956 4 fl oz + ReTain 5.85 oz	P- 4C 3PH 1PH	6.3b	2.9a	2.7a	10. 1b	12. 1a	11. 2a
8	Microfine Sulfur 90W 4 lb Indar 75W 1 oz+ B-1956 4 fl oz	P- 4C 3 & 1PH	9.3ab	2.8a	1.9b	12. 8a	11. 6a	11. 3a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Test of three fruit from each of five replicate trees / date.

Table 21. Comparison of ReTain-treated Redgold nectarine fruit for postharvest firmness, and soluble solids.

	Treatment and rate/100 gal dilute	Timing	Firmness (psi) 0 days	2 days	4 days	6 days	Soluble solids (%) 0 days	2 days	4 days	6 days
0	No fungicide	---	13.a 0	4.7a	3.1a	3.0a	12.a 4	12.a 3	12.a 3	11.b 7
7	Microfine Sulfur 90W 4 lb Indar 75W 1 oz+ B-1956 4 fl oz Indar 1 oz + B-1956 4 fl oz + ReTain 5.85 oz	P- 4C 3PH 1PH	8.0a	3.2b	2.6b	2.6a	13. 5a	12. 9a	12. 6a	12. 5a
8	Microfine Sulfur 90W 4 lb Indar 75W 1 oz+ B-1956 4 fl oz	P- 4C 3 & 1PH	9.6a	3.8ab	3.0ab	2.6a	13. 1a	12. 3a	11. 2a	11. 5b

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Test of three fruit from each of five replicate trees per test date.

NECTARINE (*Prunus persica* 'Redgold')
Leaf curl; *Taphrina deformans*

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Leaf curl on Redgold nectarine in 2005 as related to treatments in 2004:

In 2004 several experimental and registered fungicides were compared for broad spectrum disease control on 12-yr-old trees. The planting is composed of 3-tree sets. each including Redhaven peach (which was not treated with fungicides in 2003 to allow the buildup of scab inoculum). Redgold nectarine in test in 2003, and Loring peach which was not treated with fungicides in 2004. In 2004, dilute treatments were applied to the point of run-off with a single nozzle handgun at 300 psi (approximately 200 gal/A) in a randomized block design with four single-tree replicates 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); First through 4th covers: 21 May, 3 June, 18 June, 2 July. In 2004-05, commercial insecticides were applied to the entire test block at 2-3 wk intervals with a commercial airblast sprayer. In 2005 fungicides were specifically avoided at the normal spring (bud swell) timing for leaf curl control treatment. Trees in the test planting were re-randomized for 2005 treatment regimes. Following favorable infection conditions in March '05, leaf curl was rated on 25 shoots per tree 10 May.

In 2004 and 2005 leaf curl infection on untreated Redgold trees was moderately severe. Ziram, Bravo or Kocide, applied at bud swell 11 Mar '04 and treated with sulfur the rest of the year, gave excellent control as expected in 2004, and also remained relatively free of leaf curl although not treated at bud swell in 2005. Sulfur, applied in the pink to preharvest sprays in 2004, gave only partial control in 2004-05. Trees treated with Indar, Pristine or V10116 at pink and preharvest, or with Elite + Flint or with USF2010 in the early cover and preharvest sprays in 2004, had significantly less infection than sulfur-treated trees in 2005.

Table 22. Leaf curl on Redgold nectarine in 2005 as related to treatments in 2004.

2004 treatment and rate/100 gal dilute (no bud swell treatment in 2005)	2004 timing	Leaf curl, incidence (%) 10 May '04	5 May '05
0 No fungicide	---	65 c	48 e
1 Microfine Sulfur 90W 3 lb	P- PH	35 a-c	20 d
2 Ziram Granuflo 76WDG 2 lb	BS	0 a	4 a-c
Microfine Sulfur 90W 3 lb	P- PH		
3 Bravo Weather Stik 6F 1 pt	BS	2 a	5 a-c
Microfine Sulfur 90W 3 lb	P- PH		
4 Kocide 2000 35DF 3 lb	BS	6 ab	9 cd
Microfine Sulfur 90W 3 lb	P- PH		
5 Ziram Granuflo 76WDG 2 lb	Pink-SS	30 a-c	3 a-c
Microfine Sulfur 90W 3 lb	1C - 5C		
Indar 75W 1 oz+ B-1956 8 fl oz	3 & 1PH		
6 Bravo Weather Stik 6F 1 pt	Pink-SS	41 a-c	10 b-d
Microfine Sulfur 90W 3 lb	1C - 5C		
Indar 75W 1 oz+ B-1956 8 fl oz	3 & 1PH		
7 Microfine Sulfur 90W 3 lb	P-PF, 3C-5C	36 a-c	5 a-c
Topsin M 70W 4 oz + Sulfur 90W 3 lb	SS-2C. 3 & 1PH		
8 Microfine Sulfur 90W 3 lb	P-PF, 3C-5C	15 a-c	<1 a
USF2010 500SC 3.0 fl oz	SS-2C. 3 & 1PH		
9 Microfine Sulfur 90W 3 lb	P-PF, 3C-5C	60 bc	<1 ab
Elite 45DF 1.74 oz + Flint 50WG 1.56 oz	SS-2C. 3 & 1PH		
10 Indar 75W 1 oz+ B-1956 8 fl oz	P-1C. 3 & 1PH	22 a-c	3 a-c
Microfine Sulfur 90W 3 lb	2C-5C		
11 Pristine 38WDG 7.25 oz	P-1C, 3 & 1PH	43 a-c	6 a-c
Microfine Sulfur 90W 3 lb	2C-5C		
12 V10116 1.81FI 2.83 fl oz+ B-1956 8 fl oz	P-1C. 3 & 1PH	22 a-c	<1 a
Microfine Sulfur 90W 3 lb	2C-5C		
13 V10116 50WD 1.28 oz + B-1956 8 fl oz	P-1C, 3 & 1PH	65 c	<1 a
Microfine Sulfur 90W 3 lb	2C-5C		

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

POST-INFECTION CONTROL OF FLYSPECK WITH NEW FUNGICIDES

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Objectives:

1. Determine post-infection activity of Topsin M, Sovran, Flint, and Pristine against flyspeck when treatments were applied within 350 hr of accumulated wetting from petal fall (AWPF) as compared to effectiveness when the same applications were delayed until approximately 450 hr AWPF.
2. Determine if liquid-lime sulfur can be used as a post-infection fungicide to control flyspeck.

Methods:

Treatments were replicated four times using single-tree replicates in a randomized block design in an 8-yr-old orchard containing Golden Delicious on MM.111 rootstocks with M.9 inter-stems. Treatments were applied to drip using a handgun and a high-pressure sprayer set at 200 psi. Cedar trees were planted between plots within rows to minimize drift between plots. Early season fungicides were applied to trees in these plots to prevent scab, rust, and mildew. The last two fungicide applications prior to initiation of this test were, with rates per acre, Bayleton 50W 5 oz plus Penncozeb 75DF 3 lb on 30 May and Bayleton 50W 4 oz plus Captan 80WDG 2 lb on 8 June. A total of 2.25 inches of rainfall between 10 and 18 June removed fungicide residues from the 8 June spray before trees reached 270 hr AWPF on 29 June, the time when the first conidia of the flyspeck fungus were presumably released from infections in the orchard perimeter. The test block has poor air drainage and is surrounded by hedgerows and woodlots on three sides.

Our assumption at the start of this trial was that flyspeck ascospores are released beginning at about petal fall, but that the ascospores are of relatively minor importance on apples. Ascospores infect other hosts in orchard perimeters and those primary infections produce conidia that are blown into orchards starting at about 270 hr AWPF. Based on prior trials, we assumed that fungicides with limited systemic activity can inactivate flyspeck during its initial stages of growth on apples so long as the fungicide is applied before 100 hr of wetting accumulates between infection and the time that fungicides are applied. Therefore, in this trial we opted to apply the same fungicide treatments at approximately 350 hr AWPF on the assumption that this timing would provide excellent control of flyspeck. (We chose 350 hr AWPF with the objective of allowing 270 hr for the primary infections on perimeter hosts plus 80 hr of incubation for the first conidia to reach apples.) Most of these treatments were repeated at 430 hr AWPF on the assumption that the fungicides would not control flyspeck when applied more than 100 hr after conidial infections were initiated on fruit. Captan was included as "control" because we assumed that, as a contact fungicide, captan would not provide post-infection activity. Liquid lime-sulfur was included as a potential fungicide for organic farmers based on the comment from an organic farmer in New England who reported that a single spray during mid-summer was very effective. After test plots received their initial spray on either 11 or 26 July, trees were re-sprayed at regular intervals so as to avoid the possibility that infection visible at harvest might have originated with lapses in fungicide protecting during late summer or fall. We assumed that most of the test fungicides would protect fruit for either 21 days or until 1.5 inches of rainfall had accumulated since the last application. Lime sulfur was applied only twice and was followed by an application of Topsin M plus Captan because we were uncertain if lime-sulfur would provide residual protection comparable to other treatments.

None of the treatments provided complete control of flyspeck. Flyspeck incidence in control plots (no fungicide after 8 June) increased rapidly from 8.5% on 15 Aug (516 hr AWPF) to 46% on 18 Aug (538 hr AWPF) and to 77% on 23 Aug (554 hr AWPF). Fruit in plots treated with captan alone at either spray timing reached 46-48% infection by 12 Sep, approximately 25 days after disease incidence in the control plots had reached that level. By 19 Sep, disease incidence exceeded 10% in all treatments.

Comparisons of disease progress is the various treatments (Fig. 1) suggested that disease development in all of the treatments followed the same general pattern, but some fungicides slowed development more than others. Because the summer was relatively dry and fungicides were timed to prevent any subsequent infections from occurring after the first summer spray was applied, the flyspeck observed in this trial indicates that all of the fungicides tested are fungistatic rather than fungicidal when applied to pre-existing infections. The period of fungistasis was shortest for captan and longest for Sovran. In plots where no treatments were applied until 430 hr AWPF, flyspeck infections had progressed further before fungicides were applied and disease progress was therefore slightly advanced (a higher incidence on any given date) for most of the fungicide treatments. Lime sulfur suppressed early development of flyspeck more effectively than any of the other fungicides, but we did not have room in the orchard to include a lime sulfur treatment initiated at 430 AWPF.

The incidence of red lenticel spots (presumed lenticel infections by *Botryosphaeria* species) was significantly higher were treatments were first applied on 26 July as compared to where treatments were applied on 11 July.

Results from this experiment suggest that fungicides for summer disease control should be initiated at approximately 250 hr AWPF. Leaving trees unsprayed until later in the summer resulted in unacceptable development of flyspeck and red lenticel spotting prior to harvest. The rapid increase in flyspeck incidence in late summer after fungistasis from post-infection sprays had dissipated parallels observations in commercial orchards where flyspeck sometimes appears unexpectedly in orchards where fruit had less than 270 hr accumulated wetting after fungicide residues were removed by September rains. Based on observations in this trial, it seems likely that such episodes occur when lapses in mid-summer fungicide protection allow flyspeck infections to occur during summer, the incubating infections are suppressed by later fungicide application, and flyspeck then resumes growth and appears on fruit when residues from the last summer spray are depleted.

Acknowledgments:

The authors thank Anne Rugh, Richard Christiana, Sr., and Albert Woelfersheim for technical assistance in carrying out the trial reported here. We also thank the fungicide manufacturers for providing product for testing.

Material and rate of formulated product per 100 gal	Spray timing (11 Jul = 337 hr AWPF[1]; 26 Jul = 430 hr AWPF)	% Golden Delicious with flyspeck:[2] hr AWPF as shown below the dates: 23 Aug 554 hr	30 Aug 611 hr	6 Sept 647 hr
1. Control [3]		76.7 d[4]	98.3 e	100.0 d
2. Captan 80W 10 oz	11 Jul, 29 Jul, 19 Aug	6.7 bc	35.8 d	30.0 c
3. Captan 80 W 10 oz + Topsin M 4 oz	11 Jul, 29 Jul, 19 Aug	1.7 ab	9.2 bc	2.5 a
4. Flint 50W 0.67 oz	11 Jul, 29 Jul, 19 Aug	2.5 ab	3.3 ab	8.3 ab
5. Sovran 50W 1.33 oz	11 Jul, 29 Jul, 19 Aug	0.8 a	4.2 ab	8.3 ab
6. Pristine 38WDG 4.8 oz	11 Jul, 29 Jul, 19 Aug	2.5 ab	3.3 abc	4.2 ab
7. Liquid lime sulfur 1 gal	11 Jul, 29 Jul			
Captan 80W 10 oz +Topsin 4 oz	19 Aug	1.7 ab	0.0 a	2.5 ab
8. Captan 80W 10 oz	26 Jul, 19 Aug	19.2 c	45.0 d	35.8 c
9. Captan 80 W 10 oz + Topsin M 4 oz	26 Jul, 19 Aug	5.8 ab	10.8 c	10.8 b
10. Flint 50W 0.67 oz	26 Jul, 19 Aug	1.7 ab	2.5 ab	3.3 ab
11. Sovran 50W 1.33 oz	26 Jul, 19 Aug	2.5 ab	0.0 a	5.0 ab
12. Pristine 38WDG 4.8 oz	26 Jul, 19 Aug	5.8 ab	6.7 bc	9.2 ab

See footnotes below the next table.

Material and rate of formulated product per 100 gal	% Golden Delicious fruit with flyspeck[2] with hr AWPF as shown below the dates: 12 Sept 663 hr	Sept 19 720 hr	Sept 26 750 hr	Oct 5 841 hr
1. Control [3]	100.0 e	100.0 d	100.0 d	100.0 e
2. Captan 80W 10 oz	48.3 d	68.3 c	88.3 c	85.3 d
3. Captan 80 W 10 oz + Topsin M 4 oz	11.7 bc	20.0 ab	30.8 ab	23.4 a
4. Flint 50W 0.67 oz	5.0 ab	17.5 ab	29.2 ab	39.2 bc
5. Sovran 50W 1.33 oz	8.3 b	14.2 ab	19.2 a	24.2 a
6. Pristine 38WDG 4.8 oz	6.7 b	16.7 ab	33.3 ab	27.7 ab
7. Liquid lime sulfur 1 gal Captan 80W 10 oz +Topsin 4 oz	0.0 a	6.7 a	23.3 ab	29.5 a
8. Captan 80W 10 oz	46.7 d	75.0 c	88.3 c	90.9 d
9. Captan 80 W 10 oz + Topsin M 4 oz	21.7 c	21.7 ab	44.2 b	39.5 bc
10. Flint 50W 0.67 oz	5.0 ab	15.8 ab	30.8 ab	40.5 bc
11. Sovran 50W 1.33 oz	9.2 b	10.0 a	24.2 ab	29.8 ab
12. Pristine 38WDG 4.8 oz	20.8 c	31.7 b	35.0 ab	48.4 c

[1] hr AWPF = hr accumulated wetting counting from petal fall.

[2] 30 random apples per tree were rated for presence of flyspeck. Apples were rated on the tree except for the 5 October rating when apples were rated after harvest.

[3] Control trees were evaluated on a weekly basis beginning 25 Jul. Flyspeck incidence in controls was 1% on 25 Jul, 1% on 1 Aug; 1% on 8 Aug at 466 hr AWPF, 8.5% on 15 Aug at 516 hr AWPF, and 46% on 18 Aug at 538 hr AWPF.

[4] Means followed by the same letters are not significantly different (Fisher's Protected LSD, $P \leq 0.05$). The arc-sine transformation was used for statistical analyses, but arithmetic means are shown in the table.

Material and rate of formulated product per 100 gal.	% Golden Delicious fruit harvested 5 Oct 05 with: sooty blotch	Out of grade due to SBFS	*Botryosphaeria* sp. fruit rot	*Botryosphaeria* sp. red lenticels	Lime-sulfur chemical burn
Control	100.0 c	100.0 e	3.3 a	22.6 c	0.0 a
Captan 80W 10 oz	43.9 b	61.1 d	3.0 a	14.6 bc	0.0 a
Captan 80W 10 oz + Topsin M 70WSB 4 oz	6.6 a	6.3 ab	0.6 a	5.5 a	0.0 a
Flint 50WDG 0.67 oz	7.7 a	12.6 bc	1.3 a	11.3 ab	0.0 a
Sovran 50W 1.33 oz	2.0 a	5.0 ab	0.7 a	5.3 a	0.0 a
Pristine 38WDG 4.8 oz	5.0 a	4.7 ab	1.4 a	9.4 ab	0.0 a
Liquid Lime Sulfur 4 qt Captan 80W 10 oz +Topsin 4 oz	1.6 a	2.6 a	1.3 a	13.0 abc	4.9 b
Captan 80W 10 oz	52.9 b	67.0 d	12.1 a	20.3 bc	0.0 a
Captan 80W 10 oz + Topsin M 70WSB 4 oz	4.2 a	12.1 bc	2.7 a	16.4 bc	0.0 a
Flint 50WDG 0.67 oz	7.0 a	10.3 abc	2.0 a	16.7 bc	0.0 a
Sovran 50W 1.33 oz	5.6 a	7.2 abc	1.6 a	17.9 bc	0.0 a
Pristine 38WDG 4.8 oz	5.0 a	16.3 c	3.3 a	15.6 bc	0.0 a

Means followed by the same letters are not significantly different (Fisher's Protected LSD, $P \leq 0.05$). The arc-sine transformation was used for statistical analyses, but arithmetic means are shown in the table.

Results of two-way analyses (five fungicide treatments X two application timings) for effects of treatments and spray timing on the incidence of flyspeck and red lenticel spots at harvest.

Materials and rate of formulated product per 100 gal	% Golden Delicious fruit harvested 5 October 2005: with flyspeck, Initial spray date 11 Jul	with flyspeck, Initial spray date 26 Jul	Grand means: fungicides	with red lenticels, Initial spray date 11 Jul	with red lenticels, Initial spray date 26 Jul	Grand mean for material
Captan 80W 10 oz	85.4 c	90.9 c	88.1 c	14.6	20.3	17.5
Captan 80W 10 oz + Topsin M 70WSB 4 oz	23.4 a*	39.5 ab	31.5 ab	5.5*	16.4	10.9
Flint 50WDG 0.67 oz	39.2 b	40.5 ab	39.9 b	11.3	16.7	14.0
Sovran 50W 1.33 oz	24.2 ab	29.8 a	27.0 a	5.3*	17.9	11.6
Pristine 38WDG 4.8 oz	27.7 ab*	48.4 b	38.1 b	9.4	15.6	12.5
Grand mean for spray date	40.0 A	49.8 B		9.2 A	17.4 B	

Means within columns followed by the same letters are not significantly different ($P \leq 0.05$) as determined from a 2-way analysis of five fungicide treatments tested at two different timing intervals. The arc-sine transformation was used for statistical analyses, but arithmetic means are shown in the table. Asterisks following simple means indicate that a significant difference exists between dates for the fungicide treatment in that row.

P-values for analysis of flyspeck: Fungicide =<0.001, Spray date =0.004, Fungicide* Spray date = 0.363.
P values for red lenticels: Fungicide = 0.289, Spray date =0.002, Fungicide* Spray date = 0.622

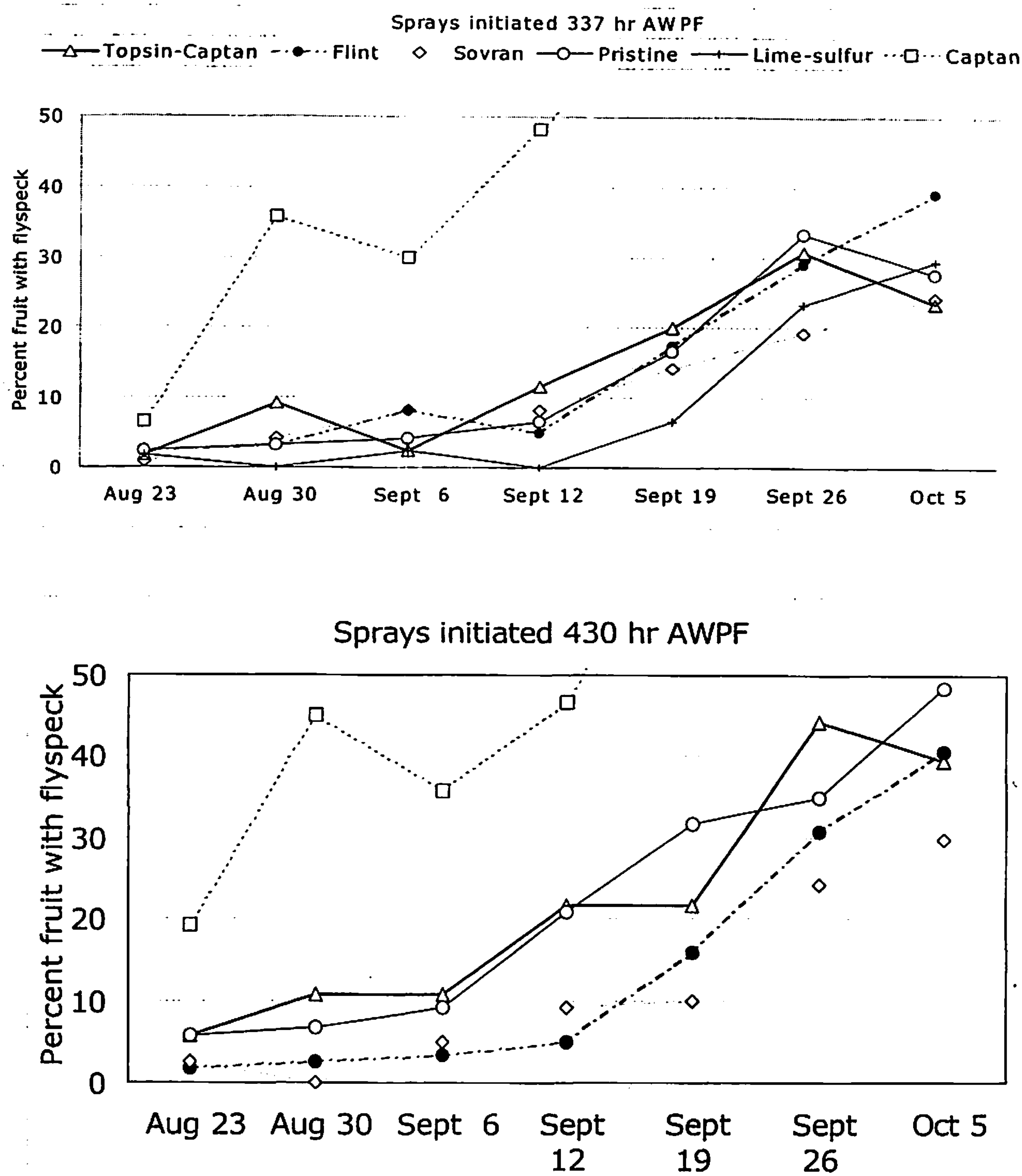

Fig. 1. Incidence of flyspeck on Golden Delicious fruit at various dates as effected by fungicide treatments initiated on 11 July (337 hr AWPF) or 26 July (430 hr AWPF).

Combinations of Bactericides and Fungicides for Fire Blight and Summer Disease Management on Apple

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Bactericides and fungicides were examined for their efficacy against the full spectrum of apple diseases encountered during the growing season. Of particular interest were combinations of streptomycin (Firewall), copper (Cuprofix), and the biocontrol Serenade for management of fire blight blossom blight. Cuprofix alone and Ziram alternating with the strobilurins Flint, Sovran, and Pristine were examined in cover sprays for control of summer fruit diseases and rots. The effect of Cuprofix on apple fruit finish was also examined.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2005 growing season. The test block was a Rome Beauty apple orchard with Golden Delicious trees dispersed throughout for pollination. Trees were grafted on M7A rootstock and planted 14 feet apart in rows spaced at 18 feet.

Treatments were replicated four times in a randomized complete block design with three-tree plots consisting of Rome Beauty. For the standard and Cuprofix cover spray treatments, an adjacent Golden Delicious tree was also sprayed. A Durand-Wayland airblast sprayer calibrated to deliver 100 gpa at 150 psi and 2.17 mph was used for applications.

Fungicide applications were made on the following dates and tree growth stages: 19 Apr (½"G, 1/2" green tip), 22 Apr (TC, tight cluster), 29 Apr (P, pink), 3 May (B, bloom), 28 May (PF, petal fall) 8, 24 Jun, 9, 22 Jul, 9, 29 Aug, 19 Sep (1C -7C, 1st through 7th cover). Bactericide applications were made during bloom between 3 May and 23 May; although timing varied according to treatment, all trees received a total of 3 to 4 applications. Standard insecticides and miticides were applied as needed to the block using a commercial airblast sprayer.

Environment. Overall, the growing season was dry, especially during the months of August and September (Fig 1). Rainfall for May, August and September were well below average with 2.11, 1.68, and 0.60 inches, respectively, versus 4.42, 4.85, and 4.28 inches for the 30-year average. Rainfall for April, June, and July was near average; however the majority of rain occurred in a few days leaving longer periods with little or no rainfall. The number of rain days with >0.10 inches accumulation following each bloom and cover spray were: ½"G, 0; TC, 2; P, 2; B, 2; PF, 4; 1C, 1; 2C, 5; 3C, 2; 4C, 3; 5C, 4; 6C, 3 and 7C, 0.

Assessment. Fire blight was evaluated on 6 Jul by examining all the shoots on each treated group of trees. Scab, powdery mildew, and cedar apple rust on foliage were evaluated on 23 Sep by examining 10 shoots from each treated plot. Sooty blotch, fly speck, and bitter, black, and white rots were evaluated 26 Sep by examining 40 fruit per plot. For the standard and Cuprofix treatments, fruit finish on both Rome Beauty and Golden Delicious trees was assessed on 26 Sept. Forty fruit from treated trees of both varieties were picked and given a rating of 1 (very low or no russet) to 5 (near 100% surface russet).

RESULTS AND DISCUSSION

Fire blight. Weather conditions were unfavorable for fire blight strikes because of cool temperatures and only 2 rain days during bloom. Consequently, the incidence of blossom blight was relatively low and there were no significant differences between treatments (Table 1). Trees receiving the Cuprofix / Firewall alternation, Cuprofix / Serenade alternation, and Firewall alone had the fewest fire blight strikes. Those trees treated only with Cuprofix had the most strikes. This result appears to suggest that the Firewall and Serenade were the more active ingredients in these combinations. However, additional data under higher disease pressure are needed for confirmation.

Foliar Diseases. Since all treatment trees received the same early season fungicide program (Rubigan + Dithane), treatment differences were attributed to variations in the cover spray fungicides (Table 2). Disease pressure for scab was severe, as indicated by the near 100% incidence for the non-sprayed control. Although all treatments significantly reduced foliar scab incidence, disease levels were still quite high. A 25-day gap in fungicide applications between bloom and petal fall may have allowed scab to get a foothold; rainfall occurred toward the end of this period when residues would have been lowest. Under these conditions, subsequent cover sprays of Ziram/Sovran provided the most control (81.7%), but Ziram/Pristine and Cuprofix were not significantly different from it and provided 69.9% and 63.8% control, respectively. Powdery mildew pressure was very low; all treatments significantly reduced foliar incidence. Ziram/Flint provided the highest powdery mildew control at 84.1%, while the Captan+Ziram mixture yielded significantly less control at only 36.7%. All treated trees had a lower incidence of cedar apple rust than the non-treated trees; however, none of the treatments differed significantly from each other or from the non-treated control.

Fruit Diseases. Since the early season fungicide program was identical across all treatments, similar levels of fruit scab control were expected and did occur (Table 3). Treatments provided between 89.9% and 100% scab control and did not differ significantly from one another. Disease pressure for sooty blotch and fly speck was very high. The Ziram/Pristine and Ziram/Sovran alternation treatments provided the best control of both diseases. Ziram/Pristine reduced sooty blotch and fly speck by 99.4% and 93.1%, respectively, while Ziram/Sovran provided 96.8% and 95% control, respectively. The Captan+Ziram and Ziram/Flint treatments provided very good control of sooty blotch, but were not as effective for fly speck. Cuprofix provided significantly less control than all other treatments for both diseases.

All treatments significantly lowered fruit rot incidence (Table 4). Ziram/Pristine reduced overall rot by 96.6% followed by Ziram/Flint (90.0%), Captan+Ziram (88.5%), and Ziram/Sovran (85.3%). Cuprofix provided 63.7% control and had significantly higher rot levels than most other treatments. Bitter rot was the most common summer fruit rot encountered. Percent control ranged from 91.1% to 100% for all treatments except Cuprofix, which provided only 50.2% control. Non-treated fruit had a black rot incidence of 6.9% (not shown). All treatments significantly reduced black rot incidence and no significant differences were observed among them. White rot incidence was very low with 3.1% infected fruit on non-treated trees. All treatments provided *significant* control of white rot except Captan+Ziram.

Fruit Finish. An analysis of variance was performed on the combined Rome Beauty and Golden Delicious fruit russet rating data for the Cuprofix and standard Captan + Ziram treatments (Table 5). Both the cultivar and treatment main effects were statistically significant ($P < 0.0001$). Furthermore, a significant interaction between these two effects indicated that the two cultivars reacted differently to the two treatments.

Russetting on Golden Delicious fruit was rated at 2.9 for the Cuprofix treatment and 1.3 for the standard, a significant increase of 1.6 or 123% ($P < 0.0001$, Tukey's HSD). In contrast, russetting on Rome Beauty fruit increased only by 0.5 rating from 1.0 for the standard to 1,5 for Cuprofix treated fruit, an increase of 50% that was just barely significant ($P = 0.0472$, Tukey's HSD).

TABLE 1. Fire Blight Incidence on Rome Beauty[1]

Treatment	Rate / A	Timing[2]	# Strikes per tree[3]
Non-sprayed	--------	--------	6.0 a
Rubigan 1EC + Dithane 75DF **Firewall 17WP + Regulaid** Captan 50WP + Ziram 76DF	8 fl oz + 3 lb **8 oz + 8 fl oz** 3 lb + 3 lb	½"G, TC, P, B, PF **Every 4-5 d during B** 1C-7C	3.3 a
Rubigan 1EC + Dithane 75DF **Cuprofix Ultra 40DF** Cuprofix Ultra 40DF	8 fl oz + 3 lb **1 lb** 12 oz	½"G, TC, P, B, PF **Every 7 d during B** 1C-7C	6.9 a
Rubigan 1EC + Dithane 75DF **Streptrol 17WP + Regulaid** Ziram 76DF Flint 50WG	8 fl oz + 3 lb **8 oz + 8 fl oz** 6 lb 2.5 oz	½"G, TC, P, B, PF **Every 4-5 d during B** 1C 3C 5C 7C 2C 4C 6C	4.3 a
Rubigan 1EC + Dithane 75DF **Cuprofix Ultra 40DF alternated with Firewall 17WP + Regulaid** Ziram 76DF Pristine 38WG	8 fl oz + 3 lb **1 lb** **8 oz + 8 fl oz** 6 lb 14.5 oz	½"G, TC, P, B, PF **Every 7 / 4 days during B** 1C 3C 5C 7C 2C 4C 6C	2.7 a
Rubigan 1EC + Dithane 75DF **Cuprofix Ultra 40DF alternated with Serenade 10WP** Ziram 76DF Sovran 50WG	8 fl oz + 3 lb **1 lb** **8 lb** 6 lb 5 oz	½"G, TC, P, B, PF **Every 7 / 4 days during B** 1C 3C 5C 7C 2C 4C 6C	3.1 a

[1] Fire blight treatments, rates, and application timings in **boldface**.
[2] For the Cuprofix/Firewall and Cuprofix/Serenade alternations, the spray interval was 7-days following Cuprofix and 4-days following either Firewall or Serenade.
[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). Means were calculated from 12 trees (4 replicates @ 3 trees / rep).

TABLE 2. Foliar Disease Incidence on Rome Beauty [1]

			% Infected Leaves [2] - 23 Sep		
Treatment	**Rate / A**	**Timing**	**Scab**	**Powdery Mildew**	**Cedar A. Rust**
Non-sprayed	-------	--------	99.3 a	4.4 a	14.2 a
Rubigan 1EC + Dithane 75DF Firewall 17WP + Regulaid **Captan 50WP + Ziram 76DF**	**8 fl oz + 3 lb** 8 oz + 8 fl oz **3 lb + 3 lb**	**½"G, TC, P, B, PF** Every 4-5 d during B **1C-7C**	48.1 b	2.8 b	7.8 a
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF **Cuprofix Ultra 40DF**	**8 fl oz + 3 lb** 1 lb **12 oz**	**½"G, TC, P, B, PF** Every 7 d during B **1C-7C**	35.9 bc	1.2 c	6.1 a
Rubigan 1EC + Dithane 75DF Streptrol 17WP + Regulaid **Ziram 76DF** **Flint 50WG**	**8 fl oz + 3 lb** 8 oz + 8 fl oz **6 lb** **2.5 oz**	**½"G, TC, P B, PF** Every 4-5 d during B **1C 3C 5C 7C** **2C 4C 6C**	38.0 b	0.7 c	10.4 a
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF alternated w. Firewall 17WP + Regulaid **Ziram 76DF** **Pristine 38WG**	**8 fl oz + 3 lb** 1 lb 8 oz + 8 fl oz **6 lb** **14.5 oz**	**½"G, TC, P, B, PF** Every 7 / 4 days during B **1C 3C 5C 7C** **2C 4C 6C**	30.1 bc	1.1 c	6.4 a
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF alternated with Serenade 10WP **Ziram 76DF** **Sovran 50WG**	**8 fl oz + 3 lb** 1 lb 8 lb **6 lb** **5 oz**	**½"G, TC, P, B, PF** Every 7/4 days during B **1C 3C 5C 7C** **2C 4C 6C**	18.2 c	1.5 bc	7.1 a

[1] Foliar disease 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). Means based on observations on 10 shoots / replicate.

TABLE 3. Fruit Disease Incidence on Rome Beauty [1]					
			% Infected Fruit - 26 Sep [2]		
Treatment	**Rate / A**	**Timing**	**Scab**	**Sooty Blotch**	**Fly Speck**
Non-sprayed	-------	--------	18.8 a	95.6 a	100.0 a
Rubigan 1EC + Dithane 75DF Firewall 17WP + Regulaid **Captan 50WP + Ziram 76DF**	8 fl oz + 3 lb 8 oz + 8 fl oz **3 lb + 3 lb**	½"G, TC, P, B, PF Every 4-5 d during B **1C-7C**	0.6 b	3.8 c	23.8 c
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF **Cuprofix Ultra 40DF**	8 fl oz + 3 lb 1 lb **12 oz**	½"G, TC, P, B, PF Every 7 d during B **1C-7C**	1.9 b	50.0 b	84.4 b
Rubigan 1EC + Dithane 75DF Streptrol 17WP + Regulaid **Ziram 76DF** **Flint 50WG**	8 fl oz + 3 lb 8 oz + 8 fl oz **6 lb** **2.5 oz**	½"G, TC, P B, PF Every 4-5 d during B **1C 3C 5C 7C** **2C 4C 6C**	0.6 b	8.8 c	24.4 c
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF alternated w. Firewall 17WP + Regulaid **Ziram 76DF** **Pristine 38WG**	8 fl oz + 3 lb 1 lb 8 oz + 8 fl oz **6 lb** **14.5 oz**	½"G, TC, P, B, PF Every 7 / 4 days during B **1C 3C 5C 7C** **2C 4C 6C**	0.0 b	0.6 c	6.9 d
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF alternated with Serenade 10WP **Ziram 76DF** **Sovran 50WG**	8 fl oz + 3 lb 1 lb 8 lb **6 lb** **5 oz**	½"G, TC, P, B, PF Every 7/4 days during B **1C 3C 5C 7C** **2C 4C 6C**	1.3 b	3.1 c	5.0 d

[1] Fruit disease 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). Means based on observations on 40 fruit / replicate.

TABLE 4. Fruit Rot Incidence on Rome Beauty [1]				
			% Infected Fruit - 26 Sep [2]	
Treatment	**Rate / A**	**Timing**	**All Rots**	**Bitter Rot**
Non-sprayed	-------	--------	38.1 a	21.3 a
Rubigan 1EC + Dithane 75DF Firewall 17WP + Regulaid **Captan 50WP + Ziram 76DF**	8 fl oz + 3 lb 8 oz + 8 fl oz **3 lb + 3 lb**	½"G, TC, P, B, PF Every 4-5 d during B **1C-7C**	4.4 c	1.3 c
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF **Cuprofix Ultra 40DF**	8 fl oz + 3 lb 1 lb **12 oz**	½"G, TC, P, B, PF Every 7 d during B **1C-7C**	13.8 b	10.6 b
Rubigan 1EC + Dithane 75DF Streptrol 17WP + Regulaid **Ziram 76DF** **Flint 50WG**	8 fl oz + 3 lb 8 oz + 8 fl oz **6 lb** **2.5 oz**	½"G, TC, P B, PF Every 4-5 d during B **1C 3C 5C 7C** **2C 4C 6C**	3.8 c	0.6 c
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF alternated w. Firewall 17WP + Regulaid **Ziram 76DF** **Pristine 38WG**	8 fl oz + 3 lb 1 lb 8 oz + 8 fl oz **6 lb** **14.5 oz**	½"G, TC, P, B, PF Every 7 / 4 days during B **1C 3C 5C 7C** **2C 4C 6C**	1.3 c	0.0 c
Rubigan 1EC + Dithane 75DF Cuprofix Ultra 40DF alternated with Serenade 10WP **Ziram 76DF** **Sovran 50WG**	8 fl oz + 3 lb 1 lb 8 lb **6 lb** **5 oz**	½"G, TC, P, B, PF Every 7 / 4 days during B **1C 3C 5C 7C** **2C 4C 6C**	5.6 bc	1.9 c

[1] Fruit disease 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). Means based on observations on 40 fruit / replicate.

Table 5. Analysis of Variance of Fruit Finish Data: Comparison of Russet Ratings				
Source[1]	**DF**	**Mean Square**	**F Value**	**Pr > F**
Model	6	1.4290	31.63	< 0.0001
Cultivar	1	3.0844	68.27	< 0.0001
Treatment	1	4.1260	91.33	< 0.0001
Cultivar x Treatment	1	1.1691	25.88	0.0007
Replicate	3	0.0648	1.44	0.2959
Error	9	0.0452		

[1] Cultivar main effect compares Rome Beauty vs. Golden Delicious; treatment main effect compares Cuprofix cover sprays vs. Standard (captan + Ziram) cover sprays.

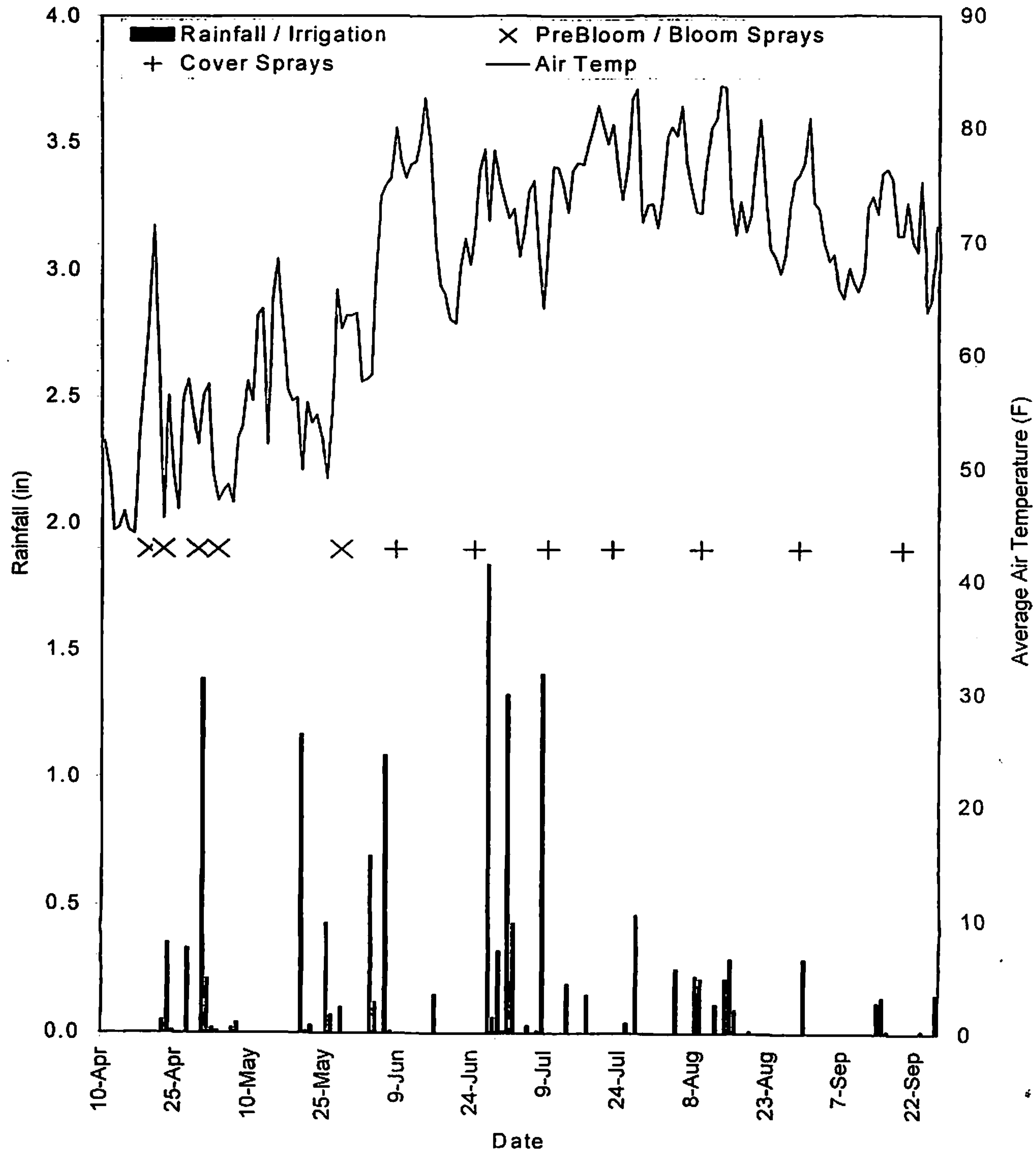

Figure 1. Rainfall, air temperature, and fungicide application timing for a 'Rome Beauty' apple orchard during the 2005 growing season, Rutgers Fruit Research and Extension Center, Cream Ridge, NJ. Timing of bactericide applications varied according to treatment, but occurring during the length of the bloom period from 3 to 23 May.

POST-INFECTION CONTROL OF APPLE SCAB WITH SYLLIT, VANGARD, AND SCALA

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Objectives:

1. Determine effectiveness of Scala, Vangard, and Syllit for controlling scab when applied 48 hr after the start of rains.

2. Determine rate-response for post-infection activity of Vangard, Scala, and Syllit. Rates of Vangard and Scala were chosen to provide 3 matching rates of active ingredient. Rates of Syllit were chosen to compare the old standard rate recommended for kick-back activity to the lower rate on the new Syllit SC formulation.

Methods:

Treatments were replicated four times using single-tree replicates in a randomized block design in an 8-yr-old orchard on MM.111 rootstocks with M.9 inter-stems. Lower scaffold limbs on test trees were McIntosh and the upper portion of each tree was Ginger Gold. Treatments were applied to drip using a handgun and a high-pressure sprayer set at 200 psi. Cedar trees were planted between plots within rows to provide inoculum for rust diseases and to minimize drift between plots. Scab in this block was near baseline when tested for sensitivity to dodine, DMI's, and strobilurins in Jun 2003.

Trial 1:

The wetting period used for Trial 1 started 10:30 pm on 22 Apr and provided 32.75 hr wetting, 0.67 in. rain, with mean temperature of 51.1 °F, thereby comprising a moderate Mill's infection period if night wetting is discounted. Trees were left untreated until test fungicides were applied on 25 Apr, roughly 48 hr after infections were initiated. Mean temperature between the start of rain and the fungicide application (10:30pm 22 Apr to 9:00am 25 Apr) was 48.9 °F as measured by a HOBO record of temperatures recorded every 5 min at an orchard site approximately one-half mile away from the test orchard. Another scab infection period occurred 27-28 April in a wetting period that began 2:15 AM and resulted in 23 hr wetting and 0.67 inches rain at a mean of 50 °F.

On 29 April, Penncozeb 3 lb/A was applied across the entire block with an air-blast sprayer so that differences in protectant activity of fungicides would not be a factor in final ratings. The Penncozeb follow-up spray on 29 April would not have reached back to the 27 April infection period. Thus, the test fungicides needed to provide 48 hr of post-infection activity (assuming no night discharge of ascospores) plus 3 days of protection.

Results for this test were determined by counting lesions on all cluster leaves and fruitlets from 15 clusters/cultivar harvested 27 May. Scab infections resulting from 14 May were not yet visible when these samples were collected.

Trial 2:

Plots in the same orchard were re-randomized and replications were blocked based on expected severity of primary scab from the Trial-1 treatments. Residues from the 29 April Penncozeb spray were assumed to have been diluted by the spring growth flush and by the 0.4-in. rainfall that occurred between 30 April and 13 May.

The wetting period used for this trial started 10:30pm on 14 May and provided 13 hr wetting, 0.06 in. rain, with a mean temperature of 61.0 °F. This was a moderate Mill's period and also a secondary infection period. Treatments were applied on 17 May and were followed up with an air-blast application of Penncozeb 3 lb/A applied across the entire block on 23 May. Mean temperature from

10:30pm on 14 May to 9:00am on 17 May was 60.2 °F as determined from the HOBO temperature recorder.

Another scab infection period began 4:45pm 21 May and resulted in 40.5 hr wetting, 0.18 inches rain, at a mean temperature of 50.5 °F. The Penncozeb follow-up on 23 May would not have reached back to infection period that started on 21 May, so the test treatments needed to provide 56 hr kickback plus 5 days protection. (Night wetting is counted here because conidia were present at the time this trial was initiated.) Results for this trial were determined by rating all leaves on 10 terminals/cultivar on 17 Jun.

Other fungicides applied to entire block, with rate/A were Bayleton 50W 5 oz + Penncozeb 3 lb on 30 May; Bayleton 50W 4 oz + Captan 80WDG 2 lb on 8 June.

Results:

Mean scab incidence for control trees (both cultivars combined) on 27 May was 14.9%, whereas Penncozeb applied after the 22 April infection period reduced scab incidence to 3.7%. Since Penncozeb probably did not provide 2-days of post-infection activity, we assume that the disease evident in the Penncozeb plots resulted from the 22 April infection period whereas the additional 11.2% leaf scab in the control plots resulted from infections that occurred during the 27-28 April infection period when both Penncozeb and the other test fungicides would have acted as protectants.

In both trials, all of the test fungicides provided excellent, though not perfect, control of scab. Control was not significantly affected by fungicide rates for any of the three fungicides that were applied at more than one rate, although trends evident among the three rates tested suggested a slight rate effect for Vangard on leaves and for Scala on fruitlets in Trial-1. Rate effects might have been more evident for Vangard and Scala if we had been testing extended protectant activity rather than post-infection activity or if we had tested post-infection activity beyond 48 hr from the start of infection periods.

None of the treatments were very effective against rust diseases, but Syllit and Scala provided more control than expected and Flint was less effective than expected.

Conclusion:

In the absence of fungicide resistance problems, Scala, Vangard and Syllit all provided 48 hr of post-infection activity. These fungicides may provide options for prebloom scab control when post-infection activity is required.

Acknowledgments:

The authors thank Anne Rugh, Richard Christiana, Sr., and Albert Woelfersheim for technical assistance in carrying out the trial reported here. We also thank the fungicide manufacturers for providing product for testing.

Trial 1: Materials and rate of formulated product per 100 gal	% cluster leaves with scab on 27 May[1] McIntosh	Ginger Gold	Grand mean: both cultivars	% control based on combined means compared to control
Control	18.2 d[2]	11.6 d	14.9 c	
Penncozeb 75DF 1.0 lb	3.9 c	3.6 c	3.7 b	75.2
Flint 50WSG 0.67 oz	1.8 b	0.4 ab	1.1 a	92.6
Syllit 400 SC 8 fl oz	0.9 ab	0.4 ab	0.6 a	96.0
Syllit 400 SC 12 fl oz	0.6 ab	1.6 ab	1.0 a	93.3
Scala 600SC 3.3 fl oz	0.2 ab	0.5 ab	0.4 a	97.3
Scala 600SC 2.2 fl oz	0.3 ab	0.0 a	0.1 a	99.3
Scala 600SC 1.1 fl oz	0.3 ab	0.3 ab	0.3 a	98.0
Vangard 75WDG 2.5 oz	0.0 a	0.0 a	0.0 a	100.0
Vangard 75WDG 1.7 oz	0.0 a	0.4 ab	0.2 a	98.7
Vangard 75WDG 0.8 oz	0.0 a	1.8 b	0.9 a	94.0
Scala 600SC 1.67 fl oz + Penncozeb 75DF 1.0 lb	0.0 a	0.0 a	0.0 a	00.0

(See footnotes below Table 2)

Trial 2: Materials and rate of formulated product per 100 gal	% terminal leaves with scab on17 Jun[1] McIntosh	Ginger Gold	Grand mean: both cultivars	% control based on combined means compared to control
Control	6.0 b[2]	6.5 b	6.2 c	
Penncozeb 75DF 1.0 lb	1.0 a	1.4 a	1.5 b	75.8
Flint 50WSG 0.67 oz	0.4 a	0.6 a	0.5 ab	91.9
Syllit 400 SC 8 fl oz	0.7 a	0.5 a	0.6 ab	90.3
Syllit 400 SC 12 fl oz	0.3 a	0.6 a	0.5 ab	91.9
Scala 600SC 3.3 fl oz	0.2 a	0.5 a	0.3 ab	95.2
Scala 600SC 2.2 fl oz	0.0 a	0.9 a	0.4 ab	93.5
Scala 600SC 1.1 fl oz	0.2 a	0.4 a	0.3 a	95.2
Vangard 75WDG 2.5 oz	0.0 a	0.4 a	0.2 a	96.8
Vangard 75WDG 1.7 oz	0.5 a	0.5 a	0.5 ab	91.9
Vangard 75WDG 0.8 oz	0.3 a	0.7 a	0.5 ab	91.9
Scala 600SC 1.67 fl oz + Penncozeb 75DF 1.0 lb	0.4 a	0.7 a	0.5 ab	91.9

[1]Data collected from all leaves on 15 clusters/tree or 10 terminals per tree for each cultivar on dates indicated.

[2]Means followed by the same letters are not significantly different (Fisher's Protected LSD, $P \leq 0.05$) as determined by applying split-plot analyses to results from both cultivars. The arc-sine transformation was used for statistical analyses, but arithmetic means are shown in the table.

Trial 1: Materials and rate of formulated product per 100 gal	% fruitlets with scab on 27 May[1] McIntosh	Ginger Gold	Grand mean: both cultivars	% control based on combined means compared to control
Control	0.5 a[2]	1.2 b	0.8 c	
Penncozeb 75DF 1.0 lb	0.3 a	1.0 b	0.6 bc	25
Flint 50WSG 0.67 oz	0.0 a	0.0 a	0.0 a	100
Syllit 400 SC 8 fl oz	0.0 a	0.0 a	0.0 a	100
Syllit 400 SC 12 fl oz	0.0 a	0.0 a	0.0 a	100
Scala 600SC 3.3 fl oz	0.0 a	0.0 a	0.0 a	100
Scala 600SC 2.2 fl oz	0.3 a	0.0 a	0.1 ab	87
Scala 600SC 1.1 fl oz	0.0 a	0.7 ab	0.4 abc	50
Vangard 75WDG 2.5 oz	0.0 a	0.0 a	0.0 a	100
Vangard 75WDG 1.7 oz	0.0 a	0.0 a	0.0 a	100
Vangard 75WDG 0.8 oz	0.0 a	0.0 a	0.0 a	100
Scala 600SC 1.67 fl oz + Penncozeb 75DF 1.0 lb	0.0 a	0.0 a	0.0 a	100

(See footnotes below the next table)

Trial 1: Materials and rate of formulated product per 100 gal	% cluster leaves with rust 27 May[1] Mc Intosh	Ginger Gold	Grand means: two cultivars	Ginger Gold with rust: fruit stem	fruit lets
Control	41.6 b[2]	66.5 bc	54.2 d	52.8	14.4
Penncozeb 75DF 1.0 lb	31.0 ab	47.1 ab	39.0 abc	28.5	10.1
Flint 50WSG 0.67 oz	32.1 b	62.8 abc	47.4 bcd	49.5	8.2
Syllit 400 SC 8 fl oz	13.2 a	43.9 ab	28.6 a	33.3	7.9
Syllit 400 SC 12 fl oz	27.5 ab	45.4 ab	36.4 ab	33.1	9.4
Scala 600SC 3.3 fl oz	30.7 ab	54.0 abc	40.7 abcd	36.4	4.2
Scala 600SC 2.2 fl oz	38.7 b	45.7 a	42.2 abcd	43.3	12.4
Scala 600SC 1.1 fl oz	39.3 b	60.1 abc	49.7 bcd	45.8	10.9
Vangard 75WDG 2.5 oz	37.0 b	71.5 c	54.3 d	69.2	19.5
Vangard 75WDG 1.7 oz	39.7 b	62.9 abc	51.3 cd	46.9	11.9
Vangard 75WDG 0.8 oz	37.9 b	70.7 c	54.3 d	59.2	12.6
Scala 600SC 1.67 fl oz + Penncozeb 1.0 lb	33.4 b	54.7 abc	44.1 bcd	32.0	9.3

[1]Data collected from all leaves and all fruitlets on 15 clusters/tree for each cultivar on dates indicated.

[2]Means followed by the same letters are not significantly different (Fisher's Protected LSD, $P \leq 0.05$) as determined by applying split-plot analyses to results from both cultivars. The arc-sine transformation was used for statistical analyses, but arithmetic means are shown in the table.

Horticulture

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Without Consent of the Author

Potential Chemical Thinners for the 'GoldRush' Apple Cultivar [1]

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'GoldRush' is a new late maturing apple cultivar that exhibits a number of superior attributes (Crosby et al., 1994; Janick, 2001). In addition to resistance to the scab fungus [*Venturia inaequalis* (Cooke) G. Wint.] 'GoldRush' has also shown good resistance to powdery mildew [*Podosphaera leucotricha* (Ell. & Ev.) E.S. Salmon], fireblight (*Erwinia amylovora*), and black rot [*Botryosphaeria obtuse* (Schwein.) Shoemaker] (Biggs and Miller, 2004), a common apple disease in the Mid-Atlantic and southeastern United States where the length of growing season is well suited to production of 'GoldRush'. During five years of field testing over 19 planting sites across the U.S. and Canada, 'GoldRush' had the highest cumulative yield and cumulative yield efficiency among 20 apple cultivars tested (Crassweller, 2005). 'GoldRush' has very firm flesh, a high soluble solids concentration, a very good sugar:acid ratio, (Miller et al., 2004) and maintains its crisp texture after 6 to 8 months in regular cold storage (Janick, 2001; S. Miller, personal observation). 'GoldRush' has demonstrated superior processing characteristics and has scored very high in taste tests (Janick, 2001).

'GoldRush' normally produces medium size fruit (Miller et al., 2004), but it has been reported to have a tendency to over crop, resulting in small fruit size (Janick, 2001). Adequate thinning can produce fruit that range between 7.0 cm (2.75 inches) and 7.6 cm (3.0 inches). Information on the response of 'GoldRush' to chemical thinners is lacking. The purpose of this study was to examine the efficacy of several common chemical thinners for the 'GoldRush' apple.

The trees used in this study were 5-year-old (entering 6th leaf) 'GoldRush' on Malling.26 rootstock planted 3.0 x 5.5 m (10' x 18'). Trees had an average crop in 2004, and showed a moderate to heavy return bloom in 2005. Initial fruit set was estimated to be heavy. Trunk circumference was recorded just prior to the 2005 growing season and the trunk cross-sectional area (TCSA) calculated. Two alternative chemical thinning treatments were applied. The first spray treatment contained carbaryl [Sevin XLR Plus (Aventis CropScience, Research Triangle Park, NC)] plus 6-benzyladenine [MaxCel (Valent BioSciences, Libertyville, IL) at 4.73 ml/3.78 l (1 pt./100 gal.) plus 125 $mg \cdot l^{-1}$ respectively in a water solution. The second spray treatment contained carbaryl plus 1-naphthaleneacetic acid (NAA) [Fruit Fix 200 (Amvac Chemical Corp., Newport Beach, CA)] in a water solution at 4.73 ml/3.78 l plus 10 $mg \cdot l^{-1}$ respectively. No surfactant or other additives were included in either spray treatment. All treatments were applied

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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.

with a piston pump handgun sprayer to thoroughly wet the trees. The application rate was approximately 1356 $l \cdot ha^{-1}$ (145 gal./ac). Sprays were applied during the early daylight hours on 23 May under slow drying conditions when fruit averaged 10-12 mm in diameter. Each treatment was applied to 15 individual trees. A similar number of untreated control trees were maintained for comparison.

Flagging of foliage (cupping of leaf margins and drooping of leaves) on trees sprayed with NAA was clearly visible within 72 hr. of treatment. Flagging is commonly associated with uptake and activity of NAA in apple trees. "June drop" began about 2 Jun and follow-up hand thinning was performed on all chemically thinned trees on 28 Jun after June drop had ended. The number of fruit removed by hand thinning, which was intended to adjust fruit spacing over the canopy and eliminate multiple fruit per cluster, was recorded. In addition, untreated control trees were hand thinned on 28 Jun, primarily to reduce the heavy crop load and thus reduce limb breakage. On the control trees no attempt was made to adjust fruit spacing, but fruit clusters were reduced to single fruit. The number of fruit per cm^2 trunk cross-sectional area (TCSA) post thinning was computed from the total number of fruit harvested plus the number of fruit removed by hand thinning. At harvest the total number of fruit per tree and total fruit weight was recorded. Tree height and canopy spread in two positions (N-S and E-W) was recorded at harvest. Canopy volume was calculated after subtracting 0.46 m (average distance from ground to canopy) from the measured tree height assuming an inverted cone form. Data was analyzed using a one-way ANOVA and means separated using the Holm-Sidak method for all pairwise multiple comparison procedure, $P \leq 0.05$.

Both chemical thinning treatments reduced the number of fruit per cm^2 TCSA (crop load) compared to the untreated control (UTC) trees (Table 1). There was no difference in crop load between the two chemical thinning treatments post thinning (Jun), but at harvest (Oct.), trees treated with MaxCel + Sevin XLR had a lower crop load than trees treated with Sevin XLR + Fruit Fix 200. A crop load of 4 to 6 fruit per cm^2 TCSA is considered acceptable for most cultivars (personnal communication, R. Byers). Follow-up hand thinning was significantly reduced by chemical thinning. MaxCel + Sevin XLR treated trees required the fewest number of fruit removal to adjust fruit number per cluster and fruit spacing. An average of 38 fewer fruit were removed in follow-up hand thinning on the MaxCel + Sevin XLR treated trees compared to the Sevin XLR + Fruit Fix 200 treated trees (Table 1).

The MaxCel + Sevin XLR thinning combination resulted in significantly greater fruit weight and larger fruit diameter at harvest (Table 2) compared to UTC or the Sevin XLR + Fruit Fix 200 treatments. The principal ingredient in MaxCel, 6-BA, is known to have an effect on apple size independent of a thinning response (Byers, 2003). Thus the large size achieved with the MaxCel + Sevin XLR treatment may have been a result of thinning and the hormonal action of 6-BA.

While the Sevin XLR + Fruit Fix 200 spray reduced crop load (Table 1) and crop density (number of fruit per cu. ft. canopy vol.) (Table 2), this thinning treatment had no effect on fruit weight and fruit from these trees had a smaller diameter at harvest than the fruit from the UTC trees (Table 2). A lack of fruit size response to the Sevin XLR + Fruit Fix 200 treatment is difficult to explain, especially since this treatment reduced initial crop load by 47% and yield by 51% compared to the UTC. 'GoldRush' matures in late Oct. or early Nov. in most seasons. Hand thinning, although limited, on the UTC trees may have been sufficient to improve fruit size on these trees under such a long growing season beyond what would have been achieved had they had no thinning. 'GoldRush' normally produces small (Janick, 2001) to medium size (Miller et al., 2004) fruit. Excessive thinning may be needed to achieve large [7.6 cm (3 inch)] size 'GoldRush' fruit. The thinning obtained with the dose level of MaxCel + Sevin XLR used in this trial may have been excessive. This chemical thinning combination resulted in a fruit density of only 1.4 fruits/cu. ft. of canopy volume and a projected yield of just slightly more than 400 bushels (19 kg boxes)/acre (Table 2). Given the age, planting density and average size of trees in this study, a yield of 600 to 800 bushels/acre might be a more reasonable expectation. A combination of MaxCel + Sevin XLR Plus appears very promising for thinning 'GoldRush' apples, but additional studies to examine a wider chemical dose range and crop load levels are warranted.

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Table 1. Effect of chemical thinners sprays on crop load post thinning and at harvest and number of fruit removed by hand on 5-year-old 'GoldRush'/M.26 apple trees.

Treatment[z]	Fruit per TCSA (cm^2) post thinner	No. fruit removed by hand[y]	Fruit per TCSA (cm^2) at harvest
UTC[x]	21.6 a[w]	381 a	10.6 a
Sevin XLR + Fruit Fix 200	11.5 b	93 b	7.3 b
MaxCel + Sevin XLR	8.3 c	55 b	5.1 c

[z] Sevin at 4.73 ml/3.78 L; Fruit Fix 200 at 10 $mg \cdot l^{-1}$; MaxCel at 125 $mg \cdot l^{-1}$

[y] Follow-up hand thinning (28 Jun) to eliminate doubles and space fruit.

[x] UTC = untreated control

[w] Mean separation by Holm-Sidak, $P \leq 0.05$

Table 2. Effect of chemical thinners on fruit size, crop load as a function of canopy volume and the calculated yield per acre on 5-year-old 'GoldRush'/M.26 apple trees.

	Mean fruit			
Treatment[z]	weight (g)	diameter (cm)	Fruit per cu. ft. canopy volume[y]	Yield[x] (bu./ac)
UTC[w]	185 b[v]	7.36 b	3.9 a	933
Sevin XLR + Fruit Fix 200	185 b	7.27 c	2.1 b	456
MaxCel + Sevin XLR	213 a	7.71 a	1.4 c	422

[z] Sevin XLR (carbaryl) at 4.73 ml/3.78 L; Fruit Fix 200 (NAA) at 10 $mg \cdot l^{-1}$; and MaxCel (6-BA) at 125 $mg \cdot l^{-1}$

[y] Canopy volume calculated as an inverted cone.

[x] Projected yield based on 242 trees/acre (10' x 18') ≥ 25 sq cm trunk cross-sectional area and 19.05 kg (42 lb) per bushel.

[w] UTC = untreated control

[v] Mean separation by Holm-Sidak, $P \leq 0.05$

Effects of 1-Methylcyclopropane, Aminoethyoxyvinylglycine, and Naphthaleneacetic Acid on Preharvest Drop of "Golden Supreme' and 'Golden Delicious' Apples

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Many commercial apple (*Malus domestica* Borkh) fruit growers lose 5 to 25% of their apple crop due to pre-harvest fruit drop which occurs just before fruit develop optimum red color, maturity and/or size. In addition, when adequate labor is not available to harvest mature fruit in large orchards, a high percentage of the crop (as much as 30%) can be rapidly lost to drop in less than a week. On the other hand, picking fruit before adequate maturity may lead to poor storability and poor fresh and processed fruit quality. Early harvest can also result in lower yields and prices since fruit will increase in weight 5 to 7% per week and price is based on larger fruit sizes (Byers and Eno, 2002). Ideally, effective plant growth regulators or compounds should hold fruit on the tree for an additional 3 weeks past its optimum harvest date to improve fruit size, color, and crop value by as much as 20% while maintaining fruit quality (Byers and Eno, 2002).

Naphthalene acetic acid (NAA) and Aminoethyoxyvinylglycine (AVG) have been two major compounds commercial apple growers use to delay pre-harvest drop of apples since registration of daminozide (Alar) and 2,4,5-TP was canceled in 1989 and 1986, respectively. However, NAA, a synthetic auxin, is effective for 7 to 10 days after treatment and is inadequate, especially for processing cultivars such as 'Rome Beauty', 'York Imperial', and 'Stayman'. Labor shortage and poor weather often delay harvest of apples beyond the effective period for NAA (Marini et al., 1988). In addition, two applications of NAA or warm weather following the first application usually accelerate fruit softening (Smock and Gross, 1947). AVG, an inhibitor of ethylene biosynthesis, can suppress ethylene production, delay fruit ripening, reduce pre-harvest fruit drop, and slow the loss of fruit firmness in cold storage when applied within 1 month of harvest (Autio and Bramlage, 1982; Schupp and Greene, 2004), but AVG may be not very effective as a drop control compound for some cultivars such as 'York Imperial' (Byers, unpublished results).

1-Methylcyclopropene (1-MCP), an inhibitor of ethylene action, has been found to block ethylene response in plants (Sisler and Blankenship, 1996; Fan et al., 1999). Recently, a sprayable formulation of 1-MCP is available (Rohm and Haas Company, Spring House, Pennsylvania). The objective of this study was to determine the effect of 1-MCP, AVG, and NAA alone or in combination on control of pre-harvest fruit drop and maturity of 'Golden Supreme' and 'Golden Delicious' apples.

Materials and Methods

'Golden Supreme' Experiment. Sixty six 5-year-old 'Golden Supreme' apple trees grafted on M.9 rootstock, were selected and separated into six blocks of 11 trees each on 5 August 2005. A randomized complete-block design with six replications was used. One tree in each block received one of the following treatments: (1) Control-no treatment, (2) NAA 3 weeks before expected optimum harvest date (NAA3), (3) NAA 3 and 1 weeks before expected optimum harvest date (NAA3&1), (4) NAA 1 weeks before expected optimum harvest date (NAA1), (5) AVG 3 weeks before expected optimum harvest date (AVG3), (6) AVG 3 and 1 weeks before expected optimum harvest date (AVG3&1), (7) AVG and NAA 3 weeks before expected

optimum harvest date (AVG3 + NAA3), (8) AVG 3 weeks before expected optimum harvest date + NAA 3 and 1 weeks before expected optimum harvest date (AVG3 + NAA 3&1), (9) AVG 3 and 1 weeks before expected optimum harvest date + NAA 1 week before expected optimum harvest date (AVG3&1 + NAA1), (10) 2,4,5-TP 3 weeks before expected optimum harvest date, (11) 2,4,5-TP and AVG 3 weeks before expected optimum harvest date. The concentrations of NAA, AVG, and 2,4,5-TP were 20, 125, and 20 $mg \cdot L^{-1}$, respectively. The sprays were applied with a low pressure hand wand sprayer on 5 August (about 3 weeks before expected optimum harvest date) and 19 August (about 1 week before expected optimum harvest date). Fruit that dropped were counted weekly. Fruit remaining on trees were counted on 24 October 2005. Ten fruit were sampled from each tree to determine fruit weight, flesh firmness and fruit starch. Fruit ethylene production was determined by sealing 'Golden Supreme' fruit in jars for 3 h. Concentrations of headspace ethylene were measured by gas chromatography.

'Golden Delicious' Experiment. Forty eight 6-year-old 'Golden Delicious' apple trees grafted on M.9 rootstock, were selected and separated into six blocks of 8 trees each on 21 September 2005. A randomized complete-block design with six replications was used. One tree in each block received one of the following treatments: (1) Control-no treatment, (2) NAA at 20 $mg \cdot L^{-1}$, (3) AVG at 125 $mg \cdot L^{-1}$, (4) 1-MCP at 150 $g \cdot acre^{-1}$, (5) NAA at 20 $mg \cdot L^{-1}$+ AVG at 125 $mg \cdot L^{-1}$, (6) NAA at 20 $mg \cdot L^{-1}$ + 1-MCP at 150 $g \cdot acre^{-1}$, (7) 1-MCP at 20 $mg \cdot L^{-1}$ + AVG at 20 $mg \cdot L^{-1}$, (8) NAA at 20 $mg \cdot L^{-1}$ + 1-MCP at 150 $g \cdot acre^{-1}$ + AVG at 125 $mg \cdot L^{-1}$. The sprays were applied on 21 September 2005 with a low pressure hand wand sprayer. The expected optimum harvest date was 28 September. Fruit that dropped were counted weekly. Fruit remaining on trees were counted on 14 November 2005. Ten fruit were sampled from each tree to determine fruit weight, flesh firmness and fruit starch. Fruit ethylene production was determined as described previously.

Results

'Golden Supreme' Experiment. In control trees, fruit drop began on 23 August just before fruit reached optimum maturity and/or size, and increased drastically thereafter (Fig. 1). NAA and AVG alone or in combination significantly reduced fruit drop. AVG had a better effect in reducing fruit drop than NAA. Combination of one application of AVG and two applications of NAA had the best effect in reducing fruit drop, followed by combination of two applications of VAG and one application of NAA.

Fruit ethylene production from control trees was low before 15 August, and increased drastically after 22 August (Table 1). 2,4,5-TP enhanced fruit ethylene production whereas AVG inhibited fruit ethylene production. There was no significant difference in fruit ethylene production between NAA and control on 2 September, but NAA-treated fruit had higher fruit ethylene production than control on 23 September.

Fruit size increased dramatically with time regardless of treatment (Table 2). 2,4,5-TP and NAA significantly reduced fruit firmness whereas AVG reduced the loss of fruit firmness. There was no statistical difference in fruit firmness between one and two applications of AVG. Starch loss was enhanced by NAA and 2,4,5-TP but retarded by AVG.

'Golden Delicious' Experiment. 1-MCP, AVG, and NAA alone or in combination effectively reduced fruit drop (Fig. 2). Overall, combination of NAA and 1-MCP or AVG had a better effect

in reducing fruit drop than NAA, 1-MCP, or AVG alone. 1-MCP had the best effect in reducing fruit drop, followed by AVG and NAA by 18 October.

AVG and 1-MCP inhibited fruit ethylene production before 25 October (Fig.3). However, 1-MCP had a less effect in inhibiting fruit ethylene production than AVG thereafter. NAA had no effect on fruit ethylene production.

Fruit size increased with time (Table3). AVG and 1-MCP slowed the loss of fruit firmness whereas NAA enhanced it. Starch loss was enhanced by NAA but retarded by AVG or 1-MCP. Fruit background color was reduced by AVG or 1-MCP. AVG and 1-MCP had no effect on soluble solids.

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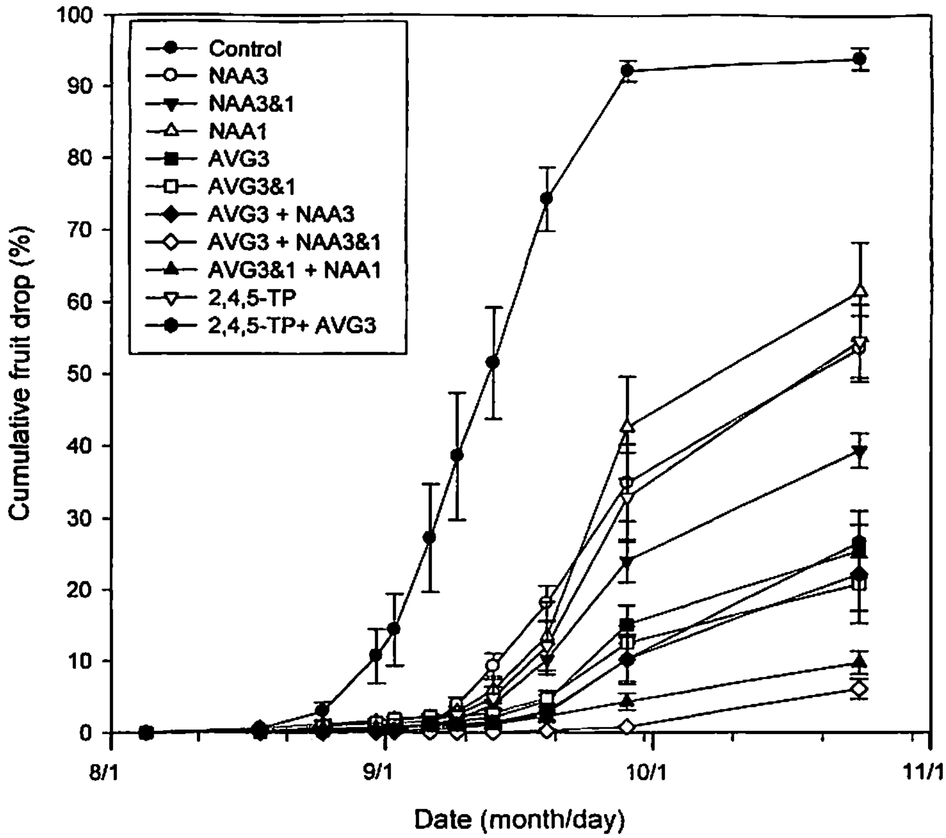

Fig. 1. Effects of AVG, NAA and 2,4,5-TP on pre-harvest drop of 'Golden Supreme' apples

Table 2. Effect of AVG at 125 mg·L-1, NAA at 20 mg·L-1, and 2,4,5-TP at mg·L-1 on fruit ethylene production of 'Golden Supreme' apples

Dates of application		Fruit weight (g)			Flesh firmness (N)			Starch (0-8)		
Aug. 5	Aug. 19	Aug. 23	Aug. 30	Sept. 20	Aug. 23	Aug. 30	Sept. 20	Aug. 23	Aug. 30	Sept. 20
-	-	174.0 ab[y]	202.1 ab	222.9 ab	94.9 ab	89.0 ab	76.3 b	2.1 e	3.5 c	6.5 b
NAA	-	164.5 b	195.0 abc	221.7 ab	94.0 abc	86.3 b	70.4 c	3.0 bc	4.7 b	7.8 a
NAA	NAA	174.0 ab	190.2 abc	221.7 ab	94.0 abc	87.2 ab	70.8 c	3.1 bc	4.7 b	7.9 a
	NAA	184.5 a	209.0 a	236.5 a	88.5 cd	86.3 ab	69.0 c	2.4 de	3.6 c	7.9 a
AVG	-	168.2 ab	195.0 abc	223.4 ab	93.1 abcd	91.7 ab	80.8 ab	2.1 e	2.1 d	4.9 c
AVG	AVG	167.2 b	186.0 bc	224.5 ab	92.6 abcd	90.4 ab	80.4 ab	2.1 e	2.4 d	4.8 c
NAA & AVG	-	166.0 b	187.0 cb	217.4 ab	91.7 abcd	88.5 ab	79.0 ab	3.1 bc	2.6 d	6.1 b
AVG & NAA	NAA	161.0 b	174.0 c	208.2 b	97.2 a	93.1 a	83.5 a	2.8 cd	2.6 d	5.9 b
AVG	AVG & NAA	175.5 ab	194.0 abc	227.9 ab	94.0 abc	90.8 ab	79.0 ab	2.0 e	2.3 d	4.5 c
2,4,5-TP	-	177.0 ab	200.0 ab	224.8 ab	87.2 d	73.6 c	54.0 d	4.5 a	6.4 a	8.0 a
AVG & 2,4,5-TP	-	173.1 ab	196.0 ab	236.0 a	90.8 bcd	87.6 ab	66.7 c	3.5 b	4.0 bc	7.4 a

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

Dates of application		Fruit ethylene production ($\mu L \cdot kg^{-1} \cdot h^{-1}$)				
Aug. 5	Aug. 19	Aug. 4	Aug. 15	Aug. 22	Sept. 2	Sept. 23
-	-	0.008 a[y]	0.067 c	1.784 b	64.438 b	39.184 c
NAA	-	0.008 a	-	-	60.1 b	62.591 b
AVG	-	0.008 a	0.064 c	0.032 d	0.010 d	2.520 d
AVG	AVG	0.008 a	-	-	-	2.516 d
NAA & AVG	-	0.008 a	-	-	0.011 d	23.979 dc
AVG & NAA	NAA	0.008 a	-	-	-	5.402 d
AVG	AVG & NAA	0.008 a	-	-	-	0.019 e
2,4,5-TP	-	0.008 a	1.869 a	23.873 a	114.456 a	86.745 a
AVG & 2,4,5-TP	-	0.008 a	0.131 b	0.231 c	8.347 c	87.065 a

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

Table 3. Effects of 1-MCP, AVG at 125 mg·L^{-1} and NAA at 20 mg·L^{-1} on fruit quality and maturity in 'Golden Delicious' apples[x]

	Fruit diameter (cm)		Fruit Wt. (g)		Flesh firmness (N)		Starch (0-8)		Fruit background color		Soluble solids (%)	
Treatment	Sept. 28	Oct. 24	Sept. 28	Oct. 24	Sept. 28	Oct. 24	Sept. 28	Oct. 24	Sept. 28	Oct. 24	Sept. 28	Oct. 24
Control	7.2 a[y]	7.6 b	164.6 a	182.1 b	76.7 b	60.4 b	5.3 ab	7.6 b	2.9 a	3.8 a	15.1 ab	17.4 ab
NAA	7.4 a	7.9 a	172.6 a	205.9 a	76.7 b	52.7 c	5.5 a	7.9 a	3.0 a	3.9 a	15.4 ab	17.7 a
AVG	7.5 a	7.7 ab	173.0 a	192.9 ab	77.6 b	67.7 a	4.3 c	7.2 c	2.9 a	3.5 b	15.6 a	17.3 ab
1-MCP	7.3 a	7.8 ab	172.6 a	197.5 ab	78.5 ab	67.2 a	4.4 bc	6.6 d	2.9 a	3.4 bc	14.9 ab	16.9 ab
NAA + AVG	7.4 a	7.7 ab	168.0 a	187.8 b	77.6 b	69.5 a	5.1 abc	7.6 b	2.9 a	3.3 cd	14.7 b	16.4 b
NAA + 1-MCP	7.3 a	7.7 ab	170.1 a	196.2 ab	79.0 ab	67.2 a	5.1 abc	7.3 bc	2.9 a	3.4 bc	14.8 ab	16.7 ab
1-MCP + AVG	7.4 a	7.6 ab	169.1 a	186.0 b	79.0 ab	69.0 a	4.5 bc	6.2 e	2.9 a	3.3 cd	15.2 ab	17.2 ab
NAA + 1-MCP + AVG	7.4 a	7.7 ab	168.4 a	186.8 b	80.8 a	68.1 a	4.4 bc	6.2 e	2.9 a	3.2 d	15.3 ab	16.9 ab

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

Treatments were applied on 21 September 2005.

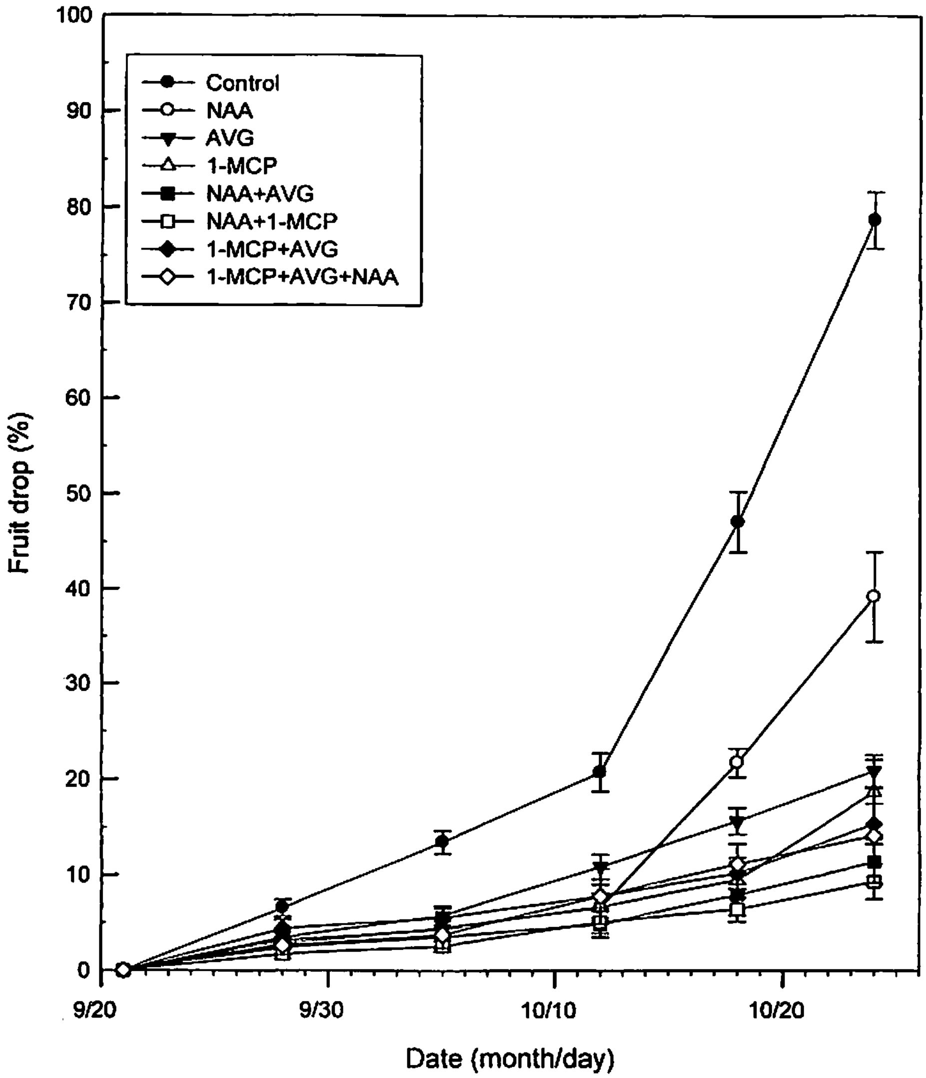

Fig.2. Effect of 1-MCP, AVG and NAA on pre-harvest fruit drop of 'Golden Delicious' apples

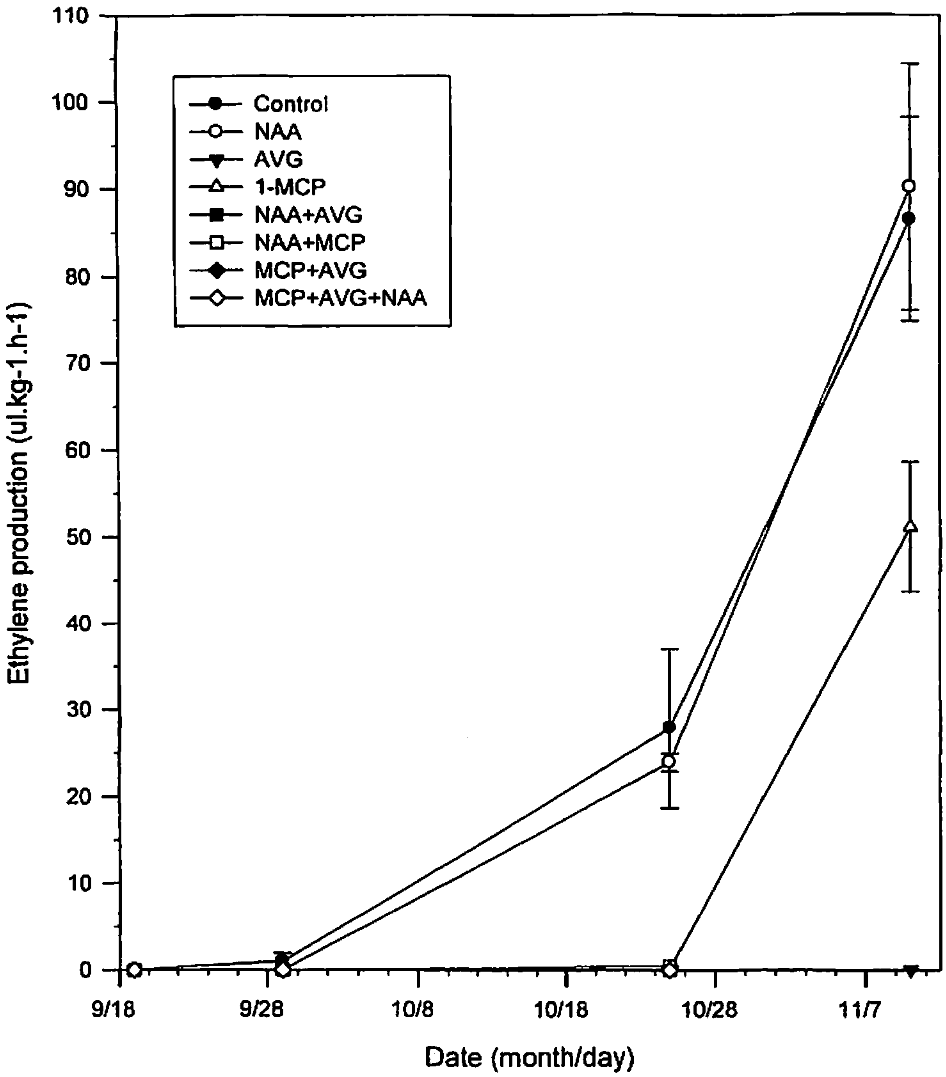

Fig. 3. Effects of 1-MCP, AVG and NAA on fruit ethylene production of 'Golden Delicious' apples

Thinning Pillar Growth Habit Peach Trees with a Spiked-drum Shaker or Chemical Bloom Thinners [1]

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Peach is self-fertile and generally sets significantly more fruit than the tree can grow to a marketable crop. Thinning of the young fruits near the pit hardening stage (about 40 to 50 days after full bloom) is commonly practiced to reduce crop load and improve fruit size at harvest (Frecon, 1996). Plant growth regulator (PGR) chemicals have proven effective for thinning apples, but peaches have responded very poorly or not at all to PGR chemical thinners. Hand removal of the unwanted fruits is still the most common method used to reduce the fruit load on peach trees. Hand thinning of fruits is one of the most expensive practices in peach production.

Researchers have studied a number of alternatives to chemical plant growth regulators for thinning peaches (Byers and Lyons, 1984; Fallahi, 1997; Moran et al., 2000; Southwick et al., 1998; Wilkins et al., 2004). Various oils, surfactants, and fertilizers, which act as a caustic or desiccant agent, have been used to thin peach flowers, but most have proven inconsistent in response and growers are reluctant to apply thinners during bloom before the threat of spring frost has passed. Mechanical bloom thinning with heavy rope drags over the tops of the tree proved effective in reducing crop load, but the thinning was disproportionate between the upper and lower canopy. A rotating rope curtain device improved bloom thinning efficiency, but detailed pruning was required to obtain maximum response in open center trained standard growth habit peach trees (Baugher et al., 1991). Glenn et al. (1994) used a spiked-drum shaking device to postbloom thin peaches on standard peach trees trained to a "Y" canopy form. Mechanical thinning was as effective as hand thinning in one year, but not in another year. The authors concluded that the spiked-drum mechanical thinning device should be applicable on any narrow, flat canopy production system.

Pillar (or columnar) growth habit peach trees produce a relatively narrow (compared to standard growth habit peach trees), upright and uniform canopy with little or no training (Bassi et al., 1994; Scorza, 1988). This new peach tree form seems well suited for adapting to mechanical production methods including thinning. The objective of this study was to evaluate a direct drive spiked-drum canopy shaker for postbloom thinning of the pillar form peach tree. Two bloom thinning chemicals were included for additional study of efficacy and for comparison.

The trees used in this study were of the pillar growth habit from the Appalachian

[1] The assistance of Larry Crim and Scott Wolford is acknowledged and greatly appreciated in this study.

Fruit Research Station's breeding program. The trees were a selection designated KV93479 planted in Dec. 1998 on 'Lovell' rootstock and were beginning their seventh growing season at the time of treatment. Trees were planted in border rows in a north-south direction and were spaced 1.5 to 2.0 m apart in rows spaced 6.0 m apart. Tree height averaged 2.5 m with an average canopy width of 1.5 m. Individual trees had been trained to either a multiple leader or central leader system at random in the row.

Bloom thinners were applied at about the 90% full bloom stage. Liquid ammonium thiosulfate (ATS) as Foli-Gro [12% ammoniacal nitrogen (Wilbur-Ellis, Fresno, CA)] was applied on 14 Apr. at 49.1 $L \cdot ha^{-1}$ (5.25 gal/acre). Matran 2 EC (EcoSMART Technologies, Inc, Franklin, TN), a contact, non-selective broad spectrum herbicide approved for organic production (50% clove oil) was applied on 16 Apr. at 6% (v/v) in a water solution. Sprays were applied dilute with a handgun piston pump sprayer to thoroughly wet the bloom. All sprays were applied in the early morning under a clear sky, at mean temperature of 7.8°C (14 Apr.) or 2.8°C (16 Apr.). Winds were from the north averaging 3 to 13 mph during application. The calculated tree-row-volume was 954 $L \cdot ha^{-1}$ (102 gal/acre). The spray handgun was moved in a serpentine pattern across the canopy parallel to the tree row beginning at the bottom of the canopy. Each side of the tree facing the drive middle was treated. Every effort was made to apply the spray as uniform as possible. Bloom thinner treatments were applied on two separate days because late morning wind conditions prevented continued treatment on the first day. Each spray treatment was replicated on nine trees at random throughout the border rows.

Fruit were mechanically thinned on 7 Jun using a vibrating direct drive double spiked-drum shaker. The shaker was a slightly modified version of the shaker designed for harvesting process oranges (Peterson, 1998). The shaker was mounted on a tractor towed trailer (Fig. 1). Each drum measured 2.43 m in diameter and 1.52 m in height. A drum was made up of 6 whorls of rods spaced 30 cm apart. A whorl consisted of 16 3.2 cm diameter nylon rods radially spaced at equal angles around the axis of the drum. Rods oscillated at 200 cycles per minute with a maximum displacement of about 20.3 cm at the tips. The spiked drums were allowed to rotate freely as they passed through the canopy. Travel speeds of 2 and 3 km/hr were evaluated. Treatments were applied to five (2 km/hr) or four (3km/hr) 10-tree plots. The number of fruit removed by mechanical thinning was counted on five trees within each 10-tree plot. Follow-up hand thinning was performed on mechanically thinned trees (8 and 9 Jun) to adjust fruit spacing (about 5.1 to 7.6 cm apart) and eliminate double fruits on a node. The number of fruit removed was recorded per tree. Nine untreated control (UTC) trees (not thinned) and a like number of hand-thinned control (HTC) trees were tagged at random throughout the 4 border rows in the block. The HTC trees were thinned on 14 Jun. Three trees from each 10-tree plot were selected at random and harvested on 30 or 31 Aug. Control trees and bloom thinned trees were harvested on the same dates. Total weight of fruit harvested was recorded and fruit diameter was taken on a random sample of 50 fruit per tree.

Mild phytotoxicity was observed on bloom of trees treated with Matran within 20 minutes of the spray application. Two hours after Matran spray treatment necrosis was prominent on all flower parts including petals, anthers, and stigma. Leaves and sepals showed some minor phytotoxicity, but not as extensive as the primary floral parts. Spray deposit from ATS was readily observed on flowers and shoots, but phytotoxicity was absent or mild from this treatment even 24 hours after spray treatment. Evidence of spray drift was observed, particularly with Matran. Three weeks after treatment the original phytotoxicity was no longer visible and bloom thinned trees appeared no different than non-thinned control trees.

The number of fruit removed by the spiked-drum mechanical shaker at 2 km/hr was numerically greater than the number of fruit removed at 3 km/hr, but the difference was not significant (Table 1). Mechanical thinning reduced follow-up hand thinning about 50% compared to the HTC trees. The spiked-drum canopy shaker reduced crop load and improved fruit size (diameter) at both travel speeds (Table 2). The HTC treatment reduced crop load slightly, but not significantly below that for the UTC trees. Fruit size was increased on the HTC trees; however, fruit size was less than that achieved with the canopy shaker plus follow-up hand thinning. Consumers are increasingly demanding larger size peaches and growers consider a peach below 6.98 cm (2.75 inch) as one of lower value than peaches between 6.98 cm and 7.62 cm (3 inches). Hand or mechanical thinning resulted in average fruit sizes above the desired size level.

While mechanical thinning generated the largest size fruit, the substantial reduction in crop load was a concern. Mechanical thinning reduced crop load an average of 51% compared to the HTC trees and by 63% over the UTC trees. Based on observations at the time of mechanical thinning and during follow-up hand thinning it was evident that the canopy shaker removed fruit disproportionately over the canopy. Some shoots and areas in the canopy were completely defruited while other areas showed little or no fruit removal. In general, it was felt that the mechanical shaker resulted in a larger portion of the tree canopy being defruited than desirable. Detailed data based on fruit counts and limb orientation was not recorded in this study as in a previous study by Glenn et al. (1994) using a similar spiked-drum canopy shaker. In their study, more fruit was removed from horizontal branches than from vertical branches. The subsequent hand thinning of the mechanically thinned trees in the current study to eliminate "doubles" (two fruit/node) and space the fruit on the branches probably contributed to additional over thinning and thus the significant reduction in crop load compared to the HTC trees. Speed of travel of the shaker, the frequency of the shaker rods, and tree training are variables that could be altered to reduce the number of fruit removed and to obtain a more uniform distribution of crop over the canopy. Peach yields average about 618 bushels/ha (250 48 lb boxes/acre) in the U.S. (National Peach Council, 2003). In our study, even the most severely thinned (mechanical, 2 km/hr) pillar trees produced crop loads at harvest above the U.S. average.

The spiked-drum mechanical shaker broke some small shoots and twigs (generally ≤ 1.0 cm diameter), but the damage was considered minimal. At the 3 km/hr travel speed a few larger branches (2.5 cm diameter or larger) were broken, but the number was not significantly different from the 2 km/hr treatment where no larger branches were broken (data not shown). During the mechanical thinning treatment it was observed that rods on the spiked-drum shaker could become temporarily lodged between two major upright scaffolds on multiple leader trained trees. While none of these "leaders" were broken as the rod attempted to free and continue rotating, the opportunity for limb breakage appeared more likely with trees trained to a multiple leader system than those trained to a central leader. Tree training has long been considered critical in attempting to adapt mechanized equipment to fruit tree culture operations. Our preliminary tests of the spiked-drum canopy shaker for thinning suggest that pruning and training should attempt to maintain no more than a single major upright scaffold in pillar trees for best adaptation of mechanized thinning equipment.

Matran and ATS applied as bloom thinners had no effect on crop load. Fruit size on ATS treated trees was significantly greater than fruit from the UTC and was about equal to the minimal desired fruit size (Table 2). Observations and harvest data indicated that the bloom thinners were erratic. Some individual trees in each treatment were effectively thinned and fruit size increased while other trees showed no response to the bloom thinner. This erratic and poor response to ATS and Matran may be the result of the handgun spray application. While every effort was made to make a uniform application of the chemical thinners, this was a difficult task. Windy conditions during application may also have contributed to poor coverage and erratic results. In a similar study with bloom thinners on apple conducted in 2005 (S. Miller and T. Tworkoski), application of ATS and Matran with an airblast sprayer produced very uniform and positive responses. Another possible contributing factor to the poor response of bloom thinners in this study may have been the very cool weather during bloom resulting in a very prolonged bloom period. Determining the 90% full bloom stage was difficult and could have easily been assigned to any one of 3 to 4 days.

Mechanical thinning of the pillar peach tree growth habit deserves additional work to adapt tree structure and machine operating parameters to maximize crop load and fruit size.

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Fig. 1. The spiked-drum canopy shaker used to mechanically thin pillar peach trees about 50 days after full bloom.

Table 1. Fruit removed by the spiked-drum mechanical canopy shaker, during follow-up hand thinning, and on hand-thinned control (HTC) pillar growth habit peach trees and time required for hand thinning.

Treatment	Fruit (no./tree) removed by Spiked-drum	Hand	Hand thinning time (sec./tree)
HTC	-------	455 a[z]	774 a
Mech. thinned, 2 km/hr[y]	275	175 b	354 b
Mech. thinned, 3 km/hr	234	222 b	413 b
P – value	0.468	<0.001	<0.001

[z] Mean separation by Duncan's New Multiple range test, $P \leq 0.05$
[y] Travel speed of spiked-drum canopy shaker down the row.

Table 2. Effect of a spiked-drum canopy shaker (mechanical thinning) or blossom thinning chemicals on crop load and fruit size in pillar peach trees.

Treatment	Crop load at harvest (kg/tree)	Fruit diameter (cm)	Projected yield per ha (ac) (bushels[z])
Untreated control (UTC)	54.3 ab[y]	6.44 c	2797 (1132)
Hand-thinned control (HTC)	40.6 b	7.18 b	2093 (847)
Mech. thinned, 2 km/hr[x]	17.6 c	7.47 a	907 (367)
Mech. thinned, 3 km/hr	22.4 c	7.46 a	1154 (467)
Bloom thinned, ATS	60.8 a	6.99 b	3133 (1268)
Bloom thinned, Matran	56.2 ab	6.64 c	2896 (1172)
P – value	<0.001	<0.001	

[z] Based on 1122 trees/ha (454 trees/ac spaced 6 ft x 16 ft) and 21.8 kg (48 lbs) per bushel
[y] Mean separation by Fisher LSD method, $P \leq 0.05$.
[x] Travel speed of spiked-drum canopy shaker down the row.

Rootstock Effect on Growth of Apple Scion with Different Growth Habits

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Rootstocks are used to propagate scion of preferred cultivars, improve fruit tree tolerance to environmental stress, and control tree size. Size-controlling rootstocks may alter tree morphology by modifying dry weight distribution, shoot elongation, and branch angle. Much work has focused on effects of size-controlling rootstocks on growth and yield of commercial apple cultivars but interactive effects of rootstock and scion with different growth habits have not been elucidated. In the current experiment the objectives were to (1) measure branch growth during a growing season to compare growth rates and termination of growth of the different rootstock-scion combinations and (2) determine rootstock effects on components of seasonal growth of scions with different growth habits.

The scion used in this experiment came from trees with different growth habits that were from an F2 generation of hybrids produced by sibcross selections from a 'Goldspur Delicious' x 'Redspur Delicious' progeny. In 1996 buds were budded to rootstock of EMLA 7, EMLA 111, M.9, and *Malus antanovka*. Tree growth was measured in April 2003 and 2004. The growth variables included tree height, canopy width, trunk diameter 10 cm above the graft union, crotch angle of main architectural branches, and growth of ten previous season's shoots per tree. Annual shoot growth from 2002 and 2003 was evaluated for amount and position of sylleptic branches. During 2004, 10 branches per tree were labeled and growth was measured each month from April through October.

Rootstock effects on whole tree dimensions were in accord with expectations. Generally, the largest-to-smallest trees grew on seedling, MM.111, M.7, and M.9 rootstocks. These rootstocks did not maintain tree size or shoot elongation by the same amount in all growth habits. Although M.9 tended to reduce growth most, the percent growth reduction differed even between scions with similar growth habits. For example, M.9 reduced tree heights of two different scions, both with excurrent growth habits, by 36 and 13%. Growth habits with decurrent growth habits had more upright branches with narrower branch angles than growth habits with excurrent growth habits. Decurrent growth habits displayed less apical control of proleptic branch growth while having greater apical dominance of sylleptic branches than excurrent growth habits. Decurrent growth habits grown on M.9 rootstock had less apical dominance than on seedling rootstock. The prevalence of rootstock-growth habit interactions highlights the complexity of root-shoot communication in grafted fruit trees. Understanding the processes responsible for such scion-rootstock interactions can assist efforts to obtain tree architecture for a desired orchard management system.

Three Successive Years of Apogee® on Young 'Nittany' Apple Trees on M.9 Rootstock [1]

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Apogee [prohexadione-calcium (BASF, Research Triangle Park, NC)], a plant growth regulator with anti-gibberellin activity, was registered in the U.S. in April 2000 to control vegetative shoot growth in apple. Research and subsequent commercial usage demonstrated the effectiveness of Apogee to reduce shoot elongation (Greene, 1999; Miller, 2002; Unrath, 1999) and to suppress the shoot blight stage of fire blight (Yoder et al., 1999; Norelli and Miller, 2004). 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).

Shoot growth suppression in young apple trees can prolong the time required for individual trees to fill their allotted space in the orchard thereby reducing yields per acre during the early life of the orchard. However, young vigorous trees are considered highly susceptible to fire blight infection and even one strike can lead to death of a tree during the first three to six years of its development. Studies to examine the effects of repeated annual applications of Apogee to young bearing apple trees have not been reported.

The objective of this study was to evaluate the long-term effects of annual Apogee sprays on young apple trees using the low to moderate rates employed by Norelli and Miller (2004). This report describes the effects in the third year of application and summarizes the effects over the first three years of treatment. Reviews of the literature describing the effects of Apogee on apple are presented elsewhere (Miller, 2003; Miller and Tworkoski, 2003).

An initial Apogee treatment was applied to 11 'Nittany' apple trees on Malling.9 rootstock in a completely randomized block design. Trees were in their fourth leaf in 2003, the first year of treatment. A similar number of trees were selected and maintained as untreated controls. Treatments were repeated in 2004 to the same trees. In each year the Apogee treatment consisted of two individual sprays applied 14 days apart. Details of the experimental planting, the previous applications, and the results of treatment have been presented (Miller, 2003, 2004). Trees were dormant pruned in early April 2005 just after bud break and pruning time and number of pruning cuts recorded per tree. On 25 April, at the early bloom stage of flower development, one representative limb per tree was tagged and the number of blossom clusters counted. Limbs selected ranged between 7.2 and 11.5 cm in circumference and were directly attached to the central leader. In

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

2005, Apogee 27.5 DF was applied at 125 $mg \cdot l^{-1}$ in a volume of 1263 $L \cdot ha^{-1}$ [about 135 gallons per acre (gpa)] on 10 May at the late petal fall stage to the same trees which had previously (2003 and 2004) been treated with Apogee. The trees previously used as untreated control trees were again maintained as control trees in 2005. The calculated tree-row-volume for the 'Nittany' trees was 1010 $L \cdot ha^{-1}$ (108 gpa). A second spray was applied at 63 $mg \cdot l^{-1}$ on 23 May. All sprays were applied with a hand pump backpack sprayer to wet the foliage and shoots to the point of drip. Yield, fruit quality, and growth data were collected as previously described (Miller, 2003). A single fire blight strike was observed and removed with sterilized pruners from one of the untreated control trees on 2 June. No other fire blight strikes were identified in the 2005 growing season. Data for 2005 was analyzed with a one-way ANOVA and treatment means compared using the Student's *t*-test. Data for yield, fruit diameter and weight was subjected to a two-way ANOVA using year and treatment (Apogee and untreated control) as factors to examine the effect of Apogee over the three years of treatment.

Apogee treated trees required an average of 7.3% less time per tree to dormant prune than the untreated control trees, but the difference between treatments was not statistically different (P = 0.736). Return bloom did not differ between treatments (P = 0.455). Apogee treated trees had an average of 7.1 flower clusters per cm limb cross-sectional area (LCSA) [standard error of the mean (SEM) = 2.948] compared to 4.3 blossom clusters per cm LCSA (SEM = 2.301) for control trees. In this study, no chemical thinners have been applied and hand thinning has been delayed until about the time of June drop in an attempt to avoid confounding thinning with Apogee response(s). All of the individual control trees had some bloom, but 25% of the Apogee treated trees had zero bloom. Fifty percent of the Apogee treated trees and 36% of the control trees had five or fewer blossom clusters on the tagged limb and generally poor return bloom observed over the whole tree canopy. Data and these observations suggest that the trees in this study, particularly the Apogee treated trees, may be establishing a biennial bearing habit.

At harvest there was no statistical difference between Apogee treated trees and control trees for mean yield (kg) per tree, fruit weight, or fruit diameter. Numerically, Apogee treated trees had more fruit per tree at harvest (mean 175 fruit) than control trees (125 fruit), but the difference was not significant (P = 0.503). Similarly, mean size (weight and diameter) of fruit harvested from Apogee treated trees was numerically less, but not statistically different from controls (data not shown). Data for fruit set was not recorded in this study, but mean crop load [fruit per trunk cross-sectional area (TCSA)] at harvest did not differ between treatments (4.8 fruit/TCSA for Apogee vs. 4.6 fruit/TCSA for control trees). When the Apogee trees with no yield were removed from the analysis, the crop load increased to 6.3 fruit/TCSA, but the difference was not significant compared to the control trees' mean crop load. Crop loads between 4 and 6 fruit/TCSA are generally considered normal for trees of this age and size (personal comm., Ross Byers and Duane Greene). However, it should be pointed out that considerable variation in crop load existed among trees within the two individual treatments. Twenty-five percent of the Apogee trees and 27% of the control trees in the study had crop loads greater than 10.0 fruit/TCSA. At the same time 50% of the Apogee treated trees and 36% of the control trees had crop loads at or below 1.0 fruit/TCSA. Mean cumulative yield beginning with 2003 through 2005 did not differ between treatments (Apogee 69 kg/tree compared to control at 65 kg/tree).

Methods used to measure fruit quality have been presented by Miller (2003). Fruit quality parameters (flesh firmness, soluble solids concentration, and starch index rating) did not differ between the two treatments at harvest in 2005. This concurs with results in 2004 and with previous studies that have shown little or no effect of Apogee on fruit quality, when used at rates of 250 $mg \cdot l^{-1}$ or lower (Byers and Yoder, 1999; Miller, 2002; Schupp et al., 2001).

As in the two previous growing seasons, two Apogee sprays in 2005 at an effective cumulative dose of 188 $mg \cdot l^{-1}$ (the sum dose of the two individual sprays) reduced terminal shoot growth, tree height, and canopy spread compared to control trees (data not shown). Filling the allotted orchard space as quickly as possible is a concern for many commercial apple growers.

The trees in this study were spaced 2.4 m apart in the row, spacing considered liberal for trees on M.9 rootstock. Following three years of annual spray treatments, Apogee treated trees had reached an average canopy spread of 2.6 m, thus exceeding the allotted space during the sixth year in the orchard.

A two-way ANOVA of the data using Year and Treatment as independent variables revealed a significant effect of year for mean yield, fruit diameter, and fruit weight (Table 1). Treatment did not have a significant effect on these variables. There was a significant interaction for Year x Treatment for fruit diameter (Table 1 and Fig. 1). Most studies have reported no effect of Apogee on fruit size except when fruit set is increased (Greene, 1999). However, I have observed apparent reductions in fruit size in commercial orchards treated with Apogee when there was obviously no increase in fruit set. As previously suggested (Miller, 2004) this negative effect on fruit diameter may be related to below normal temperatures during the critical cell division stage of fruit development. However, fruit set effects on fruit diameter can not be dismissed in the current study since fruit set data was not collected.

The cost of Apogee has been a concern voiced by commercial growers. Based on the median local retail price for Apogee in 2005 of $50 per pound and the size and planting density of the experimental orchard, the annual material cost for my Apogee treatment in the 6th-leaf was US$41.90 per acre (about US$103/ha). Given the relative small tree size and the limited pruning time in this study, it is not likely the material cost would be recovered though improved spraying efficiency or saving in dormant pruning cost. However, the material cost may be easily justified based on the reduced fire blight infection provided by Apogee (Miller, 2004; Norelli and Miller, 2004).

Summary of findings on 'Nittany' apple trees, 2003-2005: 1) Two annual moderate to low-dose Apogee sprays applied beginning at late petal fall through 3 weeks after petal fall consistently reduced terminal shoot growth, which led to reduced tree height and canopy spread compared to the untreated control trees; 2) Apogee had no effect on return bloom in two seasons following spray treatment and little or no effect on fruit quality; 3) Two Apogee sprays significantly reduced the number of fire blight strikes in a year with heavy fire blight infection pressure; 4) Except for the initial treatment year, Apogee sprays had no effect on annual yield and no effect on cumulative yield; and, 5) Apogee may reduce fruit size independent of fruit set. The potential reduction in fruit size as it relates to fruit set on Apogee treated trees warrants additional study.

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Table 1. *P* – values from two-way ANOVA for three successive annual Apogee spray treatments applied to young 'Nittany' apple trees on M.9 rootstock.

	Dependent variable		
Source of variation	Yield	Fruit diameter	Fruit weight
Year	0.022	0.043	0.027
Treatment	0.779	0.246	0.059
Year x Treatment	0.426	0.029	0.364

Fig. 1. Effect of Year x Treatment (Apogee vs. Control) interaction on fruit diameter of 'Nittany' apples, $P = 0.029$.